RECLAMATION

Managing Water in the West

Operation of Flaming Gorge Dam Final Environmental Impact Statement Technical Appendices

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Salt Lake City, Utah

September 2005

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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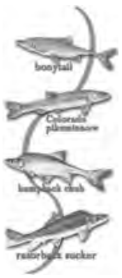

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Operation of Flaming Gorge Dam Final Environmental Impact Statement

Forest Service Position Paper Technical Appendix

FOREST SERVICE POSITION PAPER
TECHNICAL APPENDIX

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Forest Service Position Paper Technical Appendix

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United States Department of Agriculture | Forest Service | Ashley National Forest | 355 North Vernal Ave Vernal, UT 84078

File Code: 1950

Date: August 23, 2000

Bruce C. Barrett, Area Manager
USDI – BOR Upper Colorado Region
302 East 1860 South
Provo, Utah 84606-7317

Subject: **Addendum** - Cooperating Agency Position for the Operation of Flaming Gorge Dam Environmental Impact Statement

Dear Mr. Barrett:

We have developed an addendum to the USDA Forest Service Position as a Cooperating Agency for the subject EIS. The addendum and the August 10 position paper are enclosed. All items in the addendum and position paper address policies and procedures that are in place for the Flaming Gorge National Recreation Area, including operation and management responsibilities for the Flaming Gorge Reservoir and Green River. The enclosed documents include information that is necessary to adequately address management concerns; and therefore, we request that these concerns guide data gathering, and analysis and evaluation steps in the EIS process.

Please provide us with a response to our requests and concerns, including how each will be displayed or otherwise used in the EIS process and EIS.

To date, we have coordinated closely with EIS team leaders and members and will continue to cooperate fully during the process.

Sincerely,

BERT KULESZA
Forest Supervisor

Enclosures (2)

cc:
Eileen Richmond, Flaming Gorge District Ranger
Terry Clark, Public Service Group Leader
Garth Heaton, consultant

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OPERATION OF FLAMING GORGE DAM
ENVIRONMENTAL IMPACT STATEMENT

Addendum to
The revised (8/10/00) USDA Forest Service Position Paper

August 23, 2000

The Purpose and Need for Action for the Flaming Gorge Dam Operations EIS is: "…to protect and assist in the recovery of the population and designated critical habitat of the four endangered fishes, **while maintaining the other authorized purposes** of the Flaming Gorge Unit of the Colorado River Storage Project." (emphasis added). The "Authorizing Legislations" are described by BOR as; 1) The Colorado River Storage Project Act of 1956, and 2) the Colorado River Basin Project act of 1968.

The Forest Service believes that a third legislated Act needs to be added to the list of Authorizing Legislation **(PL 90-540, the Flaming Gorge National Recreation Area Act of 1968)**. The Forest Service requests that the following wording be added to all purpose and need narratives in the EIS, with such wording serving as the basis for analysis and evaluation of natural and socioeconomic resources:

> *PL 90-540 was enacted "... in furtherance of the purposes of the Colorado River Storage project." The purposes of the Flaming Gorge National Recreation Area are to provide "(1) Public Outdoor Recreation benefits; (2) Conservation of Scenic, Scientific, Historic, and other values contributing to public enjoyment; and (3) such management, utilization, and disposal of natural resources as in his (Secretary of Agriculture) judgment will promote, or are compatible with and do not **significantly impair** the purposes for which the recreation area is established." (emphasis added).*

The Forest Service proposes that the EIS identify and describe the…." **other authorized purposes** of the Flaming Gorge Unit of the Colorado River Storage Project" for each of the three acts cited above. Appropriate EIS sections should also define what would be entailed in maintaining these other purposes, display any and all deviations from the conditions that are to be maintained, and include specific mitigation measures for maintenance of the purposes.

In the case of PL 90-540 the purposes that should be specified and analyzed for effects are: 1) Recreation Benefits (i.e.: supply and economic contribution of land based, river based, and reservoir based recreation opportunities), 2) Scenic, 3) Scientific, and 4) Historic.

The Forest Service proposes to work with the socio-economic and/or other appropriate resource teams to describe the current or desired conditions to be maintained and to identify changes that would exceed the threshold of concern for each of the primary purposes identified in PL 90-540. We will work with the EIS team to define a level of "Significant Impairment" (sec 2, PL 90-540)

Addendum cont.

for each of the primary purposes, and to develop mitigation measures that could be employed if significant impairment results from implementing an alternative.

The Forest Service does not support the development of alternatives designed to emphasize one resource area, such as a recreation emphasis alternative. We prefer that all of the alternatives incorporate measures that lessen the effects on the authorized purposes of the Flaming Gorge National Recreation Area, while improving the recovery of the endangered fish species.

Operation of Flaming Gorge Dam Environmental Impact Statement

USDA Forest Service Position as a Cooperating Agency

Revised - August 10, 2000

Representatives of the USDA Forest Service (Forest Service) have responded to all invitations to participate as a cooperating agency in the preparation of the environmental impact statement for Operation of Flaming Gorge Dam. We have attending initial planning meetings, site visits, and public scoping meetings. We have also provided a Forest Service "fact sheet" to the Bureau of Reclamation NEPA managers for distribution during public scoping. We will continue to participate as a cooperating agency as defined in Council of Environmental Quality guidelines, and regulations for the National Environment al Policy Act of 1969.

The Forest Service has the following management concerns that need to be addressed in appropriate sections of the subject EIS. We will work with Bureau of Reclamation EIS team members to provide data, and corresponding analysis and evaluation that will be necessary to address and mitigate these concerns.

The EIS must adequately address the Forest Service role and responsibility to manage the Flaming Gorge National Recreation Area, including all infrastructure and uses associated with the management of this area. This includes: a) Flaming Gorge Reservoir from Green River, Wyoming to Flaming Gorge Dam; b) on-water and reservoir shoreline infrastructure and use; and c) Green River and river corridor use and infrastructure from Flaming Gorge Dam to a point 12 miles below the dam. The Forest Service places special emphasis on the need for the EIS to analyze economic affects (revenue, cash flow, etc.) to Forest Service operations, as well as to Forest Service concessionaire and permittee operations within the Flaming Gorge National Recreation area and the Green River Corridor. The EIS must also address the relationship and joint management role and responsibilities between the Forest Service and USDI Bureau of Land Management for managing facilities and use on the segment of the Green River from the boundary of the Ashley National Forest to the State of Utah Wildlife Refuge in Browns Park.

Therefore, the Flaming Gorge Dam EIS should include:

1. Analyses, evaluations and accompanying mitigation measures for all recreational, socioeconomic and natural resource values, benefits, and infrastructure associated with the Flaming Gorge National Recreation Area, including Flaming Gorge Reservoir, the Green River Corridor, and the Flaming Gorge-Uintas National Scenic Byway. *

1

2. Alternatives with flow regimes and draw downs that address and allow for adequate protection of existing facilities/infrastructure and uses on Flaming Gorge Reservoir and within the Green River Corridor, including maintaining the Little Hole National Recreation Trail in its present location; or if necessary due to unacceptable damage from flows, the relocation of the trail beyond high flow elevations. *

3. References to the role and responsibility of the Forest Service in regards to the Flaming Gorge National Recreation area. *

4. References to ongoing studies and considerations of Sections A and B as "Scenic" and Section C as "Wild "under the Wild and Scenic Rivers Act. *

> *
>
> In order to achieve accurate and complete data needed to address the above four points, the Forest Service asks that the Bureau of Reclamation EIS team prepare a technical report for socioeconomic values and benefits associated with the Flaming Gorge Reservoir and Green River.

The supporting rationale for the above management concerns and the need for a "socioeconomic technical report" is described in the following information on programs, actions, sites, and facilities that will be affected by the Proposed Action. We request that EIS team members gather site specific data associated with this information and address the above four points in appropriate sections of the EIS.

Flaming Gorge National Recreation Area Designation –

The Congressional Act establishing the Flaming Gorge National Recreation Area specified three broad missions and management goals. Specifically, the Secretary of Agriculture is directed *"to administer, protect, and develop the Flaming Gorge National Recreation Area in a manner to best provide for (1) public outdoor recreation benefits; (2) conservation of scenic, scientific, historic, and other values contributing to public enjoyment; and (3) such management, utilization, and disposal of natural resources as in his judgment will promote or are compatible with, and do not significantly impair the purpose for which the recreation area is established."*

As directed by the Congressional Act and the accompanying Administrative Directive, the Ashley National Forest administers and manages programs and activities associated with:

- ✓ Recreation Uses and Sites
- ✓ Scenic qualities
- ✓ Historic and Cultural values
- ✓ Special Uses, ex. Outfitters and Guides
- ✓ Transportation (roads and trails)
- ✓ Natural Resources, including grazing, wood products, and minerals

- ♦ The Flaming Gorge National Recreation Area is the flagship of the national recreation areas in the USDA Forest Service. It was the first national recreation area in the agency and remains a high priority in overall budgeting and planning actions.

- ♦ The Flaming Gorge National Recreation Area, including the Green River attracts 700 thousand to over 2 million visitors annually, depending on the year. The Green River corridor portion of the Flaming Gorge National Recreation Area has received annually between 100,000 and 150,000-user days over the past five years. The remaining use is spread out over the Flaming Gorge Reservoir and adjacent land areas. The Utah Travel Council and Utah Division of Wildlife Resources advertise the Green River as a blue ribbon fishery, and Flaming Gorge Reservoir as a major sport fishery and boating paradise. Direct and indirect annual expenditures connected with river experiences and uses are estimated to average $25 million ("Recreation Use Capacity of the Green River Corridor below Flaming Gorge Dam", dated April 1991), with close to $100 million expended on recreation pursuits for the Flaming Gorge National Recreation Area as a whole in both Wyoming and Utah (figures from Utah and Wyoming Travel Council Tourism Economic Studies).

Flaming Gorge Reservoir –

The 91-mile reservoir has approximately 360 miles of shoreline. A variety of infrastructure and uses occupy both the surface and shoreline of the reservoir.

- ♦ There are 29 developed sites immediately adjacent to the reservoir, consisting of:
  - 3 developed marinas
  - 9 concrete boat ramps with paved access roads
  - 4 boat-in campgrounds
  - 7 family or group campgrounds
  - 3 swim beaches
  - 3 undeveloped recreation sites

- In addition, there are numerous buoys, docks, signs, etc., associated with these sites.

- Both private business operations and Forest Service management activities are interconnected with each above sites. Mariana and campgrounds are operated and managed under special use permit by private companies.

- Concessionaires manage the campgrounds. Onsite management occurs 24 hours each day of the week. The majority of the campgrounds are on the National Campground Reservation System.

- Investments in recreation related infrastructure (both private and federal government) is estimated to near or slightly above 200 million dollars, with gross annual business income estimated between one and two million dollars. **

  **** These figures will be refined during the EIS Process.**

- Both investments and income can be adversely affected by unplanned, and severe changes in reservoir elevation levels. Damage to facilities can occur during severe drawdowns, causing increased business costs and loss of revenues to special use permittees and concessionaires.

Flaming Gorge-Uintas National Scenic Byway –

- Utah State Road 44 and US Highway 191 are components of the Flaming Gorge National Scenic Byway. This special designation recognizes historical, scenic, and recreational values associated with the Flaming Gorge National Recreation Area. The byway and its amenities are marketed and promoted nationally and internationally as a destination highway. The Flaming Gorge-Uintas Scenic Byway Corridor Management Plan directs programs and actions along the two routes, and includes actions and programs connected to Flaming Gorge Reservoir and Green River. The reservoir and river are major attractions and integral to successful marketing, promotion, and management of this National Scenic Byway.

Recreation and Administration of the Green River from Flaming Gorge Dam to Little Hole, including Little Hole National Recreation Trail, roads, boat ramps, parking areas, restroom facilities, day use areas, and concessionaire and outfitter/guide operations –

- Little Hole National Recreation Trail is advertised and displayed on State, Forest and other regional and national recreation maps. Primary use occurs between Flaming Gorge Dam and Little Hole Recreation Complex, with proposals to improve and extend the trail beyond the Little Hole area.

- The trail is needed to provide and manage access and use along the Green River. The trail is engineered to provide safe access. Relocation options are limited. Trail work and trail facilities have always been coordinated with the Bureau of Reclamation, Flaming Gorge Field Division.

- There is a 2.7 million dollar investment in facilities supporting the recreational fishery on National Forest System lands below Flaming Gorge Dam. Facilities considered in the investment are:

  -Spillway Recreation Complex (road, toilets, ramps, trail, etc.)
  -Trail along the river (engineered trail, including stabilizing structures)
  -Toilets in river corridor
  -Riverside campsites (13 sites)
  -Little Hole Road
  -Little Hole Overlook
  -Little Hole Recreation Complex (ramps, toilet, picnic area, jetties, etc.)
  -Dripping Spring Campground

- One million dollars of the 2.7 million dollars are invested in facilities directly within the Green River corridor on National Forest System lands.

- The Bureau of Land Management issues special use permits to outfitters/guides and concessionaires within the Green River corridor. The Forest Service administers these permits. This arrangement allows the return of up to 3 percent of special use permit revenues for the purpose of administering, improving, and maintaining river facilities. (The Forest Service does not have the authority that allows return of revenues collected within the Green River corridor.)

- Bureau of Land Management and Forest Service personnel jointly patrol the river, and manage and maintain river facilities in Sections A, B, and C, as defined in the Green River Management Plan", dated May 20, 1996. The Forest Service provides overall supervision.

- Concessionaires manage the Spillway Recreation Complex and Little Hole Recreation Complex in Section A. Onsite management occurs 14 hours each day of the week. These concessionaires also maintain the "river campgrounds" in Section B and collect a $10.00 per night fee. Several of these river campgrounds will soon be placed on the National Campground Reservation System.

- Thirteen Outfitter/Guide businesses use the Green River corridor, Sections A, B, and C as defined in the Green River Management Plan", dated May 20, 1996. Annual revenues for these businesses equal or exceed 1.3 million dollars. Each outfitter employs 7 to 9 people from early spring to late fall.

Business Ventures and Capital in the Flaming Gorge National Recreation Area–

- In addition to the developed marinas and outfitter/guide services mentioned above, several other businesses are directly related to both reservoir and river recreation activities. These businesses consist of stores, gas service stations, shuttle services, restaurants, and lodging facilities. Each business has substantial investments in infrastructure and employee many people, sometimes year round.

- Several of the businesses operate under special use permit issued by the Forest Service. We have the responsibility to provide a successful business environment and/or to inform them of pending changes that will adversely or otherwise affect their business income. The analysis and evaluation process for the EIS must address and quantify affects to these business ventures.

Dutch John Privatization –

- The town and town site of Dutch John, Utah has recently been privatized, with land and various facilities to be transferred to Daggett County. Success of this community will hinge on existing and new recreation businesses, and on regional and national recreation visits. Business success will be dependent on maintaining quality experiences for clients within the Green River corridor and on Flaming Gorge Reservoir.

Destination Resorts –

- Many visitors consider the Green River corridor and the Flaming Gorge National Recreation Area as a destination, rather than a "pass through" experience. Visitors are planning complete vacations around activities and accommodations associated with two areas. The Utah Travel Council advertises the Green River Corridor and Flaming Gorge National Recreation Area as destination resort areas. Annual recreation visits indicate that the area is within the top ten most visited sites in Utah.

Future Studies on Recreation Use –

- A "Recreation Use Monitoring Contract" will be implemented October 1, 2000, and continue through September 2001. This contract will be designed to measure use, satisfaction, and expectations. Survey data will be gathered at many locations within the Flaming Gorge National Recreation Area and in the Green River corridor.

The Forest Service will provide technical representatives to assist EIS team members in gathering specific data for the above management concerns. We review all technical reports and the preliminary draft environmental impact statement, and provide substantive comments for change, modification, and clarification of issues, concerns, affects, alternatives, and mitigation measures.

-end-

Operation of
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Hydrologic Modeling Technical Appendix

HYDROLOGIC MODELING TECHNICAL APPENDIX

Page No.

Hydrologic Modeling Technical Appendix

RESULTS OF ACTION AND NO ACTION ALTERNATIVE ANALYSIS

R. Clayton and A. Gilmore
October 1, 2001

INTRODUCTION

A model of the Green River Basin has been developed to simulate the operations of Flaming Gorge Dam under varying hydrologic conditions. The Green River model was developed for the purpose of characterizing the hydrologic effects to Flaming Gorge Reservoir and the Green River below Flaming Gorge Dam caused by the implementation of the proposed alternatives for the Flaming Gorge Dam Environmental Impact Statement (Flaming Gorge EIS).

Two alternatives have been proposed for the Flaming Gorge EIS. The Action Alternative requires Flaming Gorge Dam to be operated to achieve the flow recommendations described in the *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations). The No Action Alternative requires Flaming Gorge Dam to be operated to achieve the recommended flows described in the 1992 Biological Opinion on the Operation of Flaming Gorge Dam (1992 Biological Opinion). At the present time and since 1992, Flaming Gorge Dam has been operated to achieve the flow objectives of the 1992 Biological Opinion.

For each of these alternatives, the authorizing purposes of Flaming Gorge Reservoir are to be “maintained” in such a way that impacts to these resources are minimized. In the Green River model, rules to operate Flaming Gorge Dam to achieve the flow objectives described in the 2000 Flow and Temperature Recommendations and the 1992 Biological Opinion were developed. These rules were then modified to reduce the occurrences and magnitudes of bypass releases while still achieving the flow objectives of the alternative. Reducing the occurrences and frequencies of bypasses was the method used to "maintain" the purposes for which Flaming Gorge Dam was authorized.

The purpose of this report is to summarize the hydrologic effects observed in the model output as a result of achieving the flow objectives of each proposed alternative. The results in this report focus on the model output from Flaming Gorge Reservoir and the Green River below Flaming Gorge Dam.

MODELING SCOPE

The Green River model was created from an existing model called the Colorado River Simulation System (CRSS). The CRSS has been used for several years to identify impacts to reservoirs in the Colorado River Basin under different hydrologic scenarios. Most recently, CRSS was used to quantify the impacts of the proposed alternatives for the Colorado River Interim Surplus Criteria Environmental Impact Study (2000).

All major elements of the Green River System are represented in the Green River model, and some elements are more accurately represented than others. The Green River below Flaming Gorge Dam is divided into three sections, known as reaches, in the 2000 Flow and Temperature Recommendations. All three of these reaches are represented in the Green River model. Reach 1 extends from the tailrace of Flaming Gorge Dam to the confluence with the Yampa River. Reach 2 extends from the confluence of the Green River with the Yampa River to the confluence of the Green River with the White River. Reach 3 extends from the confluence of the Green River with the White River to where the Green River meets the Colorado River. The flows for Reaches 1 and 2 are more accurate in the model than those for Reach 3. This is because the effects of the White and Duchesne Rivers on the flows in the Green River are not fully understood. At this point, these river systems have not been adequately modeled to determine how they will be regulated and developed in the future. For this reason, results for Reach 3 have not been included in this report.

The Green River model routes natural flows (river flows that do not include human interferences such as depletion and regulation), referred to as input hydrology, through the reservoir system on the Green River (Fontenelle and Flaming Gorge Reservoirs). A monthly natural flow database was developed for the Upper Colorado River Basin for use as input hydrology for CRSS. The input hydrology for the Green River model was selected from this database. A period of record was selected that had the most complete natural flow dataset available for the upper Green River Basin. This period begins in January 1921 and ends in December 1985 (65 calendar years). The natural flow data is being extended to 1995; however, this work has not yet been completed. The Green River model will be re-evaluated with this additional data for the Final Flaming Gorge EIS.

The initial conditions of the Green River model were selected to be the state of the Green River system in January of 2002 as described in the 2000 Annual Operating Plan (AOP) for Colorado River System Reservoirs. The 2000 AOP was based on the August 2000 run of the 24-Month Study Operational Model of the Colorado River. The Green River model runs for 39 years to December 2040.

Beyond 2040, estimated depletion schedules for water users represented in the model were considered too speculative to be useful. Depletion schedules were updated to reflect water development forecasts produced by the Upper Colorado River Commission (1999). Given the uncertain nature of water development schedules far into the future and the fact that the model predicted reservoir elevations that appeared stabile in the distant future, ending the model run in 2040 was reasonable.

Different hydrologic scenarios, referred to as input traces, are routed through the Green River model. Each trace is one set of 39 years of natural flows. Because the input hydrology for the model is based on historic hydrology, all the input traces have a high probability of occurring in the future. No single input trace, or set of input traces, has a higher probability of occurring then any of the other input traces. The Index Sequential Method (ISM) was used to construct 65 input traces for the Green River model from the natural flow dataset selected. The ISM involves incrementing the beginning and ending years of the natural flows for the following input trace by 1 year. For example, the first trace of the model began with the natural flows for January 1921, and ended 39 years later with the natural flows for December 1959. The second trace began with natural flows for January 1922 and ended in December 1960. Subsequent traces were developed in this manner until the end of the period of record was reached (December 1985). Once the end of the period of record was reached, additional traces were created by incrementally appending the initial natural flows from the period of record to the end of the trace so that the length of the trace was 39 years long. For example, the 28th trace contained the natural flows for January 1948 through December 1985, but this only equaled 38 years. To extend this trace to a length of 39 years, the natural flows for January 1921 through December 1921 were added to the end of the 28th trace. The 29th trace required that 2 years of natural flows (January 1921 through December 1922) be appended to the end of the trace to achieve a length of 39 years. This process was continued until all 65 traces were constructed. When the Green River model is run, the model run is complete when all 65 input traces have been successfully routed through the Green River system.

To evaluate how well each run of the model achieved the flow objectives of the proposed alternatives, it was necessary to generate output at a daily timestep for river flows in Reaches 1 and 2. A daily post processor model was constructed for this purpose. The daily post processor model generated the spring release hydrograph from the monthly model results and processed it into daily results. The daily release hydrograph was then routed through Reaches 1 and 2 of the Green River. The historic daily flows of the Yampa River for the period from January 1, 1921, to December 31, 1985, were taken from United States Geological Survey stream flow records and were used as the input hydrology by the daily post processor. There are no rules in the daily post processor that operate Flaming Gorge Dam that are unique to the daily postprocessor model. All of the rules necessary to operate Flaming Gorge Dam to achieve the proposed alternatives are present in the monthly model and the daily post processor model.

RULESET DEVELOPMENT

The rules that operate Flaming Gorge Dam to achieve the objectives of the proposed alternatives are referred to as rulesets. For each of the proposed alternatives, one ruleset has been developed. The paragraphs below describe the specific objectives that each ruleset was designed to achieve.

During the spring (April through July), the objectives of the Action Alternative require a peak release magnitude of sufficient duration to achieve flow targets in Reaches 1 and 2. These objectives change depending on the hydrologic condition of the upper Green River Basin. Except for cases when the minimum release rate of 800 cubic feet per second (cfs) is prescribed, the objectives for Reach 2 appear to achieve the objectives for Reach 1 as well. The spring objectives of the Action Alternative for Reach 2 that are achieved by the Action ruleset are described below.

1. Achieve peak of 26,400 cfs for at least 1 day in 10 percent (%) of all years
2. Sustain peak of 22,700 cfs for at least 2 weeks in 10% of all years
3. Sustain peak of 18,600 cfs for at least 4 weeks in 10% of all years
4. Achieve peak of 20,300 cfs for at least 1 day in 30% of all years
5. Sustain peak of 18,600 cfs for at least 2 weeks in 40% of all years
6. Achieve peak of 18,600 cfs for at least 1 day in 50% of all years
7. Sustain peak of 8,300 cfs for at least 1 week in 90% of all years
8. Sustain peak of 8,300 cfs for at least 2 days in 98% of all years
9. Achieve peak of 8,300 cfs for at least 1 day in 100% of all years

These requirements were derived from table 5.5 in the 2000 Flow and Temperature Recommendations. The 2000 Flow and Temperature Recommendations are divided into five separate categories depending on the type of hydrologic conditions experienced in the upper Green River Basin. The objectives described above aggregate all of the flow objectives in the separate categories of the 2000 Flow and Temperature Recommendations into one group.

The Action Alternative also has flow objectives for the summer, autumn and winter. During this period (August through February), the Action ruleset controls the releases from Flaming Gorge Dam to achieve flow objectives for Reach 1 and 2 while attempting to lower the reservoir water surface elevation to a target of 6027 feet above sea level by the beginning of March. The Action ruleset maintains releases to achieve the flow objectives during the base flow period unless the reservoir elevation rises to 6040 feet above sea level or greater. When this occurs, releases are controlled by a maximum storage rule that prevents uncontrolled spills. When the inflow into Flaming Gorge during the base flow period is greater than anticipated and the elevation is below 6040, the flow objectives are maintained; and the target elevation will not be achieved. Releases during March and April attempt to reset the elevation of the reservoir to 6027 feet above sea level by the beginning of May by making releases in the range from 800 to 4,600 cfs.

The No Action Alternative has spring flow objectives that are less specific than the Action Alternative. Instead, the flow objectives of the No Action Alternative focus more on flows during the summer and autumn period. The flow objectives of the No Action Alternative during the spring require a peak release with a magnitude of at least 4,600 cfs (powerplant capacity) and a duration from 1 to 6 weeks in all years. In wet years, the No Action ruleset makes the duration of the peak release approach 6 weeks in length. In dry years, the duration is set to at least 1 week in length. The No Action ruleset determines a spring release volume by attempting to control the reservoir elevation to achieve a fill target for the end of July. This volume is then shaped into a spring peak hydrograph that achieves the spring objectives described above.

During the summer and autumn (before October), releases from Flaming Gorge Dam are managed by the No Action ruleset so that flows in Reach 2 are between 1,100 and 1,800 cfs. In October, releases are managed so that flows in Reach 2 are between 1,100 and 2,400 cfs. From November through February, there are no restrictions placed on flows during the base flow period. The model restricts these flows to the range from 800 to 4,600 cfs to lower the reservoir elevation to a target of 2027 feet above sea level by the beginning of March. These constraints are violated only when the reservoir elevation gets too high for safe operation of , Flaming Gorge Dam (6040 feet above sea level). In March and April, releases are controlled between 800 and 4,600 cfs to achieve a reservoir elevation target of 6027 feet above sea level by May. The rule, which operates Flaming Gorge Dam during March and April, is identical in both the Action and No Action rulesets.

MODELING ASSUMPTIONS

Because of the limitations of the modeling environment, many assumptions were made in the development of the Green River model and the Action and No Action rulesets. The assumptions that are specific to this model are described below:

1. Actual historic forecasting of the spring (April through July) unregulated inflow volume for Flaming Gorge is assumed to represent the current and future level of forecast accuracy. Forecasted spring unregulated inflow volumes into Flaming Gorge have been issued by the National Weather Service since 1963. The Green River model generates spring unregulated inflow forecasts with an error distribution that is similar to the historical error distribution.

2. It is assumed that the timing and magnitude of the peak flow of the Yampa River can be predicted accurately at least 10 days prior to its occurrence. To achieve the spring flow objectives of the Action Alternative, while efficiently managing the resources of Flaming Gorge, the peak release from Flaming Gorge Dam must be optimally timed with the peak flows of the Yampa River. The magnitude of the peak release from Flaming Gorge Dam must also be optimally chosen to efficiently supplement flows on the Yampa River.

3. It is assumed that decisions regarding the operation of Flaming Gorge will be made at the beginning of each month. Even when conditions change mid-month, decisions to react to the changing conditions must wait until the beginning of the following month. In reality, operational decisions at Flaming Gorge Dam are made on a daily basis, but the Green River model is limited by the monthly timestep process.

4. It is assumed that the natural hydrology of the Green River Basin (from 2002 to 2040) will be similar in the future to the natural hydrology that occurred during the period from 1921 to 1985.

5. Whenever flow objectives for Reach 2 are achieved, it is assumed that the flow objectives for Reach 3 are also achieved.

6. River flows in Reach 1 and Reach 2 are assumed to have the same magnitude at all points along the reach. Gains and losses as a result of infiltration, precipitation, or evaporation along the reach are not accounted for in the model.

7. All hourly flow objectives for each of the proposed alternatives are assumed to be achieved and are not directly considered within the Green River model.

8. Flaming Gorge Powerplant is assumed to have a capacity of 4,600 cfs. The bypass tubes are assumed to have a total capacity of 4,000 cfs. The spillway is assumed to have a capacity of approximately 28,000 cfs.

MODEL RESULTS

Analysis of the output for the Action Alternative model run indicated that the magnitude and duration of the peak releases increased significantly as a result of achieving all of the flow objectives of the Action Alternative. Magnitudes and durations of the peak releases in the No Action results were noticeably smaller and shorter. An investigation of the individual flow objectives for the Action Alternative discovered that one flow objective was responsible for most of these increases. The Reach 2 objective requiring a sustained flow on the Green River of 18,600 cfs for at least 2 weeks in 40% of all years required peak releases of at least 8,600 cfs in 40% of all years and at least 10,600 cfs in 20% of all years to achieve this objective.

To help understand the impacts associated with achieving this one objective, two versions of the Action ruleset were constructed. The first version, which is described as the Action (ALL) model run, achieved all flow objectives for the Action Alternative including the 18,600-cfs objective. The second version of the Action ruleset, described as the Action (ALL-1) model run, did not focus on achieving the 18,600-cfs objective. Instead this ruleset focused on achieving all other flow objectives of the Action Alternative and ignored the 18,600-cfs objective. Table 1 summarizes the Action (ALL), Action (ALL-1) and No Action model results in terms of how well the spring flow objectives of the Action Alternative were achieved under each ruleset. It is important to note that even when this objective was ignored by the Action (ALL-1) ruleset, it was still achieved 18.2% of the time as a result of achieving the other flow objectives. Analysis of the Action (ALL-1) results show that 18,600 cfs was achieved 40% of the time in Reach 2 for a duration of 6 days.

Table 1—Controlling Criteria Analysis of Action and No Action Model Results

Spring Peak Flow Recommendations for Reach 2	Target %	Model Results (%)		
		Action (ALL-1)	Action (ALL)	No Action
Achieve Peak at Jensen >= 26,400 cfs	10	11.4	16.4	5.0
Sustained Peak at Jensen >= 22,700 cfs for at least 2 weeks	10	10.8	12.3	4.1
Sustained Peak at Jensen >=18,600 cfs for at least 4 weeks	10	9.5	18.1	5.0
Achieve Peak at Jensen >= 20,300 cfs	30	44.7	57.7	40.4
Sustain Peak at Jensen >= 18,600 cfs for at least 2 weeks	**40**	**18.2**	**43.1**	**14.0**
Achieve Peak at Jensen >= 18,600 cfs	50	60.2	66.0	58.9
Achieve Peak at Jensen >= 8,300 cfs	100	99.7	99.7	98.5
Sustain Peak at Jensen >= 8,300 cfs at least 1 week	90	96.9	96.9	96.9
Sustain Peak at Jensen >= 8,300 cfs at least 2 days except in extreme dry years	98	97.3	97.3	97.3

RESERVOIR WATER SURFACE ELEVATION RESULTS

For each month of the model run, from January 2002 to December 2040, there are 65 elevations that could potentially occur in any given month (one elevation for each trace). These monthly data sets have been sorted from lowest to highest. The 10th, 50th, and 90th percentile values have been selected from each set. Figure 1 shows the 90th percentile elevations that occurred for all three runs of the model for the first 10 years of the model run. The results in figure 1 do not represent any one particular elevation trace. Rather, these curves can best be thought of as a boundary elevation that will be exceeded 10% of the time. To illustrate how individual traces fluctuate through time, trace 54, which achieved the 90% boundary elevation in July, 10 years into the model run, is included in the figure. The amplitude of the curves from year to year indicated how much water was being stored during the spring for release later in the year. The smaller the amplitude, the less storage that took place throughout the year and the less change in elevation that occurred from year to year. Both the Action (ALL) and the Action (ALL-1) model runs have smaller amplitudes than the No Action Alternative, indicating less active storage and less elevation change during the year.

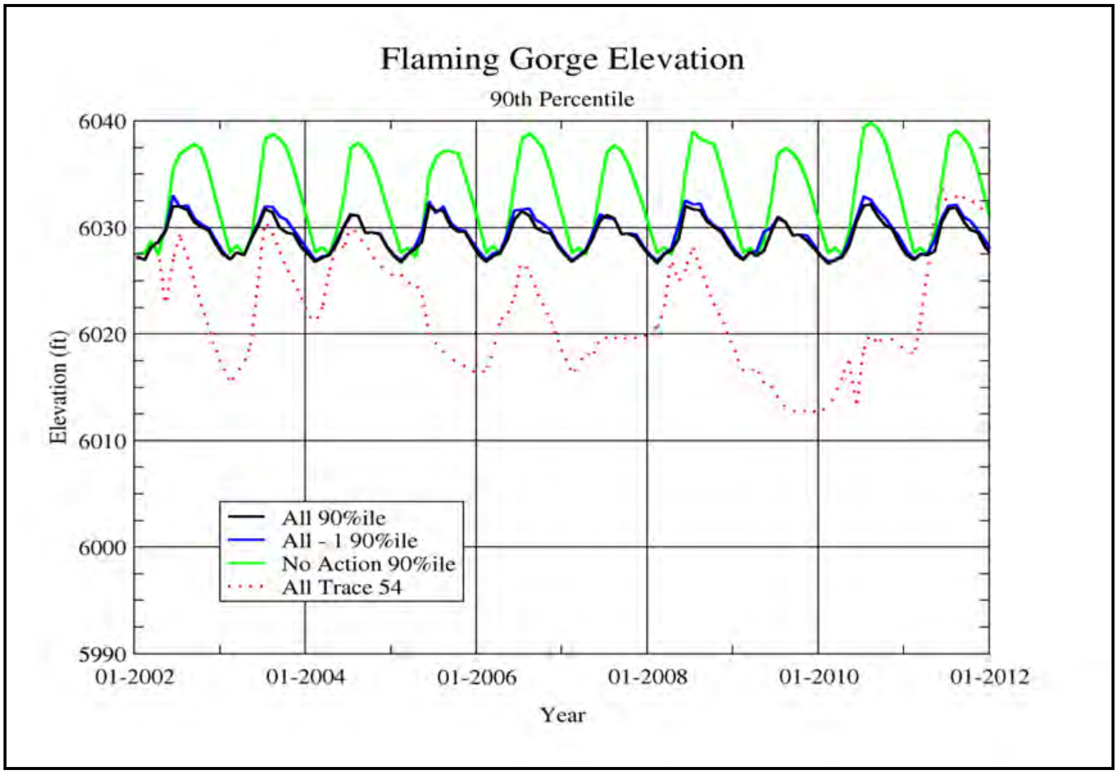


Figure 1.—90th Percentile Elevations from January 2002 to December 2011.

To illustrate an example of the impacts that achieving the 18,600-cfs objective had on the reservoir elevation, figure 2 shows trace 54 results for all three model runs during the first 10 years. Five of the ten years shown in the figure triggered the Action (ALL) ruleset to achieve 18,600-cfs objective because of high flows experienced on the Yampa River. The years when Action (ALL) ruleset was triggered were 2002, 2006, 2008, 2010, and 2011. In these years, the

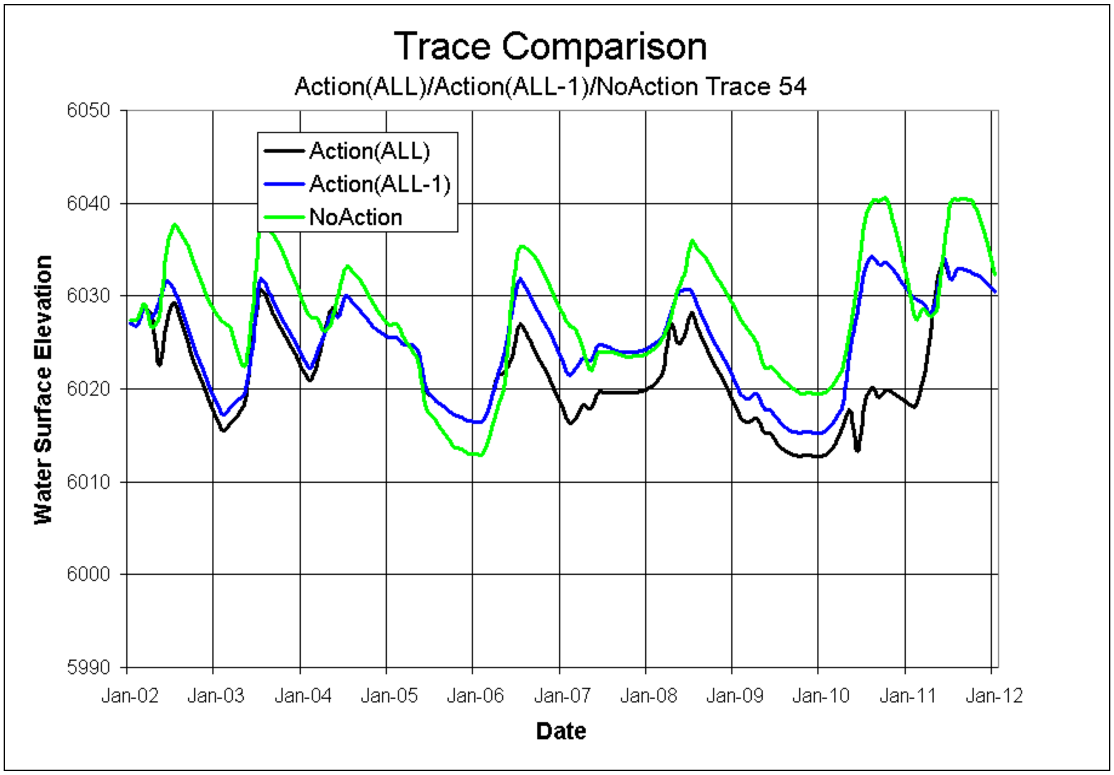


Figure 2.—Trace 54 Elevation Comparison.

peak release from Flaming Gorge Dam was increased (if necessary) to the threshold level necessary to achieve 18,600 cfs in similar years (in some years, this meant increasing to 8,600 cfs and other years to 10,600 cfs). In all years except 2011, the peak release was increased by the Action (ALL) ruleset above the peak release that was calculated for the Action (ALL-1) ruleset. In 2011, the release rate estimated in both the Action (ALL) and the Action (ALL-1) rulesets was high enough to achieve the 18,600-cfs objective. The hydrology for the upper Green River Basin during the spring of 2011 was very wet, and releases during that year were hydrologically driven to control the reservoir elevation and not by the flow objectives of the proposed alternative. The increased releases are evident by the sharp drops in elevation that occurred in the spring of each of the years mentioned above.

The 50^{th} percentile ("most probable") elevations over the first 10 years of the model runs are shown in figure 3. As compared to the two Action Alternatives, the No Action Alternative provided significantly higher reservoir elevations in the summer months. The Action (ALL) results indicated lower elevations than the Action (ALL-1) results. During the winter, elevations were very similar for all three model runs since the draw down target is the same in all three rulesets. As in figure 1, a single trace has been included in figure 3. This trace (trace 16) achieved the 50% exceedance level for the Action (ALL) results in July, 10 years into the trace.

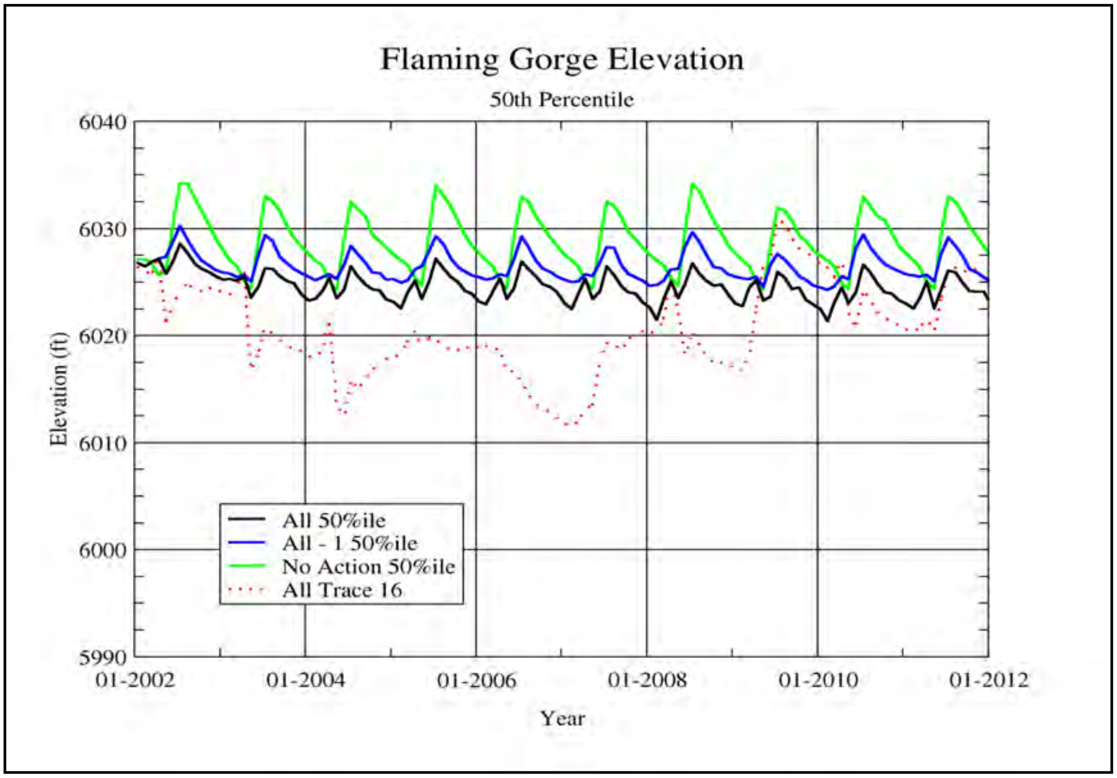


Figure 3.—50th Percentile Elevations from January 2002 to December 2011.

Figure 4 shows another example of how achieving the 18,600-cfs objective had a significant impact to the reservoir elevation of the Action (ALL) results. In this trace (trace 16), there are 5 years where the Yampa River flows during the spring were high and triggered the Action (ALL) ruleset to attempt to achieve the 18,600-cfs objective. These years were 2002, 2003, 2004, 2008, and 2010. Because of the increased peak releases that occurred in these years for the Action (ALL) model run, the reservoir elevation remained substantially lower than the Action (ALL-1) model run for most of the 10-year period shown in the figure. The elevation, fully recovered in 2009, was then depressed in 2010 when the Action (ALL) ruleset was again triggered to achieve the 18,600-cfs objective.

Figure 5 shows the 10th percentile reservoir elevations for the first 10 years of each model run. These elevations were exceeded 90% of the time but were equal or lower than these levels 10% of the time. The Action (ALL) results show a significant impact to the reservoir elevation as a result of the 18,600-cfs objective. Reservoir elevations for the Action (ALL) results decreased substantially over the first 10 years, then stabilized below 6000 feet above sea level for the remainder of the model run. The results for the Action (ALL-1) model run indicated that meeting all flow objectives except for the 18,600-cfs objective did not significantly impact the reservoir elevation through time. An example trace (trace 5) has been included in figure 5 which shows how the reservoir elevation tracked for the Action (ALL) model run. The elevation for this trace of the Action(ALL) model run achieved the 10th percentile value in July, 10 years into the trace.

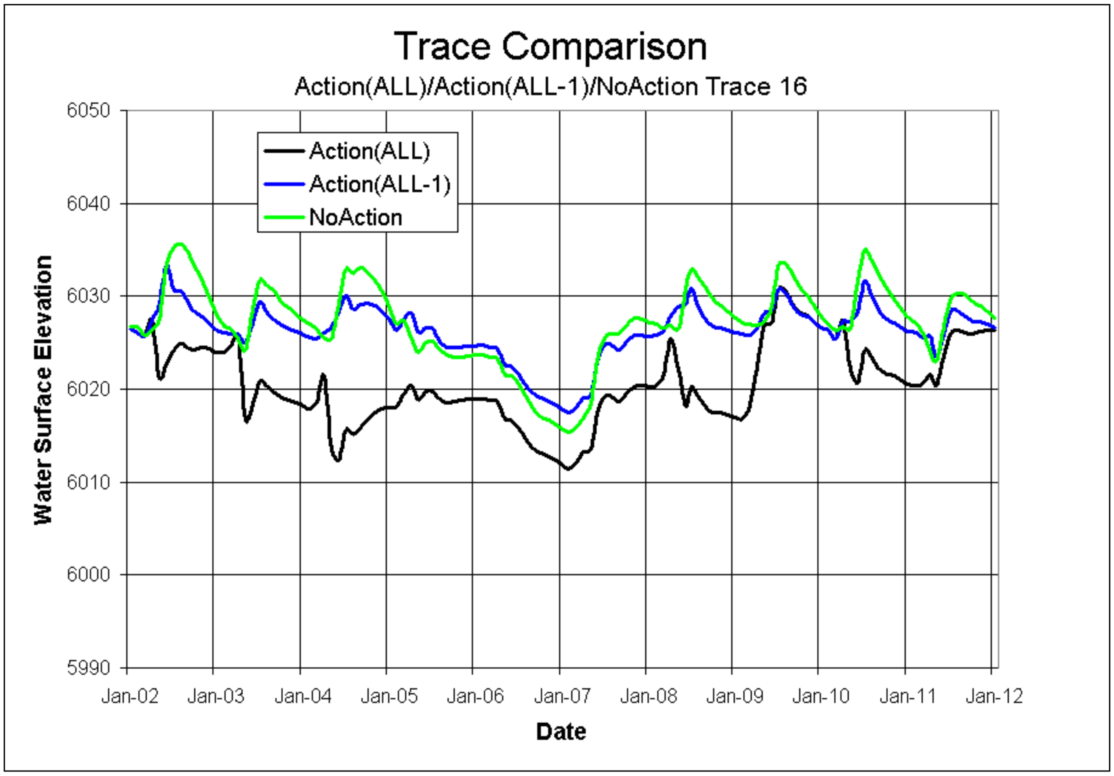


Figure 4.—Trace 16 Elevation Comparison.

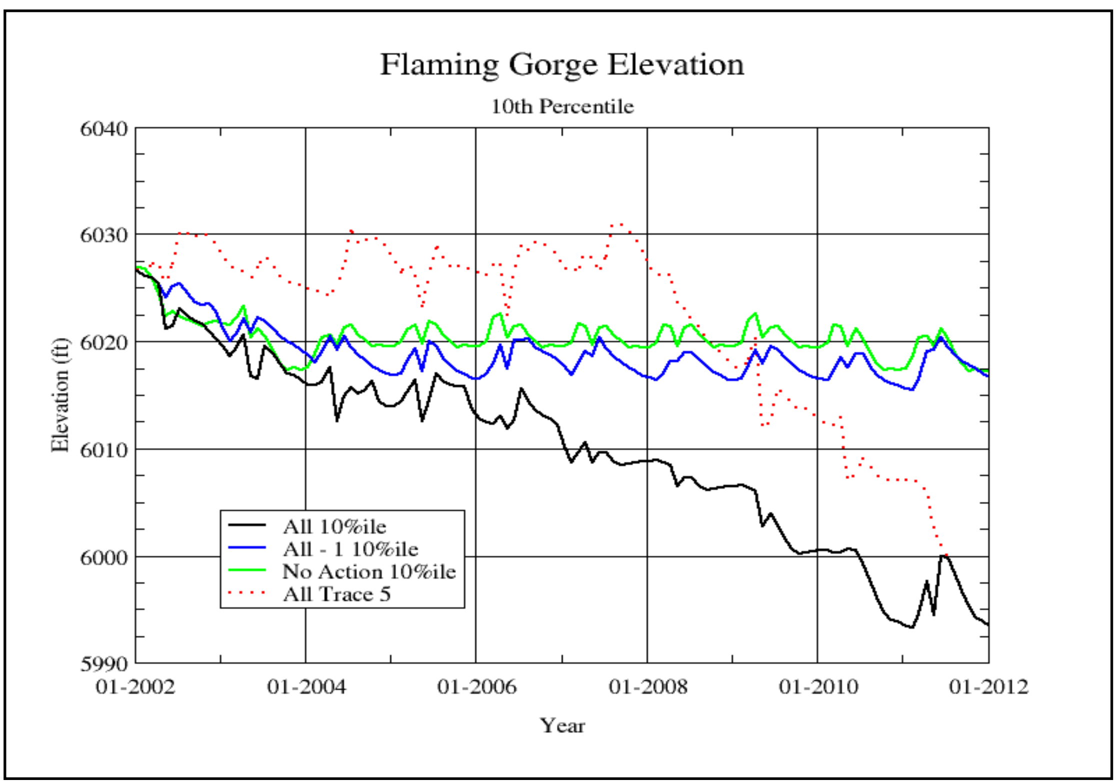


Figure 5.—10th Percentile Elevations from January 2002 to December 2001.

Figure 6 shows another example of how the Action (ALL) and Action (ALL-1) rulesets behave under identical hydrologic conditions. In the first 8 years of trace 5, the Action (ALL) reservoir elevations were the same as the Action (ALL-1) reservoir elevations. This indicated that the releases made by the two rulesets were identical for the first 8 years. However, conditions on the Yampa River in 2005, 2006, and 2007 triggered the Action (ALL) ruleset to attempt to achieve the 18,600-cfs objective. Because conditions were very wet in the upper Green River Basin in those years, the peak release established by the Action (ALL-1) ruleset was equal to or greater than the threshold peak release that the Action (ALL) ruleset would have reset the peak release to. For this reason, the Action (ALL) reservoir elevations did not deviate from the Action (ALL-1) reservoir elevations during the first 8 years of the trace. In 2010, this was not the case. The Action (ALL) ruleset reset the peak release to achieve the 18,600-cfs objective, resulting in the reservoir elevation dropping about 8 feet below the Action (ALL-1) elevation.

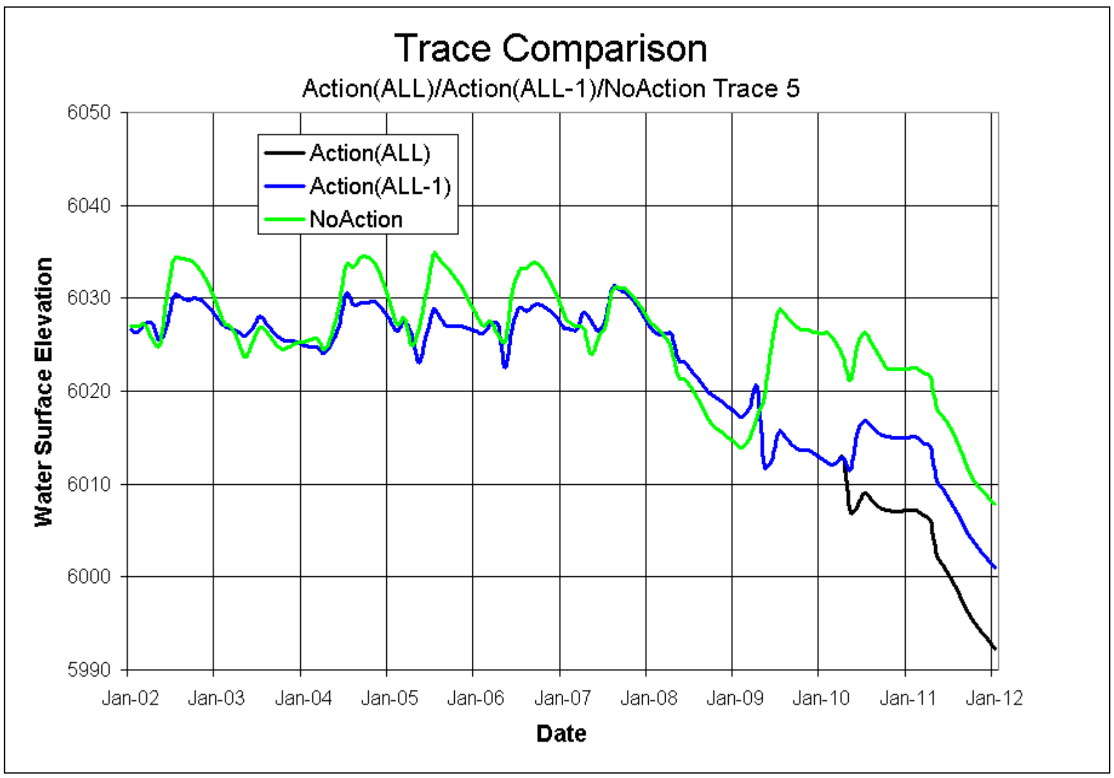


Figure 6.—Trace 5 Elevation Comparison.

During the early spring, the elevation of Flaming Gorge Reservoir is normally at its lowest level of the year. Figures 7 and 8 show the number of occurrences when the elevations at the end of April are within particular ranges. Figure 7 shows a comparison between the Action (ALL-1) and the No Action model output. Figure 8 shows a comparison between the Action (ALL) and the No Action model output. Comparison between figure 7 and figure 8 shows that achieving the 18,600-cfs objective had the effect of increasing the occurrences of lower elevations in the spring. The number of occurrences when elevations at the end of April were below 6000 feet above sea level increased from less than 50 (2% of the time) in the Action (ALL-1) model run to nearly 300 (12% of the time) in the Action (ALL) model run. There were no occurrences in the No Action results where the elevations at the end of April fell below 6000 feet.

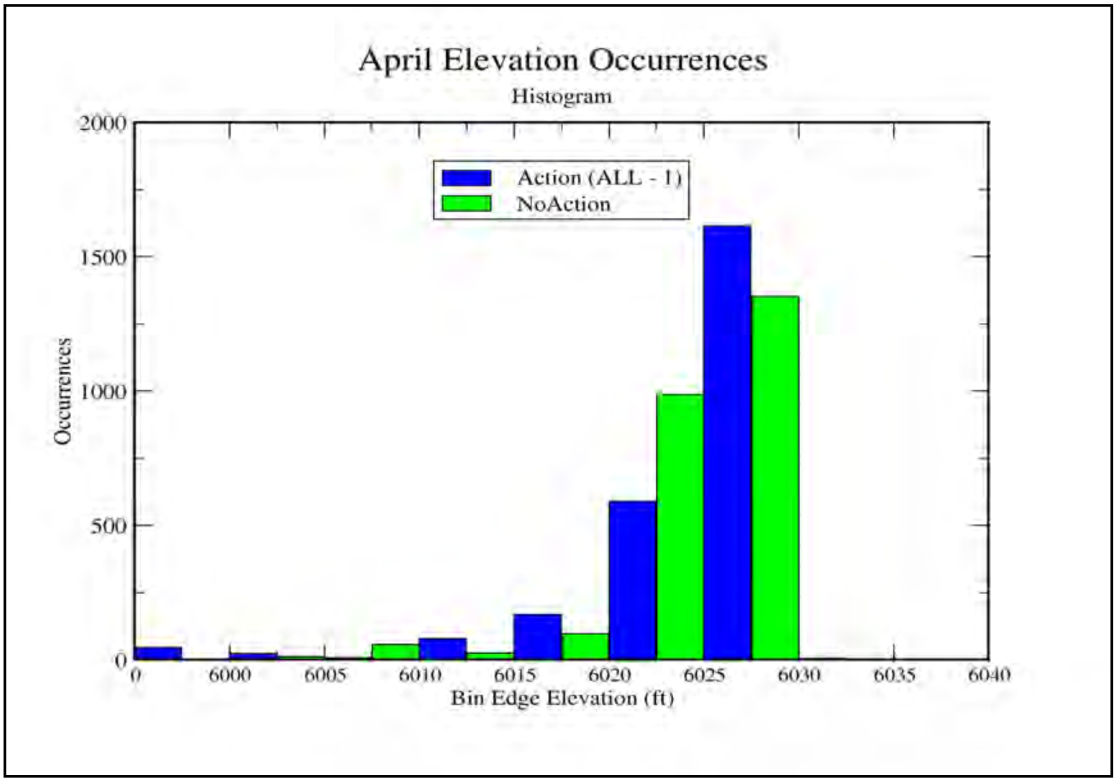


Figure 7.—Histogram of Action (ALL-1) and No Action April Elevations.

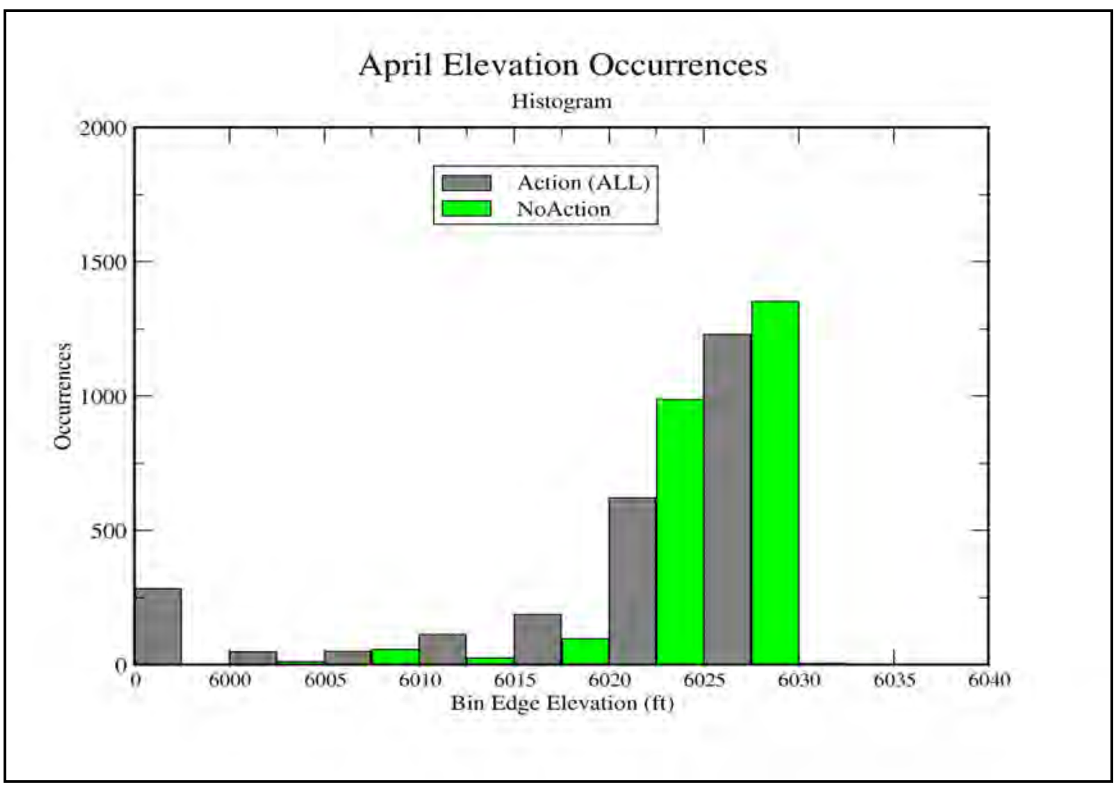


Figure 8.—Histogram of Action (ALL) and No Action April Elevations.

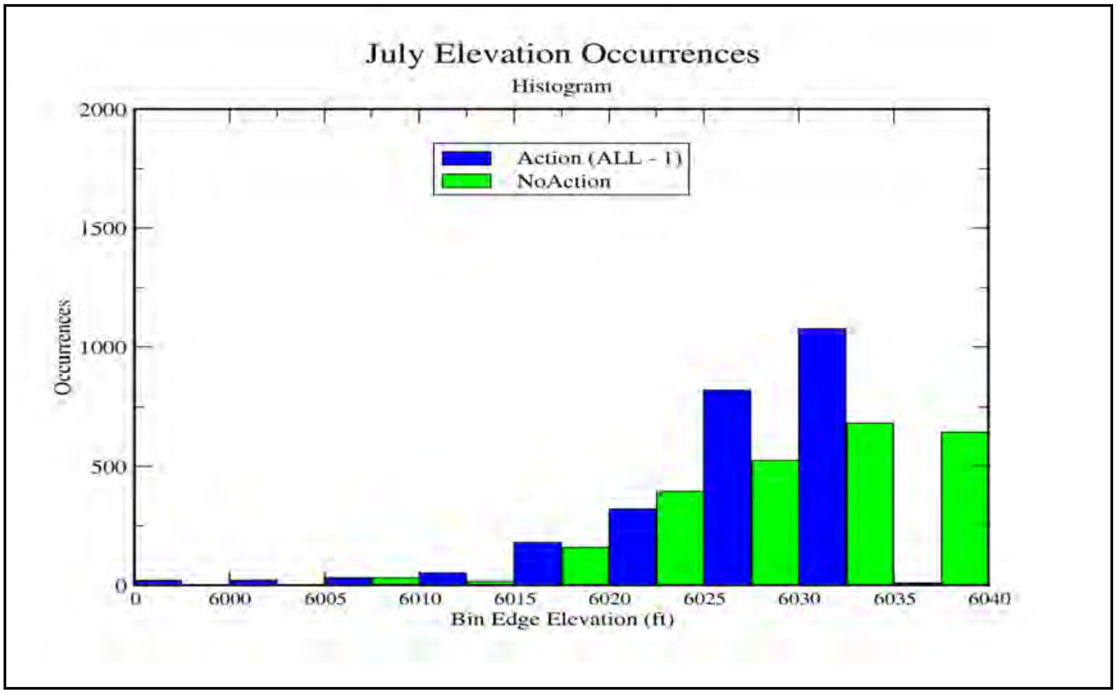


Figure 9.—Histogram of Action (ALL-1) and No Action July Elevations.

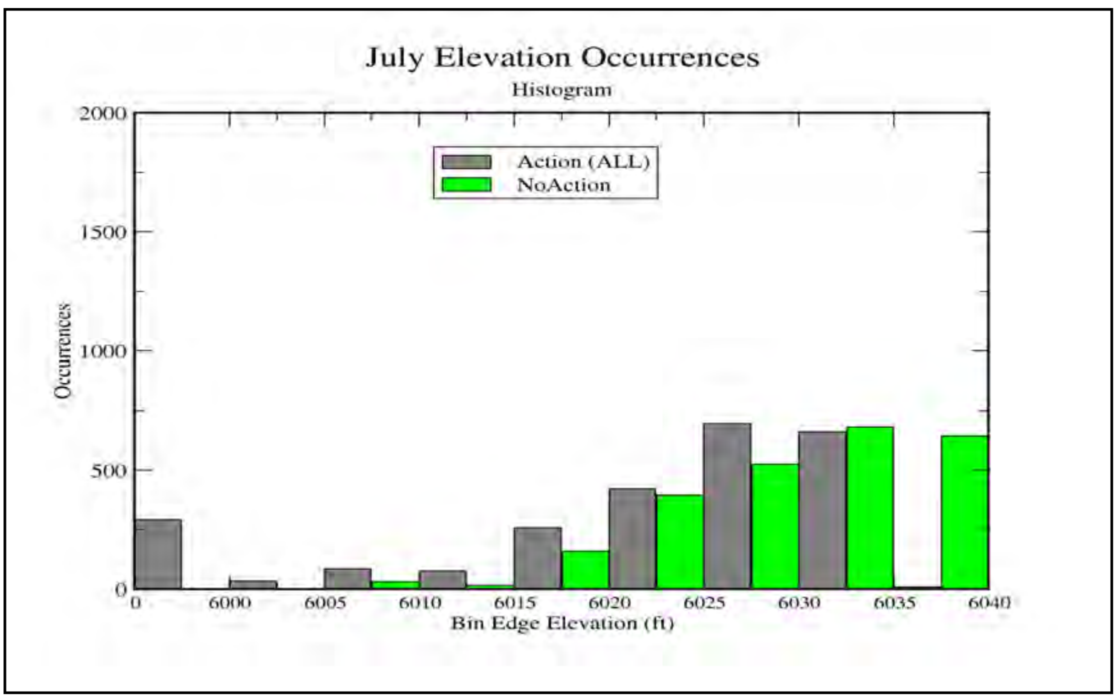


Figure 10.—Histogram of Action (ALL) and No Action July Elevations.

Typically, by the end of July, the reservoir is approaching its highest level of the year. Figures 9 and 10 show the same relationships as figures 7 and 8, only for reservoir elevations at the end of July. Inspection of these figures shows again that the occurrences of elevations at the end of July that were below 6000 feet above sea level increased significantly when the model achieved the 18,600-cfs objective. The Action(ALL-1) occurrences when elevations at the end of July were below 6000 were about 20 (>1% of the time). The Action(ALL) occurrences for this same classification were nearly 300 (12% of the time). The No Action model run had no occurrences where elevations at the end of July were below 6000.

Table 2 shows the exceedance percentage values for all February and July elevations for the Action (ALL and ALL-1) and No Action results. The results in table 2 indicate that the "most likely" (50% exceedance) reservoir elevations at the end of February for the Action (ALL-1) model run were about 2 feet lower than the No Action model run. The "most likely" end-of-July elevations had a difference of nearly 4 feet for the Action (ALL-1) and No Action rulesets. Similar comparison between the Action (ALL) ruleset and the No Action rulesets shows that the "most likely" end-of-February elevations were about 5 feet lower for the Action (ALL) then the No Action ruleset. The July elevation difference was about 7 feet.

Table 2.—Percentage Exceedance February/July Elevations

Percentage Exceedance	Action (ALL-1) (Feet above Sea Level)	Action (ALL) (Feet above Sea Level)	No Action (Feet above Sea Level)
90%	6016.4/6019.2	5992.9/5997.2	6020.1/6021.4
80%	6020.1/6023.6	6013.7/6015.7	6024.7/6024.1
70%	6022.5/6026.4	6017.7/6020.3	6026.3/6026.7
60%	6024.0/6028.0	6020.0/6023.5	6026.9/6028.7
50%	6025.1/6029.1	6022.0/6026.0	6027.0/6032.8
40%	6025.9/6030.3	6024.2/6027.9	6027.2/6033.9
30%	6026.3/6030.7	6025.5/6029.3	6027.3/6034.9
20%	6026.6/6031.2	6026.2/6030.8	6027.5/6036.1
10%	6027.0/6032.1	6026.8/6031.8	6027.7/6038.0

Figures 11 and 12 show the complete distribution of the February and July elevations that were predicted for the three model runs. For reference, historic elevations for the period from 1971 through 1991 have been included on the figures.

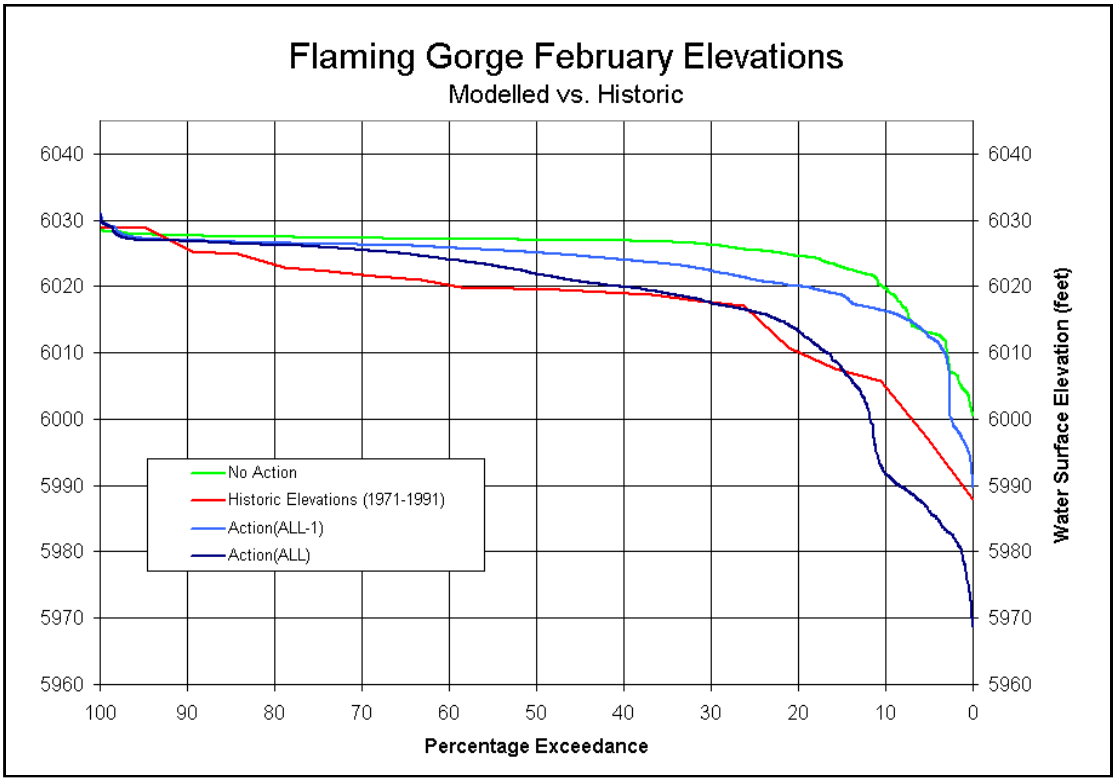


Figure 11.—Distribution of February Water Surface Elevations.

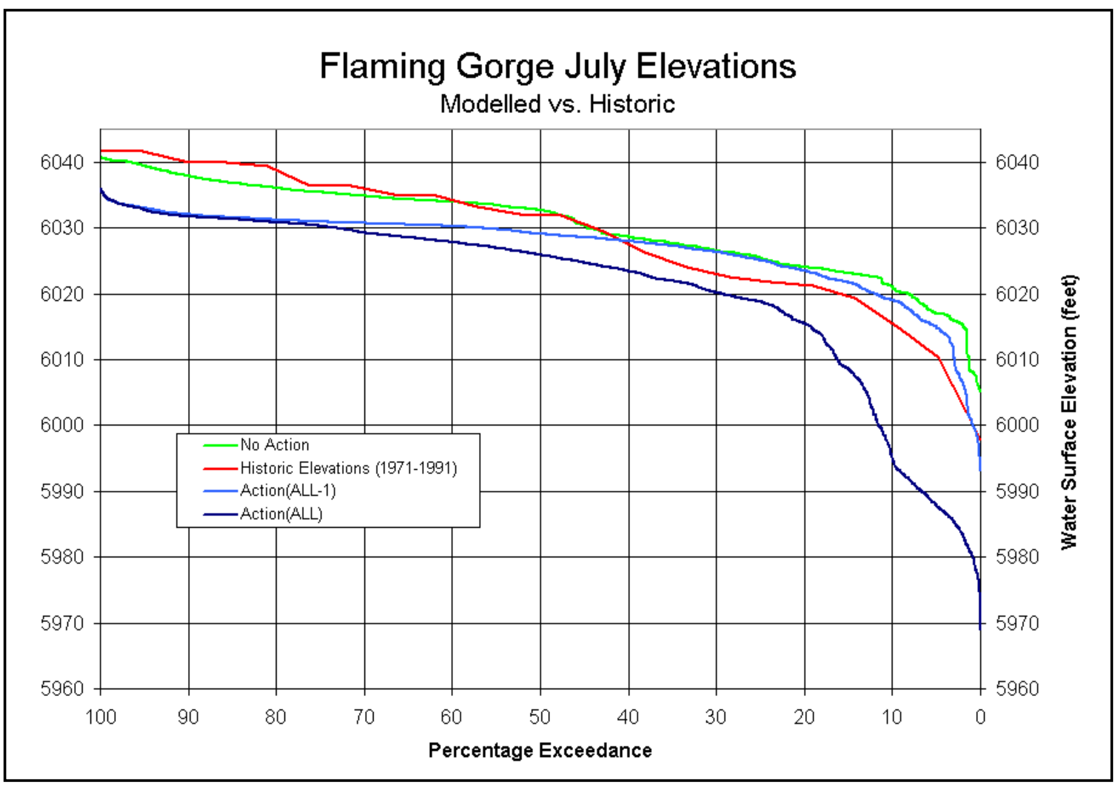


Figure 12.—Distribution of July Water Surface Elevations.

REACH 1 SPRING PEAK RELEASE RESULTS

The estimated flows at all points along Reach 1 were assumed in the model results to be the same as the release rate from Flaming Gorge Dam. During the spring, the model released the volume of water necessary to safely operate the reservoir while also achieving the objectives of the Action (ALL and ALL-1) and No Action Alternatives. Figure 13 shows the distribution of the peak flows (greatest magnitude single day average flow) that occurred in Reach 1 for all three model runs. The capacity of the powerplant at Flaming Gorge is assumed to be 4,600 cfs. Releases greater than 4,600 cfs are considered bypass releases. Figure 13 shows that water was bypassed by the No Action model run in about 18% of all years. The Action (ALL-1) model run bypassed water in about 37% of all years while the Action (ALL) model run bypassed water in about 53% of all years. It is also noted that bypasses from the Action (ALL and ALL-1) model runs had significantly higher magnitudes than those for the No Action model run. For reference, historic peak flows for the period from 1971 to 1991 are included in figure 13. This historic data includes years 1983, 1984, and 1986, which were abnormally wet years in the upper Green River Basin. Statistically, it is very unlikely that 3 years of such high magnitude would occur within 20 years of record. The historic record presented in figure 13 is, therefore, statistically skewed toward wet conditions. Figure 13 also shows that the differences in peak releases between the Action (ALL) and the Action (ALL-1) model runs were significantly larger than the differences between the Action (ALL-1) and No Action model runs.

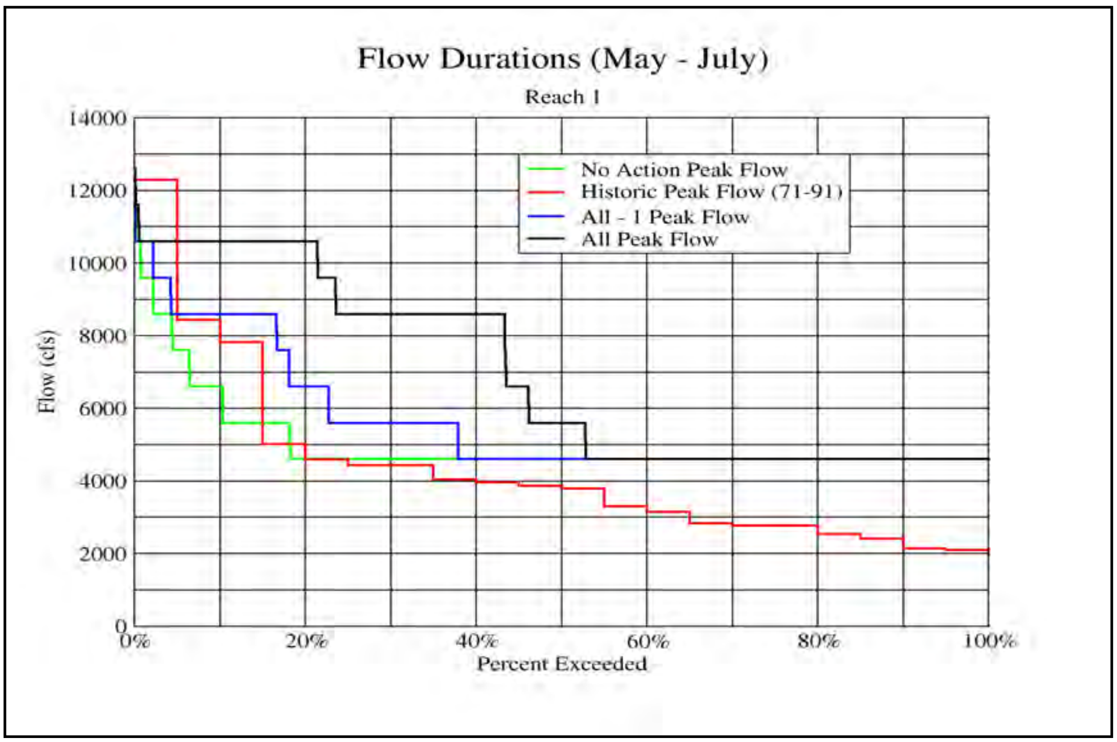


Figure 13.—Distribution of Peak Flows in Reach 1.

To illustrate the impacts to Reach 1 when the Action (ALL) ruleset was triggered to achieve the 18,600-cfs objective, figure 14 shows a sample spring hydrograph in Reach 1 for all three model runs. The data in this figure is from trace 37 in year 2015 from May through July. The peak release that achieved all flow objectives except the 18,600-cfs objective had a magnitude of 4,600 cfs and a duration of about 16 days. Because the Yampa River triggered the Action (ALL) ruleset to attempt to achieve the 18,600-cfs objective, the peak release magnitude was reset by the Action (ALL) ruleset from 4,600 cfs to 8,600 cfs; and the duration was decreased to 14 days. This caused a significant bypass to occur in a year when achieving all other flow objectives would not have required a bypass release. The historic year of this hydrology was 1970. For reference, the No Action model results and the historic spring releases that actually occurred at Flaming Gorge Dam in 1970 are included on the figure.

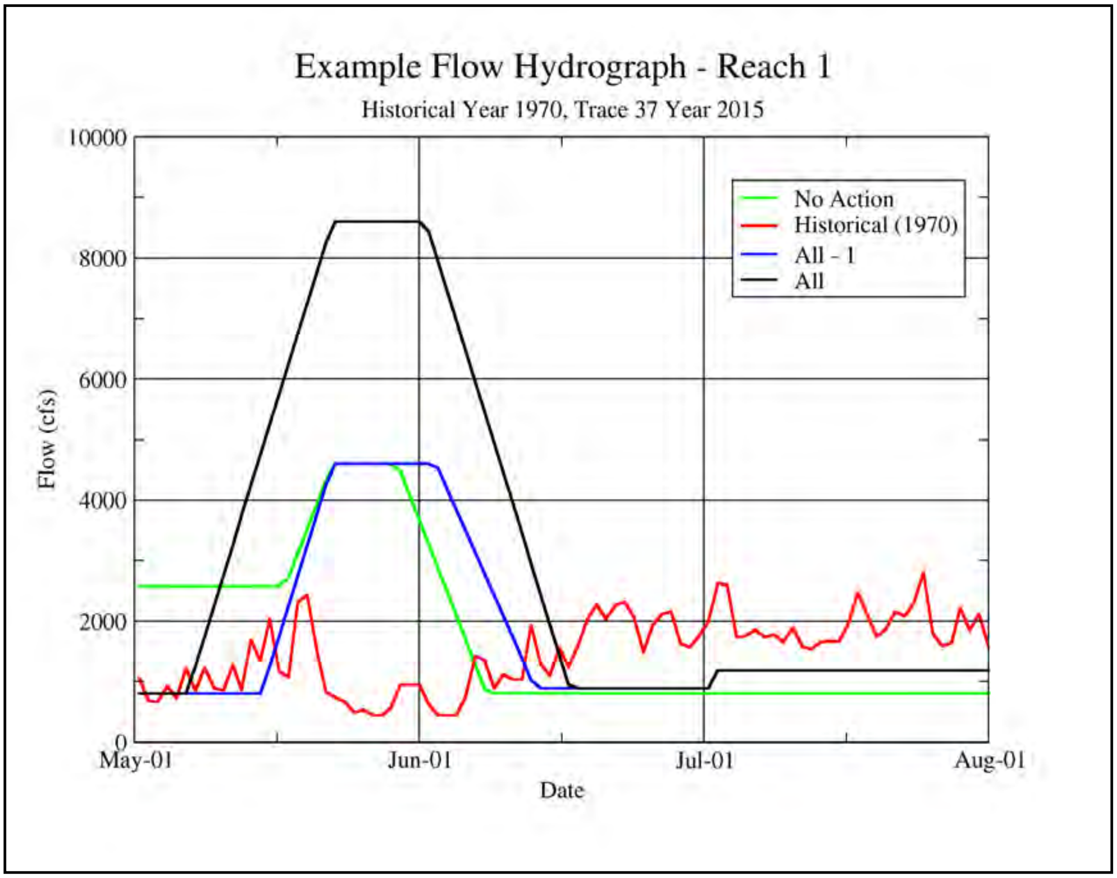


Figure 14.—Sample Hydrograph Comparison of Action (ALL and ALL-1) Reach 1.

Figure 15 shows the corresponding flows that occurred in Reach 2 as a result of the release hydrographs illustrated in figure 14. Figure 15 shows that although the Action(ALL-1) model run did not achieve the 18,600-cfs objective, that 18,600 cfs was sustained for 11 days in Reach 2 during this year. The Yampa River flows decrease very rapidly from the peak. Extending the duration of the 4,600-cfs peak release would not have sustained flows in Reach 2 above 18,600 cfs for 3 additional days.

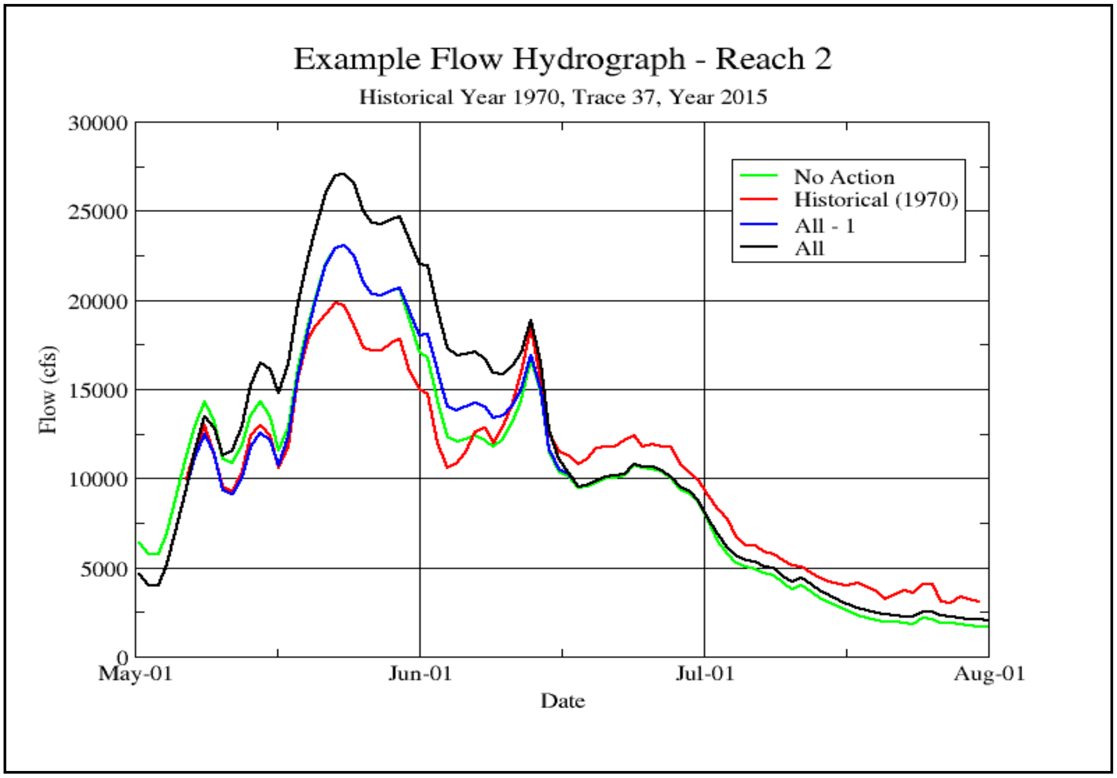


Figure 15.—Sample Hydrograph Comparison of Action (ALL and ALL-1) Reach 2.

Figures 16 and 17 show how the duration of the release peak was affected by the Action (ALL and ALL-1) and No Action rulesets. The distribution of Reach 1 flows that were exceeded for a duration of 2 weeks is presented in figure 16, while figure 17 shows the distribution of Reach 1 flows that were exceeded for 4 weeks. Distributions for all three model runs are presented, while the historic values that occurred during the period from 1971 to 1991 are also presented in these figures.

FLAMING GORGE SPRING BYPASS RESULTS

Figure 18, like figure 13, shows the frequency of bypass releases that occurred during the spring for all three model runs. Figure 18 shows this information in terms of the annual volume of water that was bypassed under the control of the three rulesets. The difference between each of these curves can be related to the power generation that was lost as a result of achieving the objectives of each of the proposed alternatives.

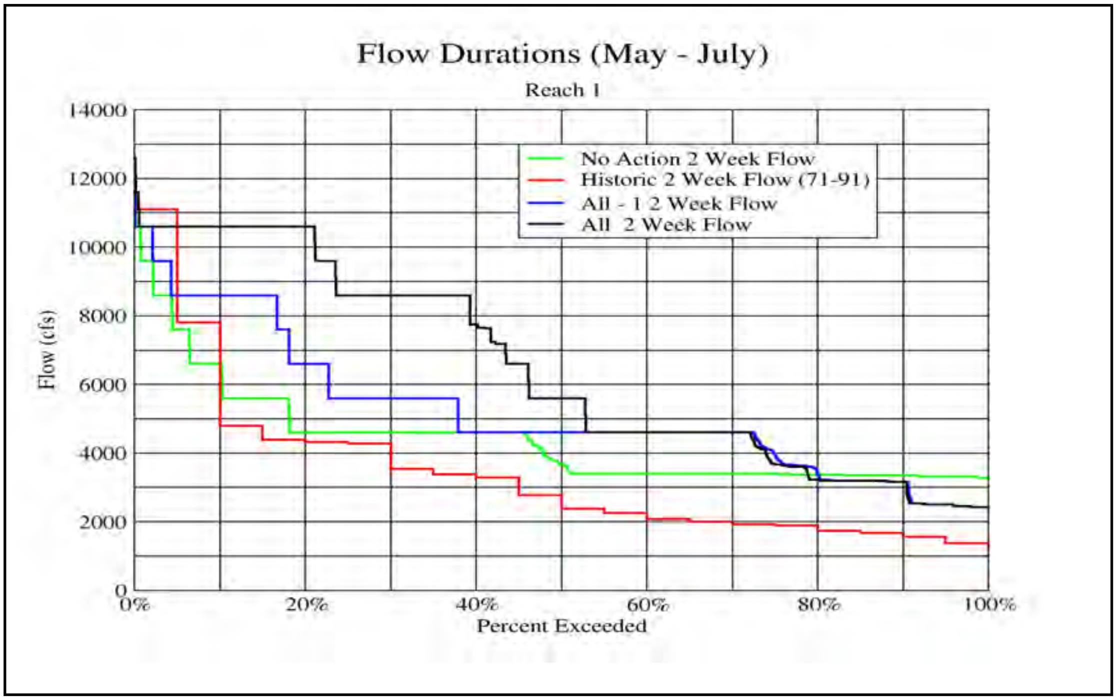


Figure 16.—Distribution of 2-Week Duration Flows in Reach 1.

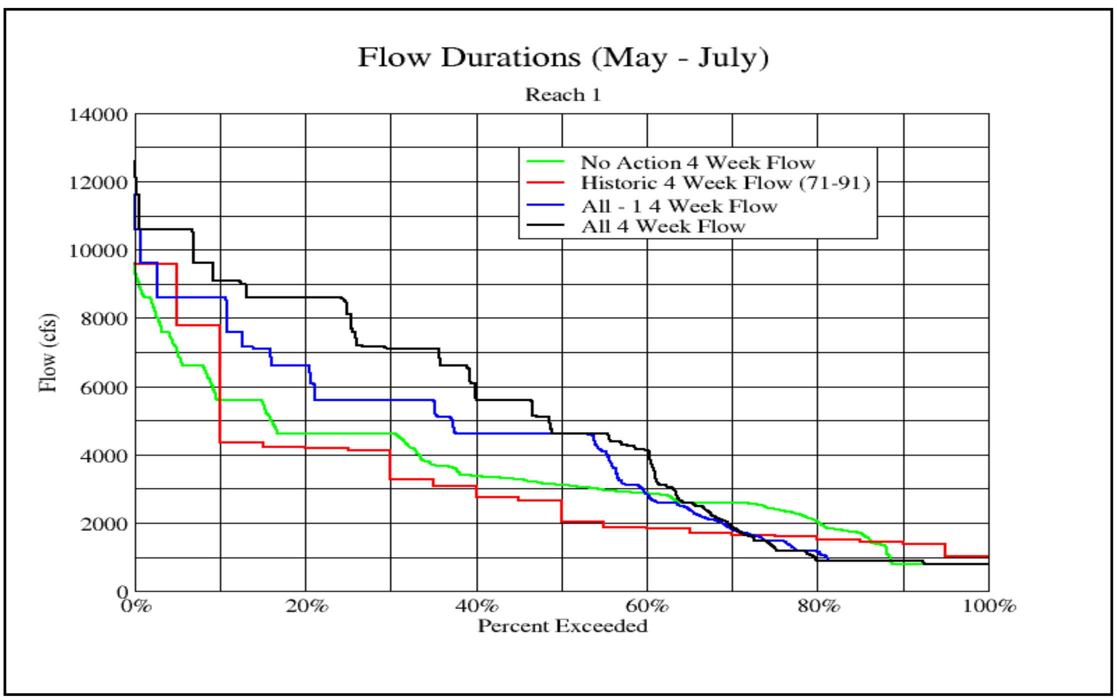


Figure 17.—Distribution of 4-Week Duration Flows in Reach 1.

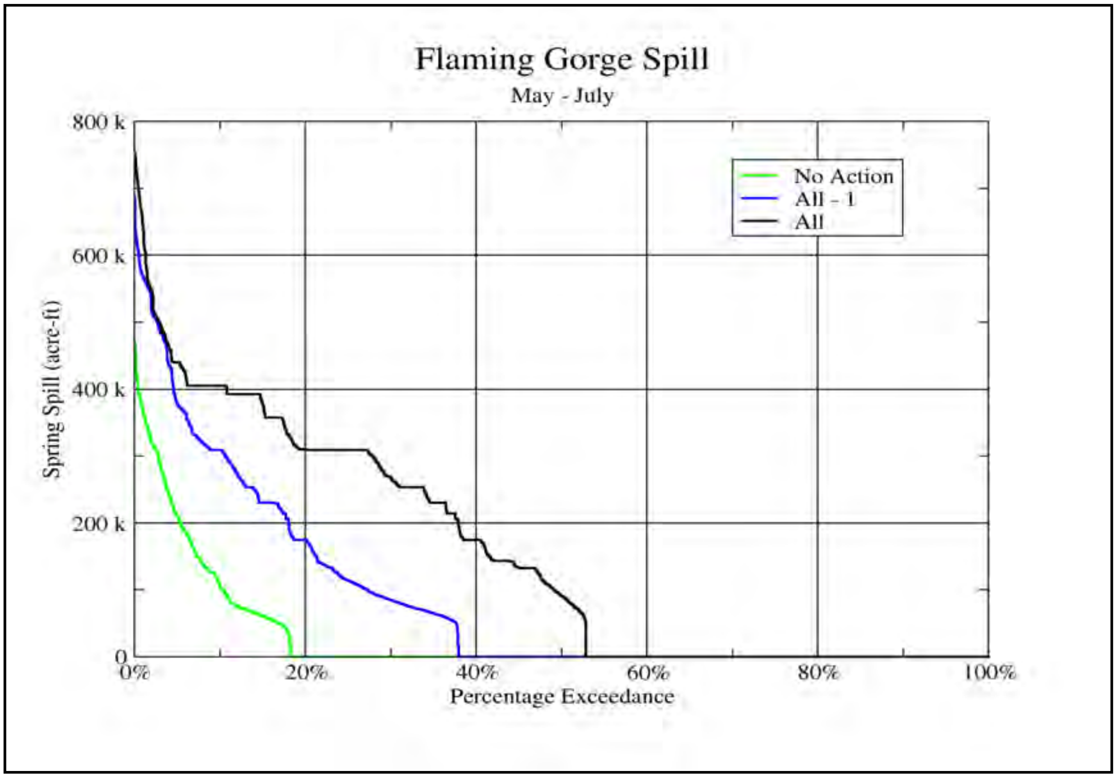


Figure 18.—Exceedance Percentage Bypasses During April Through July.

REACH 1 AUGUST THROUGH FEBRUARY BASE FLOW RELEASE RESULTS

Figure 19 shows the distributions of Reach 1 flows that occurred during the base flow period (August though February), when Reach 1 flows are typically at their lowest. This analysis shows the frequency and magnitude of the Reach 1 flows that occurred during the base flow period under the Action (ALL and ALL-1) and No Action model runs. The most notable difference between the Action and No Action flows during the base flow period was for the 0-20% exceedance flow. The No Action ruleset was more flexible during the base flow period and allowed releases to increase when conditions became wetter in the upper Green River Basin. To give some perspective to the results of the three model runs, historic Reach 1 base flows from 1971 to 1991 and historic Reach 1 unregulated base flows from 1971 to 1991 are included in the figure. The historic flows show how Flaming Gorge Dam operations, prior to the 1992 Biological Opinion, effected the distribution of flows in Reach 1 during the base flow period. Releases prior to 1992 were elevated above natural levels to produce power. The historic unregulated flows for the same period indicate how the distribution of flows in Reach 1 might have been if Flaming Gorge Dam did not regulate the flow of the river.

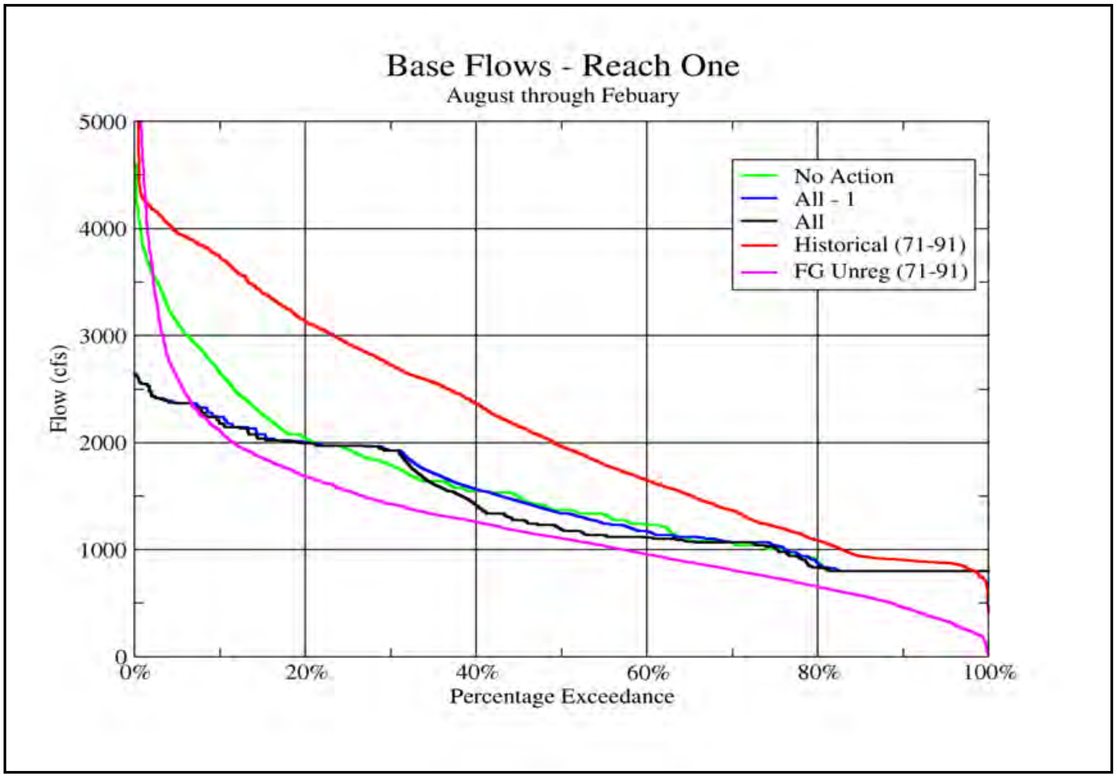


Figure 19.—Exceedance Percentage Flows for Reach 1 Flows During Base Flow Period.

REACH 2 SPRING PEAK RELEASE RESULTS

The model accounts for flows in Reach 2 by adding the flows from the Yampa River to the flows from Reach 1. The estimated flows at all points along Reach 2 were assumed to be equal to the release rate from Flaming Gorge Dam plus the flows on the Yampa River. The Green River model lagged Flaming Gorge Dam releases by 1 day to account for travel time through Reach 1.

Figure 20 shows the distributions of peak flows that occurred in Reach 2 during the spring. Figures 21 and 22 show distributions for flows in Reach 2 that had a duration of 2 and 4 weeks, respectively. Figure 21 shows a noticeable increase in the Action (ALL) results at about 40% exceedance. This was a result of the Action(ALL) ruleset attempting to achieve the 18,600-cfs objective.

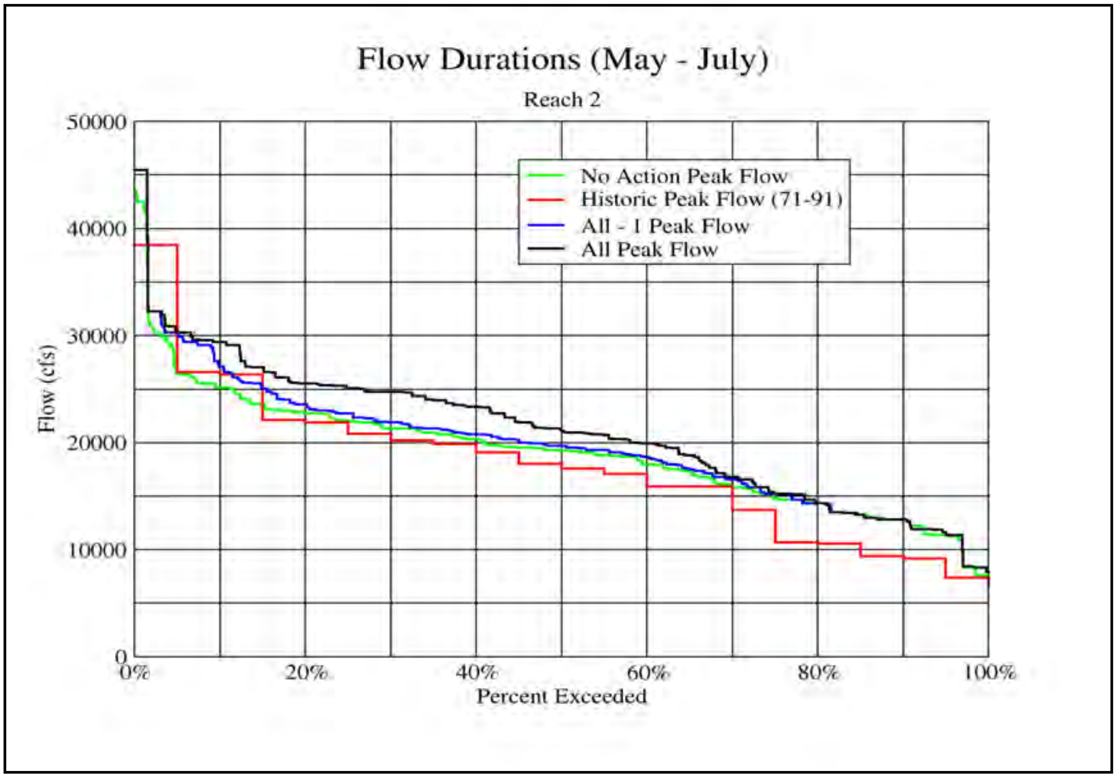


Figure 20.— Distribution of Peak Flows in Reach 2.

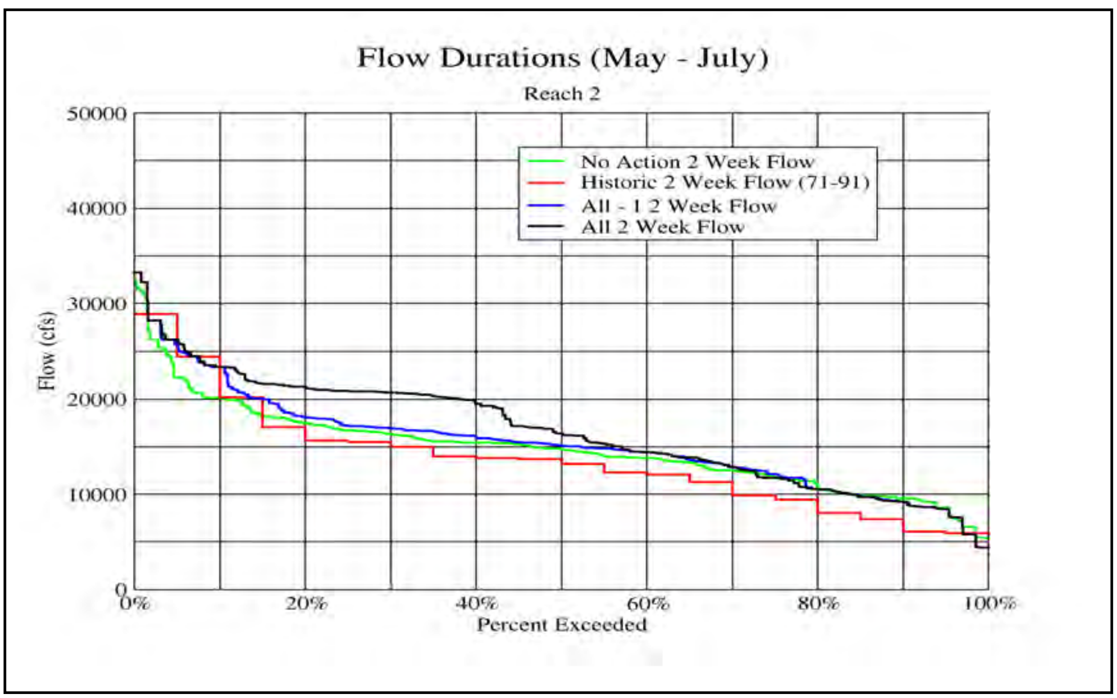


Figure 21.—Distribution of 2-Week Duration Flows in Reach 2.

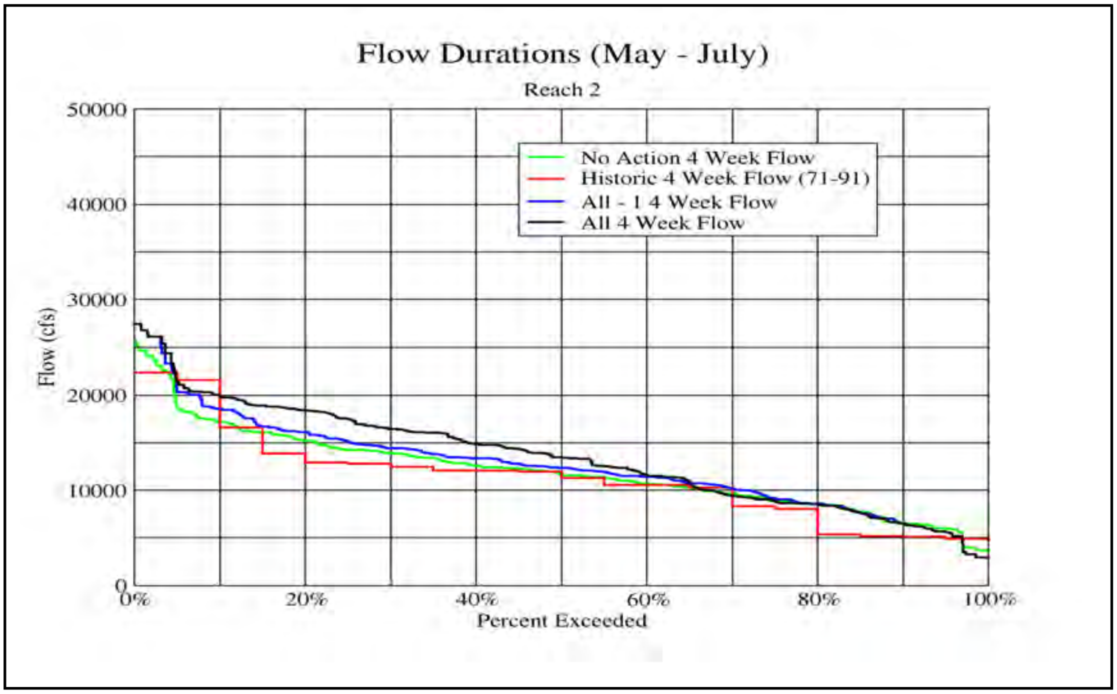


Figure 22.—Distribution of 4-Week Duration Flows in Reach 2.

REACH 2 BASE FLOW RELEASE RESULTS

Figure 23 shows the distribution of Reach 2 flows during the base flow period that occurred in the three model runs. Jensen gauge predam historic flows (1950-1961) during the base flow period and Jensen gauge post-dam historic flows (1971-1991) are also shown in the figure. The historic flows prior to 1961 show the distribution of flows in Reach 2 during the base flow period prior to the construction of Flaming Gorge Dam. Historic flows during the period from 1971 through 1991 show the distribution of Reach 2 flows after the construction of Flaming Gorge Dam but prior to the 1992 Biological Opinion. The most significant change that has occurred in Reach 2 in terms of river regulation occurred during the period from the end of the construction of Flaming Gorge Dam to 1991. Reach 2 flows during the base flow period were elevated substantially as a result of power production at Flaming Gorge Dam. The No Action curve shows the distribution of Reach 2 flows during the base flow period that as a result of operating Flaming Gorge Dam to achieve the flow objectives of the 1992 Biological Opinion. The Action (ALL and ALL-1) curves show how the Action Alternative would adjust the current distribution. Most notably, the Action Alternative operational regime depressed the flows during the base flow period in Reach 2 when conditions are wetter than average in the upper Green River Basin.

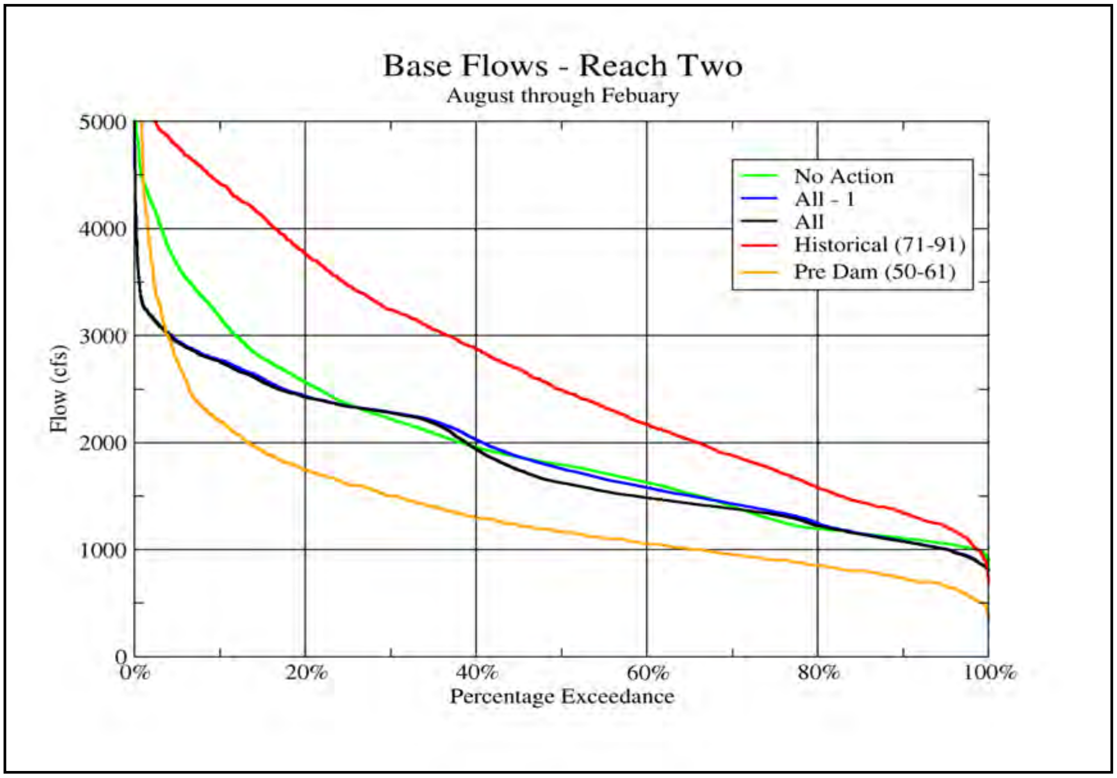


Figure 23.—Exceedance Percentage Flows for Reach 2 Flows During Base Flow Period.

SUMMARY

The results presented in this report describe three separate runs of the Green River model. Two of these runs were controlled by rulesets that achieved the objectives of the Action Alternative while the other run was controlled by a ruleset that achieved the objectives of the No Action Alternative. The Action Alternative is an operational regime for Flaming Gorge Dam that achieves the flow objectives of the 2000 Flow and Temperature Recommendations while "maintaining" the resources for which Flaming Gorge Dam was authorized. The No Action Alternative is an operational regime that achieves the flow objectives of the 1992 Biological Opinion while also "maintaining" the resources associated with the authorization of Flaming Gorge Dam. The rulesets "maintain" the resources associated with the authorizing purposes of Flaming Gorge Dam by minimizing bypass releases as much as possible while achieving the flow objectives for each of the proposed alternatives.

The difference between the two rulesets of the Action Alternative is the degree to which the flow objectives of the Action Alternative are achieved. The first version, referred to as the Action (ALL) ruleset, achieved all of the flow objectives of the Action Alternative. Results from this model run showed that the frequency and magnitude of bypass releases were much greater than in the No Action model run. Bypasses in the Action (ALL) model run were 53%, while the No Action model run had a bypass frequency of 18%. The frequency and magnitude of the bypasses in the Action (ALL) model run had a dramatic effect on the reservoir elevation when compared to the No Action model results. The occurrences of the reservoir elevations below 6000 feet above sea level were significant for the Action (ALL) model run while there were no occurrences of elevations below 6000 feet in the No Action model run. In general, the reservoir elevations during the summer months, on average, were about 7 feet lower in the Action (ALL) model run than they were in the No Action model run.

It was discovered that one flow objective for the Action Alternative caused most of the increase in the frequency and magnitude of the spring bypass releases. The Action Alternative flow objective that requires flows in Reach 2 in excess of 18,600 cfs for 2 weeks in 40% of all years caused most of the increase in the frequency and magnitude of the bypasses that occurred in the Action(ALL) results. To achieve this objective, 40% of all years were required to have peak releases with magnitudes of 8,600 cfs and durations of at least 2 weeks while 20% of all years were required to have magnitudes of 10,600 cfs and durations of at least 2 weeks. Achieving the other objectives of the Action Alternative did not require peak release magnitudes, durations, and frequencies at these levels.

The second version of the Action Alternative model run, referred to as the Action(ALL-1) model run, achieved all the flow objectives of the Action Alternative but did not specifically make any attempt to achieve the 18,600-cfs objective. While achieving all other flow objectives, the Action (ALL-1) model run was able to achieve 18,600 cfs for 2 weeks or greater in 18.2% of all years. Reach 2 flows did achieve 18,600 cfs in 40% of all years, but the duration was 6 days compared to the flow objective duration of 14 days. The results from the Action(ALL-1) model run showed a significant improvement to the impacts that were observed in the reservoir elevations of the Action (ALL) model run. Reservoir elevations for the Action (ALL-1) model run, on average, were 3 to 4 feet lower than the No Action model run results during the summer month as compared to 7 feet lower for the Action (ALL) results. Bypass releases were significantly reduced from the Action (ALL) model results. The frequency of bypass releases in the Action (ALL-1) model results was 38%; while in the Action (ALL) model results, this frequency was 53%. The Action(ALL-1) model run achieved nearly all of the objectives of the Action Alternative while dramatically reducing the impacts to the resource associated with the authorization Flaming Gorge Reservoir.

The intent of this study has been to evaluate the relative differences between the Action and No Action Alternatives proposed for the Flaming Gorge EIS. The modeling of the Green River system and these alternatives is now at a point where these differences are evident. This report provides hydrologic information for the purpose of determining the impacts to the resources associated with Flaming Gorge Reservoir. If additional information is needed for this purpose, it will be provided as needed.

HYDROLOGIC MODELING

R. Clayton and A. Gilmore
February 26, 2002 (Modified August 15, 2003)

INTRODUCTION

In October of 2001, a report titled "Flaming Gorge Environmental Impact Statement Hydrologic Modeling Study Report" was distributed to all Cooperating Agencies and Interdisciplinary (ID) Teams working on the Flaming Gorge Environmental Impact Statement (EIS). The report described the hydrologic impacts observed in the modeled implementation of the 1992 Biological Opinion (No Action Alternative) and the *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations) (Action Alternative) for the period from 2002 through 2040. Based on comments received from the Cooperating Agencies, ID Teams, as well as the authors of the 2000 Flow and Temperature Recommendations, the Flaming Gorge Model has been modified to more accurately reflect the intentions of the 2000 Flow and Temperature Recommendations and the 1992 Biological Opinion. The purpose of this report is to detail these modifications and update the model results so the Cooperating Agencies and ID Teams can conduct their impact analyses.

DESCRIPTION OF MODIFICATIONS

The Flaming Gorge Model was populated with natural inflow data generated from historic riverflow and consumptive use records. For the upper Green River and Yampa River Basins, the only records available for consumptive use were recorded as monthly volumes. For this reason, the natural inflow data used to populate the Flaming Gorge Model, as well as the model itself, were developed at a monthly timestep. The monthly timestep framework of the Flaming Gorge Model limited when operational decisions could be made to the beginning of every month. It became apparent very early in the development of this model that limiting the timing of these operational decisions, which was only an artifact of the model framework, made it more difficult for the model to achieve the target flows and durations specified in the 2000 Flow and Temperature Recommendations than would be the case in reality.

In reality, Flaming Gorge Dam is operated to adjust to changing hydrologic conditions the moment these conditions change. The Flaming Gorge Model, however, must wait until the beginning of each month to make these adjustments. Sometimes, this caused the daily average releases determined by the model under the Action Alternative to be set much higher than necessary to achieve specific targets established for Reach 2. After receiving comments from the authors of the 2000 Flow and Temperature Recommendations regarding the report issued in October, it became clear that this artifact of the model did not satisfactorily reflect the intended implementation of the 2000 Flow and Temperature Recommendations.

To get the model to operate Flaming Gorge Dam more realistically while maintaining the monthly timestep framework, a daily model was developed to take monthly results from the Flaming Gorge Model and operate Flaming Gorge Dam to react to daily hydrologic conditions.

This daily model operated Flaming Gorge Dam during the spring (May, June, and July) to match estimated Yampa River flows to achieve target flows for Reach 2. While this caused the release results of the daily model to differ from the release results of the monthly model, it did provide a more reactive approach for achieving the recommended flow targets. To maintain some integrity between the daily and monthly models, the only restriction placed upon the daily model was to match the total volume released during the spring to the total volume released during the spring by the monthly model. After a targeted duration was achieved, the daily model released the necessary volume for the remainder of the spring to match the monthly model while minimizing additional bypass releases. This enhancement of the Flaming Gorge Model greatly reduced the bypass releases that were reported in the October report.

Base flows, under the Action Alternative, are dependent upon the classification of the hydrologic conditions in the upper Green River Basin. In October (2001), the model based this classification on the volume of unregulated inflow into Flaming Gorge that occurred during the preceding spring. Once this classification was set on August 1, it could not change during the base flow period. The 2000 Flow and Temperature Recommendations, however, stated that this classification was flexible and could change if hydrologic conditions changed during the base flow period. The authors, however, did not describe how this determination was to be made. Comments received from the authors gave guidance for how this determination could be made in the model, and the model has now been modified to adjust the hydrologic classification during the base flow period when conditions warrant a change.

Under the Action and No Action Alternatives, a volume of water to be released during the spring is calculated based on forecasted inflows and reservoir conditions. From this volume of water, a peak release hydrograph is developed to achieve the specific parameters of the operational alternative. In the model presented in the October report, both the Action and No Action Alternatives extended the peak release hydrograph to the end of July, when possible, depending on the calculated volume to be released during the spring. The 1992 Biological Opinion, however, states that base flow levels are to be established by July 20 at the latest. For this reason, the No Action Alternative was modified so that July 20 is now the maximum date that the spring release hydrograph can be extended to. This modification increases the peak magnitude and the potential for bypasses in the No Action Alternative as compared to the No Action results presented in the October report.

In October, the Flaming Gorge Model, for both alternatives, had a static drawdown target established for the end of April. During the base flow and transition periods, releases from Flaming Gorge were determined in an attempt to achieve this drawdown target. For both the Action and No Action Alternatives, the drawdown target was set to 6027 feet above sea level independent of the developing hydrology in the upper Green River Basin. In years where the early indications of the developing hydrology are for wet or dry conditions, this target would, in reality, be reset to a more appropriate level. For example, when the early indications are that the spring is going to be wet, Flaming Gorge will typically be drawn down to a target somewhat lower than 6027 feet above sea level to provide space in the reservoir to absorb the above average inflow. Conversely, in years where the early indications are that the spring is going to be dry, the reservoir is typically drawn down to a target higher than 6027 so the reservoir has a better chance of filling despite the dry conditions. This flexibility has now been incorporated into the Flaming Gorge Model. In anticipated wet years, the drawdown target is now set to 6025 feet above sea level and in anticipated dry years, the drawdown target is set to 6029 feet above sea level.

MODEL RESULTS

Flow Recommendations

Table 1 shows the current state of the Action and No Action Alternatives in terms of how well each alternative achieves the specific recommendations of the 2000 Flow and Temperature Recommendations during the spring in Reaches 1 and 2. While the No Action Alternative does not attempt to meet any of these targets, a comparison between the Action and No Action results does indicate some of the key differences between the operational regimes.

Table 1—2000 Flow and Temperature Recommendations Target Flows, Durations, and Frequencies

Spring Peak Flow Recommendations	Reach	Target %	Action Ruleset	No Action Ruleset
Peak >= 26,400 cfs for at least 1 day	2	10%	11.3%	7.1%
Peak >= 22,700 cfs for at least 2 weeks	2	10%	10.7%	4.6%
Peak >= 18,600 cfs for at least 4 weeks	2	10%	11.1%	6.0%
Peak >= 20,300 cfs for at least 1 day	2	30%	46.3%	42.3%
Peak >= 18,600 cfs for at least 2 weeks	2	40%	41.1%	15.6%
Peak >= 18,600 cfs for at least 1 day	2	50%	60.3%	59.1%
Peak >= 8,300 cfs for at least 1 day	2	100%	100%	98.5%
Peak >= 8,300 cfs for at least 1 week	2	90%	96.8%	96.9%
Peak >= 8,300 cfs for at least 2 days except in extreme dry years	2	98%	99.6%	98.4%
Peak >= 8,600 cfs for at least 1 day	1	10%	30.2%	6.5%
Peak >= 4,600 cfs for at least 1 day	1	100%	100%	100%

RESERVOIR WET AND DRY CYCLE RESULTS

In the 65 traces of inflow hydrology used to populate the model, a variety of wet and dry cycles occurred. These cycles were routed through the Flaming Gorge Model with the reservoir elevation set at various levels to show the full range of potential impacts that could realistically occur. The cycles having the driest and wettest intensities with durations of 2, 3, 5, and 7 years were found in the model results. The traces where these cycles occurred at the beginning of the trace were identified so that the differences between the Action and No Action Alternatives could be directly compared. This is because the water surface elevation of the Action and No Action Alternatives were the same in these traces prior to these cycles routing through Flaming Gorge Reservoir. The difference in reservoir elevation at the end of the cycle then could be attributed solely to the operational regime. The reservoir elevations and release hydrographs generated under the Action and No Action Alternatives were plotted to show the differences between these regimes. Figure 1 shows the reservoir elevations resulting from the most intense 3-year dry cycle found in the input hydrology. The plot extends 1 year beyond the end of the dry cycle to show the rate at which the reservoir was able to recover under the two alternatives.

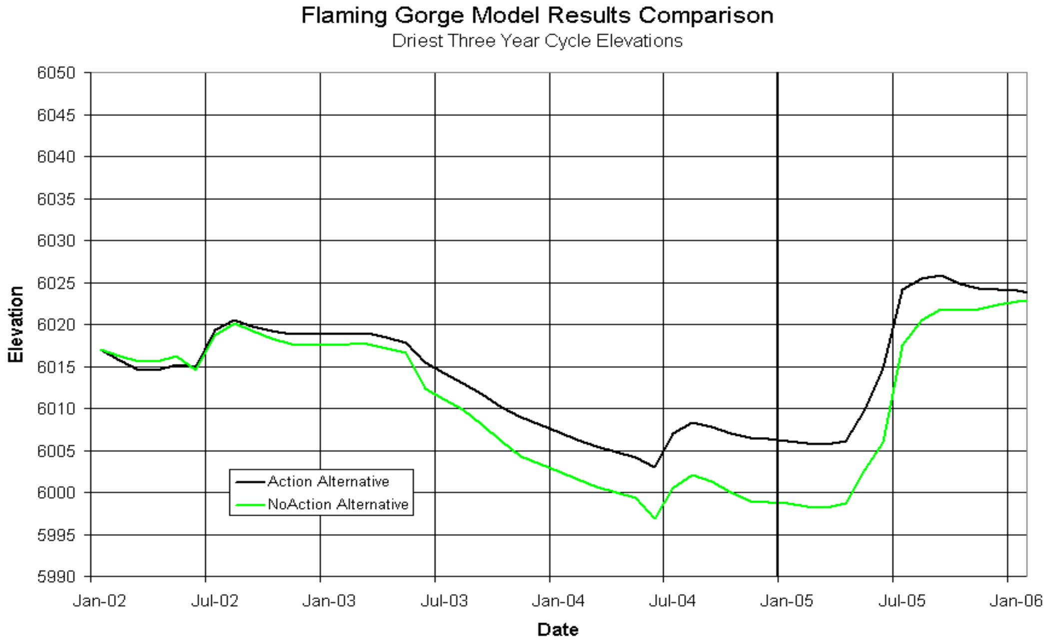


Figure 1.—Reservoir Elevations Under the Most Intense 3-Year Dry Cycle.

By the end of this 3-year cycle, operating under the No Action Alternative caused the reservoir elevation to be about 8 feet lower than operating under the Action Alternative. This can be mostly attributed to the fact that the No Action Alternative requires a spring peak each year with a minimum duration of 7 days while the Action Alternative allows the spring peak with a duration as short as 2 days. The corresponding release hydrographs produced for this 3-year cycle are shown in figure 2. While the peaks, under both alternatives, have a magnitude of 4,600 cfs (powerplant capacity), the No Action Alternative maintains 4,600 cfs for 7 days before declining back to base flow levels where as the Action Alternative peaks for only 2 days. In years classified as dry or moderately dry, the difference between the Action and No Action Alternatives, in terms of minimum duration, can have a significant impact on the reservoir elevation. When dry years occur in series, which is often the case, the year-to-year differences in reservoir elevation caused by the operational regime can compound upon each other as shown in this case.

When conditions are wet, the Action and No Action Alternatives operate Flaming Gorge Dam very differently from when conditions are dry. Spring releases for the Action Alternative in wet years are typically larger than those generated for the No Action Alternative as a result of attempting to achieve specific targets established for Reach 2. This is evident in figure 3, which shows the reservoir elevations that occurred during the most intense 3-year wet cycle found in the inflow hydrology. The higher releases that occur each spring under the Action Alternative cause the reservoir to fill less in the spring as compared to the No Action Alternative. As a result, the releases under the Action Alternative during the base flow period are not as high as those that occur under the No Action Alternative. The No Action Alternative is forced to release greater volumes during the base flow period to achieve the drawdown target established for the following year. This can be seen in figure 4, which shows the daily release hydrographs that occurred during this 3-year wet cycle. In November, the release constraints of the No Action Alternative are relaxed so that releases can increase to powerplant capacity if they are necessary to control the reservoir elevation. Figures showing the reservoir elevations and release hydrographs for 2-, 3-, 5-, and 7-year duration wet and dry cycles are located in the appendix.

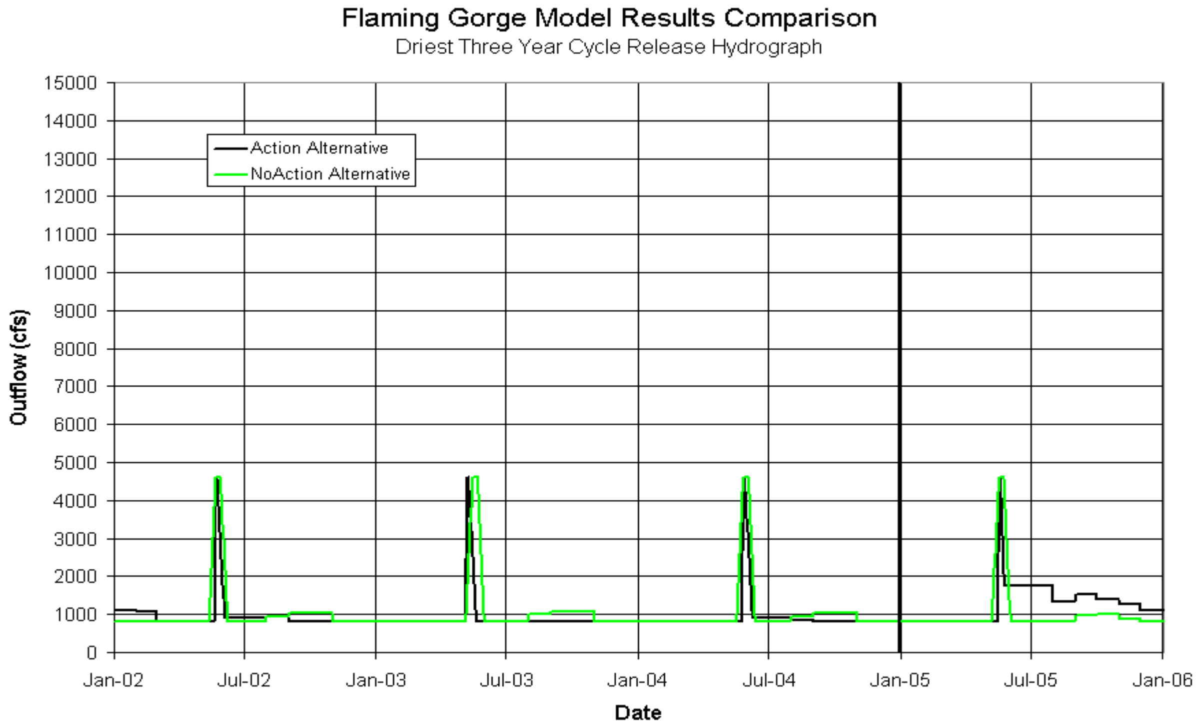


Figure 2.—Reservoir Releases Under the Most Intense 3-Year Dry Cycle.

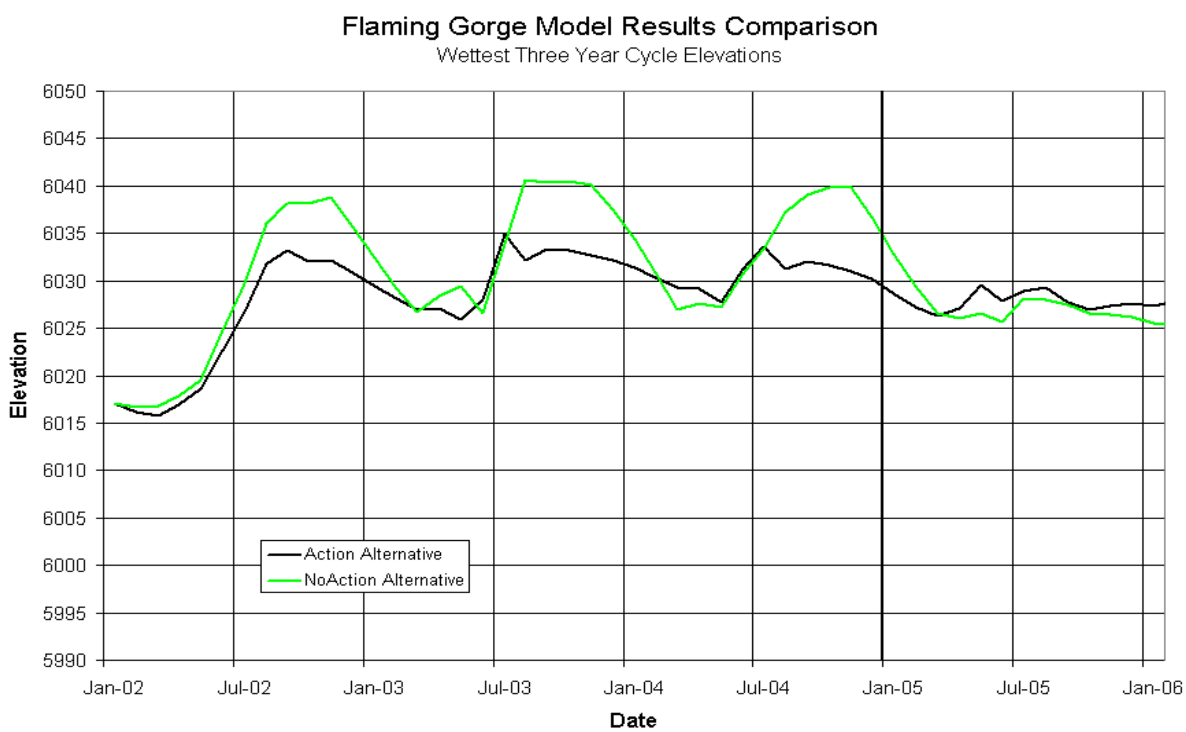


Figure 3.—Reservoir Elevations Under the Most Intense 3-Year Wet Cycle.

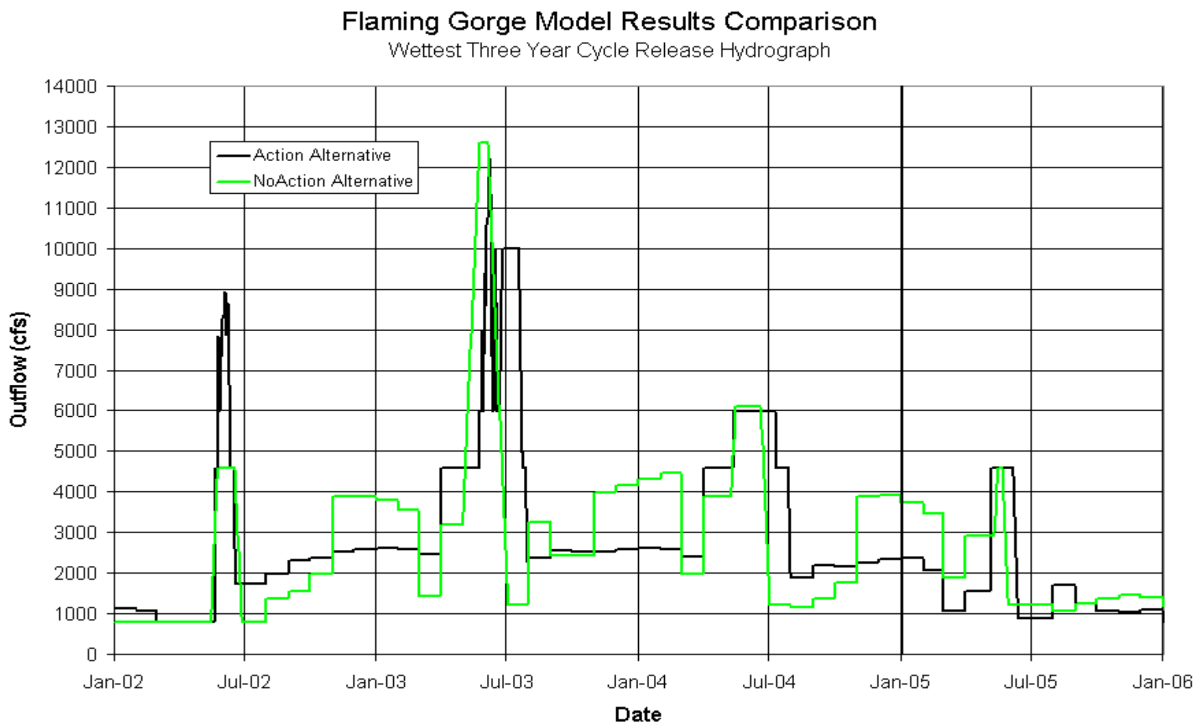


Figure 4.—Reservoir Releases Under the Most Intense 3-Year Wet Cycle.

RESERVOIR WATER SURFACE ELEVATION PERCENTILE RESULTS

For each month of the model run, from January 2002 through December 2040, there are 65 potential reservoir elevations that make up the model results for reservoir elevation for that particular month. Each set of potential elevations was ranked from lowest to highest to determine the probabilities associated with specific reservoir elevations. Figures 5, 6, and 7 show the potential reservoir elevations associated with three levels of probability. Figure 5 shows the 90th percentile reservoir elevations during the first 10 years of the model run. These reservoir elevations were exceeded by only 10% of the 65 potential elevations that occurred in the model results for that month and that year. Reservoir elevations are typically at their lowest level in early spring when the Action and No Action Alternatives attempt to achieve a drawdown target. During the late summer, reservoir elevations are typically at their highest level of the year as a result of storing a portion of the spring runoff. The No Action Alternative typically allows the reservoir elevation to rise significantly higher in the spring than the Action Alternative, as evident in figure 5. Summer reservoir elevations are typically 5 to 7 feet higher for the No Action Alternative than those for the Action Alternative.

Reservoir elevations that occur under more typical (average) hydrologic conditions are shown in figure 6. These reservoir elevations are those that were exceeded by 50% of the 65 potential reservoir elevations that occurred for each month. In the dryer scenarios, reservoir elevations are typically much lower than in the average or wet scenarios. Figure 7 shows reservoir elevations that were exceeded by 90% of the potential reservoir elevations that occurred for each month.

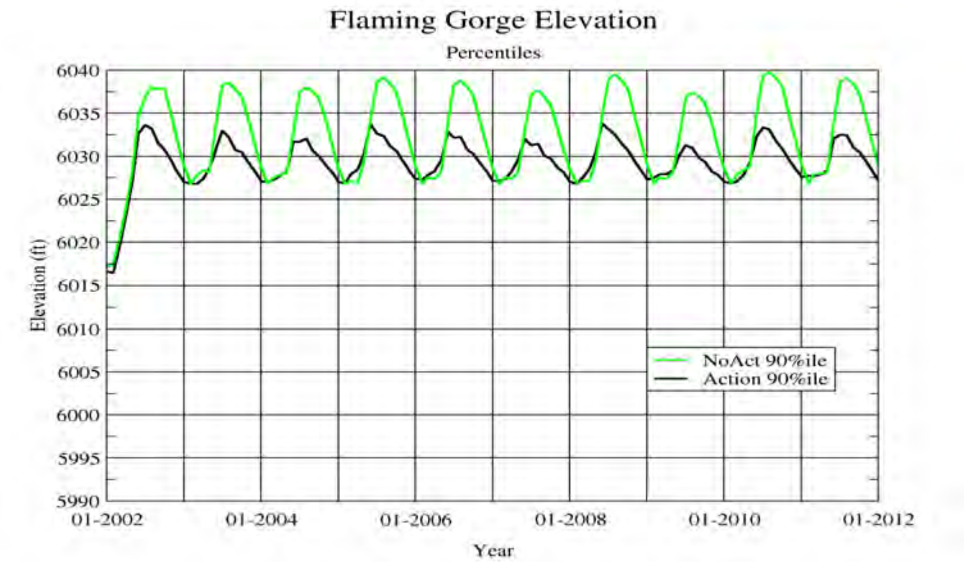


Figure 5.—90th Percentile Reservoir Elevations from January 2002 to December 2012.

Figure 6.—50th Percentile Reservoir Elevations from January 2002 to December 2012.

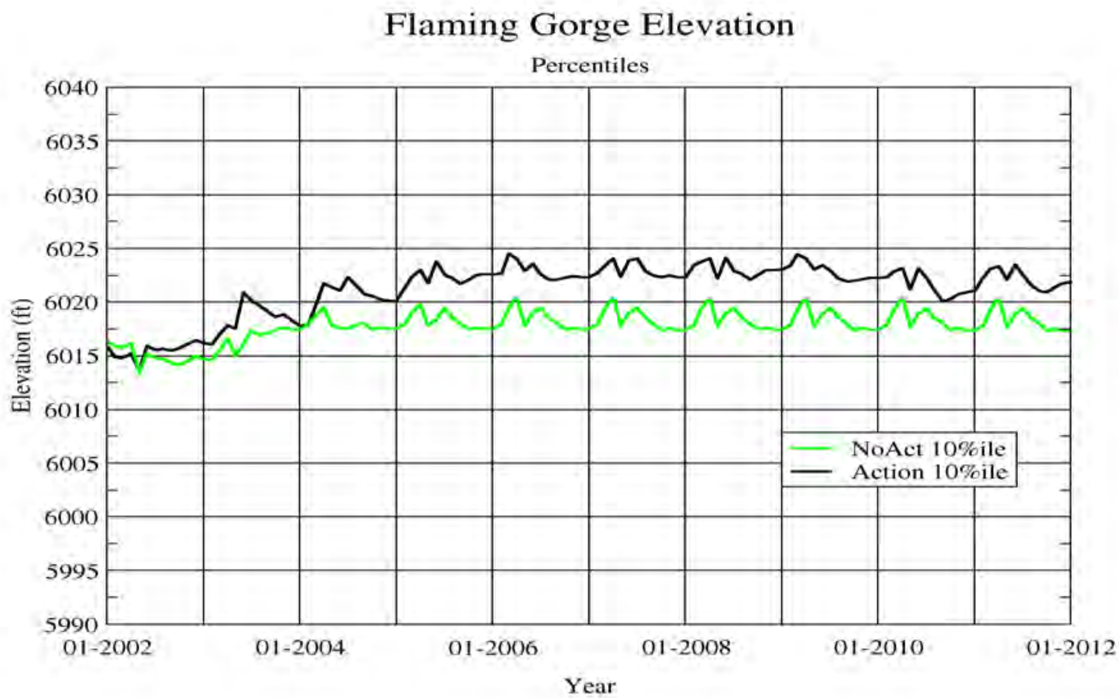


Figure 7.—10th Percentile Reservoir Elevations from January 2002 to December 2012.

Figure 7 is significant because it shows a tremendous improvement for Action Alternative in comparison to what was reported in the October report. Now, the Action Alternative yields reservoir elevations that are even higher than those yielded by the No Action Alternative. The October report showed a large disparity between the Action and No Action Alternatives with the Action Alternative much lower than the No Action Alternative.

The model results indicate that reservoir elevations are basically stable throughout the model run under both alternatives. That is to say the reservoir elevation did not gradually increase or decrease under the Action and No Action Alternatives in the later years of the run. For this reason, it was valid to combine all of the reservoir elevations into a single dataset, grouped by month and then ranked from lowest to highest into monthly distributions. Figures 8 and 9 show these distributions for the months of February and June. These months are shown because reservoir elevations are typically near their lowest level of the year by the end of February and near their highest level by the end of June. Both figures show that the distributions of reservoir elevations for the Action Alternative are now actually higher than the distributions for the No Action Alternative. These results are substantially different from those presented in October and indicate the impact of the modifications made to the model over the past 3 months. Similar plots for all months of the year are located in the appendix.

Figure 10 shows the Action and No Action Alternative reservoir elevations for all months at the 5% probability level grouped by month. The 5% probability level marks the reservoir elevations that were exceeded by 95% of all potential reservoir elevations on average. In other words, for each month of the year there were 5% of all potential reservoir elevations that were below those indicated in the figure. Figure 10 shows that at the 5% probability level, there was a 7- to 8-foot difference between the Action and No Action Alternatives. Similar plots showing the reservoir elevations for the 10%, 25%, 50%, and 75% probability levels are located in the appendix.

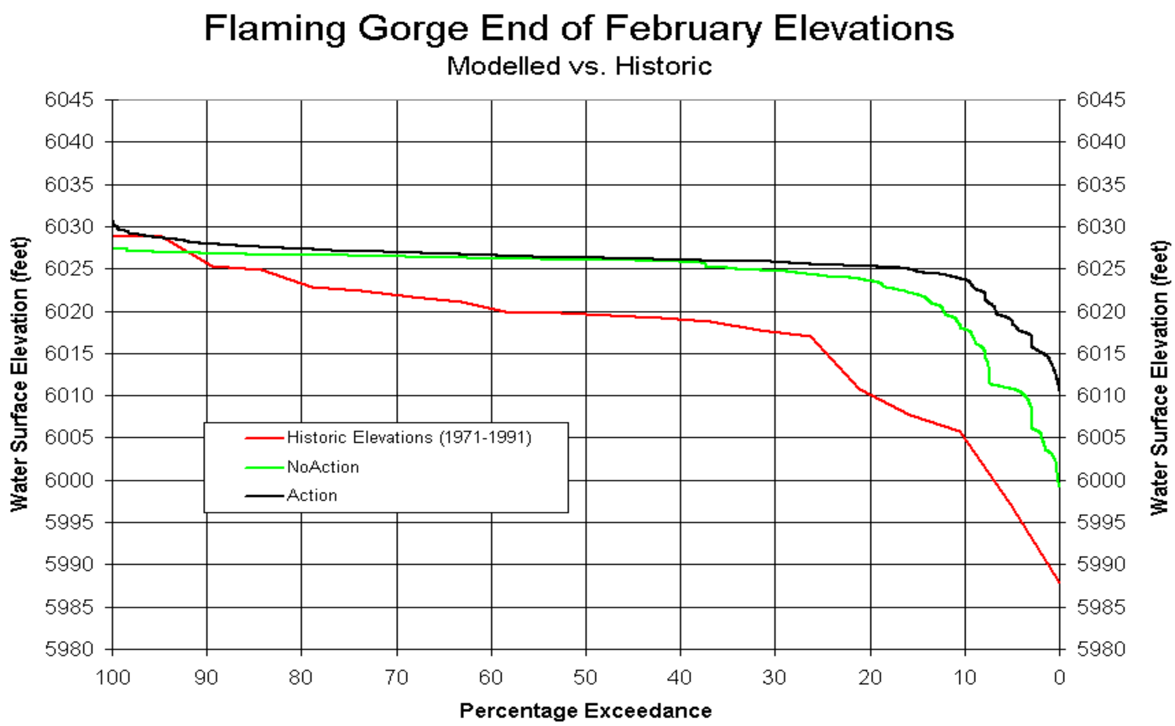


Figure 8.—February Reservoir Elevation Distribution Plot.

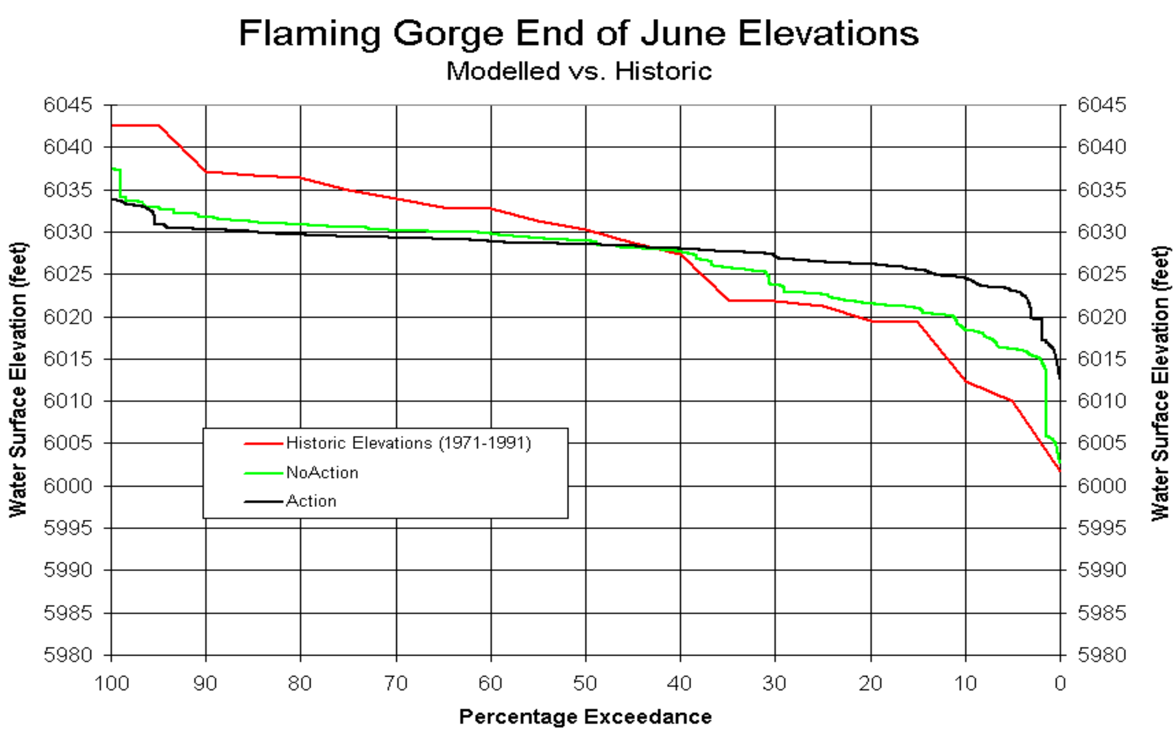


Figure 9.—June Reservoir Elevation Distribution Plot.

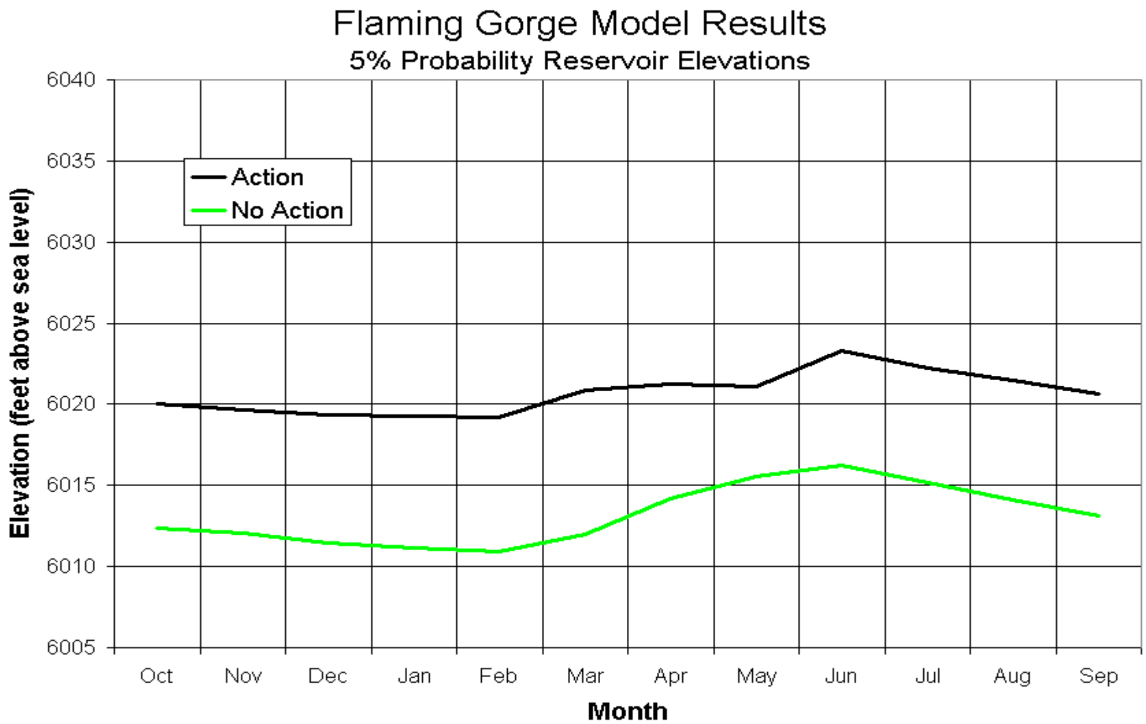


Figure 10.—5% Probability Level Reservoir Elevations (All Months).

REACH 1 SPRING PEAK FLOW RESULTS

The Flaming Gorge Model does not account for side inflows that occur along Reach 1 of the Green River. Historically, the volumes of flow contributed by tributaries to the Green River in Reach 1 have been relatively insignificant except during large thunderstorm events. Reach 1 flows that appear in this report are actually the average daily releases made from Flaming Gorge Dam. Figure 11 shows the distribution of peak flows having a duration of 1 day that occurred in the model results. It is also assumed that peak flows always occur during the spring period. Thus the distributions that appear in figure 11 can also be used to represent the distribution of annual peaks as well. For reference to how the reservoir was operated prior to the 1992 Biological Opinion, the distribution of historic peak flows in Reach 1 having a duration of 1 day for the period from 1971 to 1991 are included in the figure. Figures 12 and 13 show the distributions of peak flows in Reach 1 having durations of 2 and 4 weeks, respectively.

FLAMING GORGE ANNUAL BYPASS RELEASE RESULTS

Water released through the bypass tubes and the spillway (bypasses) can have a direct impact on the amount of power produced at Flaming Gorge Dam. For the purpose of comparing the Action and No Action Alternatives in terms of impact to power production, the distributions of annual bypass volumes are shown in figure 14. The figure shows the percentage of occurrences associated with the total volume bypassed each year. The model results indicate that the Action

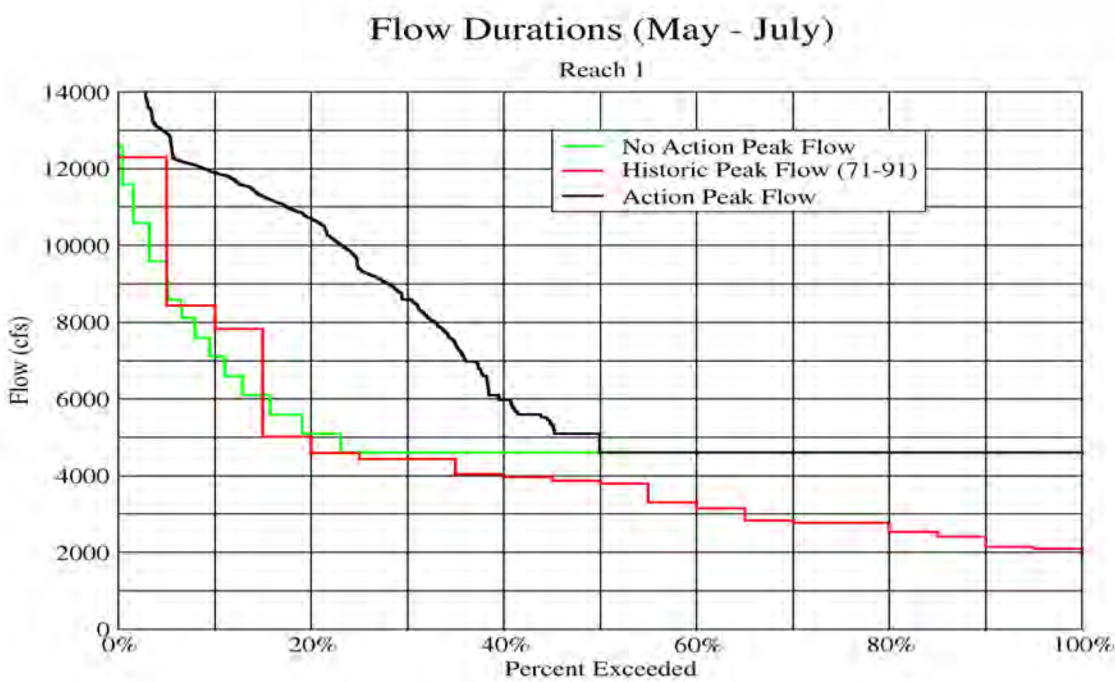


Figure 11.—5% Distribution of Peak (1-Day Duration) Releases.

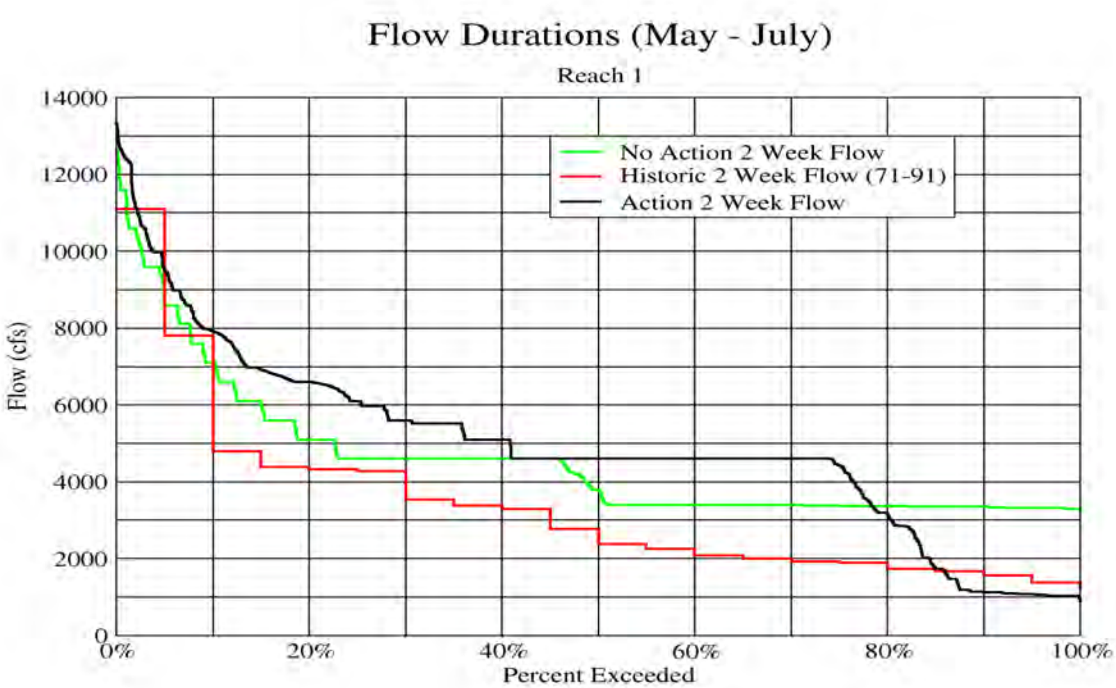


Figure 12.—Distribution of Peak (2-Week Duration) Releases.

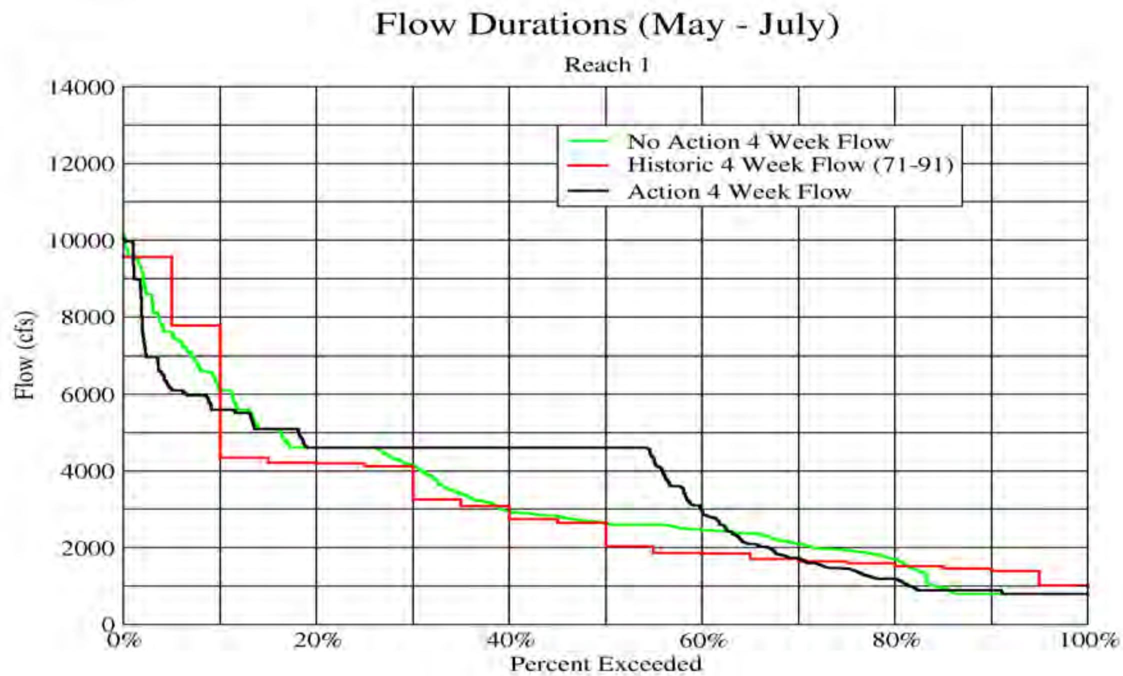


Figure 13.—Distribution of Peak (4-Week Duration) Releases.

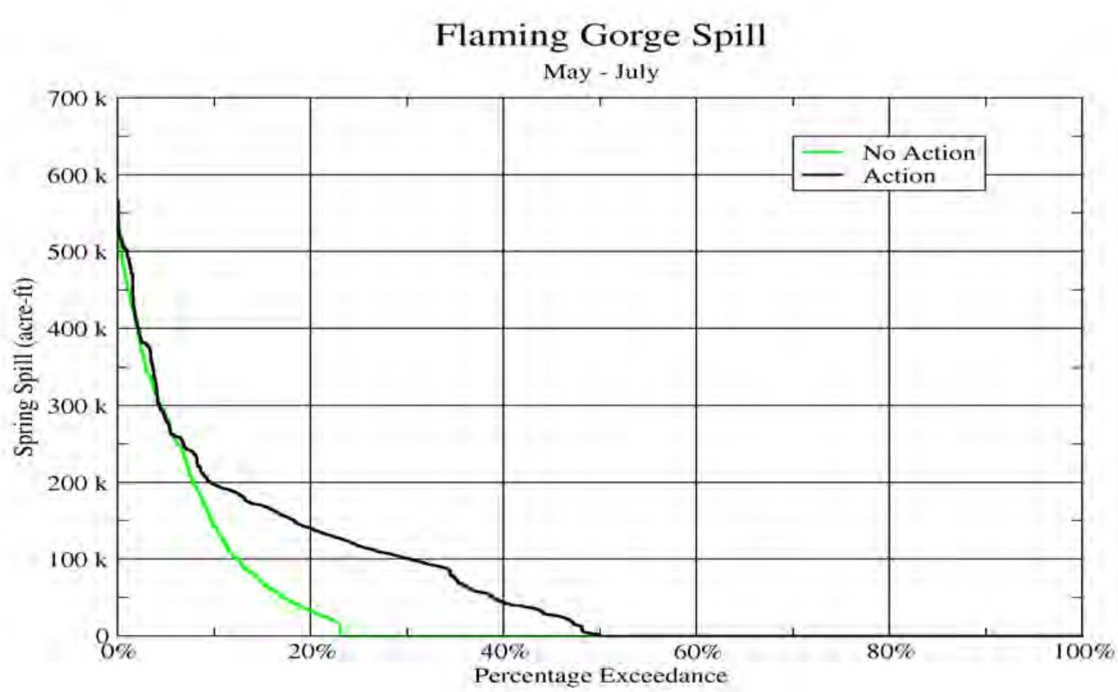


Figure 14.—Annual Bypass Volume Distribution.

Alternative will likely have about a 1 in 2 chance of requiring a bypass (about 50% of the time) in any given year while the No Action Alternative will likely have about a 1 in 5 chance of requiring a bypass (about 22% of the time) in any given year. These frequencies have not changed much from those reported in the October report, however the magnitude (volume) of these bypasses has diminished substantially.

REACH 1 AUGUST THROUGH FEBRUARY BASE FLOW RELEASE RESULTS

Releases made from August 1 through the end of February are referred to as the base flows in Reach 1. Figure 15 shows the distributions of base flows that occurred for Reach 1 in the model as a result of operating under the Action and No Action Alternatives. For reference to how Flaming Gorge Dam was operated prior to 1992, the distribution of actual base flows in Reach 1 that occurred from 1971 though 1991 are included in the figure. The distribution of unregulated inflows to Flaming Gorge Dam during this same period is also included. The unregulated inflows, in comparison to the actual base flows, indicate the effects of reservoir regulation at both Fontenelle Dam and Flaming Gorge Dam on Reach 1 flows during this period. Under the No Action Alternative, releases during the months of November through February are only restricted to be less than powerplant capacity and greater than 800 cfs. The Action Alternative maintains much stricter control of the releases during this period. This difference is evident in figure 15 between 0 and 20% exceedance. In many cases, the No Action Alternative strictly controls releases from August through October only to have releases increase dramatically in November

Figure 15.—Exceedance Percentage Flows for Reach 1 Flows During Base Flow Period.

when these controls are no longer valid. A good example of this situation is shown in figure 4. Releases during November for all three of these wet years were nearly double the releases that occurred during the preceding October.

The No Action Alternative restricts flows in Reach 2 from the end of the spring peak until September 15 to the range from 1,100 cfs to 1,800 cfs. In many cases, the Yampa River hydrograph is receding during this period and flows are above base flow levels. In order for the No Action Alternative to meet the base flow recommendation, releases are often times limited to 800 cfs (the minimum objective release). After September 15, the No Action Alternative expands the range of acceptable base flows to 1,100 to 2,400 cfs. In November these restrictions are no longer valid and releases are set within the range from 800 cfs to 4,600 cfs to achieve the drawdown target for the following year. To show the effect of these restrictions, the distribution of flows during the months of September and December were isolated. Graphs showing the distribution of flows for the Action and No Action Alternatives are included in the appendix of this report. There is a significant difference between the two months with respect to the flows generated by the Action and No Action rulesets. In September, flows in Reach 1 are typically less under the No Action Alternative than the flows of the Action Alternative. But in December, this relationship is reversed with flows of the No Action Alternative being much greater than those of the Action Alternative. This relationship translates to the other downstream reaches to a lesser degree. Flow distribution graphs for Reach 2 for the months of September and December are also included in the appendix.

REACH 2 SPRING PEAK FLOW RESULTS

Figures 16, 17, and 18 show the distributions of modeled spring peak flows that occurred in Reach 2. Figure 16 shows the distribution of peak flows having a duration of 1-day while figure 17 and 18 show distributions for peak flows having durations of 2 and 4 weeks, respectively. For perspective, the historic peak flows during the period from 1971 though 1991 are included on each of these figures. While the distributions of the Action and No Action peak flows are similar, there are notable differences at specific percentage exceedances. This is evident in figure 16 where the distribution for the Action Alternative noticeably deviates from the No Action Alternative at about 13% exceedance. Similar deviations occur in the Action Alternative at 10% and 40% exceedance levels for the 2-week duration peak flows. In the 4-week duration peak flows, a deviation in the Action distribution occurs at about 10% exceedance. All of these deviations indicate where peak flows were increased by the Action Alternative in order to achieve the specific targets of the 2000 Flow and Temperature Recommendations.

REACH 2 BASE FLOW RELEASE RESULTS

Figure 19 shows the distribution of base flows that occurred in Reach 2 under the Action and No Action Alternatives. Base flows are noticeably decreased under the Action Alternative especially in wetter years. For reference, the distribution of pre-dam (1946 to 1961) base flows and the distribution of base flows during the period from 1971 through 1991 are included in the figure.

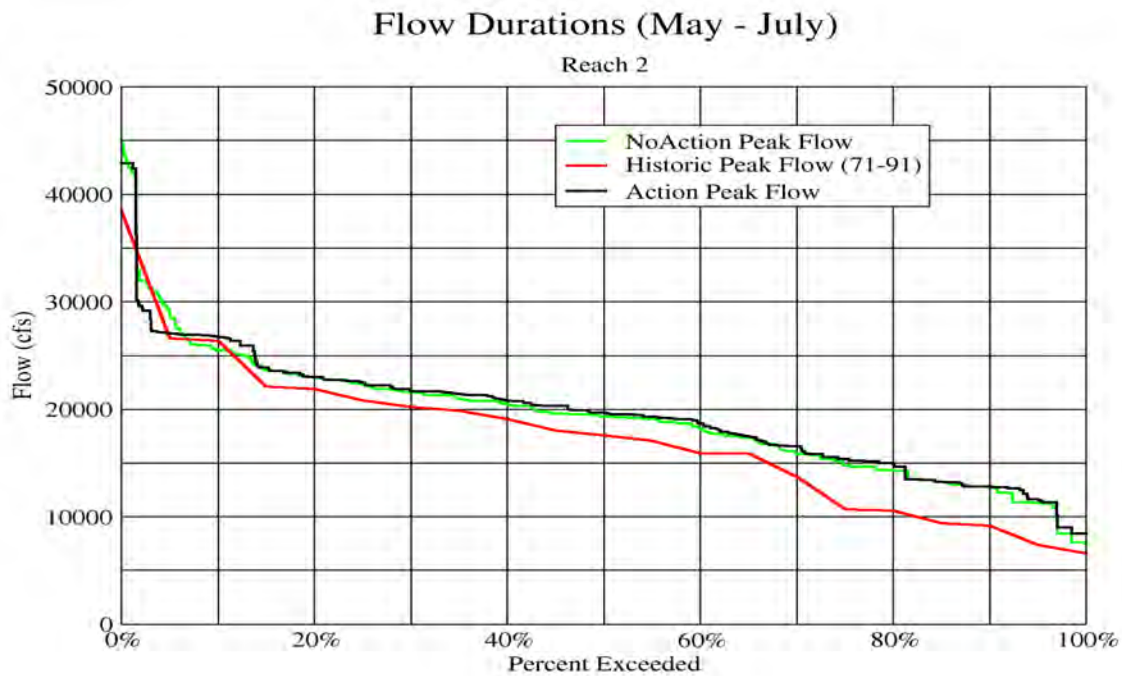


Figure 16.—Distribution of Peak Flows (1-Day Duration) in Reach 2.

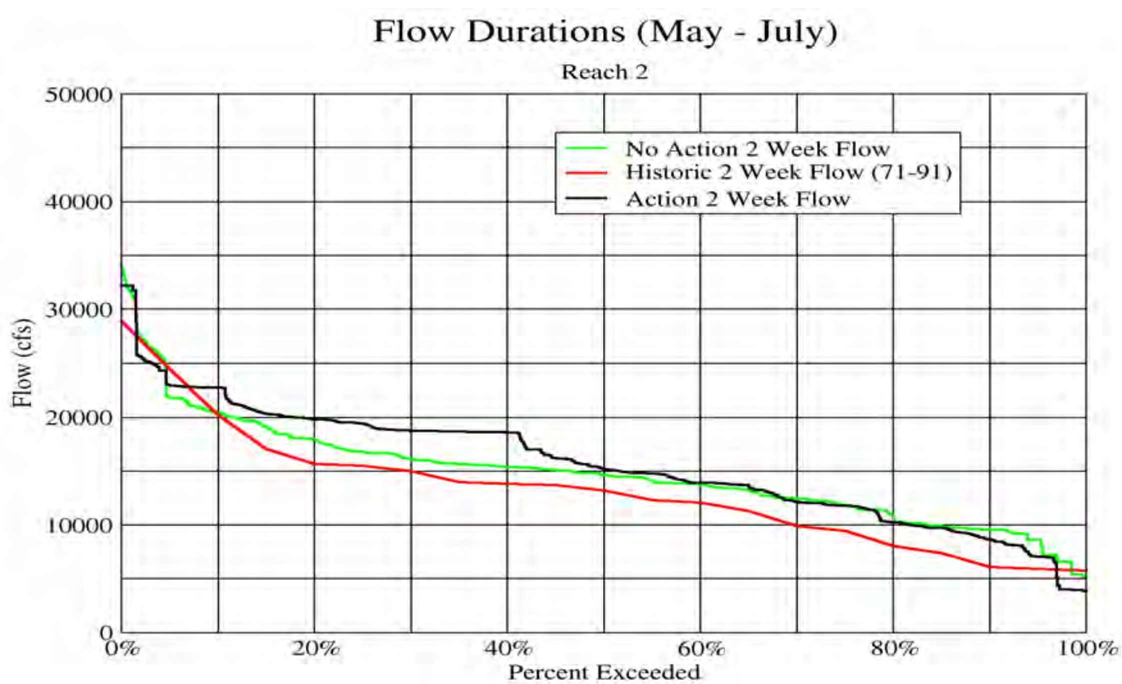


Figure 17.—Distribution of Peak Flows (2-Week Durations) in Reach 2.

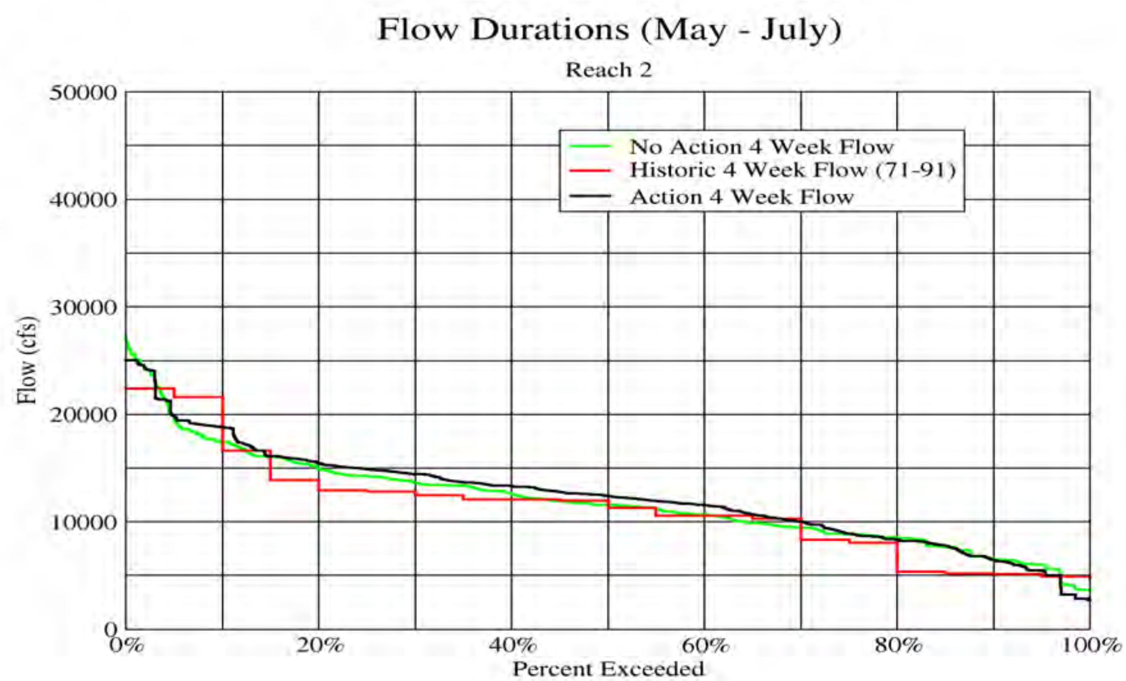


Figure 18.—Distribution of Peak Flows (4-Week Durations) in Reach 2.

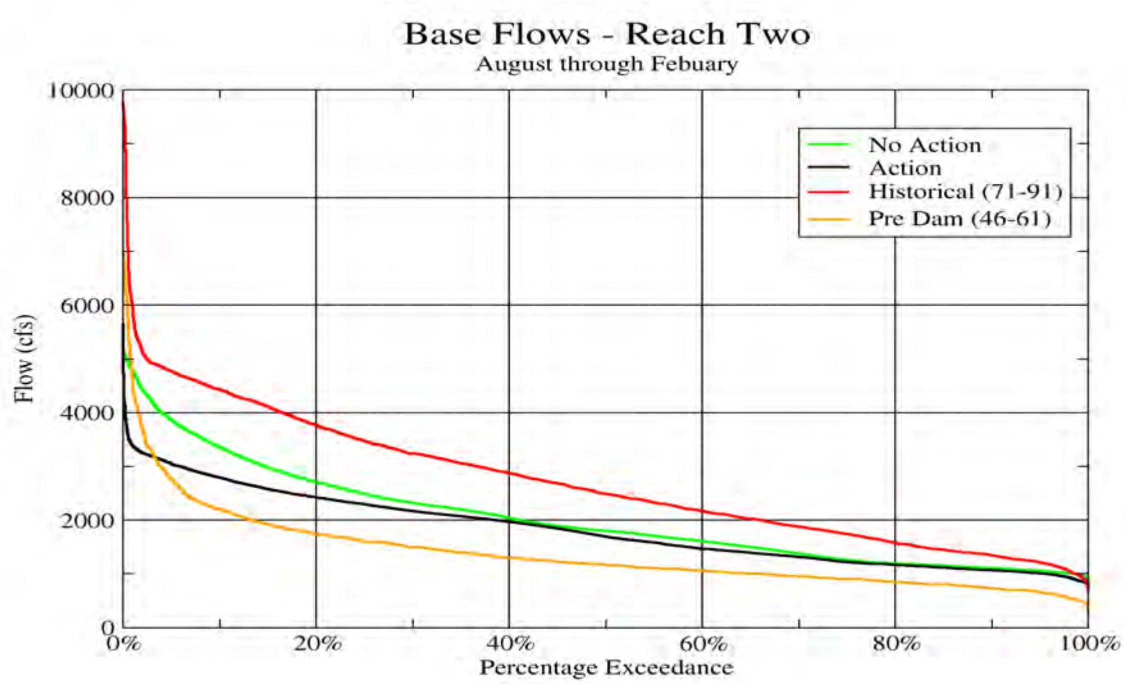


Figure 19.—Exceedance Percentage Flows for Reach 2 Flows During Base Flow Period.

The period from 1946 through 1961 does include a significant dry cycle for the Upper Green River Basin but these two distributions of historic Reach 2 flows give some perspective to the difference between the Action and No Action Alternative base flows.

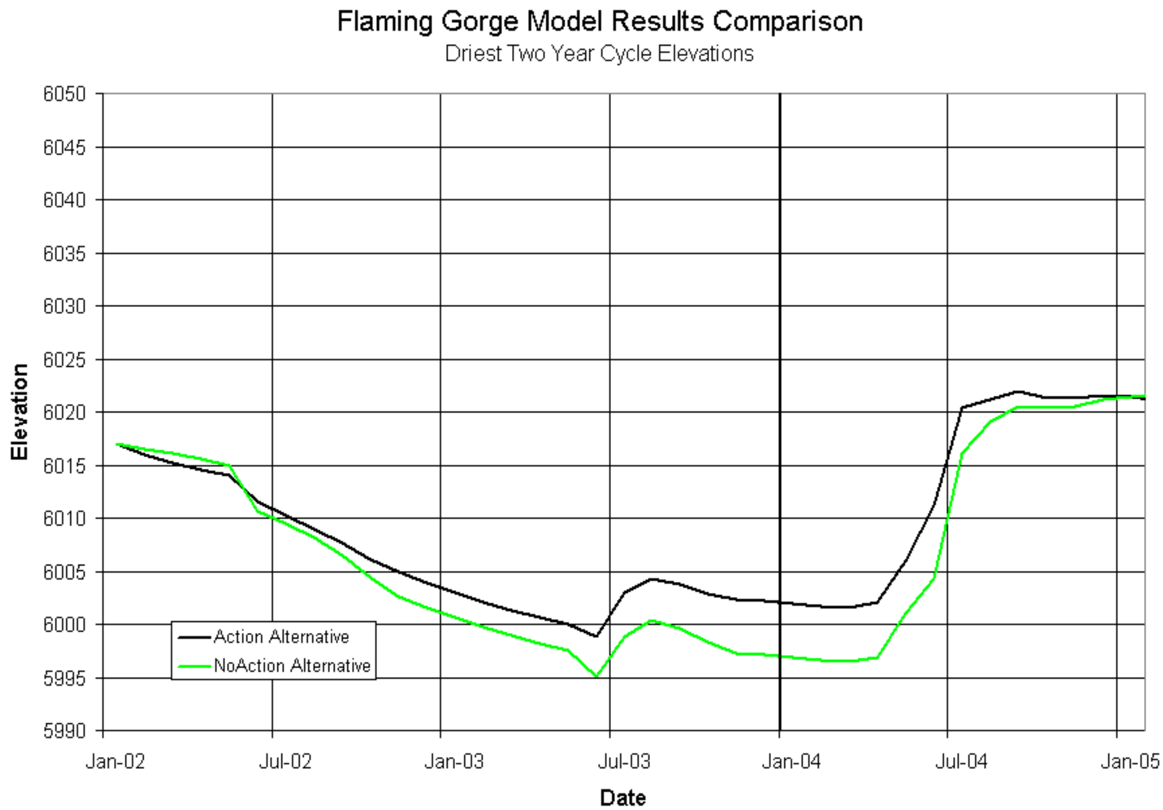
Reach 2 is also impacted by the No Action flow restrictions during the summer months. Flow distribution graphs for the months of September and December characterize how base flows in Reach 2 will transition from low to high during the fall months (October and November). These graphs are located in the appendix of this report.

SUMMARY

The results described in this report show significantly reduced impacts to reservoir related resources. Of all of the modifications made since October, the most significant was the implementation of the daily model to react to estimated Yampa River flows. This modification substantially reduced the volume of the spring releases made by the Action Alternative, which in turn, decreased the drawdown effects associated with the spring release. The Action Alternative now yields reservoir elevations that are significantly higher than those presented in the October report. While the frequency of bypasses in the Action Alternative has not changed very much from those reported in October, the bypass volumes have been significantly reduced. In October, there was about a 20% chance that any given year would have a bypass in excess of 300,000 acre-feet. With the modifications made since October, there is now a 20% chance in any given year of a bypass in excess of 150,000 acre-feet.

This report is not comprehensive in terms of the model results analysis presented. It is an attempt to provide some useful analysis for the purposes of determining other resource impacts. Statistical analysis of data depends largely on the question that must be answered. While the results presented in this report do answer many questions about impacts that may occur as a result of implementing the Action or No Action Alternatives, the results will not answer all questions. If additional analysis is required to answer your particular resource questions, it is suggested that you present your questions to the hydrologic modeling team.

APPENDIX


Flaming Gorge Model Results Comparison
Driest Two Year Cycle Elevations
Elevation
6050
6045
6040
6035
6030
6025
6020
6015
6010
6005
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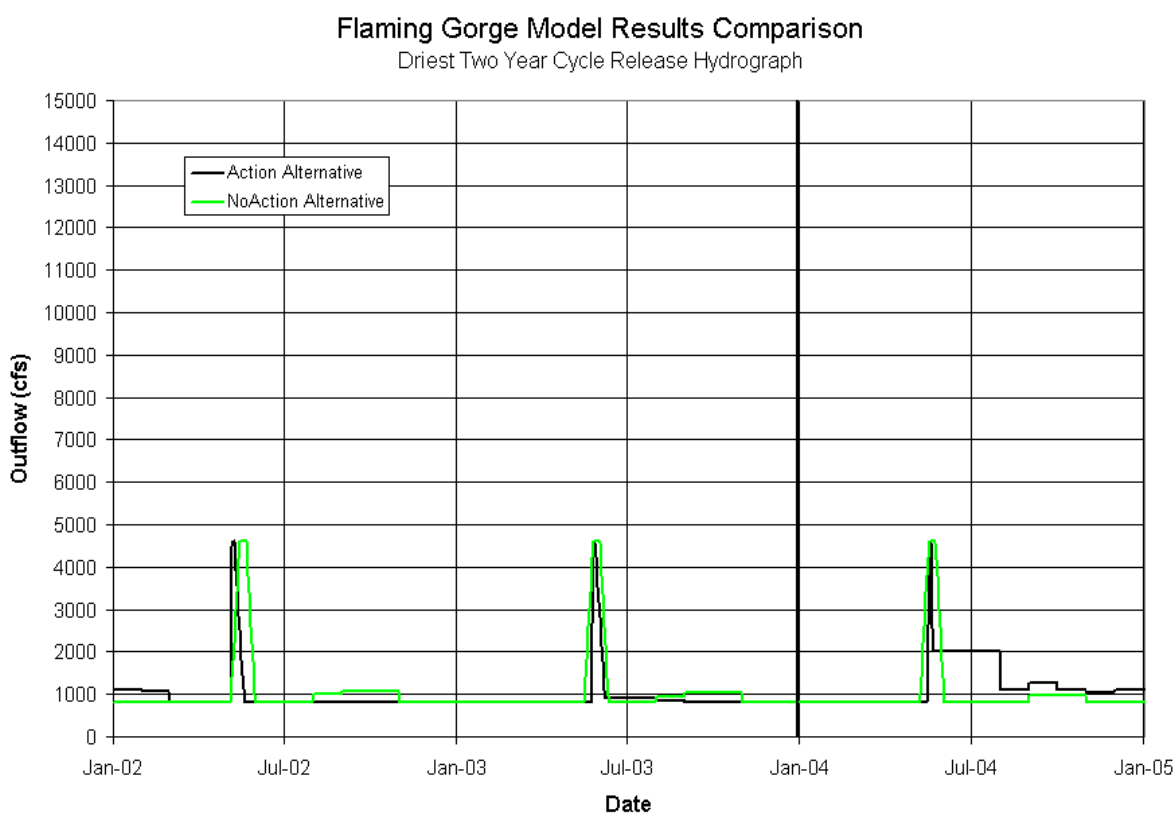
5995
5990
Action Alternative
NoAction Alternative
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Date


Flaming Gorge Model Results Comparison
Driest Two Year Cycle Release Hydrograph
Outflow (cfs)
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
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Action Alternative
NoAction Alternative
Jan-02
Jul-02
Jan-03
Jul-03
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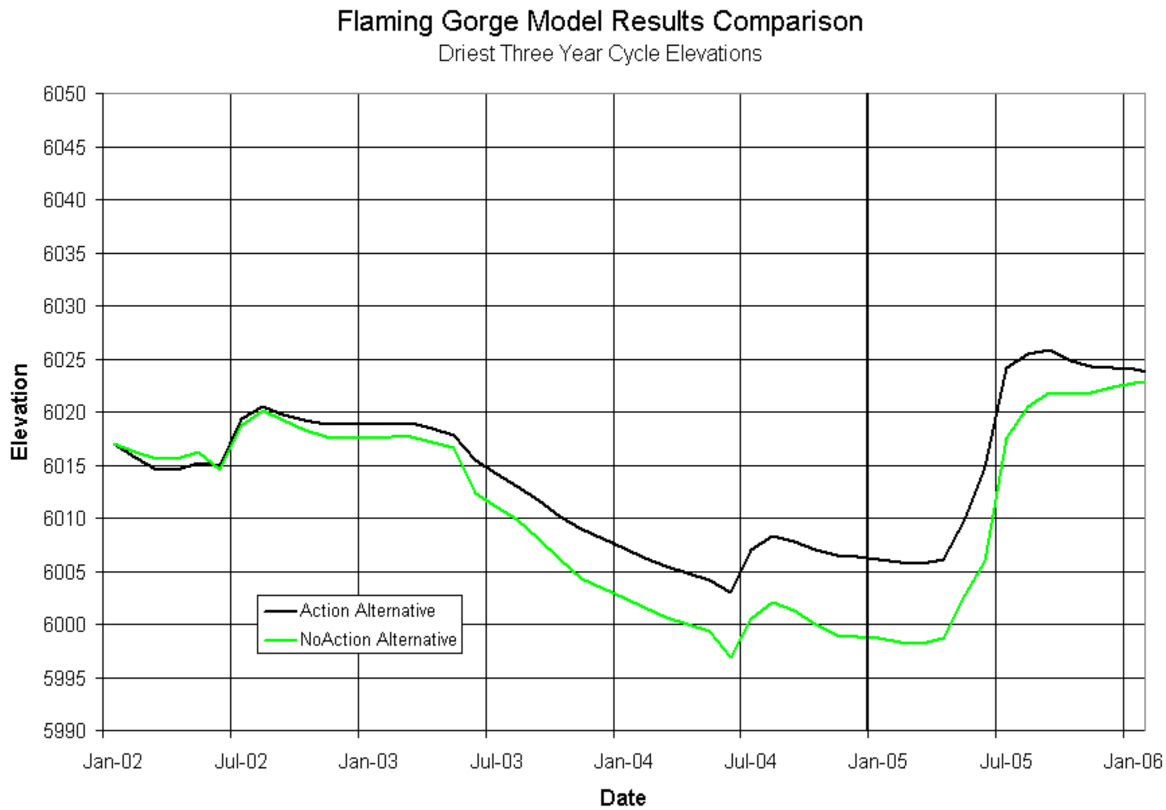
Jul-04
Jan-05
Date


Flaming Gorge Model Results Comparison
Driest Three Year Cycle Elevations
Elevation
6050
6045
6040
6035
6030
6025
6020
6015
6010
6005
6000
5995
5990
Action Alternative
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Jul-02
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Jul-04
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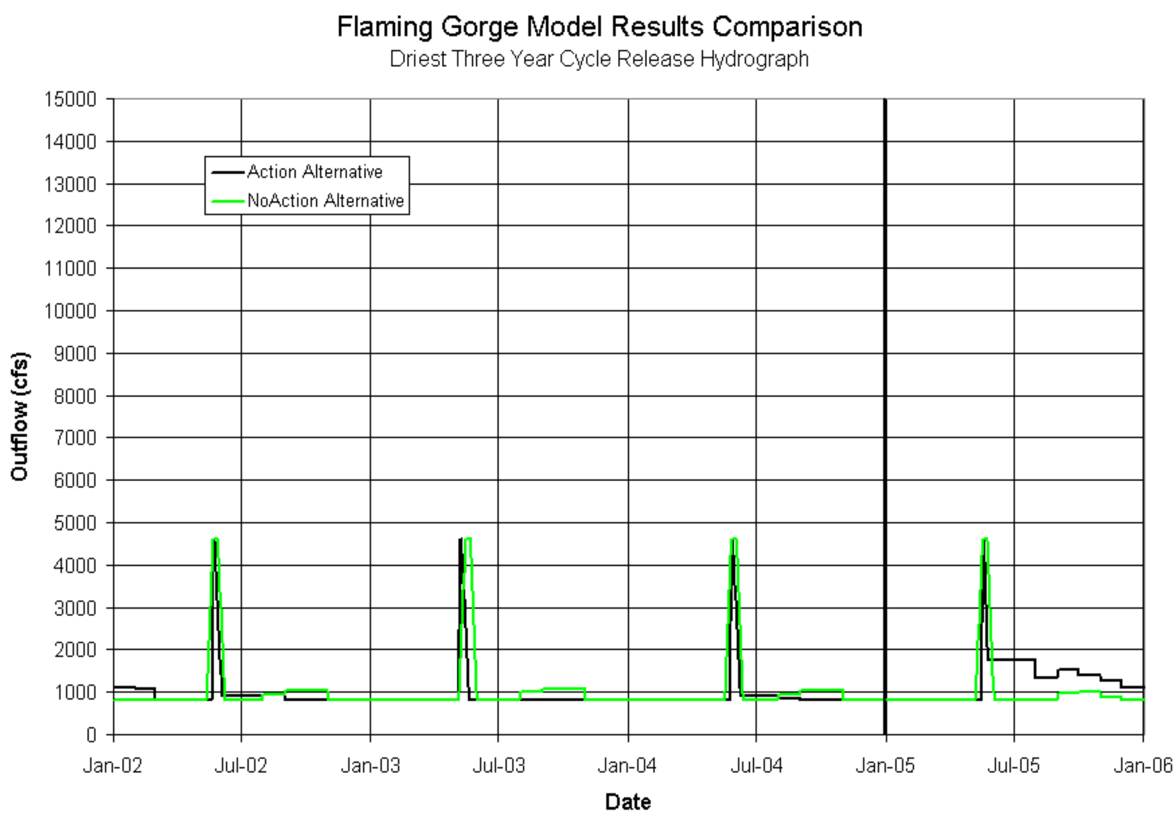
Jul-05
Jan-06
Date


Flaming Gorge Model Results Comparison
Driest Three Year Cycle Release Hydrograph
Outflow (cfs)
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14000
13000
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11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
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Action Alternative
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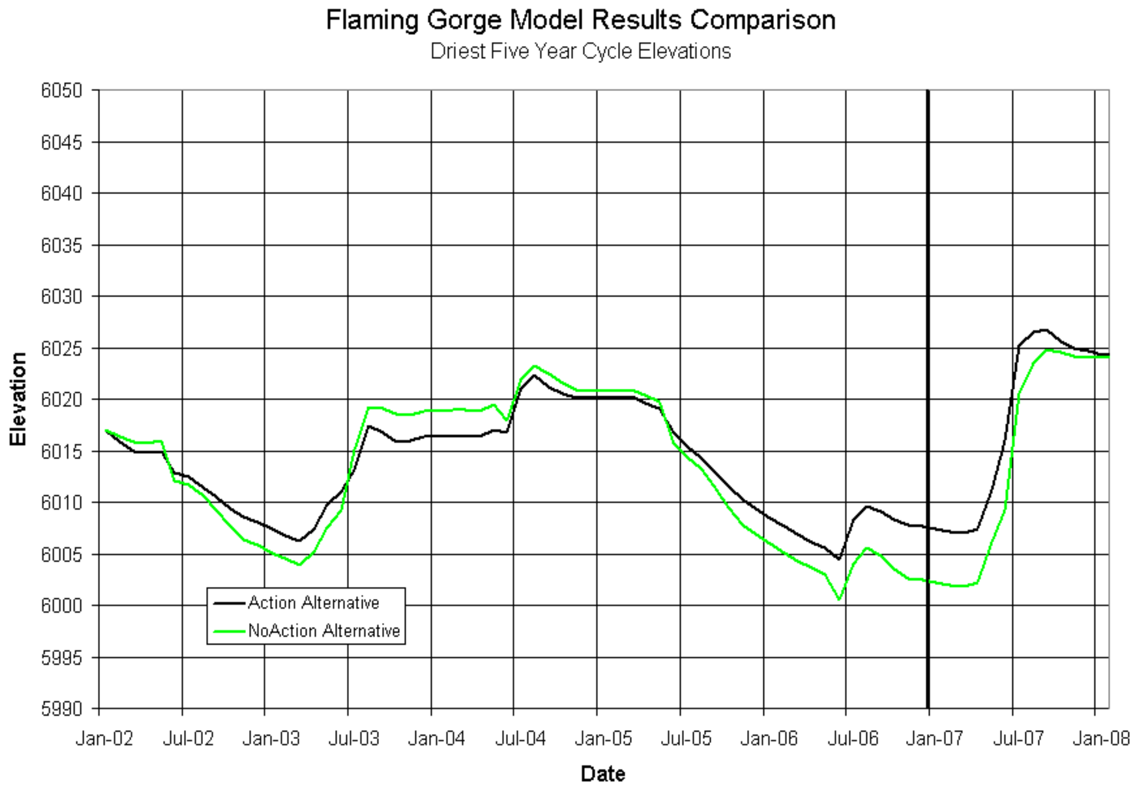
Jul-04
Jan-05
Jul-05
Jan-06
Date


Flaming Gorge Model Results Comparison
Driest Five Year Cycle Elevations
Elevation
6050
6045
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6035
6030
6025
6020
6015
6010
6005
6000
5995
5990
Action Alternative
NoAction Alternative
Jan-02
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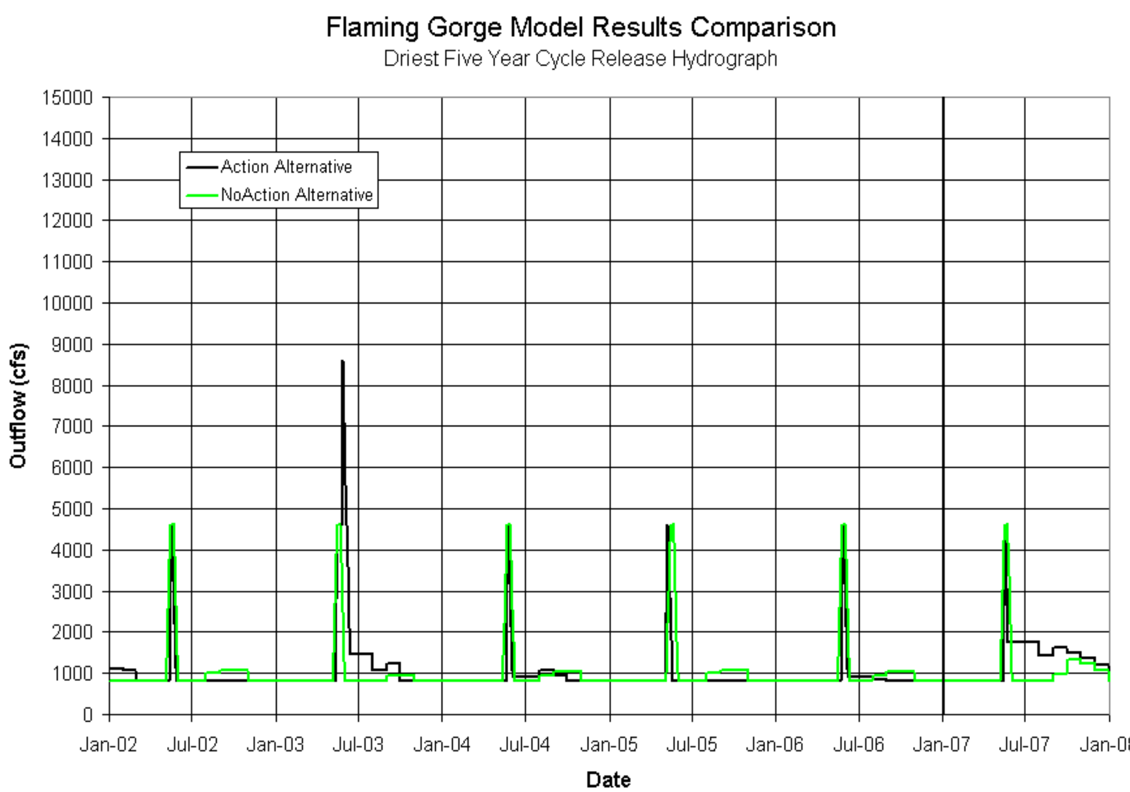
Jan-07
Jul-07
Jan-08
Date


Flaming Gorge Model Results Comparison
Driest Five Year Cycle Release Hydrograph
Outflow (cfs)
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13000
12000
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10000
9000
8000
7000
6000
5000
4000
3000
2000
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0
Action Alternative
NoAction Alternative
Jan-02
Jul-02
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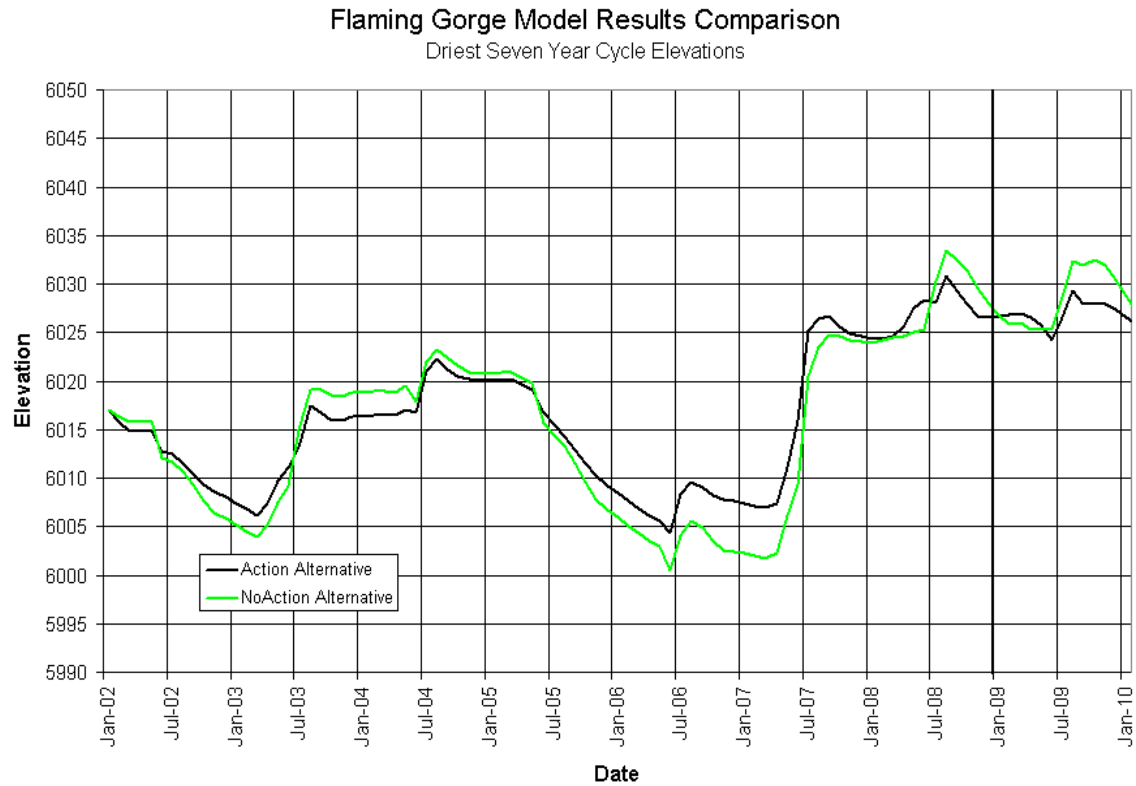
Jul-07
Jan-08
Date



Flaming Gorge Model Results Comparison
Driest Seven Year Cycle Elevations
Elevation
Date
Action Alternative
NoAction Alternative
6050
6045
6040
6035
6030
6025
6020
6015
6010
6005
6000
5995
5990
Jan-02
Jul-02
Jan-03
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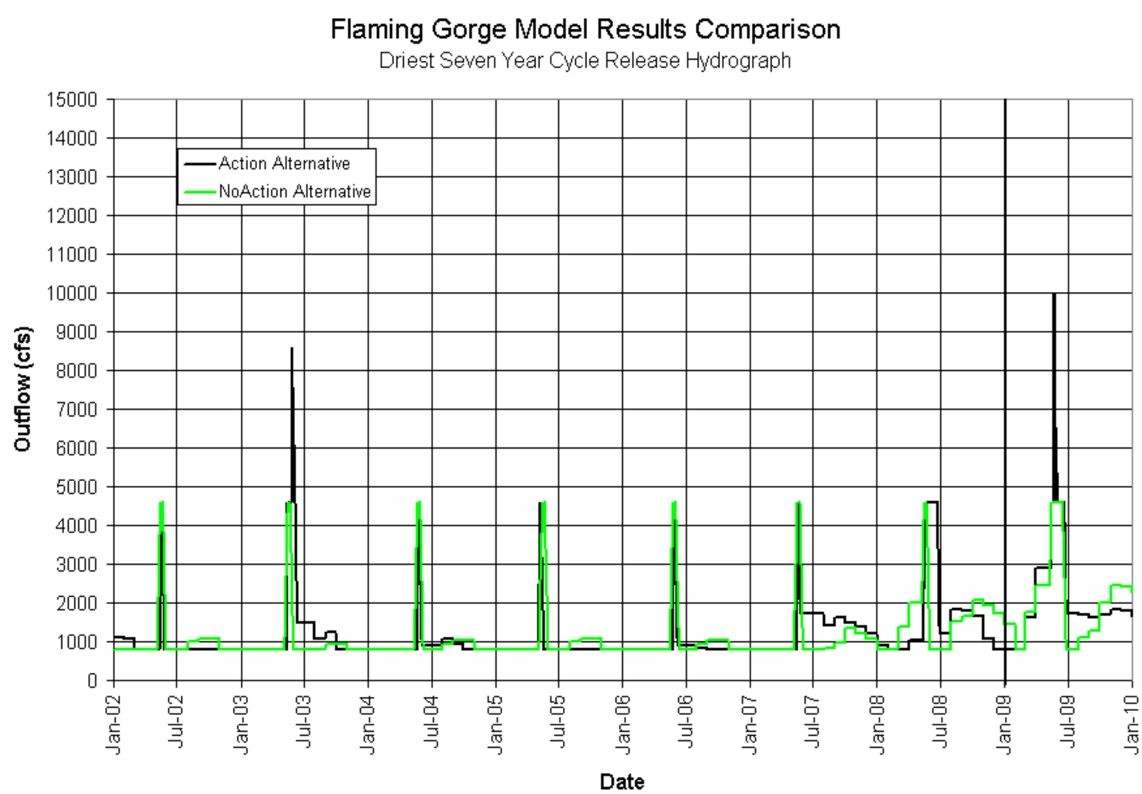

Flaming Gorge Model Results Comparison
Driest Seven Year Cycle Release Hydrograph
Outflow (cfs)
Date
Action Alternative
NoAction Alternative
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan-02
Jul-02
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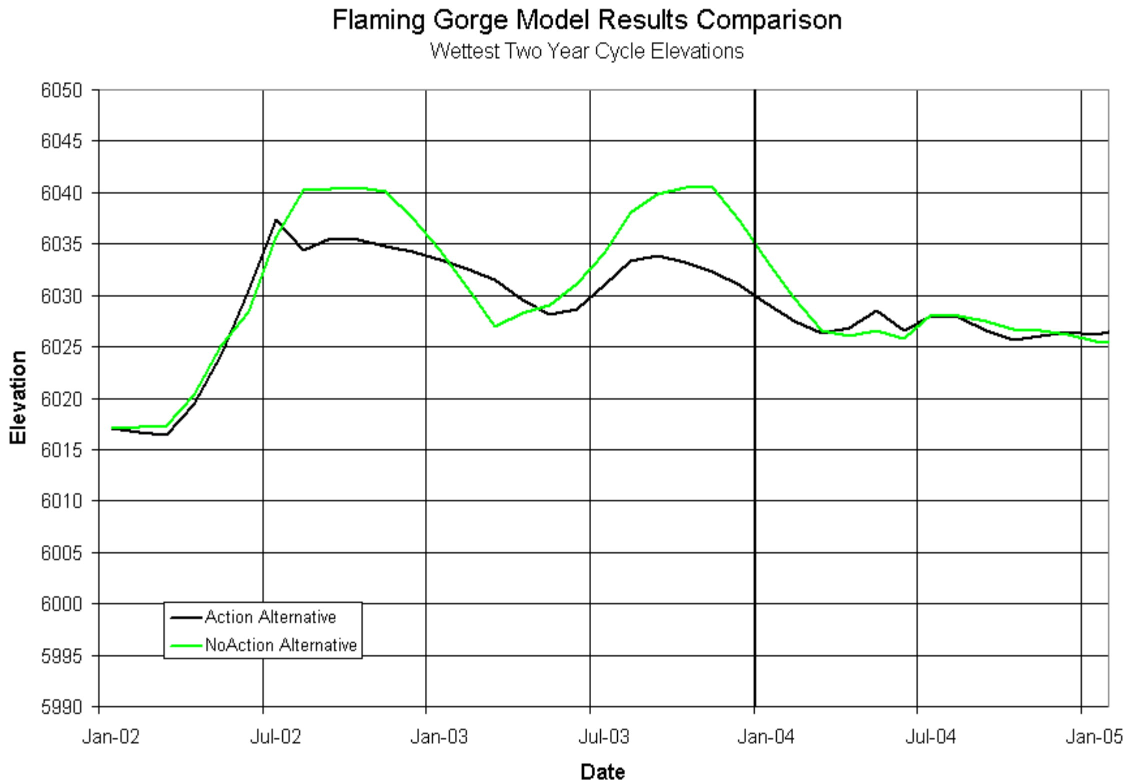
Flaming Gorge Model Results Comparison
Wettest Two Year Cycle Elevations
Elevation
6050
6045
6040
6035
6030
6025
6020
6015
6010
6005
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5995
5990
Action Alternative
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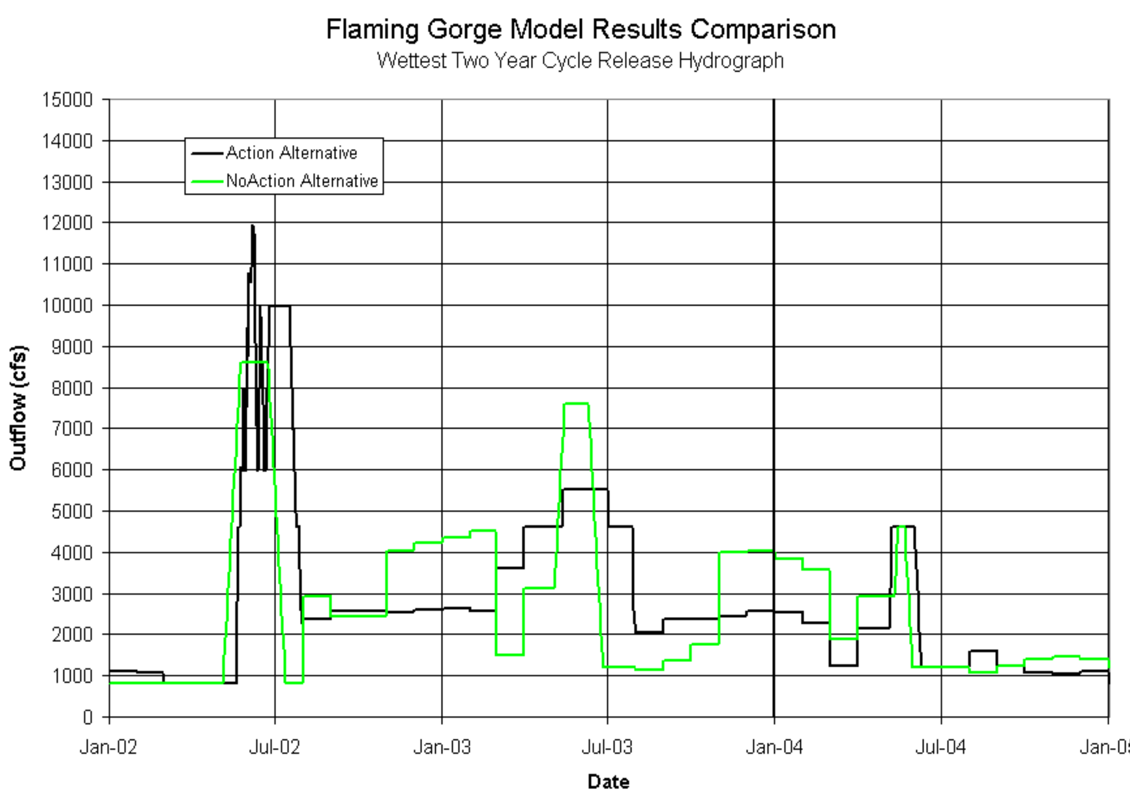
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Date


Flaming Gorge Model Results Comparison
Wettest Two Year Cycle Release Hydrograph
Outflow (cfs)
15000
14000
13000
12000
11000
10000
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4000
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Action Alternative
NoAction Alternative
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Jul-02
Jan-03
Jul-03
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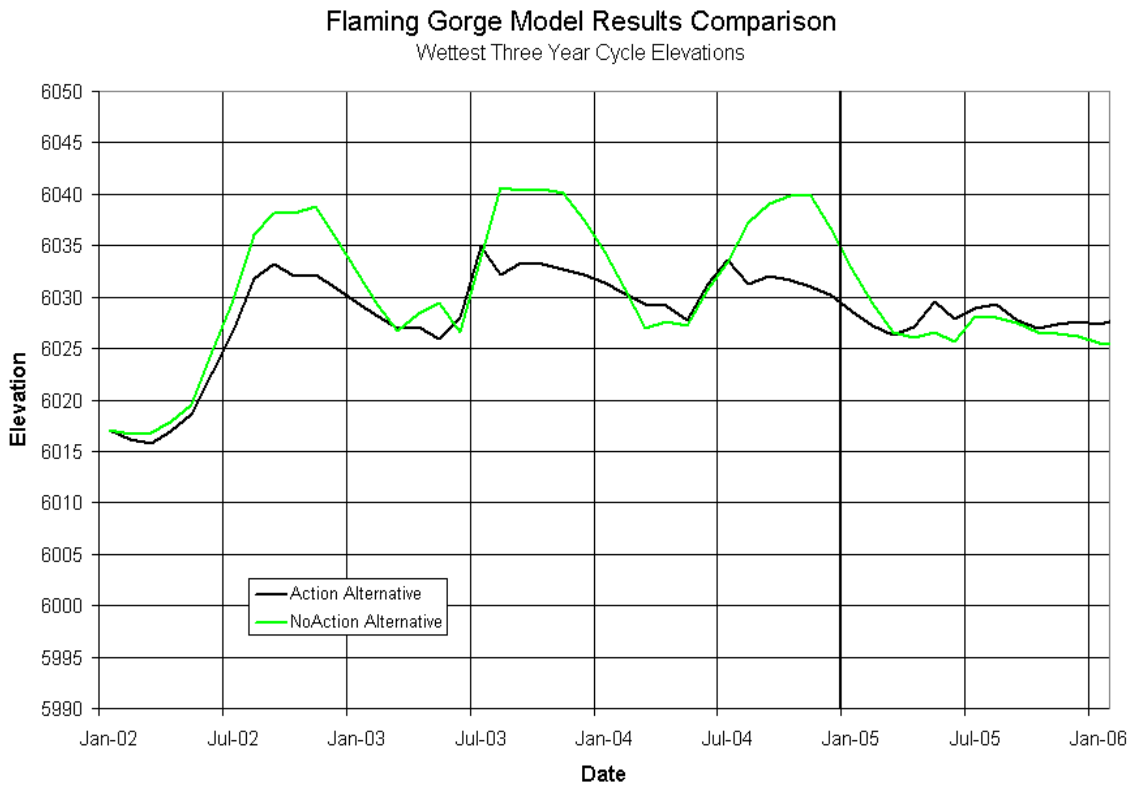
Jul-04
Jan-05
Date


Flaming Gorge Model Results Comparison
Wettest Three Year Cycle Elevations
Elevation
6050
6045
6040
6035
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6025
6020
6015
6010
6005
6000
5995
5990
Action Alternative
NoAction Alternative
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Jul-02
Jan-03
Jul-03
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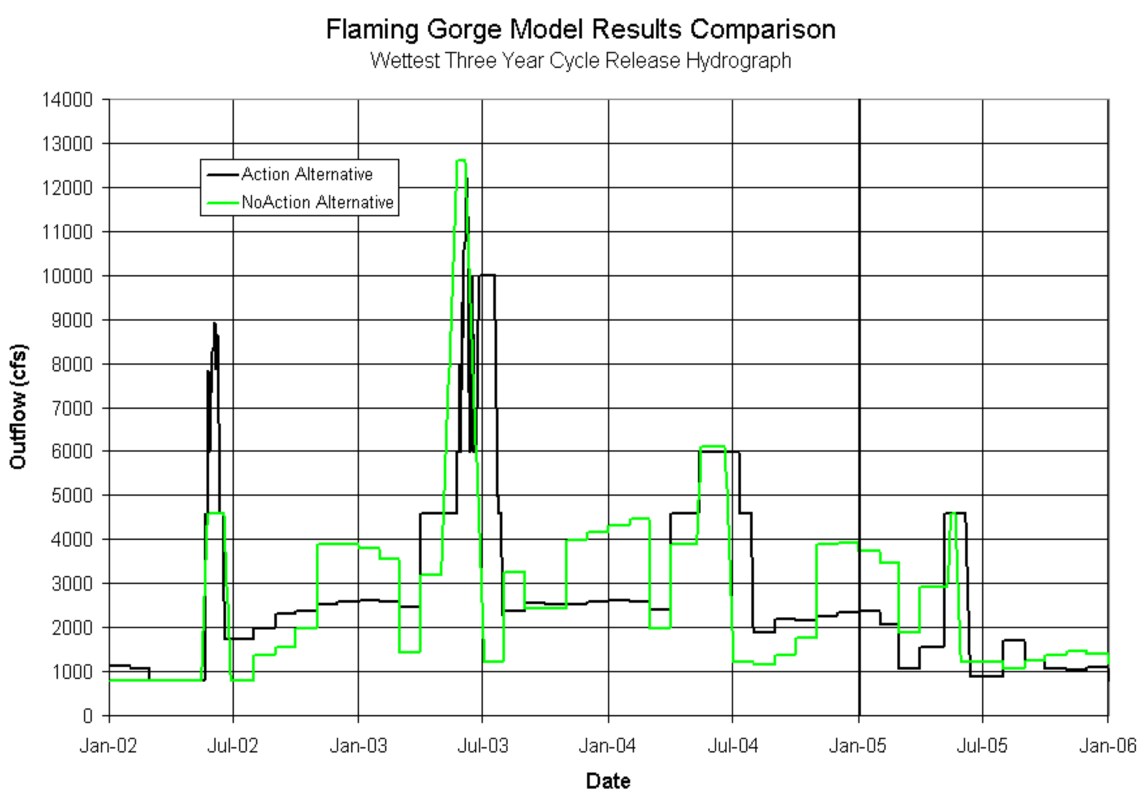
Jul-05
Jan-06
Date


Flaming Gorge Model Results Comparison
Wettest Three Year Cycle Release Hydrograph
Outflow (cfs)
14000
13000
12000
11000
10000
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8000
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2000
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Action Alternative
NoAction Alternative
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Jan-03
Jul-03
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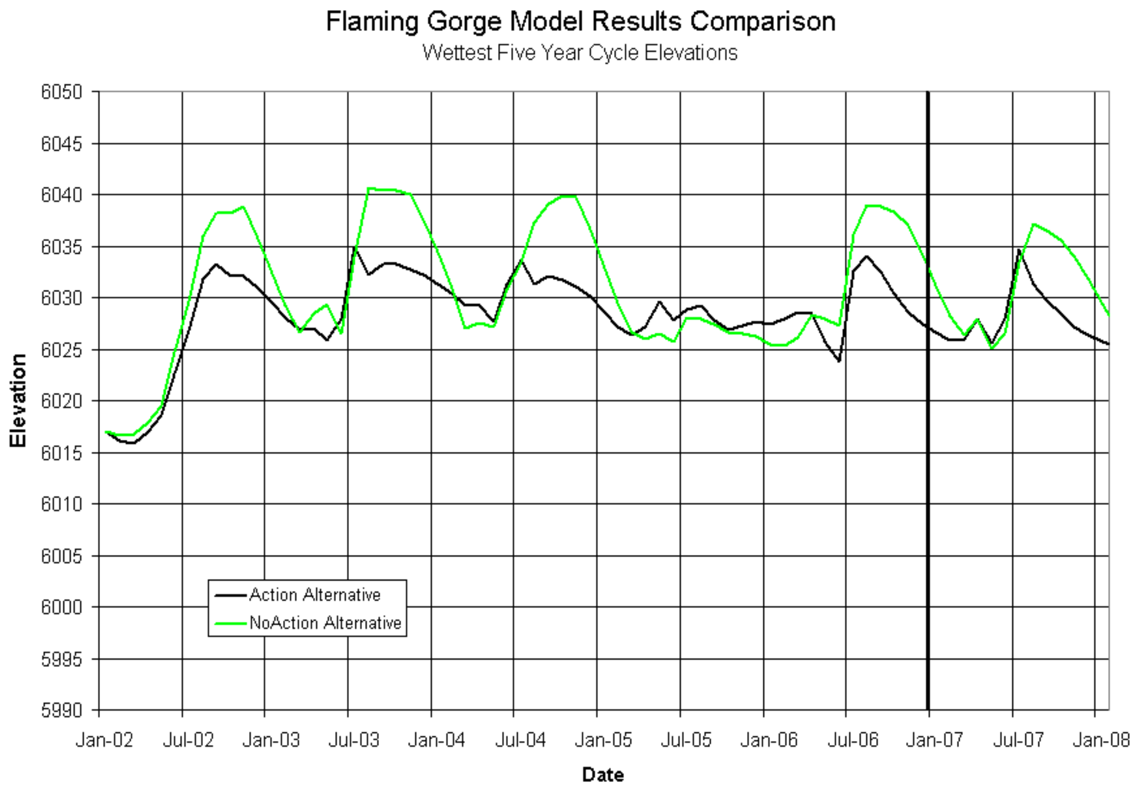
Jan-05
Jul-05
Jan-06
Date


Flaming Gorge Model Results Comparison
Wettest Five Year Cycle Elevations
Elevation
6050
6045
6040
6035
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6020
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6005
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5995
5990
Action Alternative
NoAction Alternative
Jan-02
Jul-02
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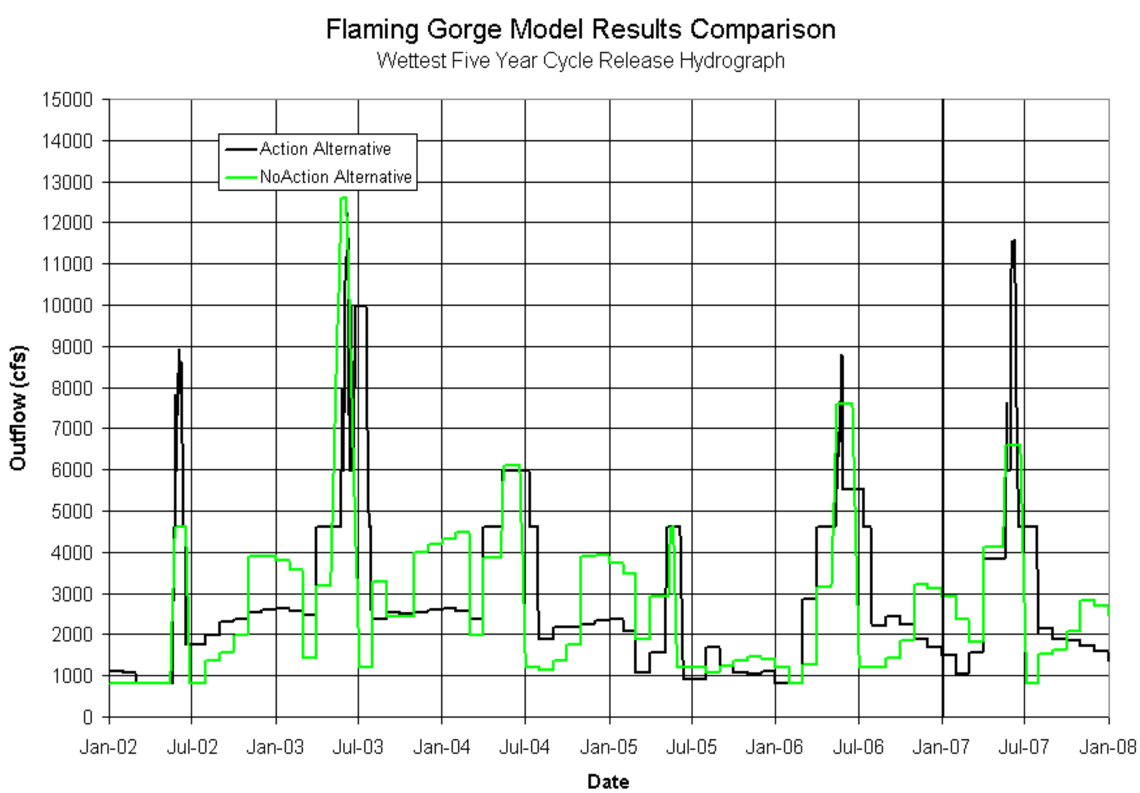
Jan-08
Date


Flaming Gorge Model Results Comparison
Wettest Five Year Cycle Release Hydrograph
Outflow (cfs)
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14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
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2000
1000
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Action Alternative
NoAction Alternative
Jan-02
Jul-02
Jan-03
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Jan-04
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Jul-06
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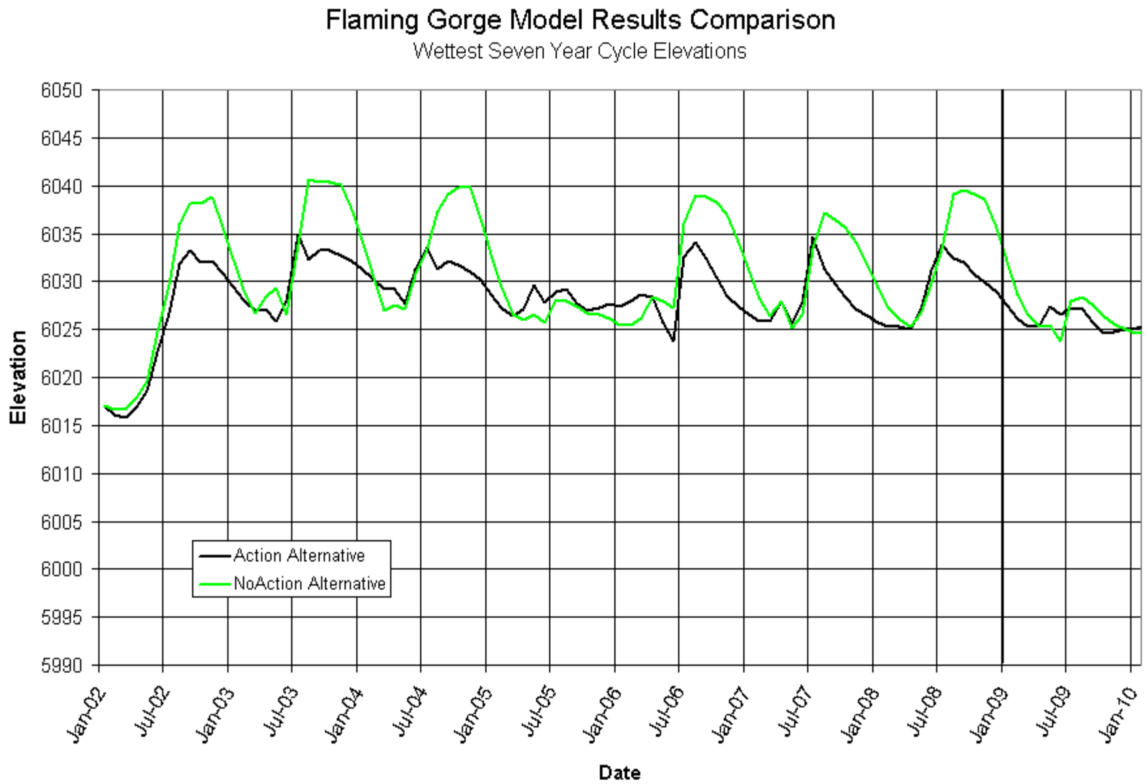
Jul-07
Jan-08
Date


Flaming Gorge Model Results Comparison
Wettest Seven Year Cycle Elevations
Elevation
Date
Action Alternative
NoAction Alternative
6050
6045
6040
6035
6030
6025
6020
6015
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5995
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Jan-02
Jul-02
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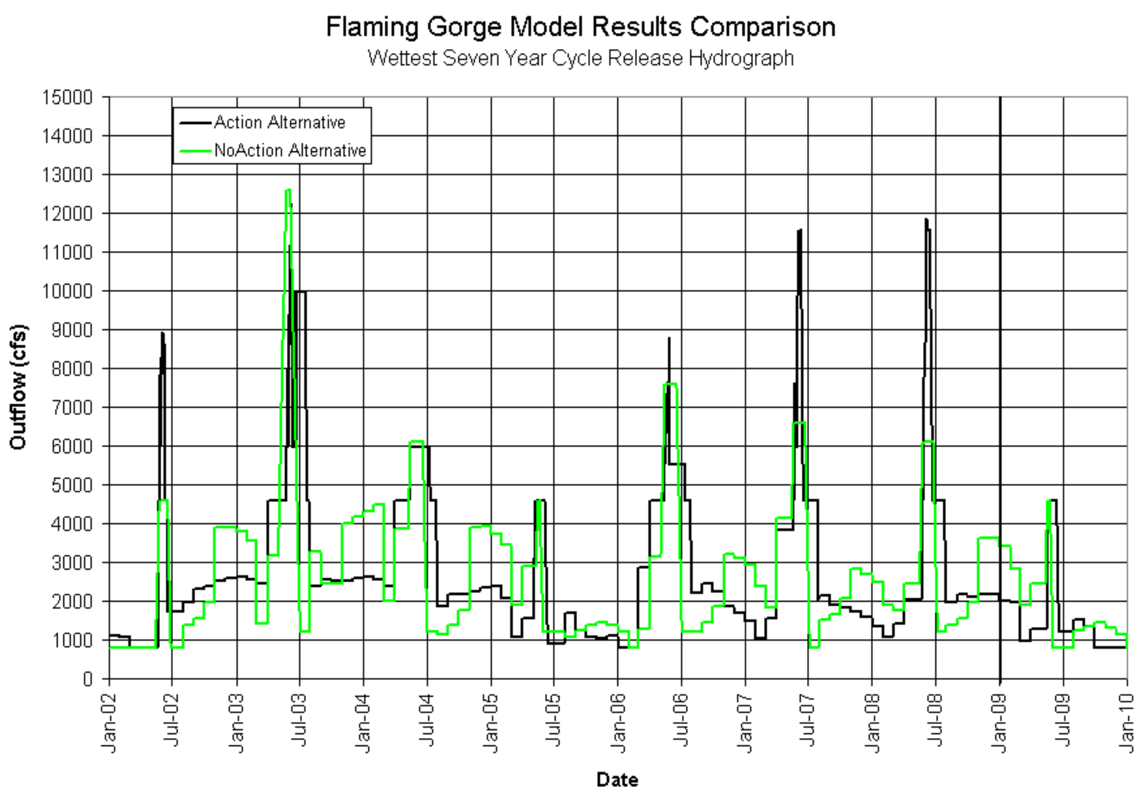
Jan-10


Flaming Gorge Model Results Comparison
Wettest Seven Year Cycle Release Hydrograph
Outflow (cfs)
Date
Action Alternative
NoAction Alternative
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
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3000
2000
1000
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Jan-02
Jul-02
Jan-03
Jul-03
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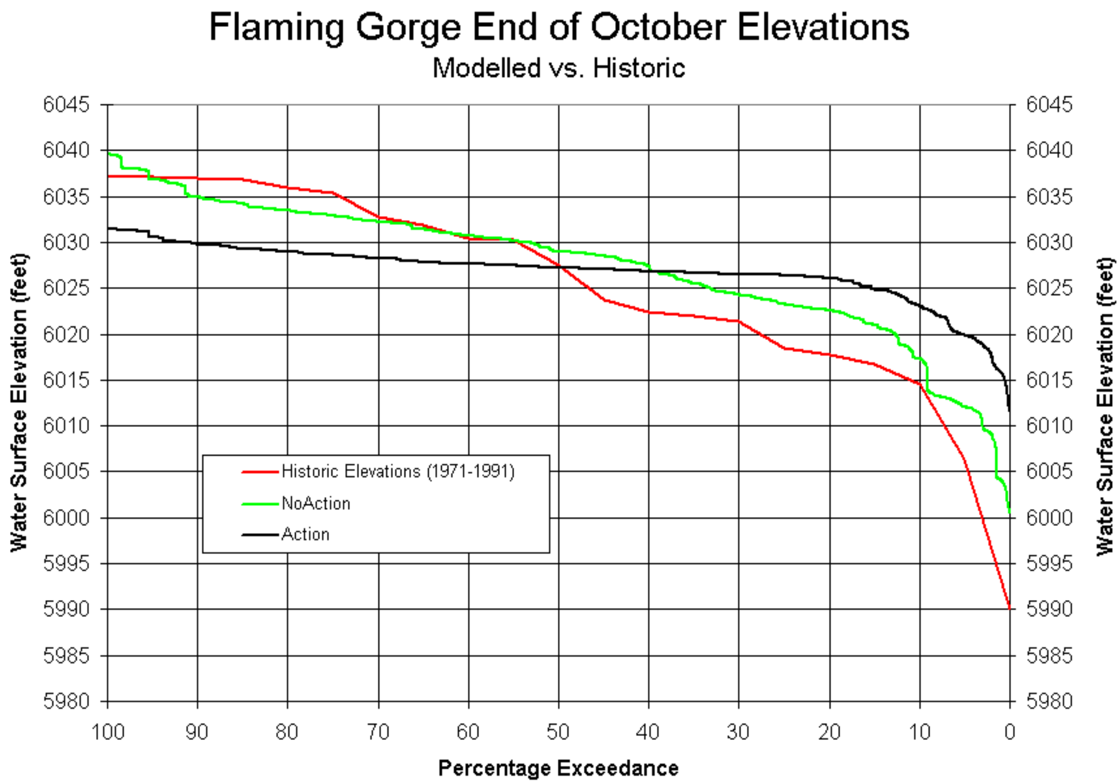
Flaming Gorge End of October Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
Action
6045
6040
6035
6030
6025
6020
6015
6010
6005
6000
5995
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30
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10
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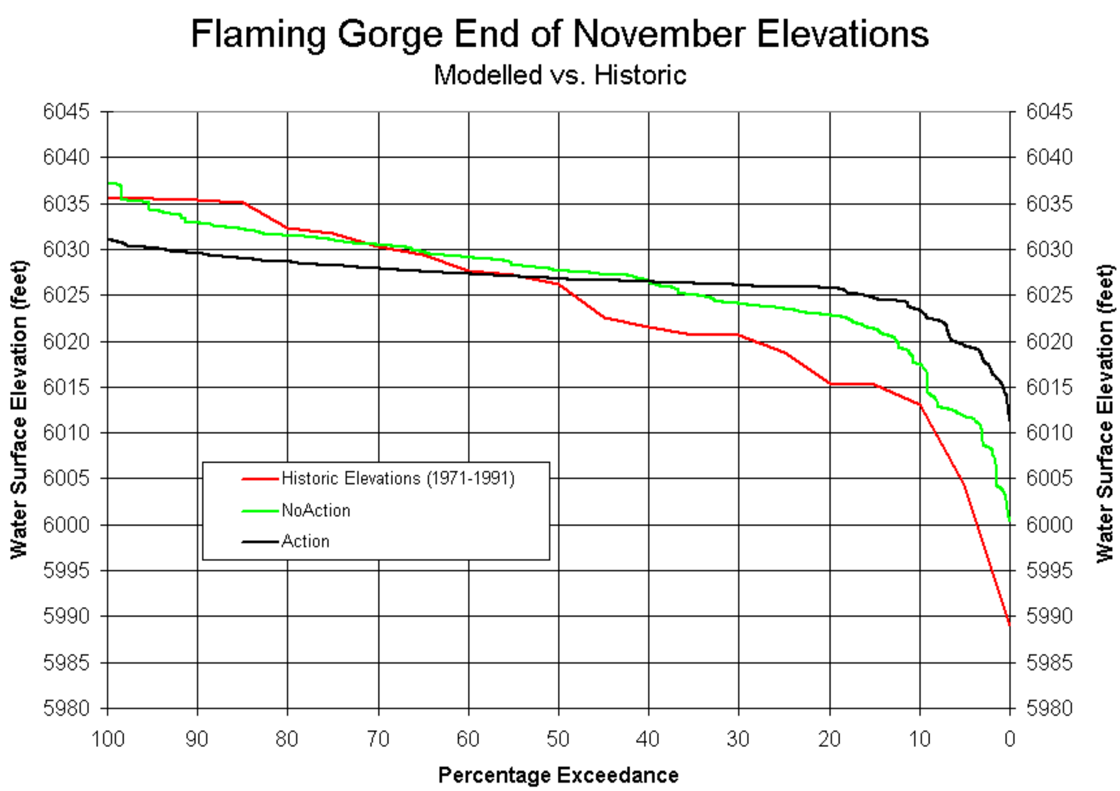
Flaming Gorge End of November Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
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6040
6035
6030
6025
6020
6015
6010
6005
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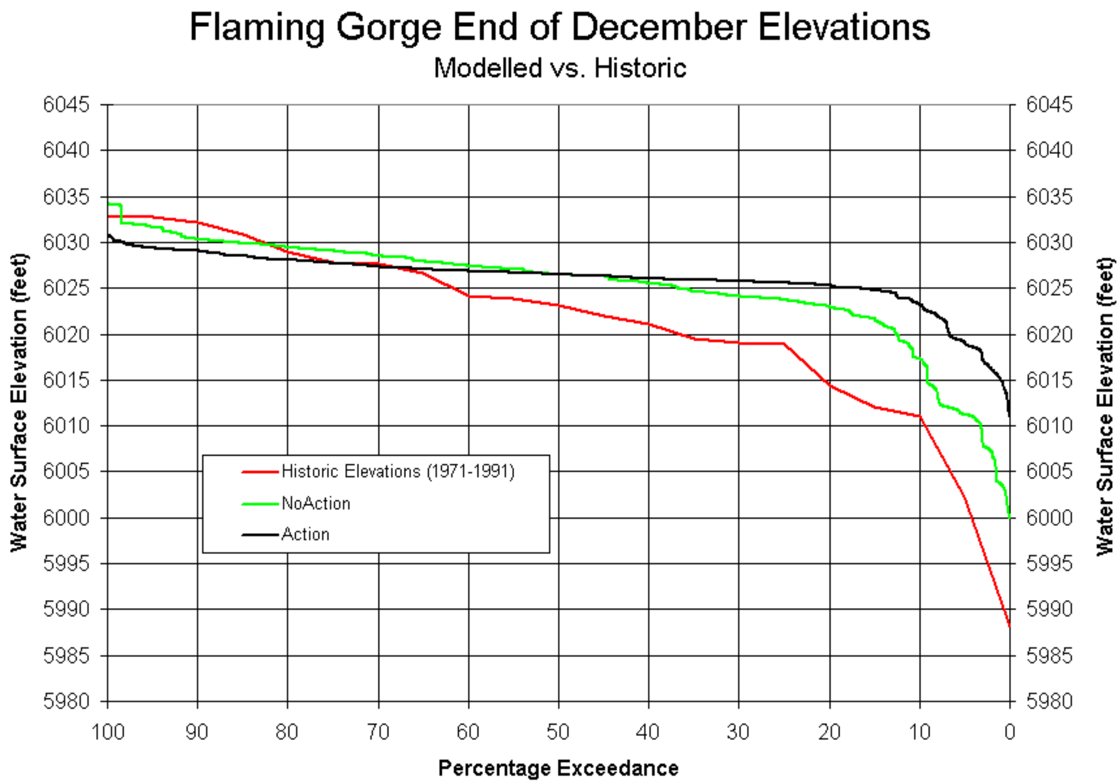
Flaming Gorge End of December Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
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6040
6035
6030
6025
6020
6015
6010
6005
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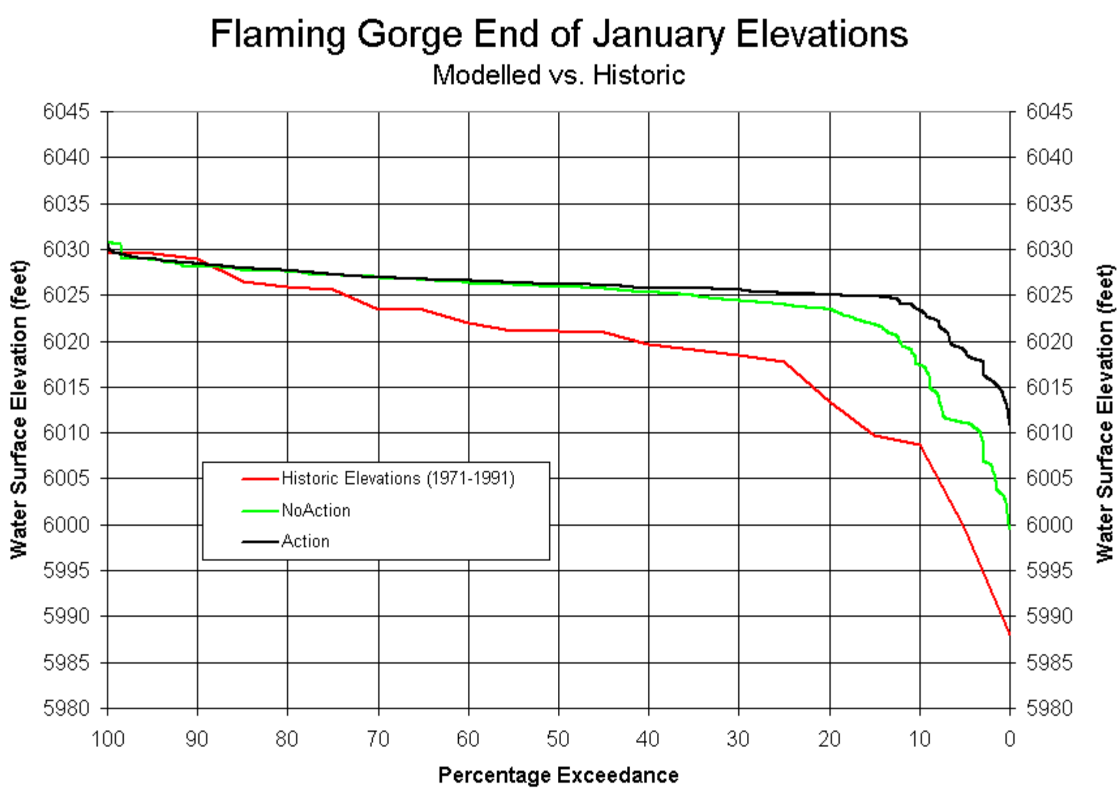
Flaming Gorge End of January Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
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6040
6035
6030
6025
6020
6015
6010
6005
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5995
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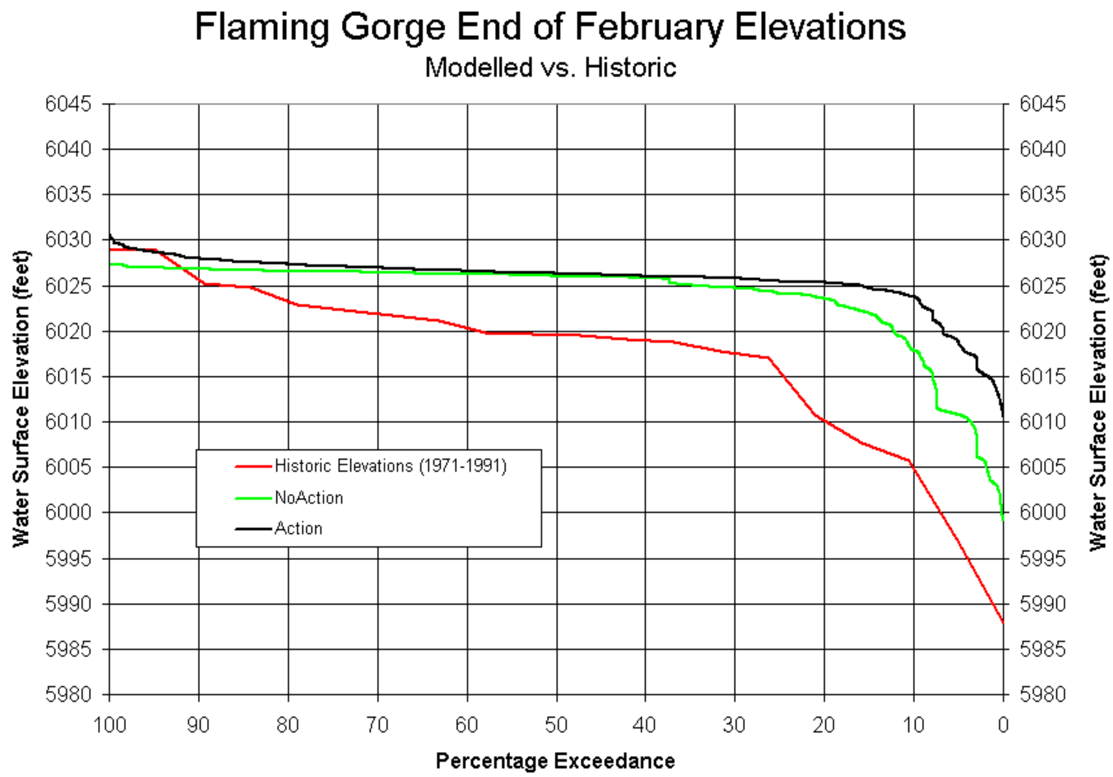
Flaming Gorge End of February Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
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6040
6035
6030
6025
6020
6015
6010
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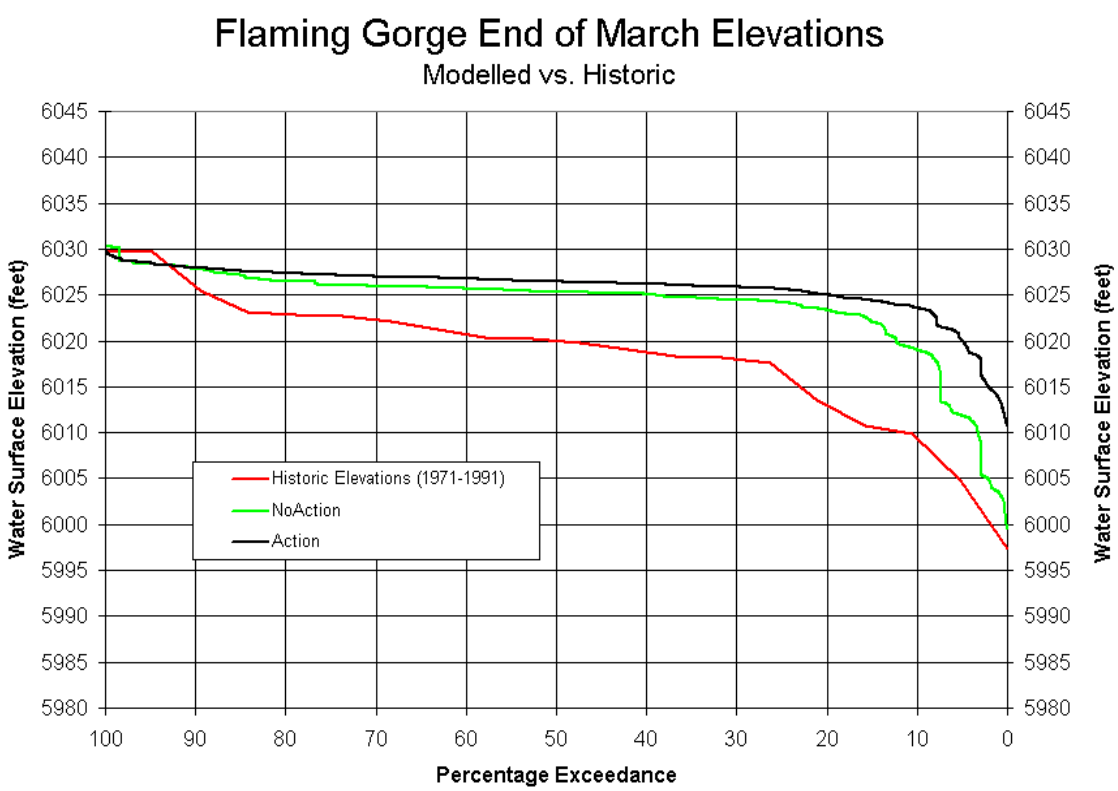
Flaming Gorge End of March Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
Action
6045
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6035
6030
6025
6020
6015
6010
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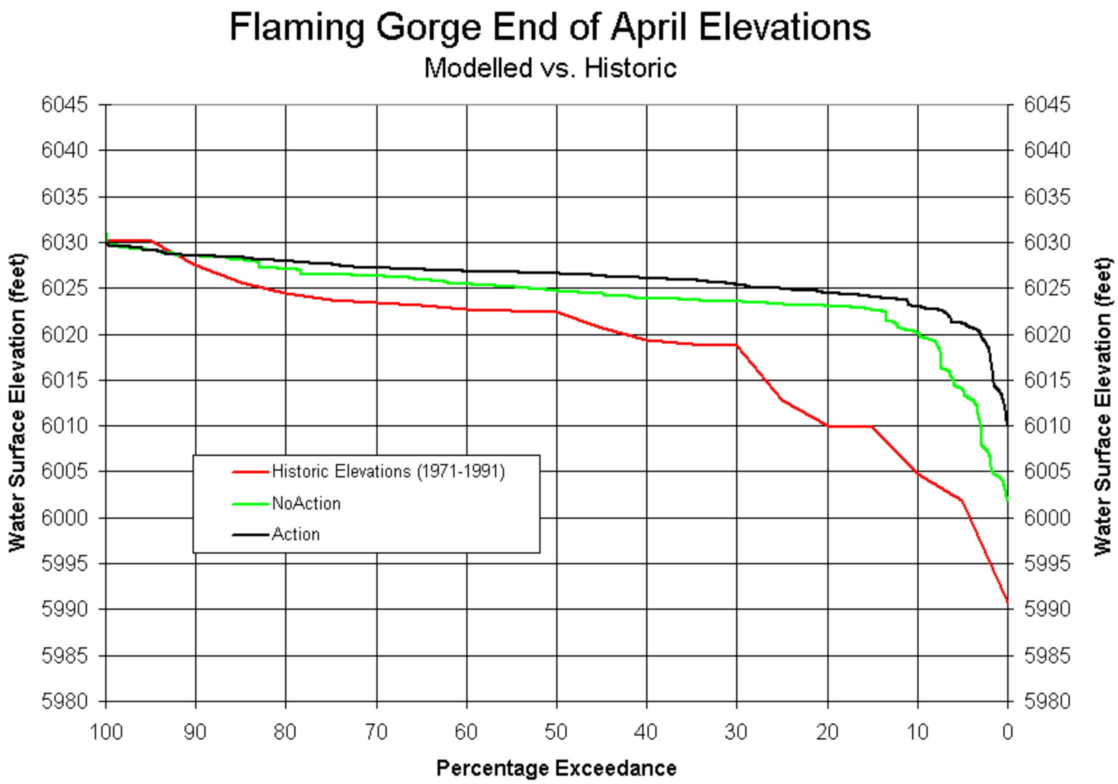
Flaming Gorge End of April Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
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6040
6035
6030
6025
6020
6015
6010
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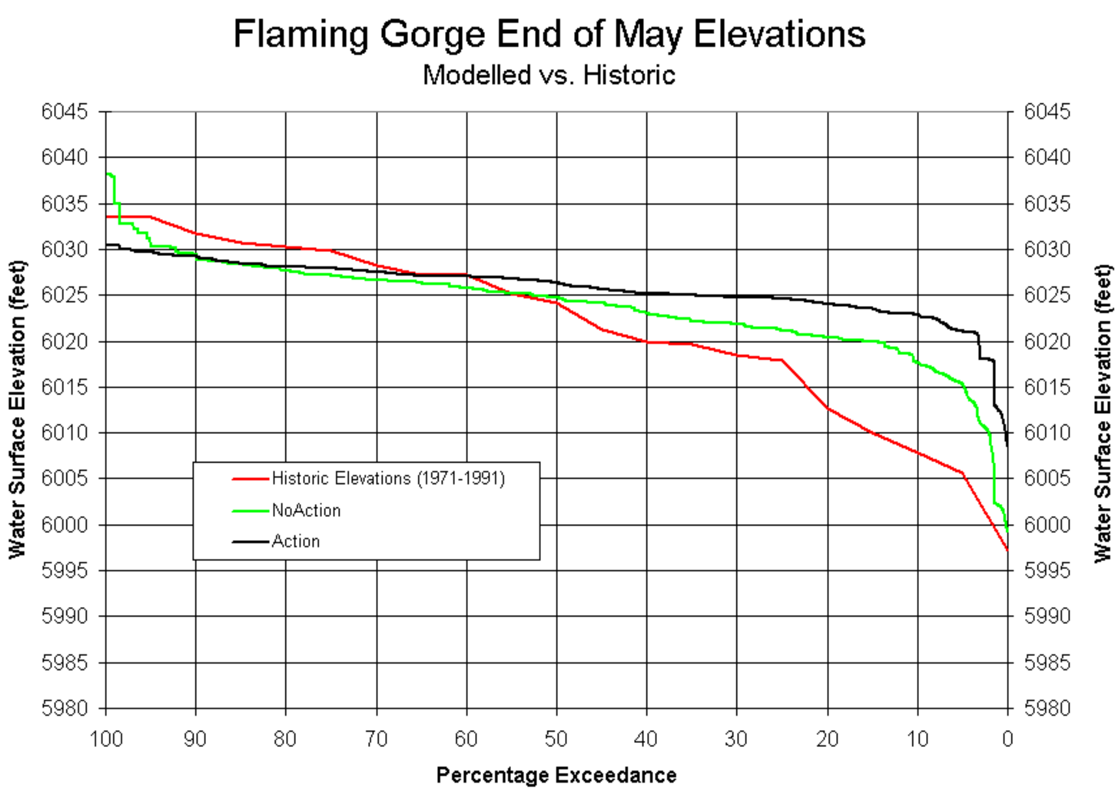
Flaming Gorge End of May Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
Action
6045
6040
6035
6030
6025
6020
6015
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20
10
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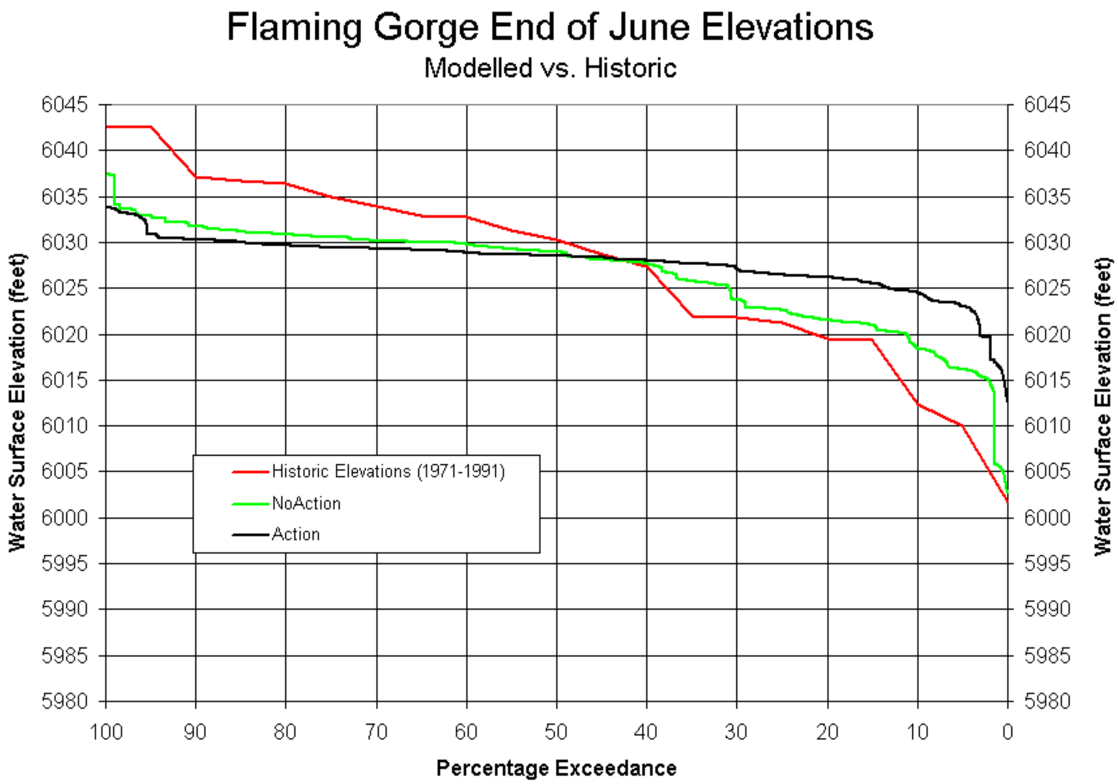
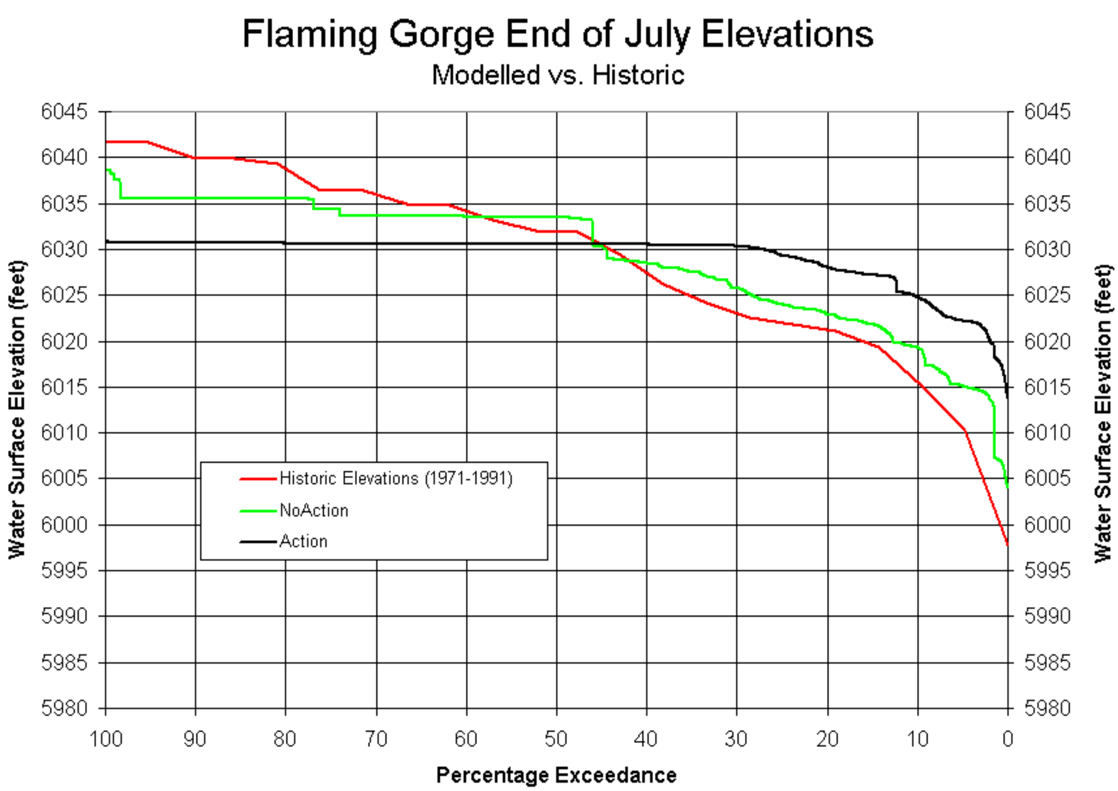
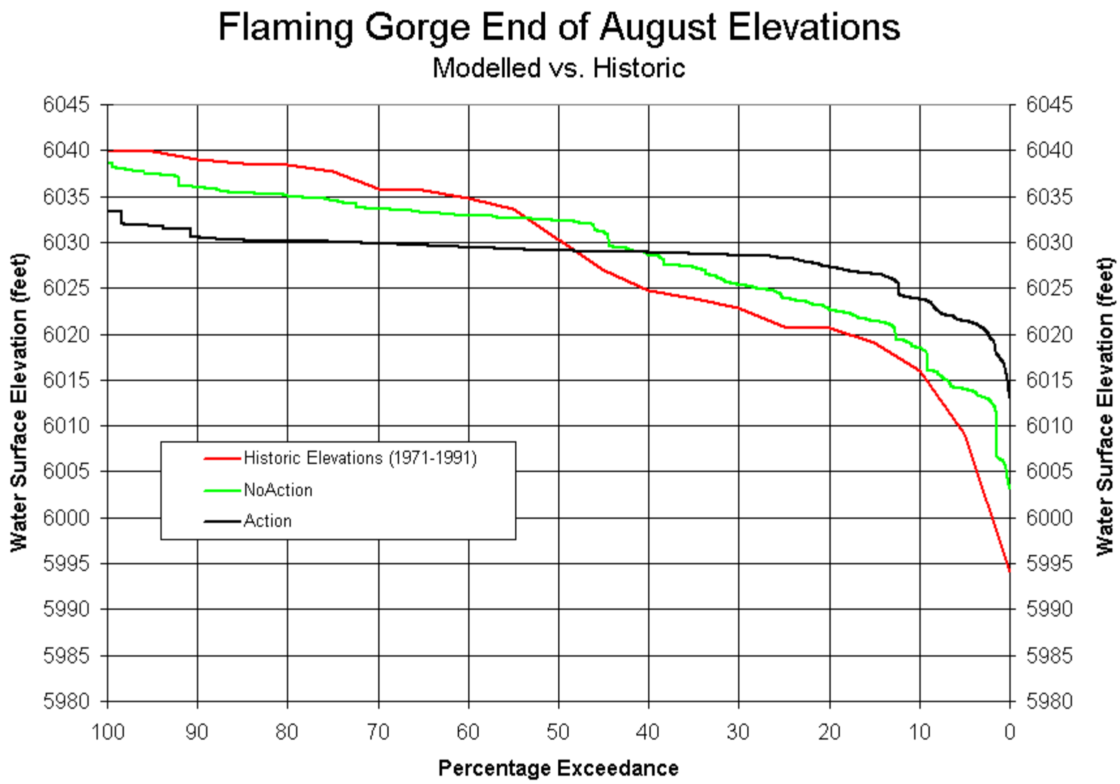
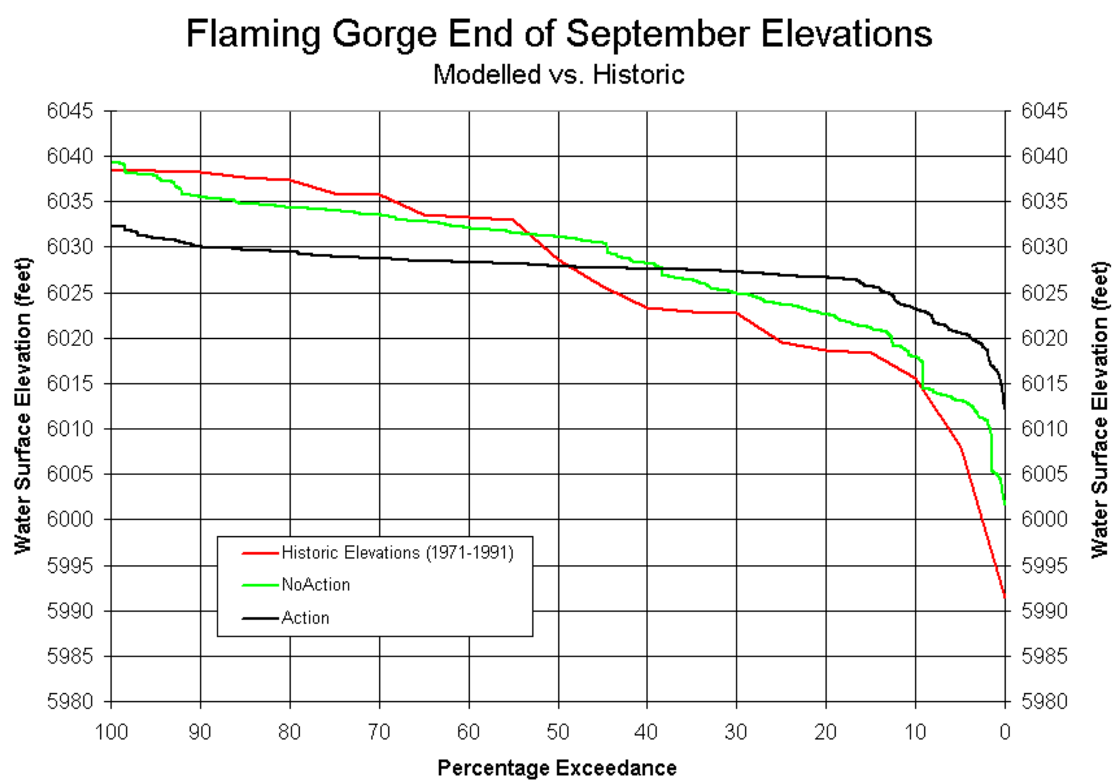

Flaming Gorge End of June Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
Action


Flaming Gorge End of July Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
Action


Flaming Gorge End of August Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
Action
6045
6040
6035
6030
6025
6020
6015
6010
6005
6000
5995
5990
5985
5980
100
90
80
70
60
50
40
30
20
10
0


Flaming Gorge End of September Elevations
Modelled vs. Historic
Water Surface Elevation (feet)
Percentage Exceedance
Historic Elevations (1971-1991)
NoAction
Action
6045
6040
6035
6030
6025
6020
6015
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30
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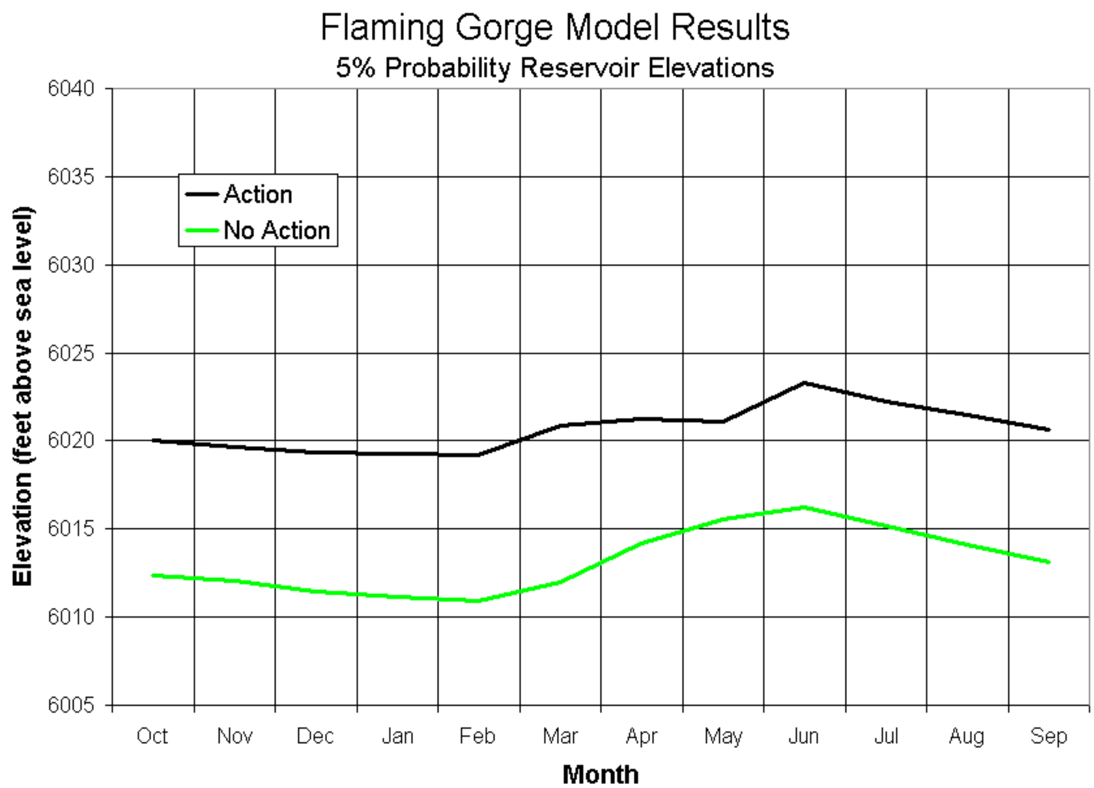
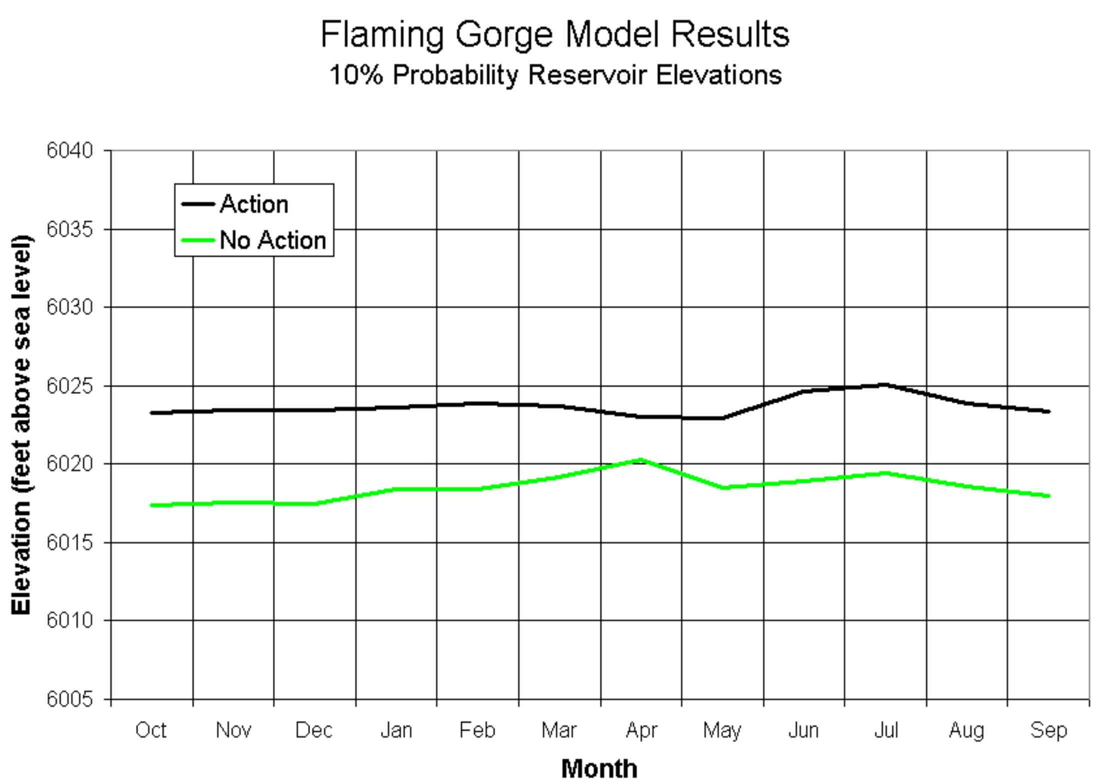
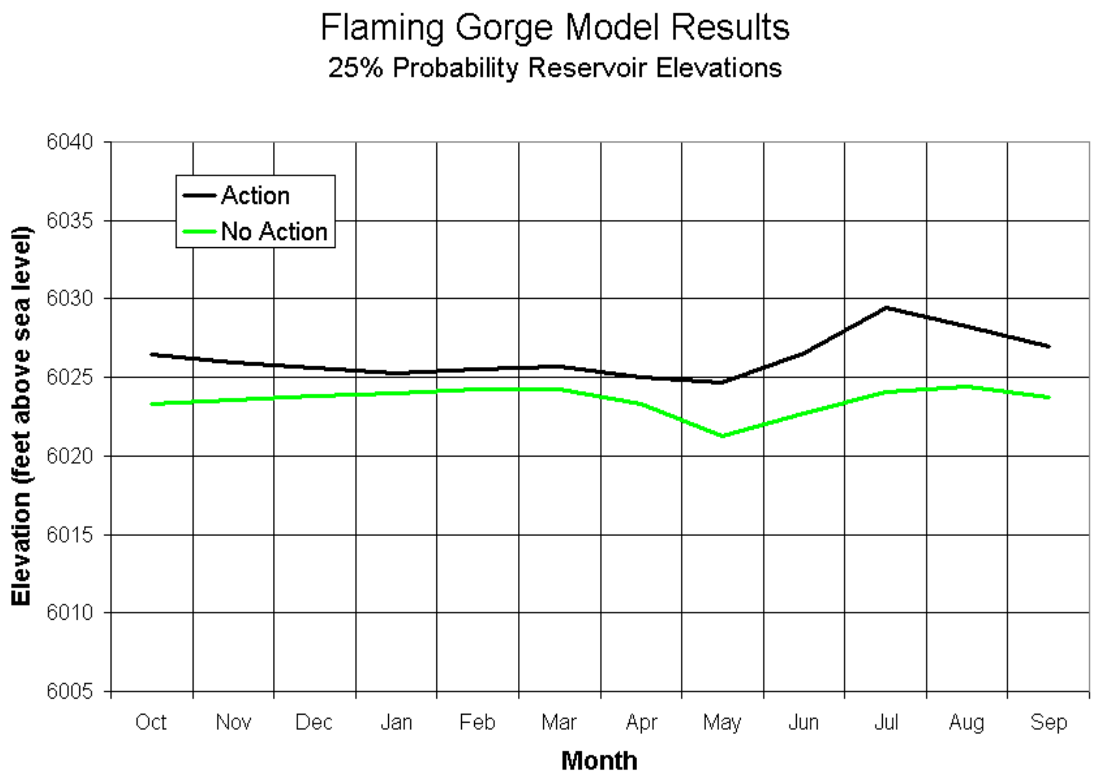


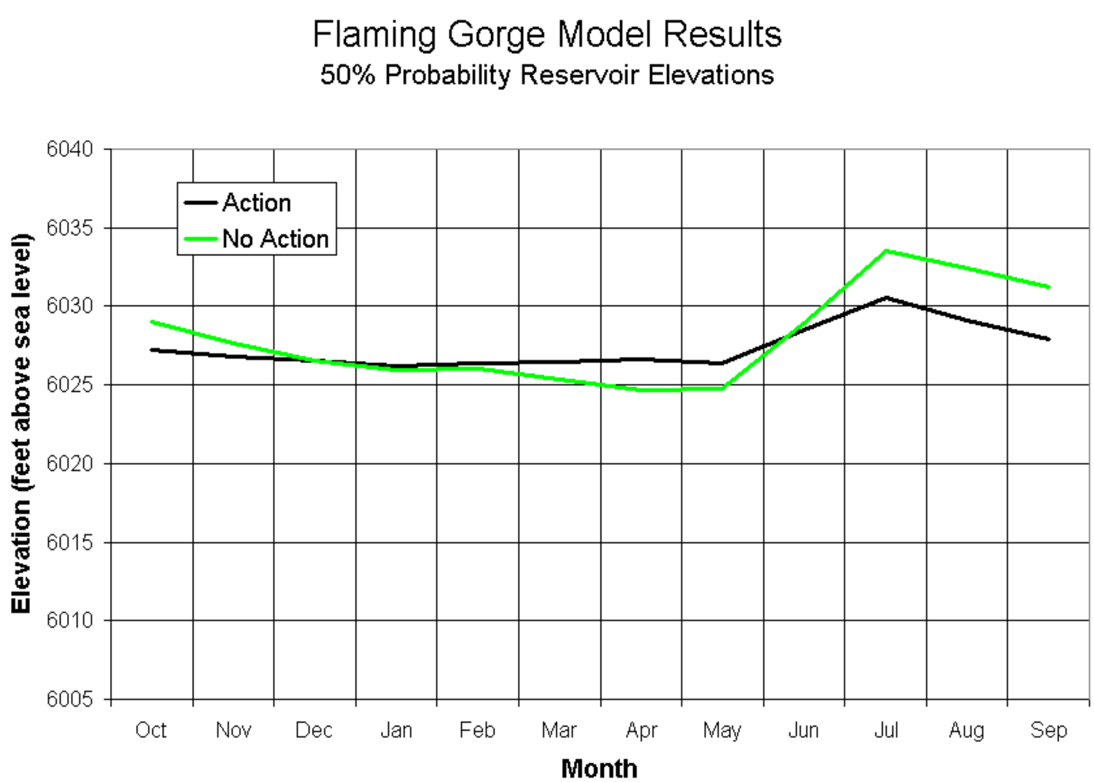
Flaming Gorge Model Results
5% Probability Reservoir Elevations
Action
No Action
Elevation (feet above sea level)
6040
6035
6030
6025
6020
6015
6010
6005
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month



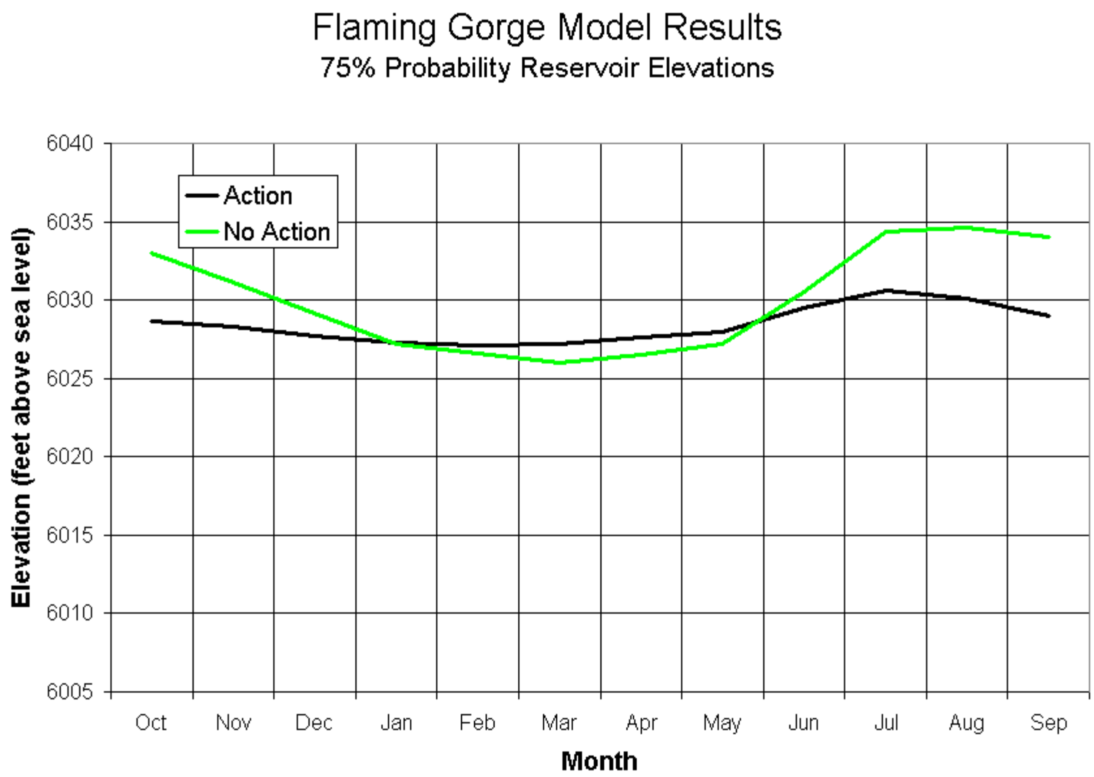
Flaming Gorge Model Results
10% Probability Reservoir Elevations
Action
No Action
Elevation (feet above sea level)
6040
6035
6030
6025
6020
6015
6010
6005
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month



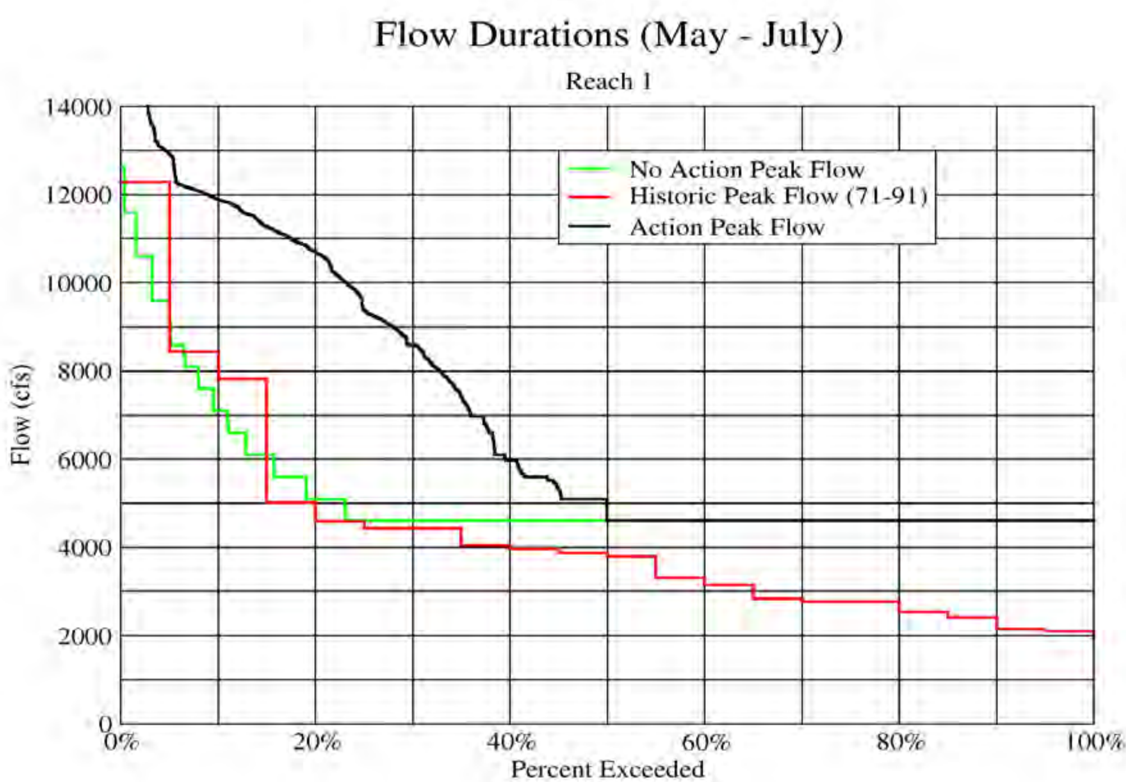
Flaming Gorge Model Results
25% Probability Reservoir Elevations
Elevation (feet above sea level)
6040
6035
6030
6025
6020
6015
6010
6005
Action
No Action
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month



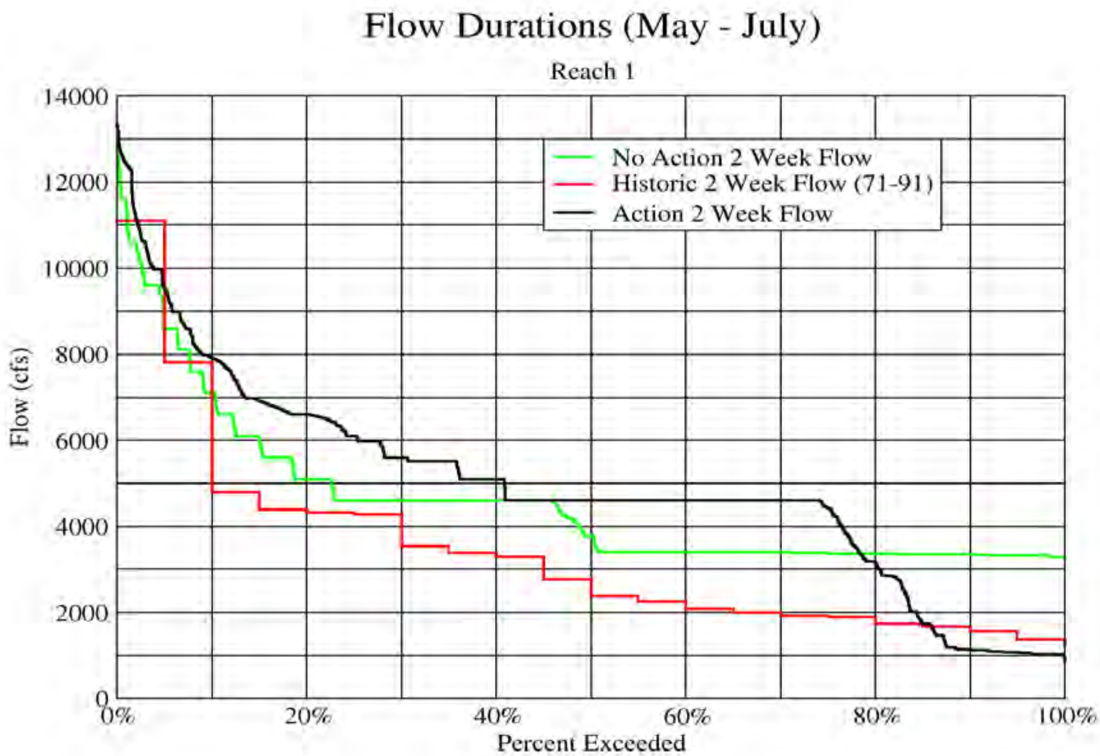
Flaming Gorge Model Results
50% Probability Reservoir Elevations
Elevation (feet above sea level)
6040
6035
6030
6025
6020
6015
6010
6005
Action
No Action
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month



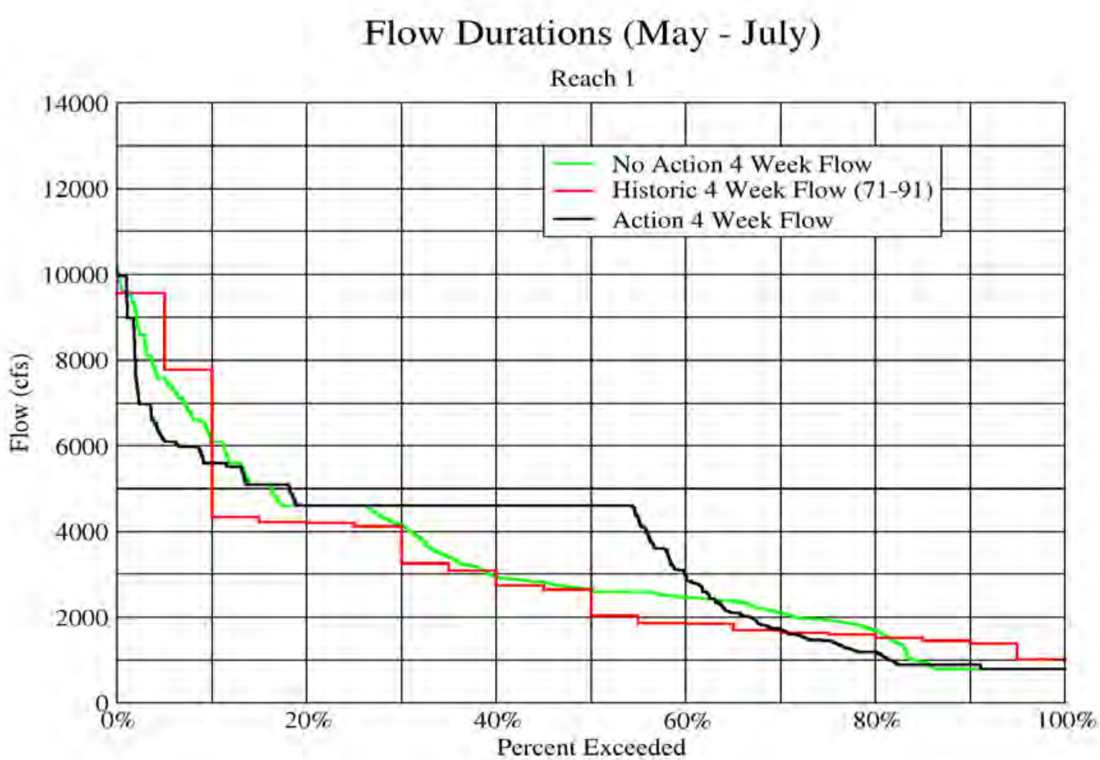
Flaming Gorge Model Results
75% Probability Reservoir Elevations
Elevation (feet above sea level)
6040
6035
6030
6025
6020
6015
6010
6005
Action
No Action
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month



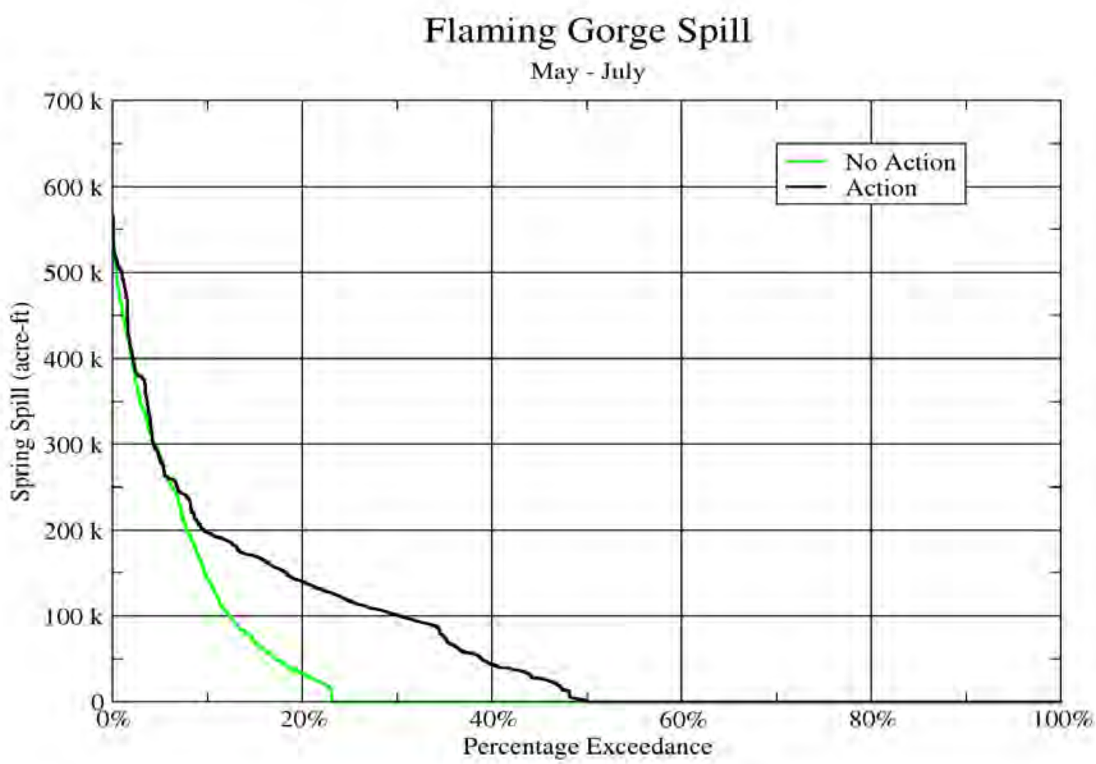
Flow Durations (May - July)
Reach 1
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
No Action Peak Flow
Historic Peak Flow (71-91)
Action Peak Flow
0%
20%
40%
60%
80%
100%
Percent Exceeded



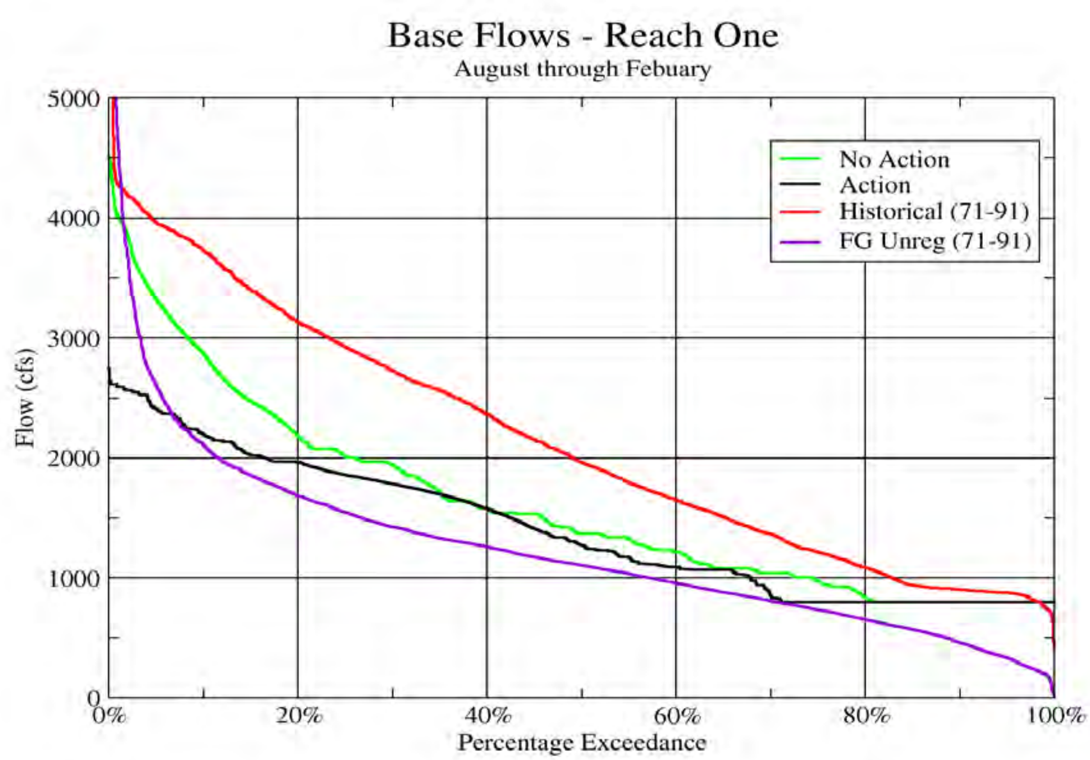
Flow Durations (May - July)
Reach 1
No Action 2 Week Flow
Historic 2 Week Flow (71-91)
Action 2 Week Flow
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
0%
20%
40%
60%
80%
100%
Percent Exceeded



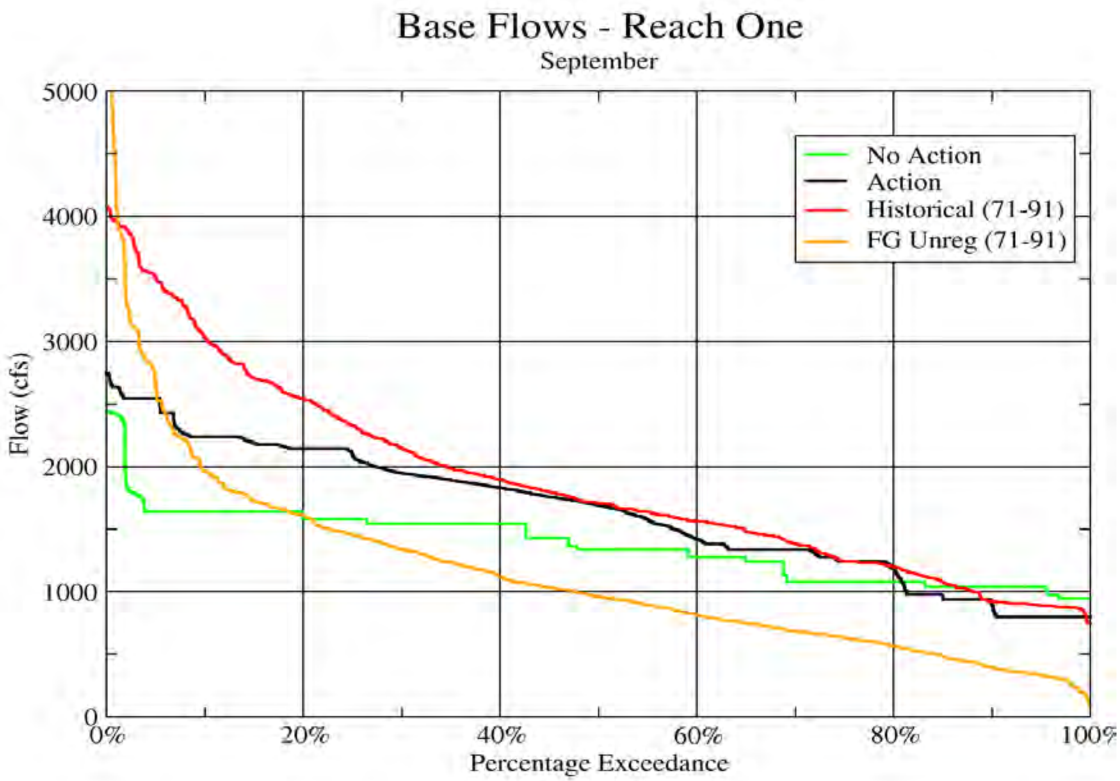
Flow Durations (May - July)
Reach 1
No Action 4 Week Flow
Historic 4 Week Flow (71-91)
Action 4 Week Flow
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
0%
20%
40%
60%
80%
100%
Percent Exceeded

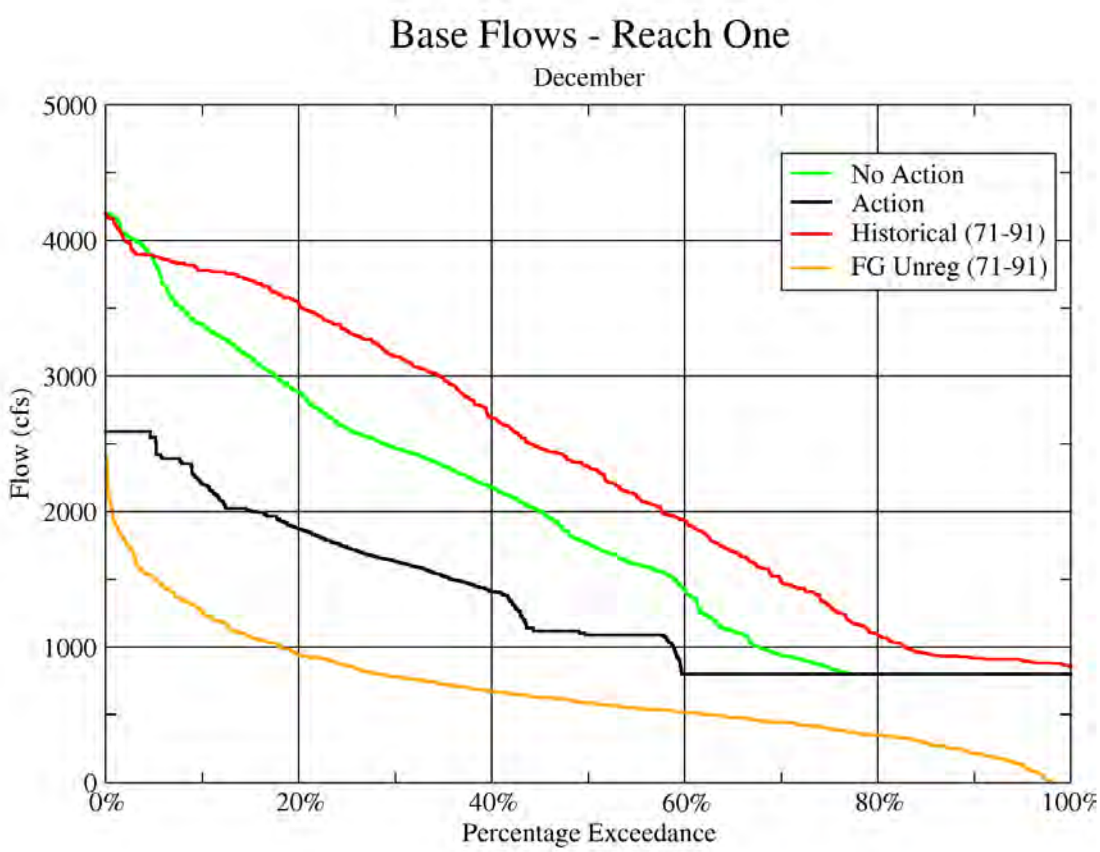


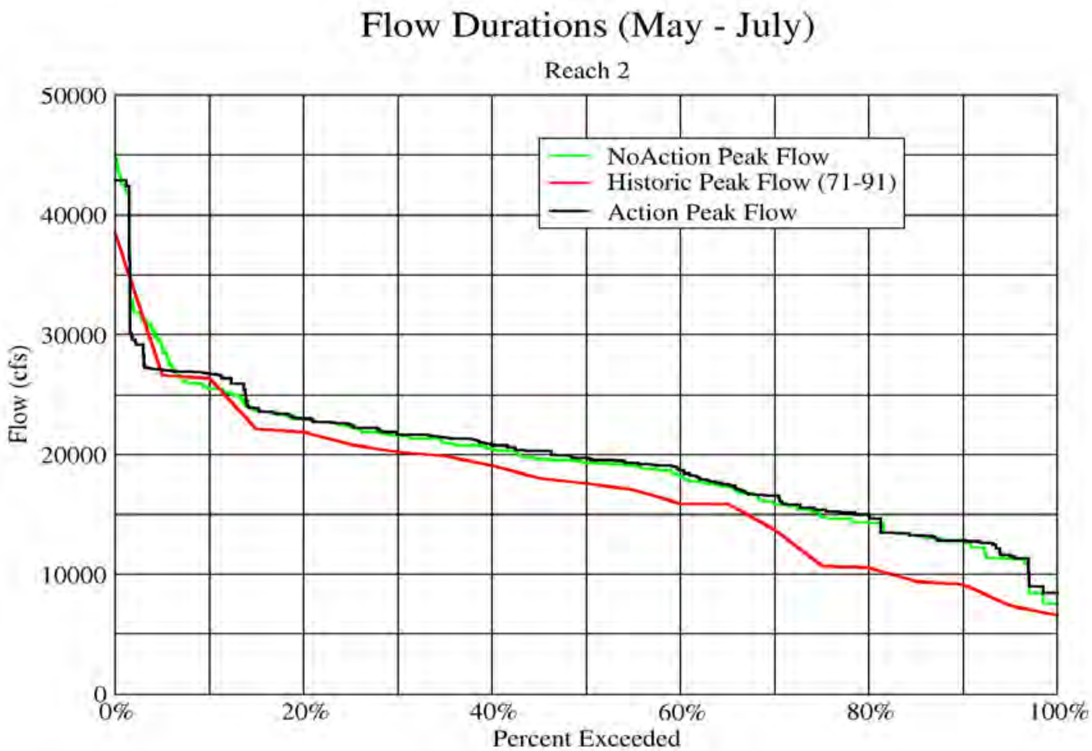
Flaming Gorge Spill
May - July
No Action
Action
Spring Spill (acre-ft)
700 k
600 k
500 k
400 k
300 k
200 k
100 k
0
0%
20%
40%
60%
80%
100%
Percentage Exceedance



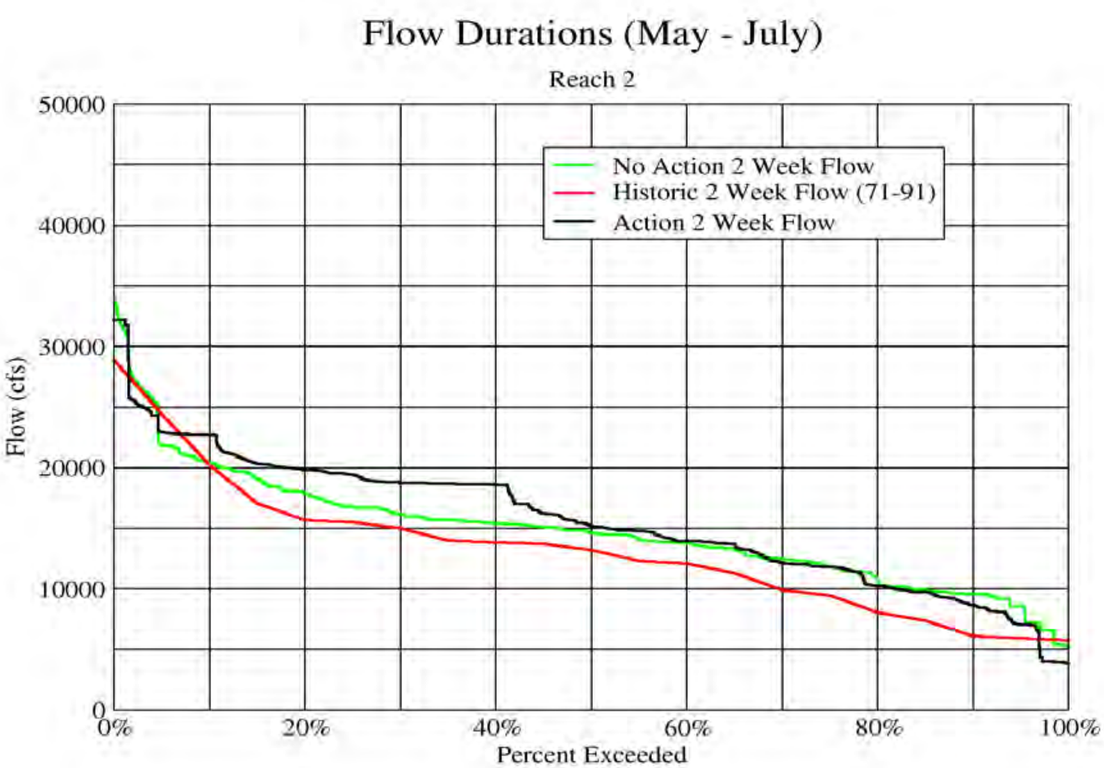
Base Flows - Reach One
August through Febuary
No Action
Action
Historical (71-91)
FG Unreg (71-91)
Flow (cfs)
5000
4000
3000
2000
1000
0
0%
20%
40%
60%
80%
100%
Percentage Exceedance


Base Flows - Reach One
September
5000
4000
3000
2000
1000
0
Flow (cfs)
0%
20%
40%
60%
80%
100%
Percentage Exceedance
No Action
Action
Historical (71-91)
FG Unreg (71-91)

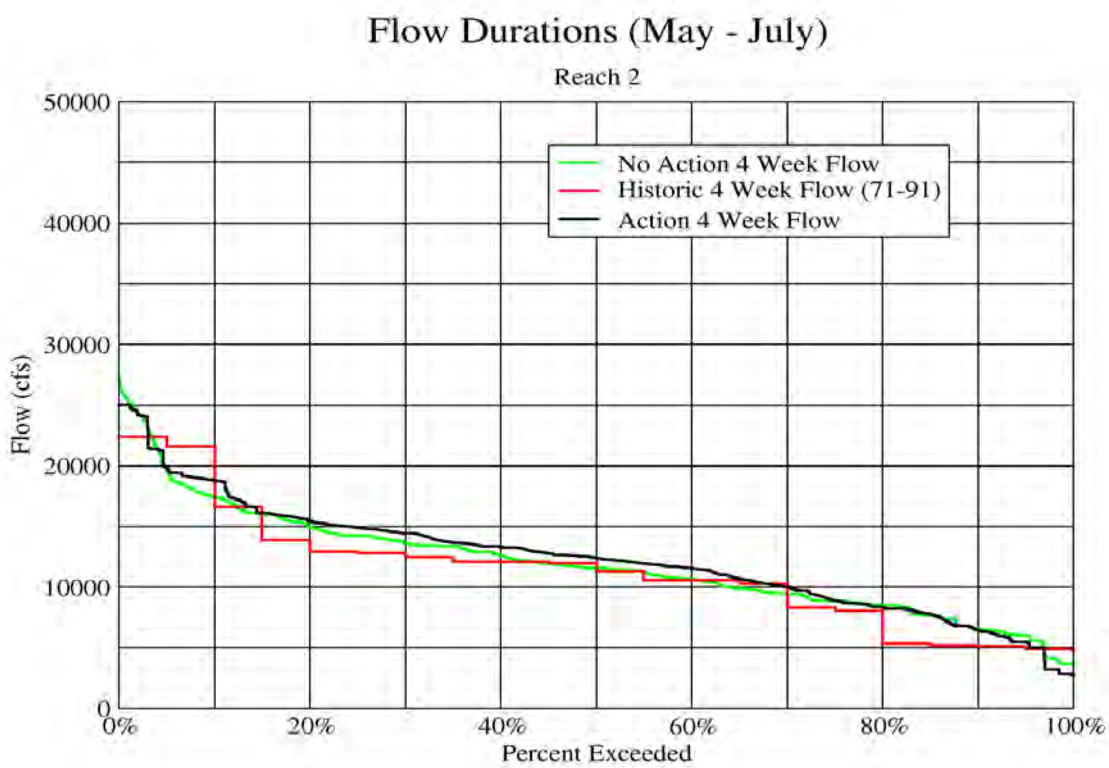

Base Flows - Reach One
December
5000
4000
3000
2000
1000
0
Flow (cfs)
0%
20%
40%
60%
80%
100%
Percentage Exceedance
No Action
Action
Historical (71-91)
FG Unreg (71-91)

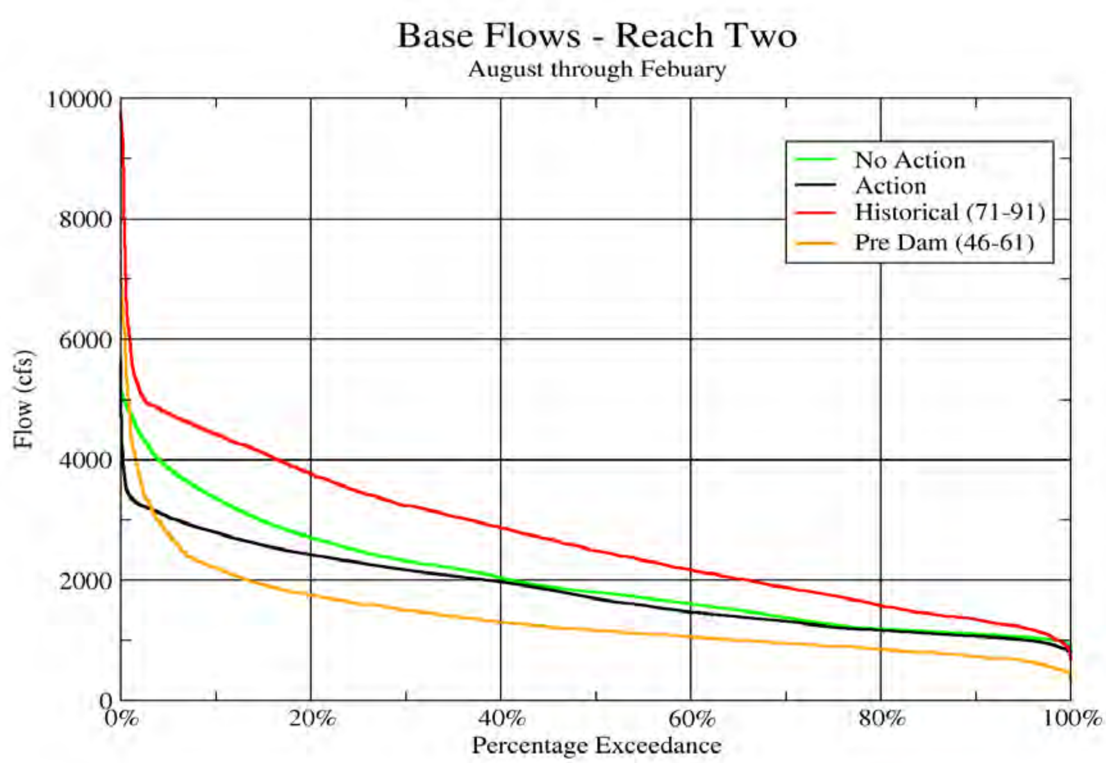


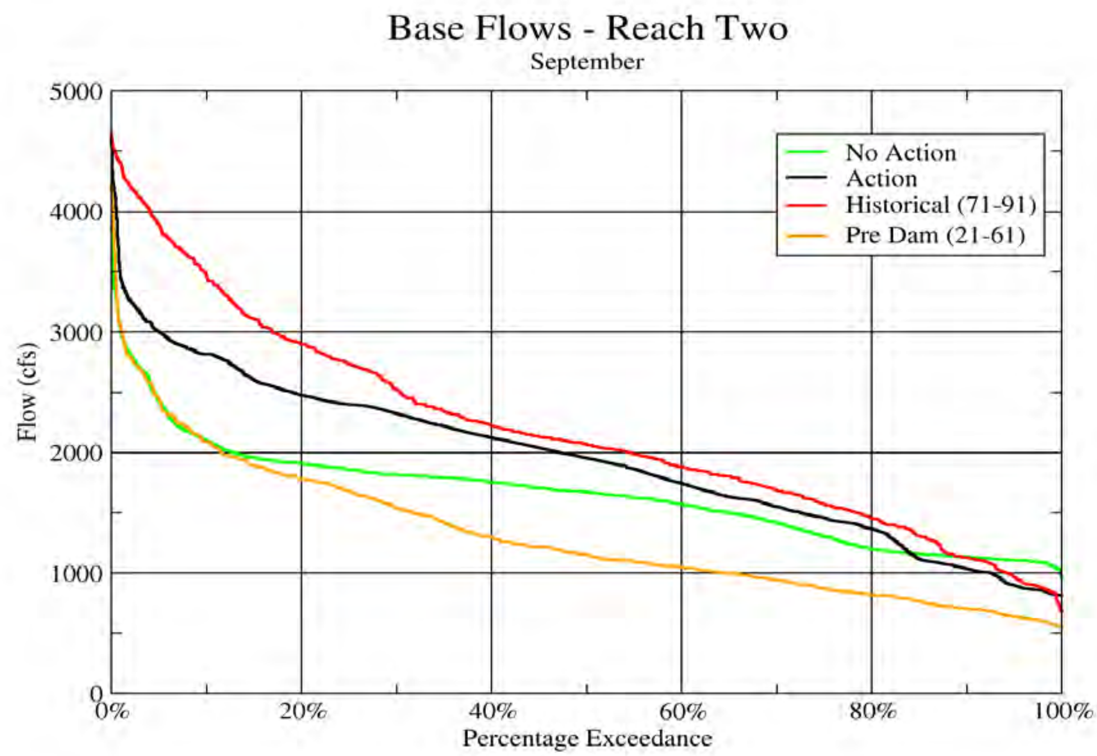
Flow Durations (May - July)
Reach 2
NoAction Peak Flow
Historic Peak Flow (71-91)
Action Peak Flow
Flow (cfs)
50000
40000
30000
20000
10000
0
0%
20%
40%
60%
80%
100%
Percent Exceeded

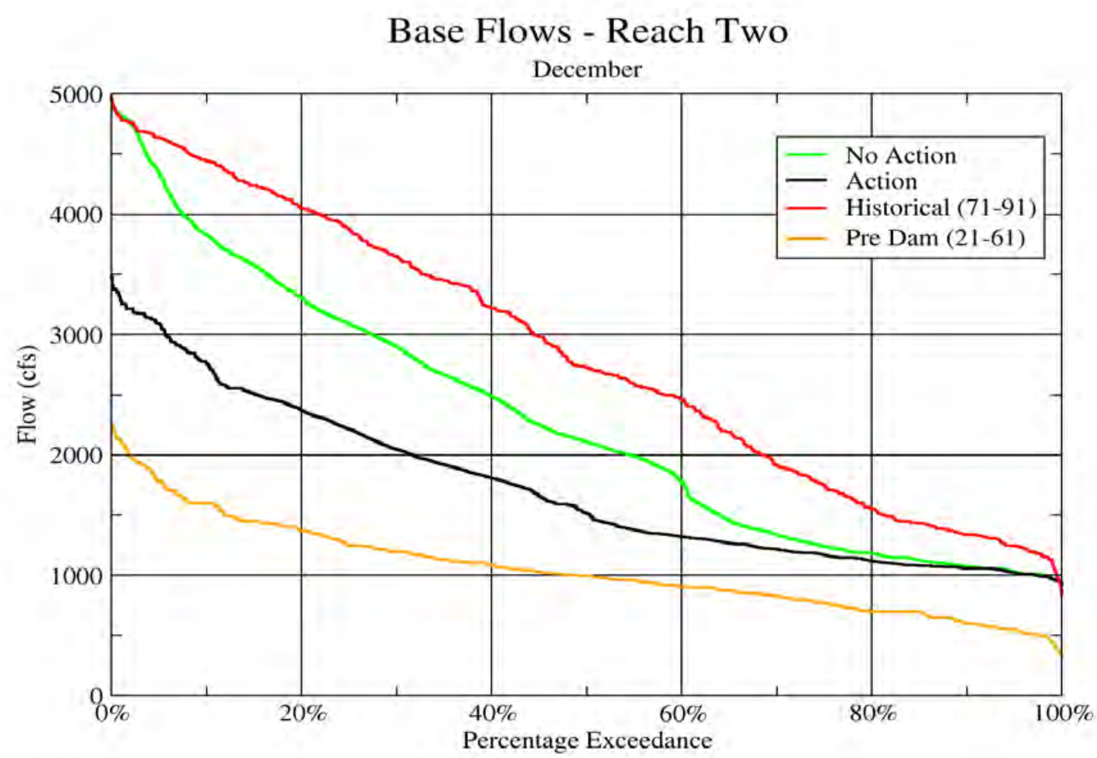


Flow Durations (May - July)
Reach 2
No Action 2 Week Flow
Historic 2 Week Flow (71-91)
Action 2 Week Flow
Flow (cfs)
50000
40000
30000
20000
10000
0
0%
20%
40%
60%
80%
100%
Percent Exceeded


Flow Durations (May - July)
Reach 2
No Action 4 Week Flow
Historic 4 Week Flow (71-91)
Action 4 Week Flow
Flow (cfs)
50000
40000
30000
20000
10000
0
0%
20%
40%
60%
80%
100%
Percent Exceeded


Base Flows - Reach Two
August through Febuary
No Action
Action
Historical (71-91)
Pre Dam (46-61)
Flow (cfs)
10000
8000
6000
4000
2000
0
0%
20%
40%
60%
80%
100%
Percentage Exceedance


Base Flows - Reach Two
September
No Action
Action
Historical (71-91)
Pre Dam (21-61)
Flow (cfs)
Percentage Exceedance
0
1000
2000
3000
4000
5000
0%
20%
40%
60%
80%
100%


Base Flows - Reach Two
December
No Action
Action
Historical (71-91)
Pre Dam (21-61)
Flow (cfs)
Percentage Exceedance
0
1000
2000
3000
4000
5000
0%
20%
40%
60%
80%
100%

FLAMING GORGE FINAL
ENVIRONMENTAL IMPACT STATEMENT
AMENDMENT TO
HYDROLOGIC MODELING REPORT

R. Clayton and A. Gilmore
August 5, 2003

INTRODUCTION

During the development of the Flaming Gorge Model, it was decided that the model would be developed to use the longest reasonable historic hydrologic record available. While records for the Green River and Yampa River extended back to 1921, historic records for the tributary rivers in Reach 3 only extended back to the mid 1940's. Because of the uncertainties associated with modeling Reach 3, it was decided that the Flaming Gorge Model would focus on Reaches 1 and 2 using the extended hydrologic record from 1921 to 1985 rather than including details for Reach 3 and having a much shorter hydrologic record.

For these reasons, the Hydrologic Modeling Report issued in February of 2002 did not include analysis of the predicted future flows in Reach 3. Since that time, a concern for the lack of Reach 3 information within the draft EIS has developed, prompting several requests for a hydrologic analysis of the Reach 3 predicted future flows for the Action and No Action alternatives. To help satisfy this request, this report provides hydrologic analysis of the estimated future flows of the Green River in Reach 3.

DATA DESCRIPTION AND ASSUMPTIONS

The Flaming Gorge Model produced the predicted future flows of the Green River in Reach 2 for the period beginning in January 2002 and extending to December of 2040. Sixty-five traces, or sequences of historic flows, were routed through the Flaming Gorge Model to generate 65 potential future operations for this future time period. The historic hydrologic record from January 1921 to December 1985 formed the basis for these inflow traces. For each inflow trace that was routed through the model there is a sequence of historic hydrology that the trace was constructed from.

In order to generate an estimate of the potential future flows in Reach 3 that would result from operating Flaming Gorge Dam under the Action and No Action Alternatives, an estimate of tributary contribution to the flows in Reach 3 is required. Without the historic records of the tributaries extended back to 1921, it was not possible to determine what each individual tributary contributed to the Green River for the historic period that the model was run. However it was possible to estimate the approximate contribution to the Green River of all tributaries located in Reaches 2 and 3 because complete historic records were available for the Green River located near Flaming Gorge Dam and Green River, Utah. The difference between the historic daily average flow for the Greendale and Green River, Utah gauges was used to estimate of historic daily contribution of all tributaries along the Green River including channel losses. This estimate included the historic flow of the Yampa River in addition to all of the other tributaries in Reach 3. The estimated future flow in Reach 3 described in this report was generated by adding the Flaming Gorge release data predicted by the Flaming Gorge Model to the corresponding historic tributary input with an estimated lag period of 5 days.

REACH 3 ANALYSIS

Flow Recommendations

Table 1 shows the Action and No Action alternatives (as modeled) in terms of how well each alternative achieves the specific recommendations of the 2000 Flow and Temperature Recommendations during the spring in Reach 3. While the No Action alternative does not attempt to meet any of these targets, a comparison between the Action and No Action results does indicate some of the key differences between the operational regimes. The Action alternative has been modeled to achieve all of the targeted flows and durations for Reach 2 and it was assumed that if the Reach 2 flow recommendations were achieved that Reach 3 flow recommendations would also be achieved. The results show that, except for the single day peak flow of 39,000 cfs in Reach 3, all other recommended flows, durations and frequencies are achieved by the Action Alternative as currently modeled.

Table 1—Reach 3 Recommendations Targets and Predicted Results

Spring Peak Flow Recommendations	Reach	Target %	Action Ruleset	No Action Ruleset
Peak >= 39,000 cfs for at least 1 day	3	10%	4.6%	5.9%
Peak >= 24,000 cfs for at least 2 weeks	3	10%	22.0%	14.4%
Peak >= 22,000 cfs for at least 4 weeks	3	10%	12.0%	8.4%
Peak >= 24,000 cfs for at least 1 day	3	30%	65.2%	59.4%
Peak >= 22,000 cfs for at least 2 weeks	3	40%	40.2%	33.8%
Peak >= 22,000 cfs for at least 1 day	3	50%	70.3%	69.4%
Peak >= 8,300 cfs for at least 1 day	3	100%	100%	98.5%
Peak >= 8,300 cfs for at least 1 week	3	90%	96.9%	96.9%
Peak >= 8,300 cfs for at least 2 days except in extreme dry years	3	98%	100%	98.5%

Peak Flows in Reach 3

Figures 1, 2, and 3 show the distribution of single day peak, 14-day duration peak, and 28-day duration peak flows that will likely occur if Flaming Gorge Dam is operated under the Action or No Action Alternative during the period from January 2002 to December 2040. Peak flows in Reach 3 are only subtly different under the two alternatives. The most notable difference between the two alternatives is that flow durations under the Action Alternative appear to be longer than those of the No Action Alternative.

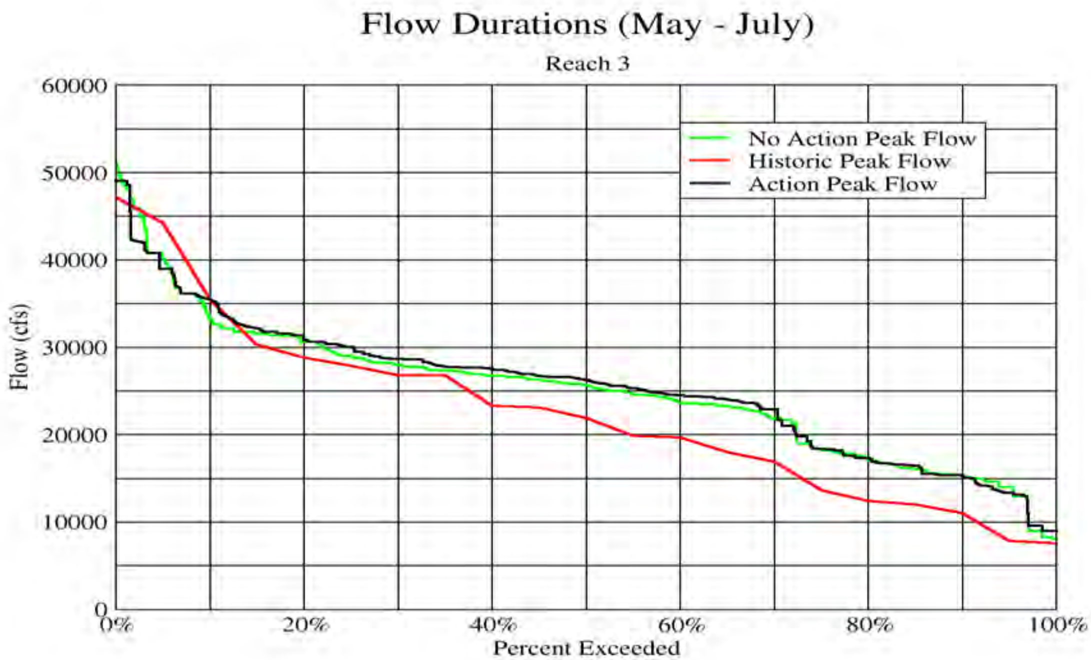


Figure 1.—Reach 3 Distribution of 1-Day Peak Flows.

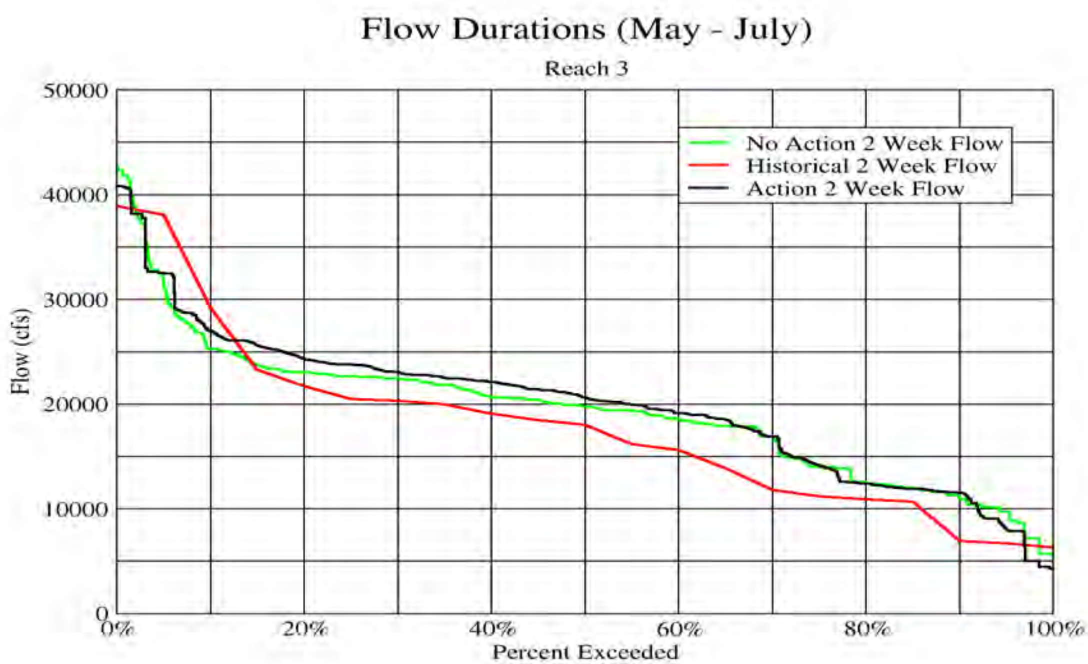


Figure 2.—Reach 3 Distribution of 2-Week Duration Peak Flows.

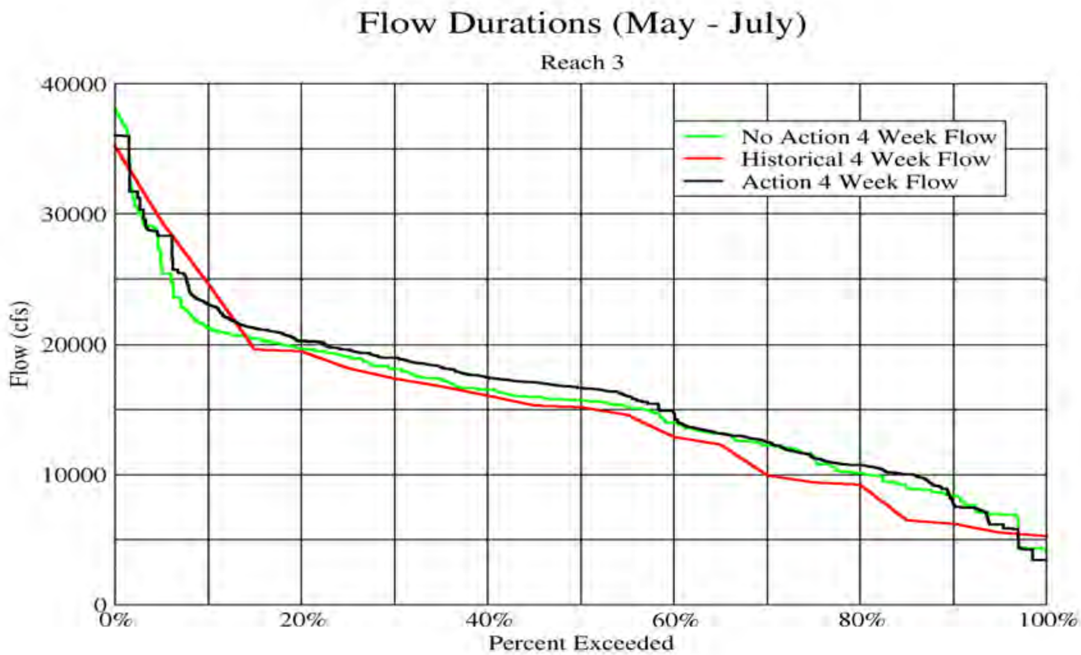


Figure 3.—Reach Distribution of 4-Week Duration Peak Flows.

Base Flows in Reach 3

Overall, the base flows in Reach 3 that will occur if Flaming Gorge Dam is operated under the Action and No Action Alternatives will be similar. In general, the base flows under the Action Alternative will be slightly lower than those of the No Action Alternative as shown in figure 4.

As with Reaches 1 and 2 the relationship between the flows of the Action and No Action Alternatives is dependant on the time of year. During the summer months, when the No Action Alternative restricts the flows in Reach 2, the base flows in Reach 2 will likely be less than those of the Action Alternative. When these restrictions are lifted in November, base flows in Reach 3 under the No Action Alternative will likely be higher than those of the Action Alternative. This can clearly be seen in figures 5 and 6 that show the distribution of flows in Reach 3 that occur under each alternative during the months of September and December. Reach 3 flows during the period from November through February will most likely be 500 to 1000 cfs greater than those of the Action Alternative. This is especially true in wet years. Reach 3 flows during the summer months including late July, August and September will most likely see flows under the No Action Alternative that are lower than those of the Action Alternative by 300 to 700 cfs.

SUMMARY

The data provided in this report has been generated to match the data that was provided for Reaches 1 and 2 in the Hydrologic Modeling Report issued in February of 2002. Although the data for this report was not a product of the model output, as was the data for Reaches 1 and 2,

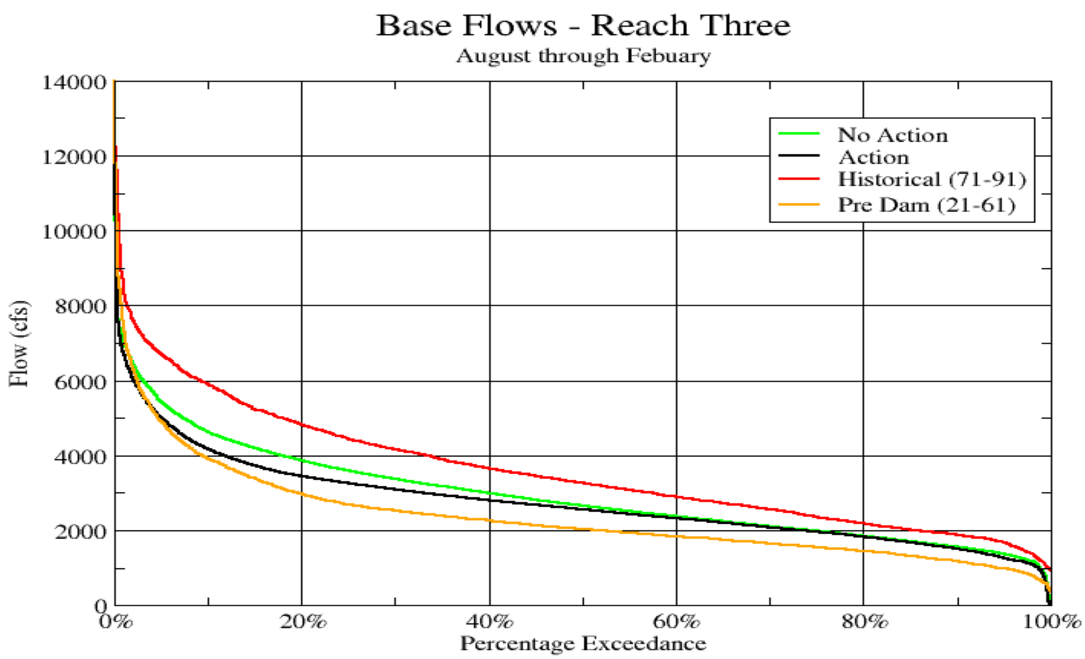


Figure 4—Reach 3 Distribution of Flows (August through February.

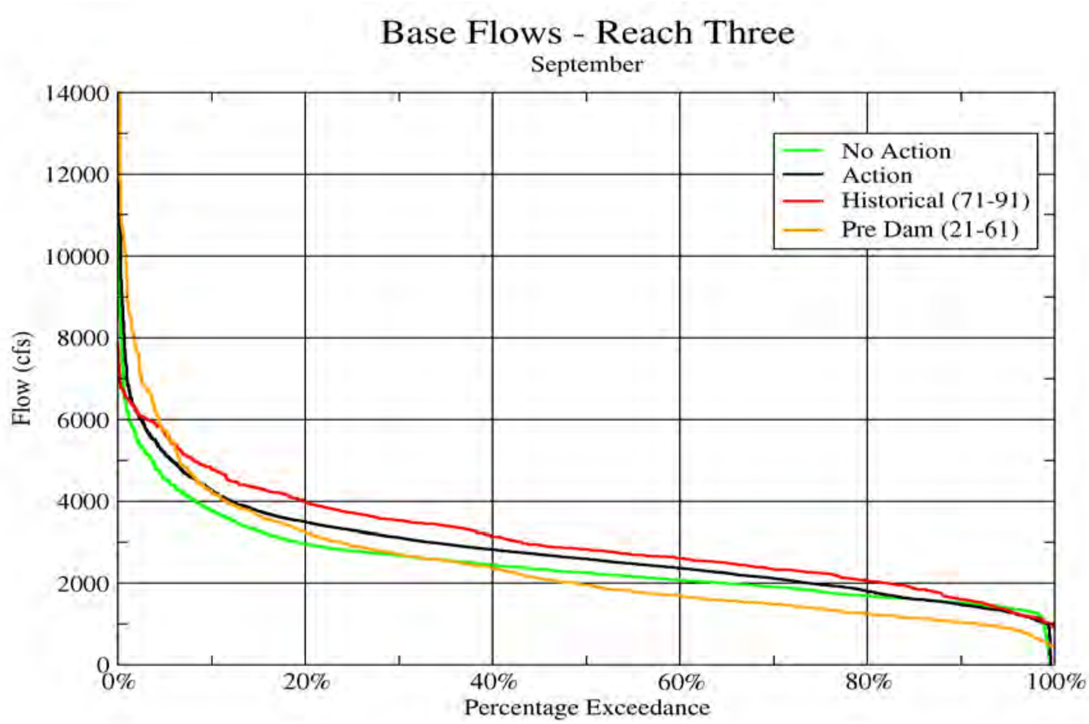


Figure 5.—Reach 3 Distribution of Flows (September).

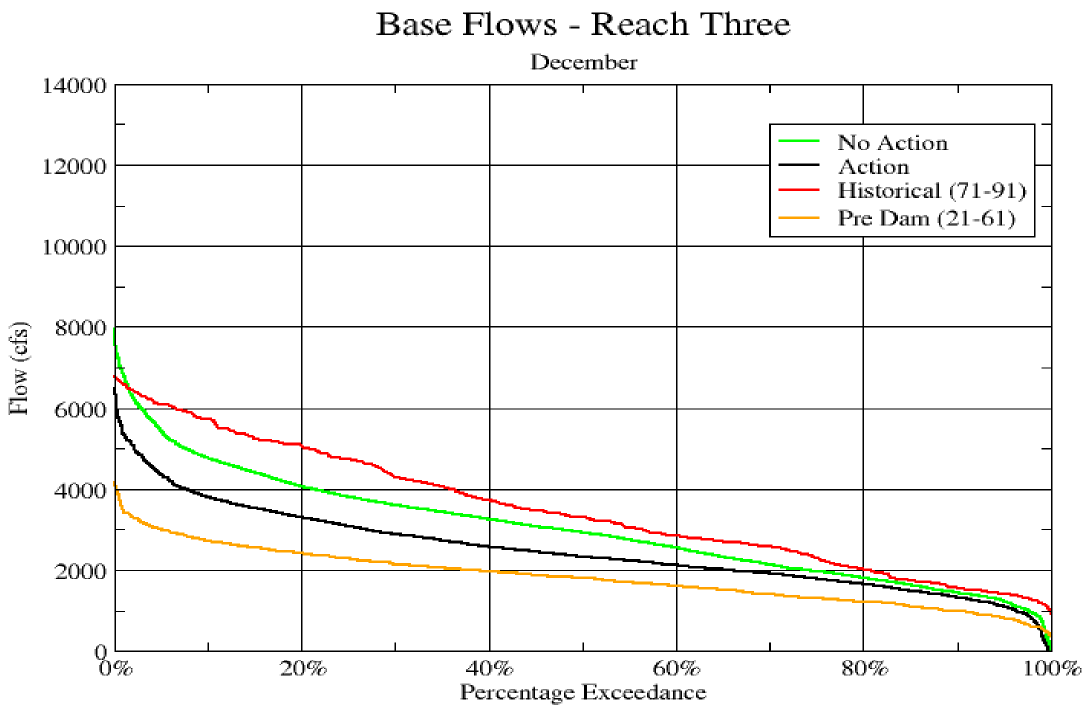


Figure 6.—Reach 3 Distribution of Flows (December).

it does represent the best possible estimate of the predicted future flows in Reach 3 that would result from operating Flaming Gorge Dam under the Action and No Action Alternatives.

It is important to note that the consumptive uses and losses implicitly included in the Reach 3 flows are historical and do not represent consumptive uses and losses that will occur in the future. The trend of water consumption in the Green River Basin is increasing so it would be safe to assume that the Reach 3 flows that would actually occur if Flaming Gorge was operated under the Action and No Action Alternatives would be marginally less than those reported here in. Future consumptive uses and losses are speculative and hard to accurately quantify and therefore no attempt has been made to characterize how these future consumptive uses and losses would affect the flows of Reach 3. However, the incremental differences between the Reach 3 flows under the two alternatives should be relatively accurate.

September 8, 2003

TO: Peter Crookston, Flaming Gorge EIS Manager

FROM: Tom Ryan[1], Kirk LaGory[2], and John Hayse[3]

SUBJECT: Review of the Green River Model Developed for the Flaming Gorge Dam EIS[4]

Background

A river simulation model was developed for the Green River system to assess impacts of Flaming Gorge Dam operations in the Operation of Flaming Gorge Dam Environmental Impact Statement (Flaming Gorge EIS). The model was developed using the RiverWare simulation modeling software package. The Green River Model evaluates two alternative operations: the no-action alternative (operation of Flaming Gorge Dam as prescribed by the 1992 Biological Opinion; FWS 1992) and the action alternative (operation of Flaming Gorge Dam to meet the flow recommendations developed by Muth et al. 2000). Input to the model includes the inflows to Flaming Gorge Reservoir and inflow to the Green River from the Yampa River, and predicts flow at the USGS streamflow gage on the Green River at Jensen, Utah approximately 93 miles downstream from Flaming Gorge Dam.

For the action alternative, the Green River Model predicts significant use of the bypass tubes and spillway at Flaming Gorge Dam when compared to the no-action alternative. Under the action alternative, the Green River Model predicts that the bypass tubes would be used in 49.9% of years and the spillway would be used in 29.4% of years. These relatively high frequencies have caused concern among those involved in the management of Flaming Gorge Dam. Our review of the Green River Model was performed to evaluate whether the degree of bypass and spill predicted by the Green River Model would be necessary to meet the requirements of the flow recommendations. Our review did not include an evaluation of the no-action alternative. While the main focus of our model review was the frequency of bypass and spillway use, we also examined the model's behavior in its entirety, and evaluated how the model simulated the year-round operation of Flaming Gorge Dam to meet the flow recommendations.

Review Approach

The Green River Model uses the indexed sequential method where multi-trace output is created. The model simulates the Green River system including the operation of Fontenelle and Flaming Gorge Dams for the years 2002 through 2040 (39 years). For the EIS, the model was used to simulate these 39 years 65 separate times using hydrology from 1921 through 1985 (rotating among these 65 years to create 65 distinct traces). Thus, the model simulates the operation of the Green River system for 2,535 different years (39 times 65). For our review, a sample of these 2,535 years was taken. The sample size was 65 years, and included one representation from each year of hydrology used in the model. Specifically, we reviewed simulations of Trace 0 from 2002 until 2040 (using the hydrology from 1921 through 1959), and Trace 39 from 2002 until 2025 (using the hydrology from 1960 through 1985). To determine if the sample was a good

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[1] Bureau of Reclamation, Salt Lake City, Utah.
[2] Argonne National Laboratory, Argonne, Illinois.
[3] Argonne National Laboratory, Argonne, Illinois.
[4] Green River Model is Flaming Gorge Model as referenced throughout the EIS and the hydrology modeling reports.

representation of all years, model statistics for meeting flow recommendations in Reach 2 were compiled for the sample and compared to results for all years. The following table shows this comparison. It can be seen that the difference between the sample (65 years) and all years (2,535) is very small.

Flow Recommendations for Reach 2 and Predicted Occurrence of Target Achievement in All Years of Analysis and in the Sample Review Period Under the Action Alternative

Spring Peak Flow Recommendations	Recommended	Sample Period (Trace 0 and 39)	All Years	Difference
Peak >= 26,400 cfs for at least 1 day	10	12.3	11.3	1.0
Peak >= 22,700 cfs for at least 2 weeks	10	10.7	10.7	0.0
Peak >= 18,600 cfs for at least 4 weeks	10	10.7	11.1	0.4
Peak >= 20,300 cfs for at least 1 day	30	47.7	46.3	1.4
Peak >= 18,600 cfs for at least 2 weeks	40	40.0	41.1	1.1
Peak >= 18,600 cfs for at least 1 day	50	60.0	60.3	0.3
Peak >= 8,300 cfs for at least 1 day	100	100	100	0.0
Peak >= 8,300 cfs for at least 1 week	90	96.9	96.8	0.1
Peak >= 8,300 cfs for at least 2 days except in extreme dry years	98	98.5	99.6	0.9
Frequency of bypass (> 4,600 cfs)	NA	50.7	49.9	0.8
Frequency of spills (>8,600 cfs)	NA	27.7	29.4	1.7

We evaluated performance of the Green River Model in each of the 65 years in the sample (1921 through 1985). We considered the May 1 forecasted inflow and actual inflow to Flaming Gorge Reservoir, reservoir storage and flow regimes on the Yampa River in evaluating how well the Green River Model simulated the operation of Flaming Gorge Dam to meet flow recommendations in Reach 2, and to manage Flaming Gorge Reservoir under existing authorities. We also evaluated how well the model met recommended base-flow targets.

We tried to be conservative in our evaluation. In some years, the Green River Model predicted bypasses or spills, and very precise adjustment of releases could eliminate these above-powerplant-capacity releases. We chose not to include these borderline years among those where spills or bypasses could more clearly be eliminated using realistic operational decisions.

Findings

In most situations, the Green River Model appears to properly simulate the operation of Flaming Gorge Dam to meet flow recommendations in Reach 2, while minimizing the effects on authorized purposes of the dam. Modeling of the action alternative is complicated by the intricacies of the flow recommendations, hydrologic variability and the degree of hydrologic difference between the Green and Yampa Rivers. Within the RiverWare modeling package a complex "rule set" has been developed for the action alternative that controls the behavior of the model and thus the simulated operation of Flaming Gorge Dam. Much of the logic of the rule set is presented in this review.

A few specific issues were identified in our review of the Green River Model in the action alternative. These issues are related to how the model moves water in wetter than average years. We found that, in some years, predicted bypass releases might not be necessary for either hydrologic reasons or to meet downstream targets. Additionally, there are some years where the model predicts spills that produce flows that are greater than recommended Reach 2 targets. The following text discusses these issues as they relate to the predicted frequency of bypasses and spills from Flaming Gorge Dam.

1. Mass balance rules result in higher bypass frequency than is needed to meet recommended flow targets

The Green River Model uses a March 1 drawdown target for the reservoir of 6,027 feet (13 feet from full pool). This drawdown target is a dam safety constraint, where the 13 feet of vacant space assures a safe spring operation even under very wet hydrology. The model balances water to achieve this March 1 drawdown target throughout the year, but it is important to understand how the model performs this balance in the spring period.

In May, the model generates an inflow forecast (which includes a forecast error term), and places the year in one of 7 hydrologic classifications (wet, moderately wet, average wet, average, average dry, moderately dry, or dry). The model determines the Flaming Gorge Dam release that would be needed to meet the base-flow recommendations in Reach 1 for the year's hydrologic classification. The model then performs a mass balance to calculate how much water should be released in the months of May, June, and July, in combination with the August through March base flows, to result in a reservoir elevation of 6,027 feet (or below in drought years) on March 1 of the following year. The model then shapes releases from May through July to meet Reach 2 peak flow and duration targets.

Generally, the Green River Model shapes this May through July release volume appropriately, matching the Yampa River peak flows and meeting recommended Reach 2 targets. However, in 6 of the 65 years evaluated in our review (1943, 1944, 1950, 1951, 1956, and 1967), the model bypassed water to meet the mass balance requirements, but these bypasses did not result in meeting any Reach 2 targets. In these years, the reservoir remained 8 to 11 feet below the full-pool elevation in July, and therefore bypass was not required for safety considerations. All of these years were either classified as moderately wet or average wet. Evaluation of the model determined that these bypasses were not necessary for safe operation of the dam or to meet base flow requirements after the runoff season. Other operating options would be available, but the model does not have the capability to evaluate all these other options, and the multiple combinations in which they might be implemented.

One option available to move additional water during the May through July time period is to extend the peak flow duration. The flow recommendations allow for peak flows to extend to July 15 in average years, August 1 in moderately wet years, and August 15 in wet years. In most of the 6 years discussed above, releases were ramped down to base flows before these specified dates.

Another option is the ability to increase releases from Flaming Gorge Dam in April and May. The Green River Model generally does not increase releases from Flaming Gorge Dam to the maximum powerplant capacity of 4,600 cfs (unless reservoir storage is above a set threshold) until the Yampa River is about to reach its peak (usually in late May). The model delays increasing releases even in wetter than average years. Unless the model is constrained by meeting a drawdown target in the months of April and May (which it generally is not), simulated increases in releases from Flaming Gorge do not generally begin until the middle of May. In wetter than average years, the model frequently misses an opportunity to move water in these months. In the all of the 6 years mentioned above, additional water could be moved in April and May. In wet, moderately wet, and average wet years, it is appropriate to increase releases in this period to release water and avoid a bypass later without compromising the recommended flow targets (releases could be increased to a level intermediate between the base flow and 4,600 cfs or in very wet years, all the way to 4,600 cfs).

In making mass balance adjustments, the Green River Model first assures that the base flow is consistent with the flow recommendations by targeting the mean base flow for the hydrologic category. However, the flow recommendations provide a range for target flows rather than a single flow and also allow for adjustment of flows during the base-flow period. For the period reviewed, there were several years in which Reach 2 peak flow targets could not be reasonably met, and in which more runoff could be put into storage and base flows raised to meet the March 1 drawdown target. Some bypasses predicted by the Green River Model are being driven by the need to meet the base flow targets, even though the flow recommendations allow for a range of base flows.

The option of increasing releases from Flaming Gorge Dam in April or May in wetter years has an additional benefit as well. There are some years (e.g., 1962 and 1974) where the Yampa River has an early ‘first’ peak in late April or early May that sometimes exceed 14,000 cfs. The model has been developed to match the later more significant peak, but in wetter years additional days at 18,600 cfs (a significant duration target in the flow recommendations) in Reach 2 could be achieved by appropriately increasing releases in April or May in wetter years, and, on occasion, eliminate the need for bypass releases to reach downstream targets.

The year 1962 was also identified as one in which bypass releases would not be required. It is an ‘early’ runoff year with two large peaks on the Yampa River, one in late-April and one in mid-May. It was a moderately wet year in the upper Green River Basin (upstream of Flaming Gorge Dam) with the need to release a significant amount of water from the reservoir for hydrologic reasons. The modeled operation shows a large bypass and spill (with a peak release of 12,200 cfs) in late May to achieve the 18,600 cfs, 2-week, Reach 2 target. This large release is made as the Yampa River flow declines from its second peak. This same target could be met, and the same volume of water released from the reservoir, by eliminating the bypass and spill entirely, and releasing 4,600 cfs from late April through mid July.

There were 3 years identified as borderline years in terms of the use of the bypass tubes in the Green River Model. These were 1932, 1970, and 1974. In each of these years, bypass releases were used to meet the 18,600-cfs, 2-week, Reach 2 target. In these 3 years, a steady release of 4,600 cfs would achieve the same Reach 2 target without bypass. Because of the difficulty in precisely predicting the behavior of the Yampa River, however, our review concludes that the use of the bypass to meet downstream targets may have been warranted in these years.

2. Spillway releases frequently occur when Reach 2 targets are being exceeded.

In some years, the Green River Model predicts releases from Flaming Gorge Dam that are higher than those needed to achieve recommended Reach 2 peak flow targets. In the rule set for the model, bypass and spill releases are increased by a factor of 1.2 when the mass balance calculation indicates that additional water needs to be bypassed after the Yampa River has finished peaking. The 1.2 rule in the model may be causing releases from Flaming Gorge Dam to exceed 8,600 cfs, the threshold where spillway use is required in wet and moderately wet years.

There are 10 years (1922, 1923, 1927, 1947, 1971, 1973, 1975, 1978, 1980, and 1982) where releases exceed 8,600 cfs, where flows in Reach 2 are greater than target levels. In each of these years, all of the same Reach 2 targets could be met using bypass releases. With the exception of 1973, these years are all moderately wet or wet years. The spillway was not required for dam safety considerations in these years because in each one, there is at least 6 feet of vacant space at the end of the runoff period. Other operating options would be available to meet the downstream targets and evacuate the appropriate amount of water from the reservoir. In most cases the volume released through the spillway could be shifted to an extended use of the bypass tubes to meet the downstream target. In other years, the spill could be eliminated and the additional water evacuated by extending the period of powerplant capacity flows to the end of July (in moderately wet years) or to August 15 (in wet years), by releasing additional water in April or May, or by storing some additional water and making minor adjustments to base flows.

In our review, we classified 2 of these 10 years as borderline years (1927 and 1947). Given the hydrologic uncertainty in these 2 years, and the fact that the Reach 2 targets would just barely be reached without releases greater than 8,600 cfs, our review concludes the use of the spillway in these 2 years to be reasonable.

There are 2 years where the Green River Model predicts releases from Flaming Gorge Dam that are just above 8,600 cfs. This occurs in 1938 when releases of about 9,000 cfs are made for 3 days, and in 1942, when releases for 2 days are about 8,800 cfs. In each of these 2 years, releases could be limited to 8,600 cfs to achieve the same Reach 2 targets. There is no sensitivity to 8,600 cfs as a threshold in the Green River Model. The 2 years mentioned show up as “spill” years in the Flaming Gorge Model, even though the volume released through the spillway is negligible. In actual practice, the spillway would not likely be used for such a small amount of release (200 to 400 cfs).

The following table displays those years in which the Green River Model predicted bypass or spill, but we concluded that such use may not be necessary.

Years In Which Bypass or Spill Was Predicted by the Green River Model, but May Not Be Necessary

Unnecessary Bypass Release Years	Unnecessary Spillway Release Years
1943	1922
1944	1923
1950	1938
1951	1942
1956	1962
1962	1971
1967	1973
	1975
	1978
	1980
	1982

3. Other Findings

There is considerable variability between the hydrology of the Green River and Yampa River basins on a year-to-year basis. There are numerous wetter years in the Yampa River Basin where hydrologic conditions are average in the upper Green River Basin. The reverse is also true. The Green River Model's approach is to capitalize on Yampa River Basin hydrology so to limit the volume of spills and bypasses from Flaming Gorge Dam while achieving the flow recommendations. The model attempts to achieve Reach 2 targets by considering Yampa River Basin hydrology in combinations with hydrologic conditions in upper Green River Basin. There are numerous years where moderately wet or wet Reach 2 targets are met with a limited amount of bypass (with 1929, 1957, 1958, 1970, and 1984 as example years). We believe the approach used in the Green River Model is appropriate, and that if the model were configured to try and 'force' the achievement of the flow recommendations based solely on hydrologic classifications in the upper Green River, that significantly larger volumes of water would have to be bypassed or spilled at Flaming Gorge Dam.

Down-ramp rates when the bypass tubes or the spillway are used in the Green River Model vary. In moderately wet and wet years the down-ramp rate is 1,000 cfs per day. Occasionally the model bypasses some water in average or average wet years to take advantage of opportunities on the Yampa River. In these years, the down ramp rate is only 500 cfs per day. Consideration should perhaps be given to increasing this down ramp to 1,000 cfs per day to reduce the volume of water bypassed.

Conclusions

The Green River Model predicts the use of the bypass or spillway at Flaming Gorge in 33 of 65 years. Our review concludes that in 26 of these 65 years this use is appropriate for hydrologic reasons or to meet targets in Reach 2. In 11 of these 26 years (1921, 1922, 1923, 1927, 1928, 1929, 1947, 1952, 1972, 1978, and 1980), it appears that the volume of bypass produced by the Green River Model was higher than necessary, and could be reduced while still meeting the same objectives in Reach 2. The same strategies discussed previously to reduce bypass and spills are relevant, i.e., extend the duration of the peak flow to August 1 in moderately wet years and August 15 in wet years, increase releases from Flaming Gorge Dam in April or early May in wetter years, and take advantage of flexibility in the base-flow period when needed.

The Green River Model performs well in dry, moderately dry, average dry, and average years. In many of the wetter years the model also performs well (1957 and 1984 are examples of excellent wet year operations). The model appears to bypass or spill more water than may necessary in average wet, moderately wet, and wet years, however. The Green River Model operates Flaming Gorge Dam to assure that frequencies of peak flow targets and duration targets as specified in the flow recommendations are met. The model also meets base flow targets as specified in the flow recommendations.

A key issue with river simulation modeling is lack of flexibility. Rules must be 'hard coded'. While rules allow for decision trees, a model such as the Green River Model will not be able to adjust to all situations and be able to consider the balance of all available operating options. The inability to program extensive flexibility into the model's rules makes precise modeling of the effects of flow recommendations, which are inherently flexible, more difficult.

Three key findings were made in reviewing the model:

- ❖ The model does not take advantage of the ability to move water in April and early May in wetter than average years. By not increasing releases during this period the frequency of spills and bypass releases in the Green River Model is increased, and some opportunities to more easily achieve targets in Reach 2 are missed.
- ❖ Modeled releases frequently exceed 8,600 cfs (requiring spillway use) even when such spillway releases are not needed to meet downstream targets or for hydrologic reasons. The 1.2 rule may be contributing to this phenomenon.
- ❖ The Green River Model mass balance procedure in the spring ‘locks’ in base flows for the following August through February time frame and also locks in the amount of water to be released in the May through July time period. The model is not able to capitalize on the flexibility allowed by the flow recommendations for base flows as it moves through the operation in the May through July time period.

Each of these factors contributes to the Green River Model bypassing and spilling more water than may be necessary. Based on the evaluation of the Green River Model, the frequency of use of the spillway and bypass predicted by the model in the action alternative is probably higher than necessary to achieve the flow recommendations. We found 7 years out of 65 when bypasses occurred, but were not required. We believe that operations at Flaming Gorge Dam could meet the flow recommendations by using the bypass tubes about 40.0% of the time, a reduction of 9.9% from that predicted by the Green River Model. The frequency of spillway use appears to be overstated by the model as well. We found 11 years in which the model predicted spills (releases greater than 8,600 cfs), but those spills did not result in meeting downstream targets nor were they needed for hydrologic reasons. We believe that the use of the spillway may be needed about 10.8% of the time to meet the flow recommendation, a reduction of 18.6% percent from that predicted by the Green River Model. The total volume of water released above powerplant capacity (as bypasses or spills) as predicted by the Green River Model may also be greater than necessary.

Operation of
Flaming Gorge Dam
Final Environmental
Impact Statement

Modified Run of the River Modeling Report Technical Appendix

MODIFIED RUN OF THE RIVER MODELING REPORT TECHNICAL APPENDIX

Page No.

Modified Run of the River Modeling Report Technical Appendix

R. Clayton and A. Gilmore
July 17, 2002

INTRODUCTION

At the request of the National Park Service, a "Run of River" approach for operating Flaming Gorge Dam was modeled by the hydrologic modeling team to see if this type of approach could achieve the *2000 Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations). The Action and No Action Alternatives of the Flaming Gorge Environmental Impact Statement (Flaming Gorge EIS) are the only two alternatives that have been fully modeled. This study was done to potentially create a third alternative for the Flaming Gorge EIS.

A "Run of River" operational approach provides a more natural hydrograph to river reaches downstream of a reservoir because releases from the reservoir are patterned to mimic the reservoir inflow pattern. The "Run of River" approach modeled for this study followed a simple rule where the daily release volume was set equal to a percentage of the previous day's unregulated inflow volume. There were two main goals this study attempted to achieve. The first goal was to determine what percentage of the previous day's unregulated inflow volume to release so that the flow objectives of the 2000 Flow and Temperature Recommendations would be achieved. This percentage had to meet these flow objectives while also minimizing impacts to other resources associated with the Flaming Gorge facility. The second goal was to compare and quantify the hydrologic effects of this operational approach to the approaches used for the Action and No Action Alternatives.

MODEL METHODOLOGY

The basic methodology of the "Run of River" approach used for this study was to release a percentage of the previous day's unregulated inflow during the period from March through July. During other months of the year, the "Run of River" approach determined releases in the same way that the Action Alternative determined releases.

Unregulated inflow is a measure of what volume of water would have flowed into the reservoir over a period of time assuming no upstream regulation occurred. In the case of Flaming Gorge Reservoir, the unregulated inflow is the actual inflow, over a period of time, adjusted for any change in storage or evaporation in Fontenelle Reservoir located upstream from Flaming Gorge Reservoir.

The main difference between the "Run of River" approach and the approach taken by the Action Alternative was the method by which releases from Flaming Gorge Dam were determined during the March through July period. The Action Alternative divided this period into a transitional operations period (March and April) and a spring period (May, June, and July). During the transitional period, the Action Alternative operated Flaming Gorge Dam to achieve a drawdown target by a deadline date of May 1st each year. During this period, a minimum release rate of 800 cubic feet per second (cfs) and a powerplant capacity release rate of 4,600 cfs were the only limits placed upon releases. During the spring period, the Action Alternative classified the anticipated spring hydrology into one of five classifications (dry to wet). From this classification the Action Alternative developed a spring release pattern that would most likely meet the flow objectives defined for that particular classification. It was assumed that future flows of the Yampa River could be predicted within a reasonable degree of accuracy.

The "Run of River" approach, on the other hand, was more indirect in terms of how it attempted to achieve the flow objectives of the 2000 Flow and Temperature Recommendations. Under the "Run of River" approach during the period from March through July, each day Flaming Gorge releases were controlled so that a percentage of the unregulated inflow for the previous day was released. During this period, the "Run of River" approach did not make any direct attempt to achieve the flow objectives of the 2000 Flow and Temperature Recommendation. It was assumed that by releasing a particular percentage of the unregulated inflow, that these flow objectives could be achieved coincidentally. Preliminary analysis of the historic inflows into Flaming Gorge indicated that releasing 87 percent (%) of the unregulated inflow would most likely provide enough storage during the spring to achieve the base flow targets. This percentage was applied to the rule that governed releases under the "Run of River" approach during the period from March through July.

The 2000 Flow and Temperature Recommendations call for riverflows during the base flow period (August through February) that are higher than flows that would have occurred naturally. To achieve these flows, water is released from storage during the base flow period. This draws the water surface elevation of Flaming Gorge down during the base flow period. The challenge of this "Run of River" approach was to find a percentage of the spring unregulated inflow that would provide enough storage to achieve the flow objectives during the base flow period while also setting releases high enough during the spring to achieve the flow objectives for the spring. This proved to be very challenging and was not fully accomplished in this study.

MODEL RESULTS

Table 1 shows the results of how the “Run of River” approach compared to the Action and No Action Alternatives for the spring flow and duration objectives described in the 2000 Flow and Temperature Recommendations. For many of the spring flow objectives, the “Run of River” approach achieved or exceeded the recommended flows and durations for the recommended frequencies. But for flow objectives with extended durations, the “Run of River” approach did not successfully achieve these flow and duration combinations as frequently as recommended. For example, one flow objective of the 2000 Flow and Temperature Recommendations calls for flows in Reach 2 to meet or exceed 18,600 cfs for at least 2 weeks in 40% of all years. The “Run of River” approach, with a release percentage of 87%, accomplished these flows only about 21% of the time. Even when the release percentage was increased to 100%, which would cause the reservoir to store no water during the spring, this flow objective was achieved only 30% of the time. This was a strong indication that the “Run of River” approach implemented for this study could not achieve the 2000 Flow and Temperature Recommendations without having significant impacts on other resources associated with Flaming Gorge. Without achieving all of the flow objectives of the 2000 Flow and Temperature Recommendations, the “Run of River” approach could not meet the purpose and need for the Flaming Gorge EIS and thus was not considered as a viable alternative. Despite these findings, a study of the hydrologic impacts of this “Run of River” approach was done and the results of which are presented in the remainder of this report.

Table 1.—Spring Flow Objectives of the 2000 Flow and Temperature Recommendations with Model Results

Spring Peak Flow Recommendations	Reach	Target %	Action Ruleset	No Action Ruleset	Run of the River Action Ruleset
Peak >= 26,400 cfs For at least 1 day	2	10%	11.3%	7.1%	13.8%
Peak >= 22,700 cfs For at least 2 weeks.	2	10%	10.7%	4.6%	6.2%
Peak >= 18,600 cfs For at least 4 weeks.	2	10%	11.1%	6.0%	7.9%
Peak >= 20,300 cfs For at least 1 day.	2	30%	46.3%	42.3%	47.2%
Peak >= 18,600 cfs For at least 2 weeks.	2	40%	41.1%	15.6%	21.5%
Peak >= 18,600 cfs for at least 1 day.	2	50%	60.3%	59.1%	58.5%
Peak >= 8,300 cfs for at least 1 day.	2	100%	100%	98.5%	96.9%
Peak >= 8,300 cfs for at least 1 week.	2	90%	96.8%	96.9%	89.2%
Peak >= 8,300 cfs for at least 2 days except in extreme dry years.	2	98%	99.6%	98.4%	96.9%

RESERVOIR WET AND DRY CYCLE RESULTS

To capture the uncertainty of future hydrologic events, 65 sets of historic inflows for the years 1921 through 1985 were routed through the Flaming Gorge model. Each set was systematically varied from the others to provide a range of reasonable inflow patterns that could potentially happen in the future. Because the inflow sets were constructed from historic hydrology over the period from 1921 though 1985, the extreme wet and dry cycles that occurred in these inflow sets were assumed to be the most reasonable extreme events that could likely occur in the future. An example of how the "Run of River" approach, and the Action and No Action Alternatives, operated Flaming Gorge Dam differently under the most extreme wet and dry events that occurred in the model results are shown in figures 1 through 4. Figures 1 and 2 show a comparison of how the three rulesets operated Flaming Gorge Dam through the most extreme 3-year dry cycle. These historic years are 1939, 1940, and 1941. Figure 1 shows what happened to the reservoir elevation while figure 2 shows the release patterns generated by the three rulesets. For consistency of comparison, the initial elevations were all normalized to the actual water surface elevation that occurred on January 2002. Figures 3 and 4 show a comparison of how the rulesets operated Flaming Gorge Dam through the most extreme 3-year wet cycle. These historic years are 1982, 1983, and 1984. Figure 3 tracks the reservoir elevation for each ruleset through this cycle, while figure 4 shows the release patterns generated by the three rulesets.

RESERVOIR WATER SURFACE ELEVATION PERCENTILE RESULTS

For each of the 65 sets of inflows that were routed through the model, a potential reservoir elevation was calculated for each month. The potential reservoir elevations for each month were ranked from lowest to highest. Figures 5, 6, and 7 show the reservoir elevations for various probabilities of exceedance. Figure 5, for example, shows the reservoir elevations that the model predicted would have a 10-percent chance of being exceeded over the next 10 years with Flaming Gorge operated under the three rulesets. Figure 6 shows reservoir elevations that would have a 50-percent chance of being exceeded, and figure 7 shows reservoir elevations that would have a 90-percent chance of being exceeded. It is important to note that figures 5, 6 and 7 do not represent the reservoir elevations for any single set of inflows but are rather a composite of all of the results from all 65 sets of inflows that were routed through the model.

Typically, Flaming Gorge Reservoir reaches the lowest elevation of the year in late winter. This is because the reservoir is intentionally drawn down to an water surface elevation that provides enough storage space to safely route the anticipated snowmelt runoff during the spring. For this reason, the distribution of February reservoir elevations is shown in figure 8. Figure 8 shows that reservoir elevations for February, under the "Run of River" approach, are the lowest of the three rulesets studied. Similar results are shown in figure 9, which shows the distributions of June reservoir elevations. At the end of June, the reservoir elevation of is typically nearing the highest level of the year. These figures characterize the general trend of how each of the operational regimes will likely affect the reservoir elevation at the high and low points of the year.

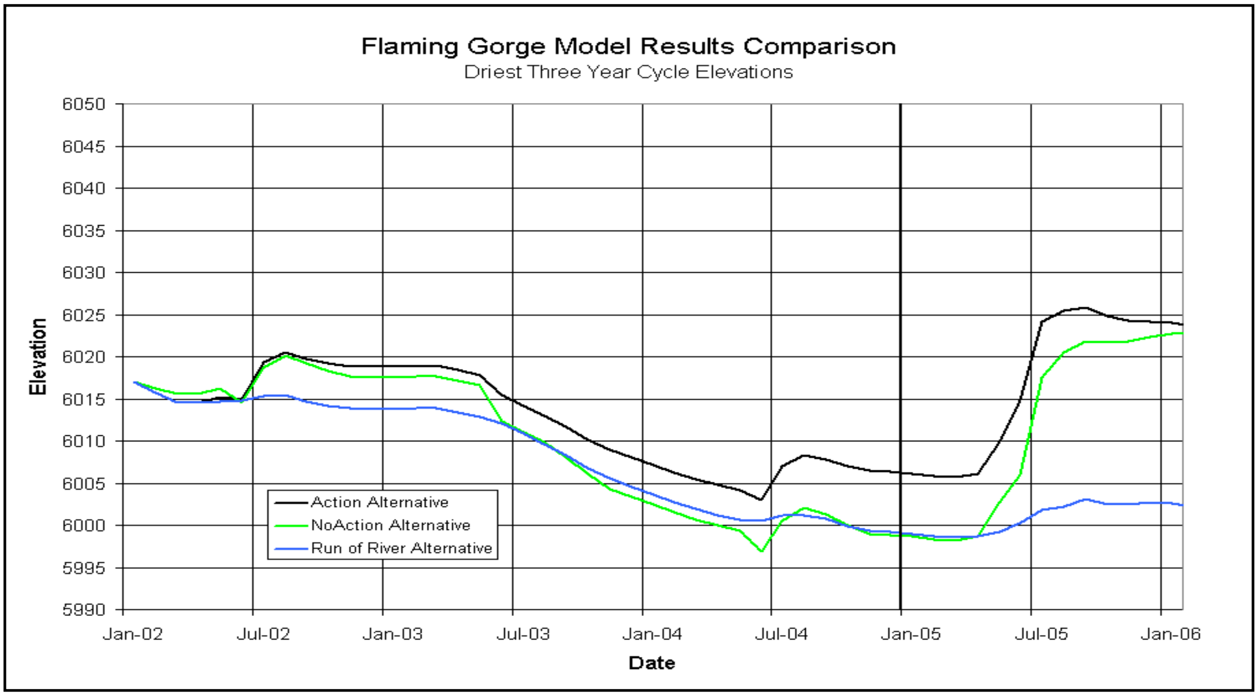

Figure 1.—Reservoir Elevations Under the Most Extreme 3-Year Dry Cycle.

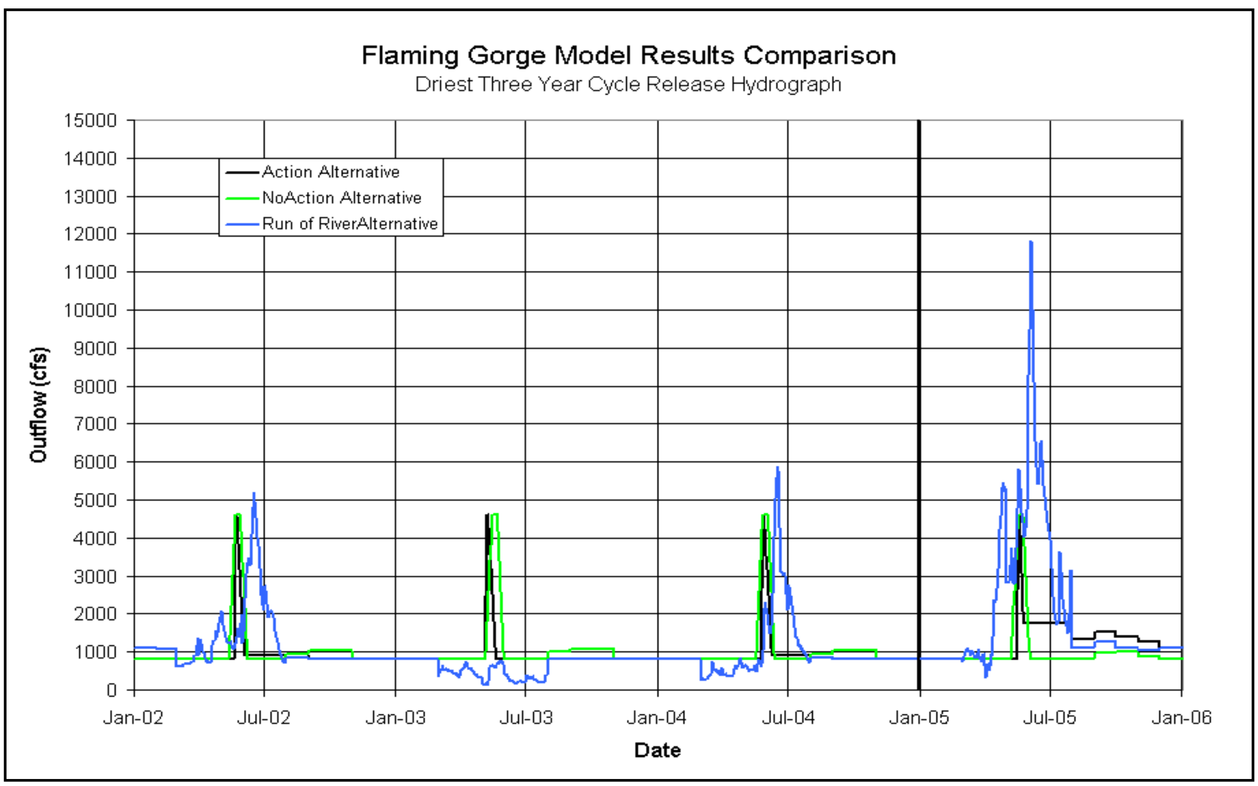

Figure 2.—Reservoir Releases Under the Most Extreme 3-Year Dry Cycle.

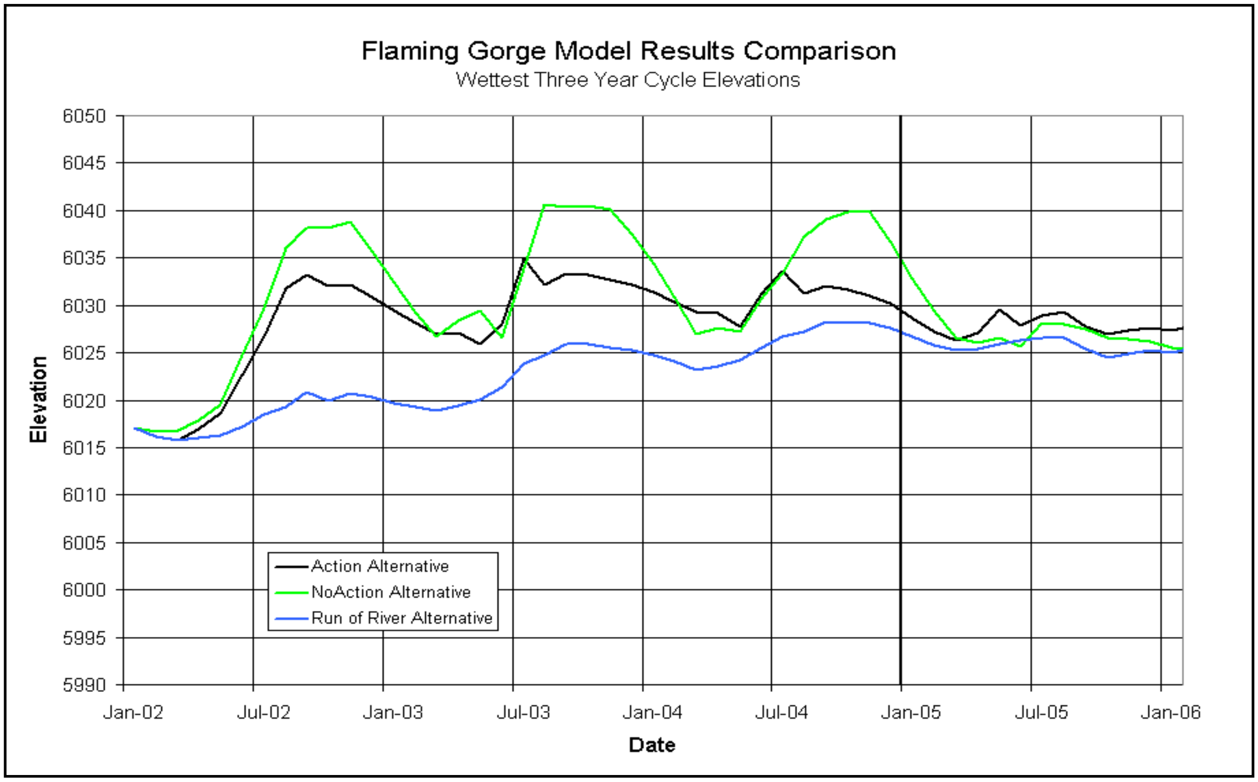

Figure 3.—Reservoir Elevations Under the Most Extreme 3-Year Wet Cycle.

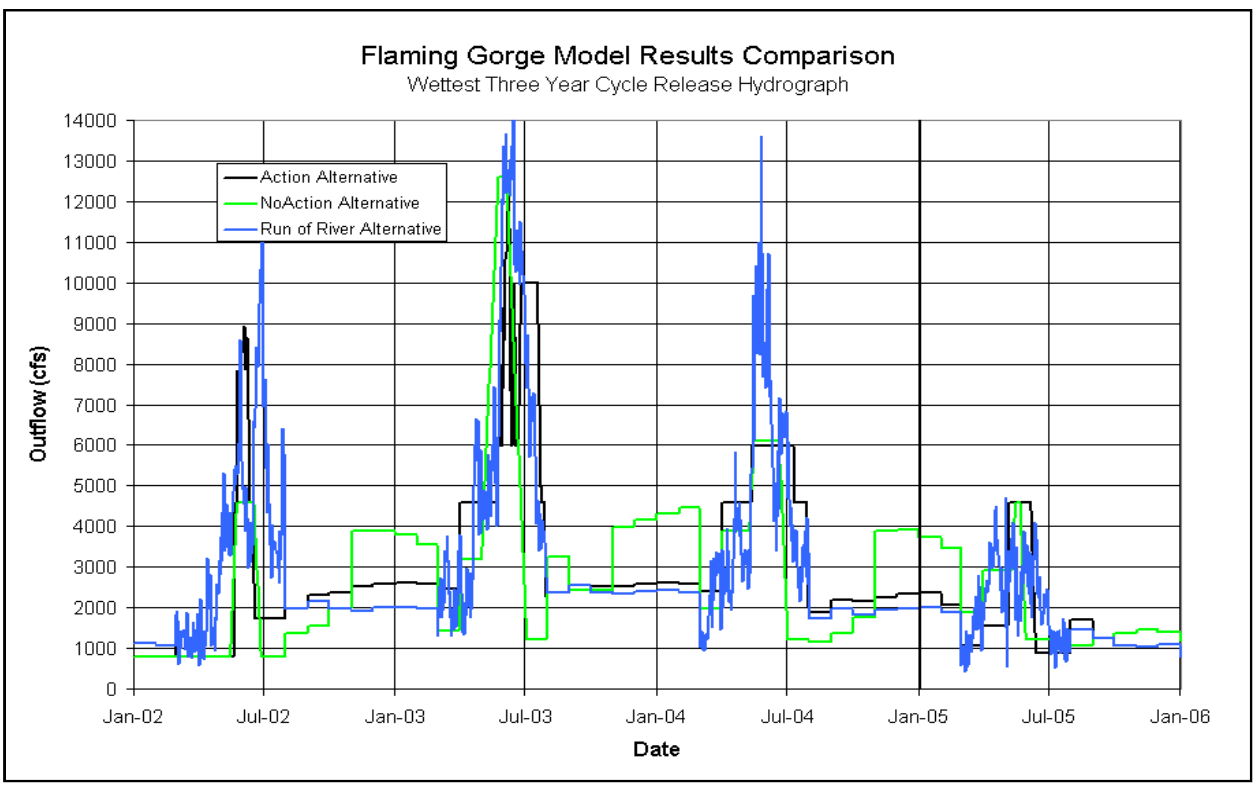

Figure 4.—Reservoir Releases Under the Most Extreme 3-Year Wet Cycle.

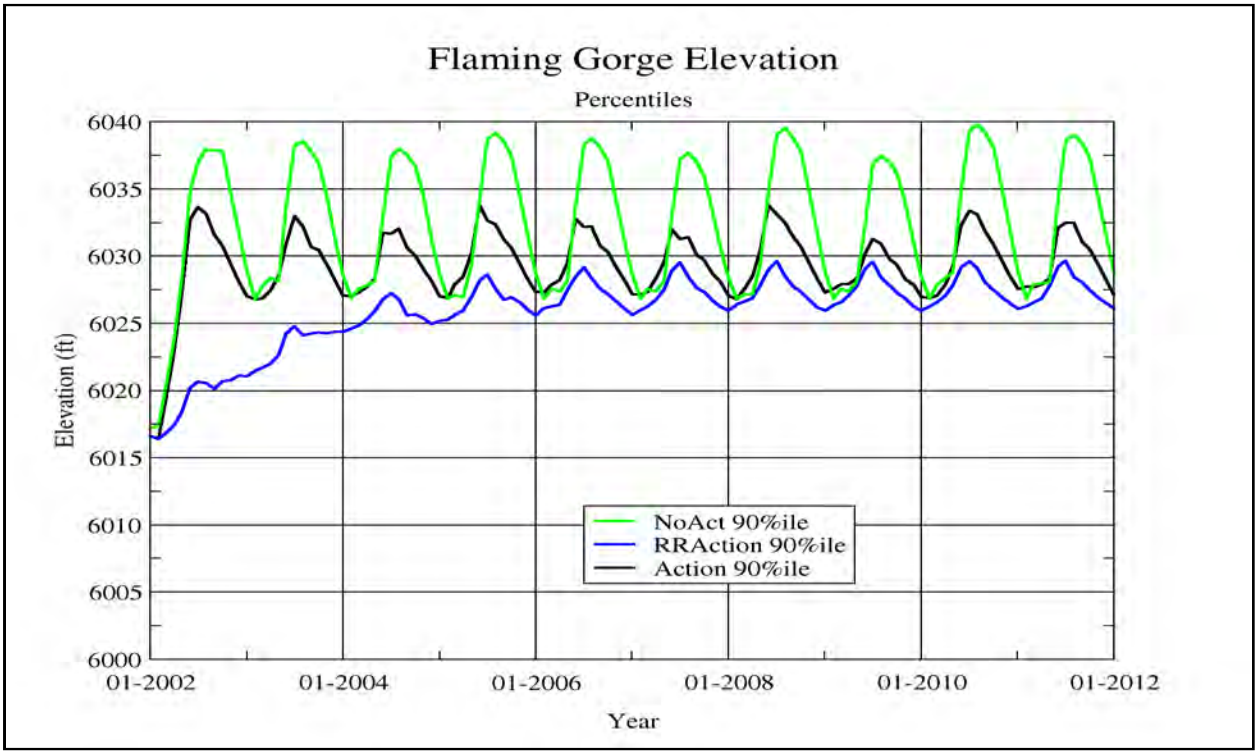

Figure 5.—10% Exceedance Reservoir Elevations From January 2002 to December 2012.

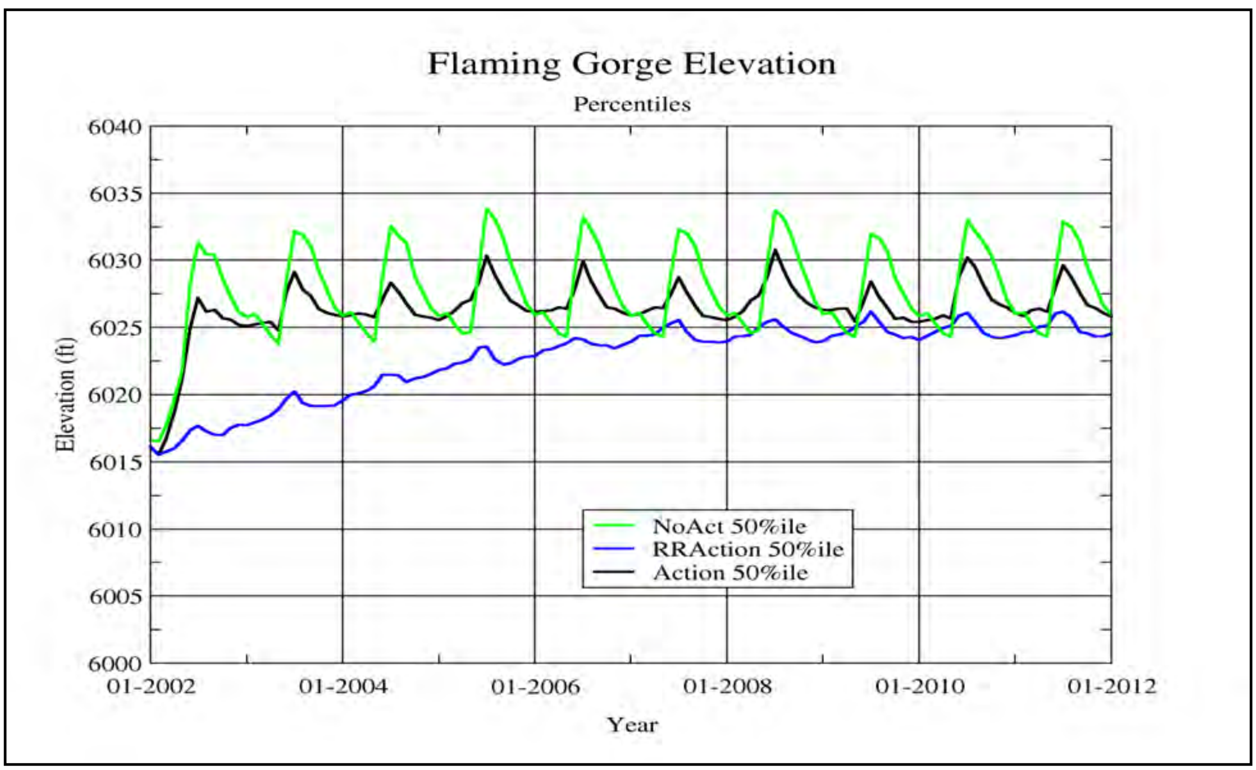

Figure 6.—50% Exceedance Reservoir Elevations From January 2002 to December 2012.

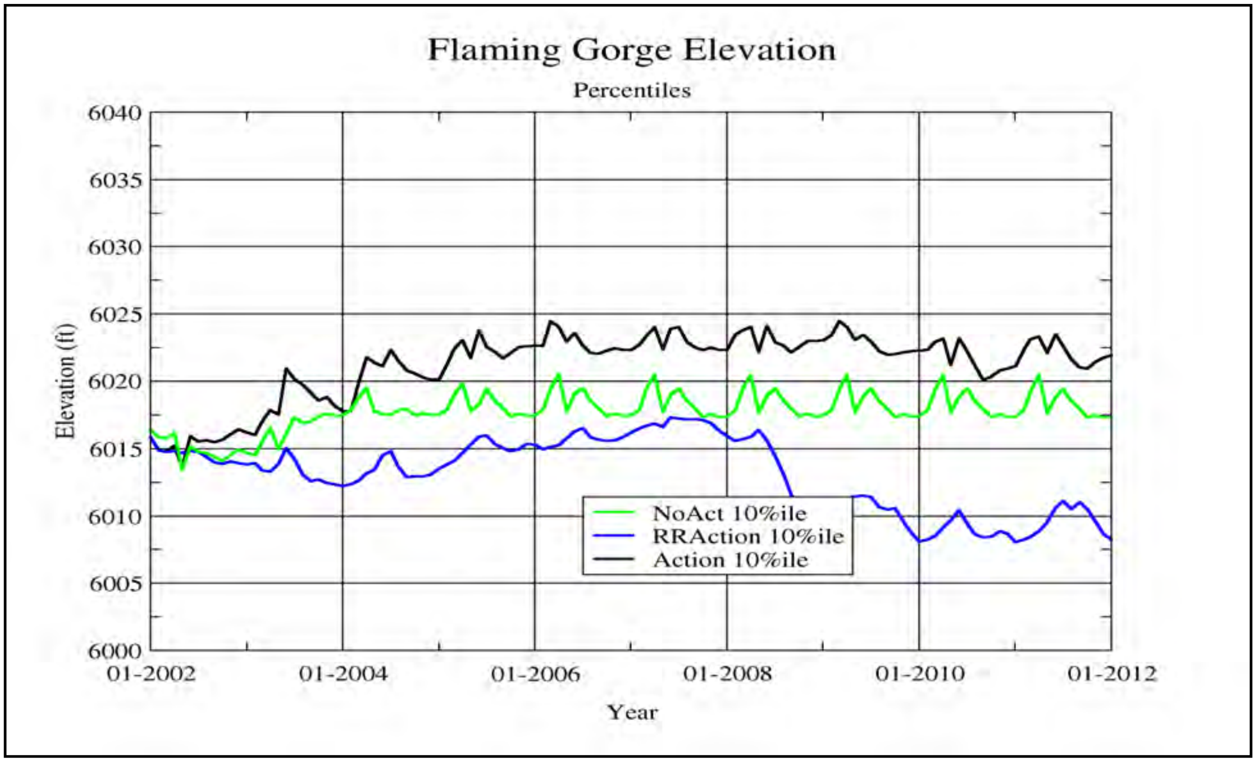

Figure 7.—90% Exceedance Reservoir Elevations From January 2002 to December 2012.

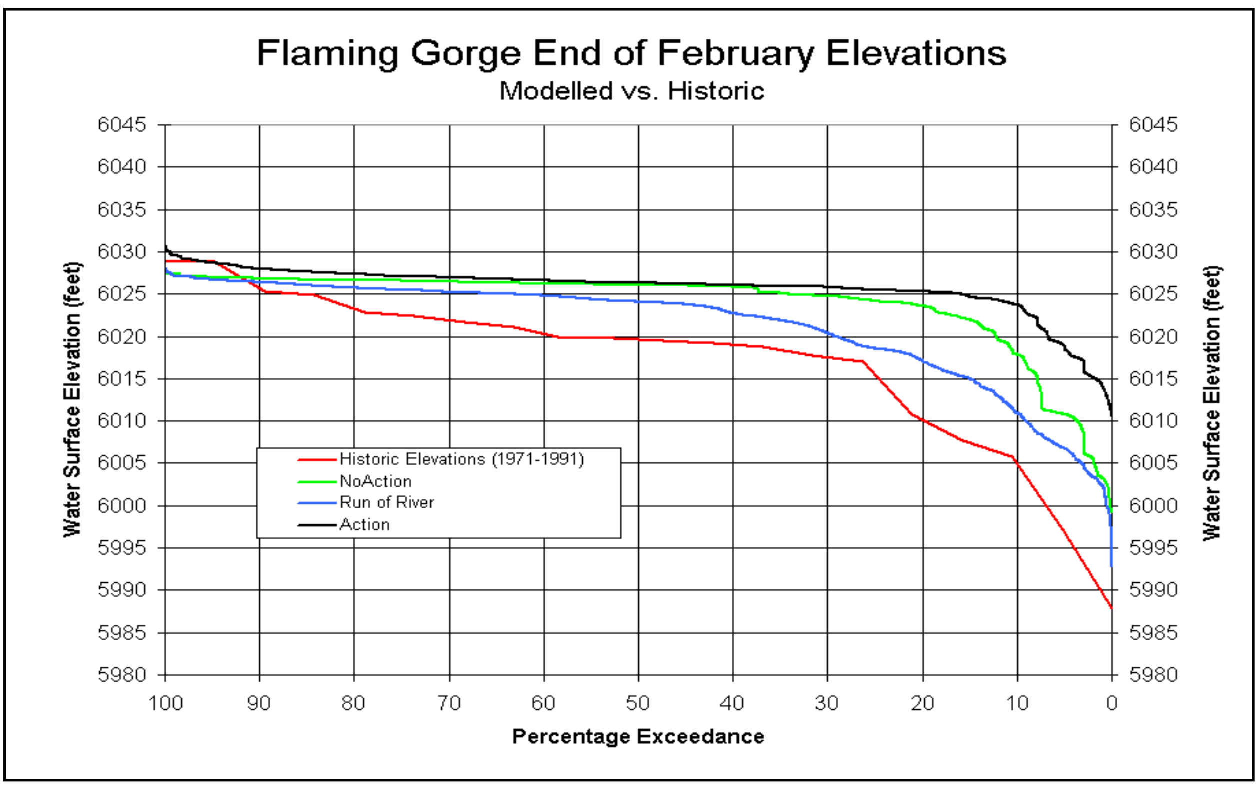

Figure 8.—February Reservoir Elevation Distribution Plot.

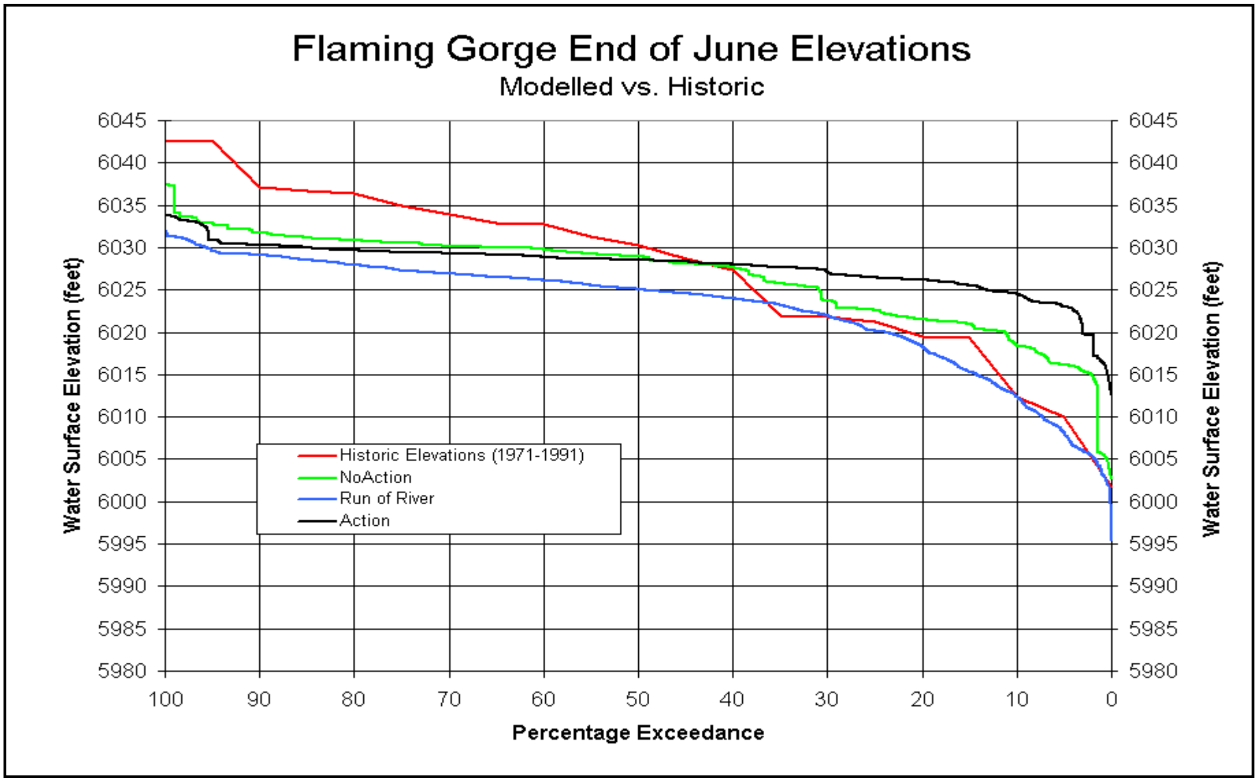

Figure 9.—June Reservoir Elevation Distribution Plot.

REACH 1 SPRING PEAK FLOW RESULTS

The Flaming Gorge model does not account for side inflows that occur along Reach 1 of the Green River. Historically, the volumes of flow contributed by tributaries to the Green River in Reach 1 have been relatively insignificant except during large thunderstorm events. Reach 1 flows that appear in this report are actually the average daily releases made from Flaming Gorge Dam. Figure 10 shows the distribution of peak flows that occurred in the model results having durations of one day for the Action, No Action and "Run of River" approach. Originally, it was assumed that the peak flows would be limited to the months of May, June and July. For the "Run of River" approach, however, it was possible for peak flows to occur in the months of March and April. For this report, however, the peak flows were only analyzed for the May through July period. This is because the flow objectives of the 2000 Flow and Temperature Recommendations during the spring were expected to occur during May-July timeframe and not for the months of March and April. Figures 11 and 12 show the distributions of flows in Reach 1 having durations of two and four weeks respectively. These durations were chosen because the 2000 Flow and Temperature Recommendations specified them as minimum durations for target flows in Reach 2.

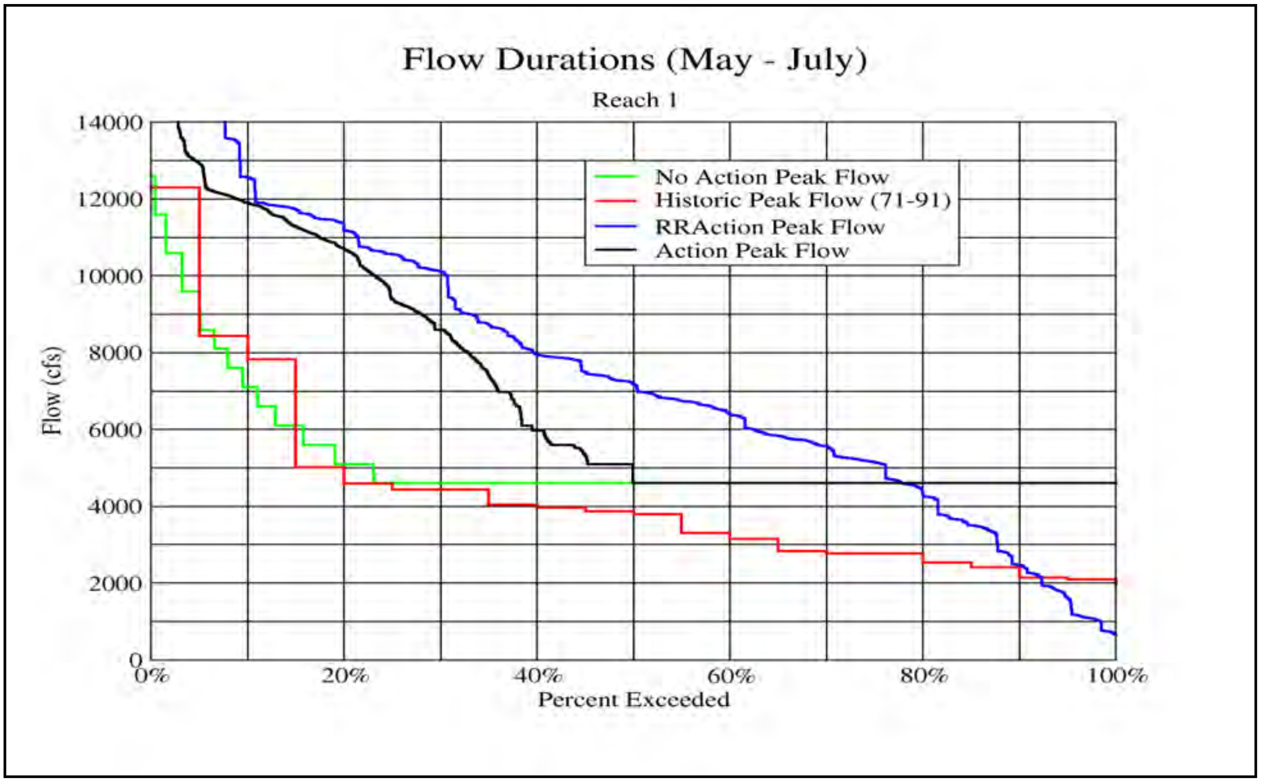

Figure 10.—Distributions of Peak (1-Day Duration) Releases During May-June.

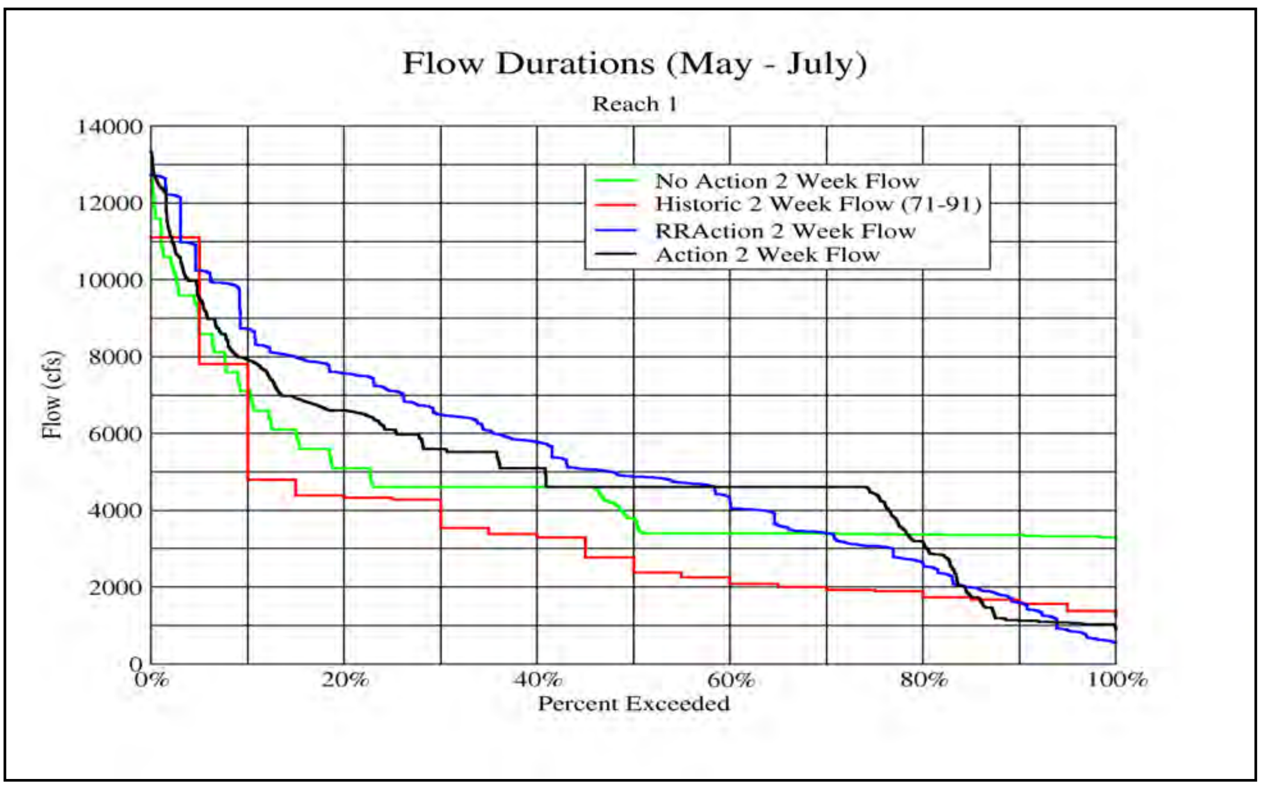

Figure 11.—Distribution of Peak (2-Week Duration) Releases.

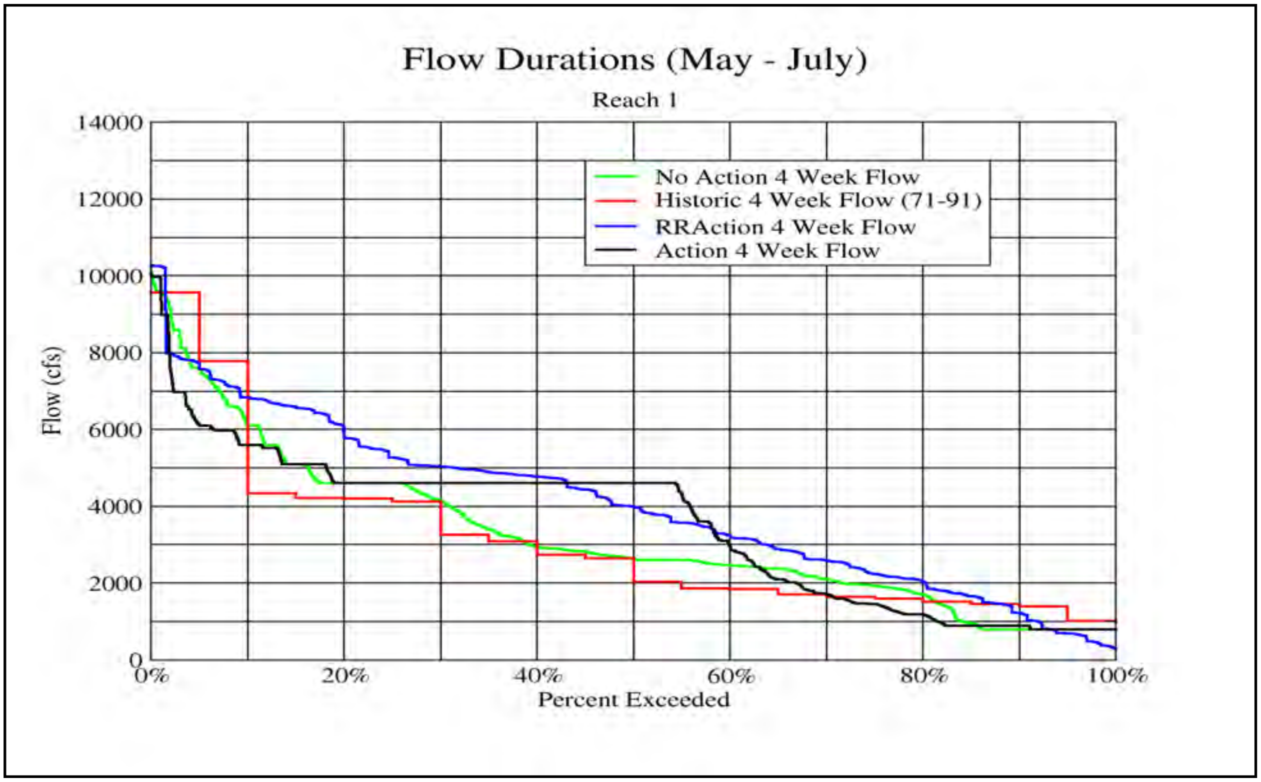

Figure 12.—Distribution of Peak (4-Week Duration) Releases.

FLAMING GORGE ANNUAL BYPASS RELEASE RESULTS

Releases made through the bypass tubes or the spillway that might otherwise have been made through the powerplant have a direct impact on power produced at Flaming Gorge Dam. As a rough method of comparing the Action and No Action Alternatives to the "Run of River" approach in terms of impact to power production, the distributions of annual bypass volumes are shown in figure 13. The figure shows that bypasses occurred most often for the "Run of River" approach and that bypass volumes of the same frequency of occurrence were higher for the "Run of River" approach than for the other two alternatives.

REACH 1 AUGUST THROUGH FEBRUARY BASE FLOW RELEASE RESULTS

The 2000 Flow and Temperature Recommendations call for specific ranges of base flow levels depending on the hydrologic classification that was determined at the end of the spring period. Under the Action Alternative, and "Run of River" approach, the total spring volume of unregulated inflow measured on August 1st of each year set the hydrologic classification, which in turn, set the target range of flows to be established for the base flow period. A target range of flows was specified for both Reaches 1 and 2. Depending on the reservoir elevation, the model

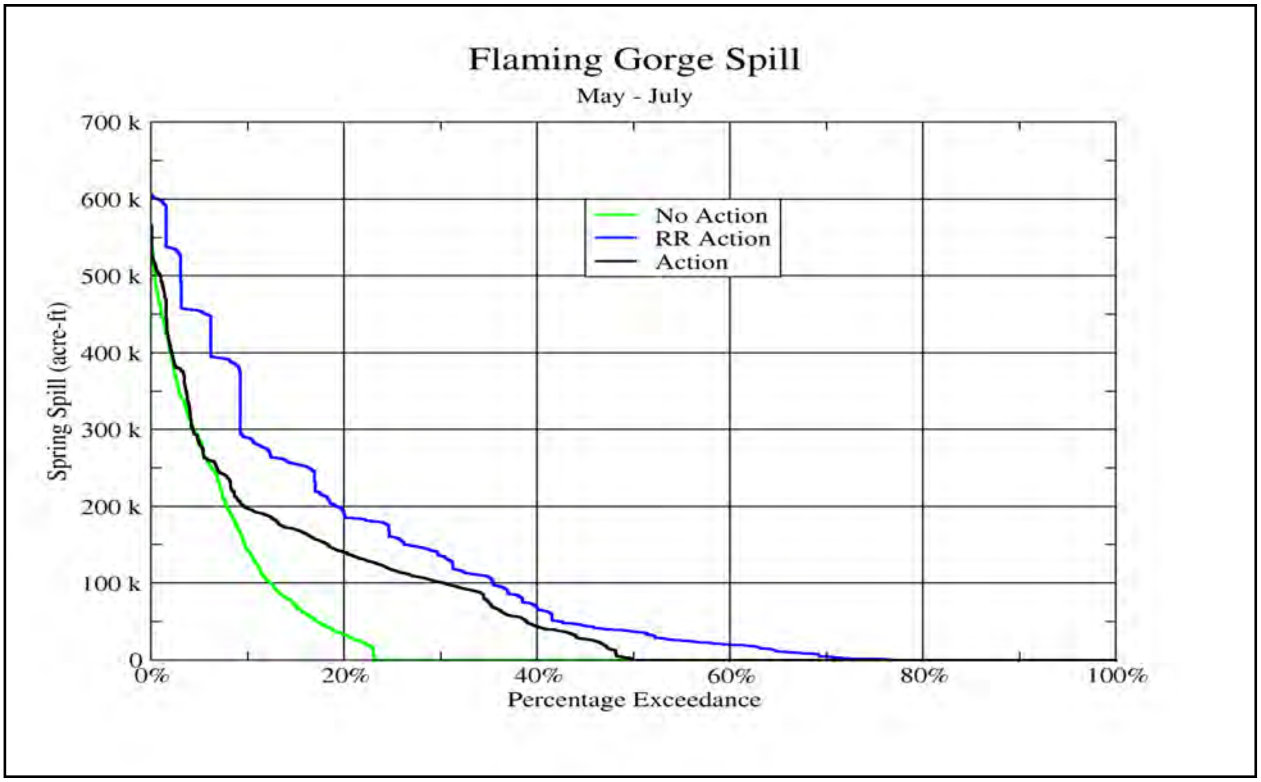

Figure 13.—Annual Bypass Volume Distributions.

determined what release rate would achieve the base flow objectives while also achieving a drawdown target by the end of February. When the reservoir elevation was below the normal operational elevation, the release rate was set to a lower level within the specified range. When the reservoir elevation was above the normal operational elevation, the release rate was set to a higher level within the specified range. In all cases, except when safety of the dam was in question, releases were controlled so that the flow objectives in Reach 2 were always achieved for the hydrologic classification, even when the drawdown target for the end of February could not be achieved. Figure 14 shows that the "Run of River" approach consistently selected base flow levels that were lower than the Action and No Action Alternatives. The most likely reason for this was because the reservoir elevations under the "Run of River" approach were often lower than the corresponding elevations under the Action and No Action Alternatives. To give some perspective to the model results shown in figure 14, the distribution of historic inflows and historic unregulated inflows are also shown in the figure. Unregulated inflows are corrected for river regulation at Fontenelle Reservoir and give a better idea of what inflows would be like without upstream reservoir regulation.

REACH 2 SPRING PEAK FLOW RESULTS

Figures 15, 16, and 17 show the relationships between the peak flows that occurred each spring in Reach 2. Although, the "Run of River" approach did not achieve all of the flow objectives of the 2000 Flow and Temperature Recommendations, the distribution of peak flows generated by the "Run of River" approach, compared to those for the Action and No Action Alternatives, was very similar in Reach 2.

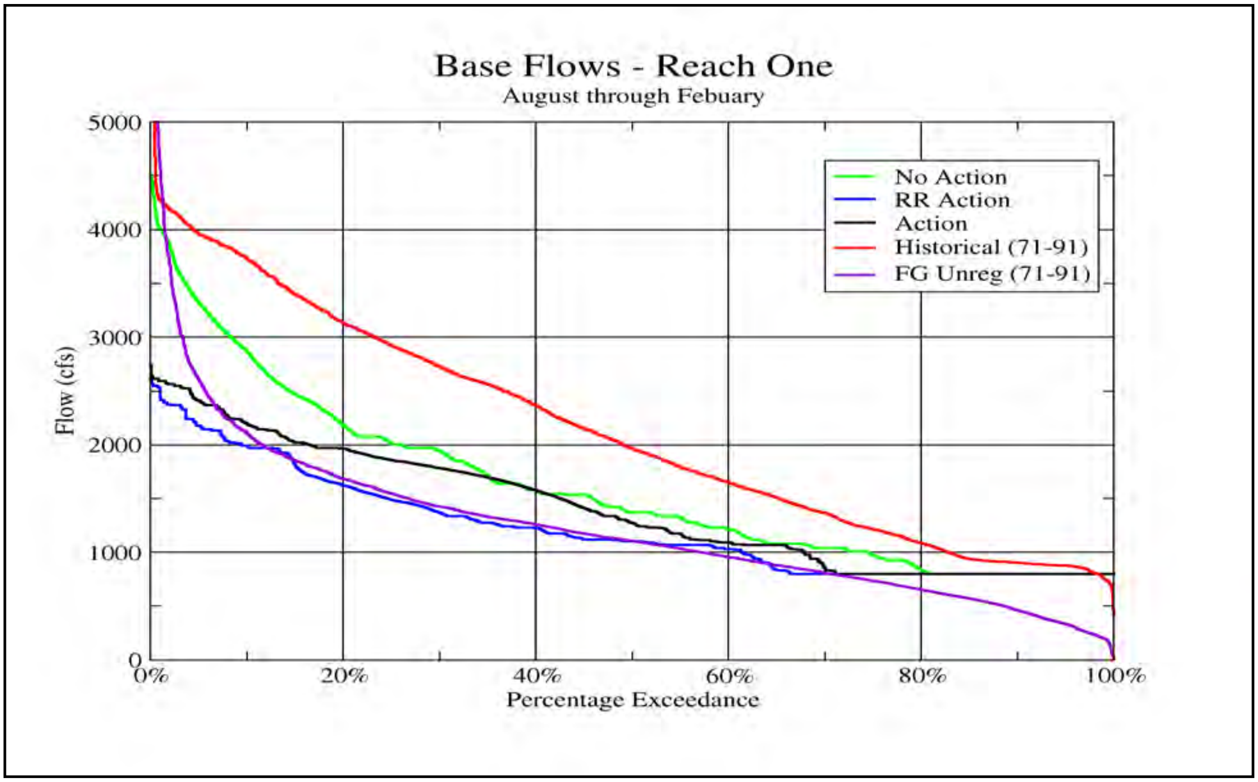

Figure 14.—Exceedance Percentage Flows for Reach 1 Flows During Base Flow Period.

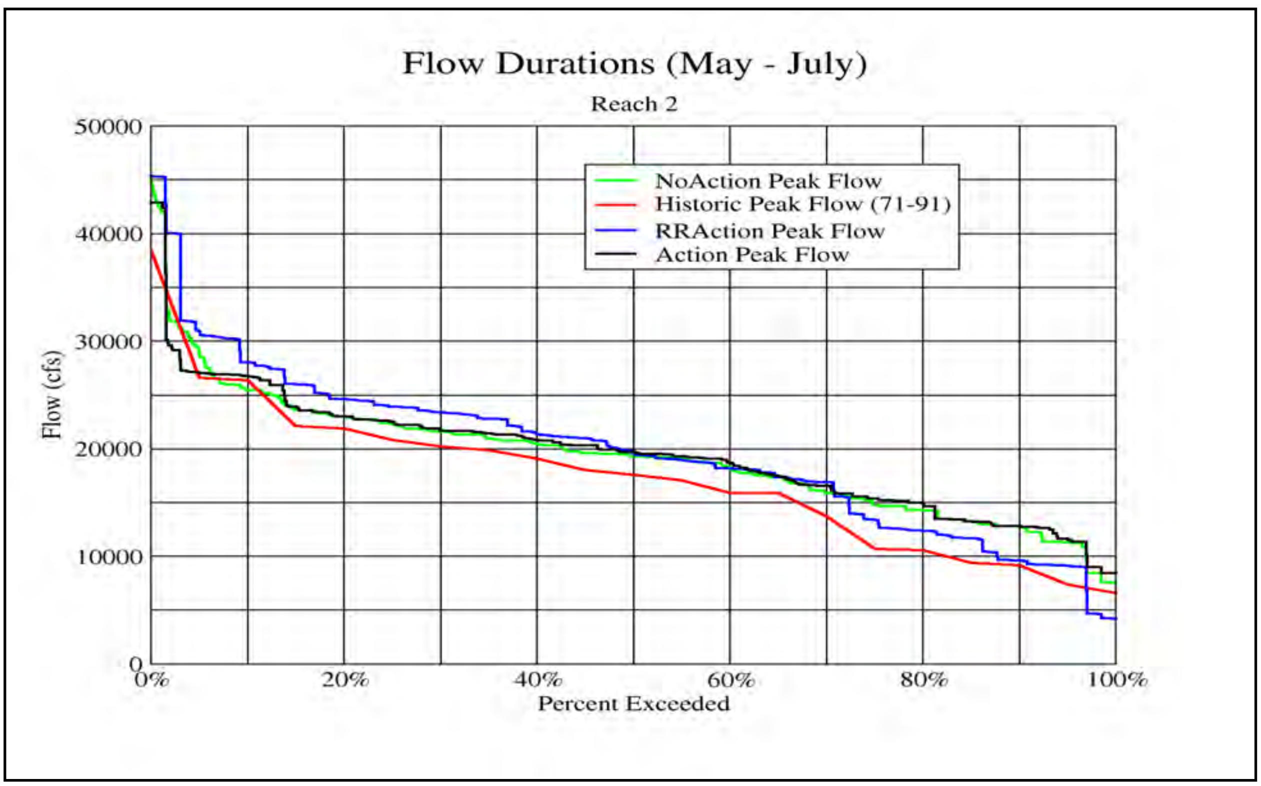

Figure 15.—Distribution of Peak Flows (1-Day Duration) in Reach 2.

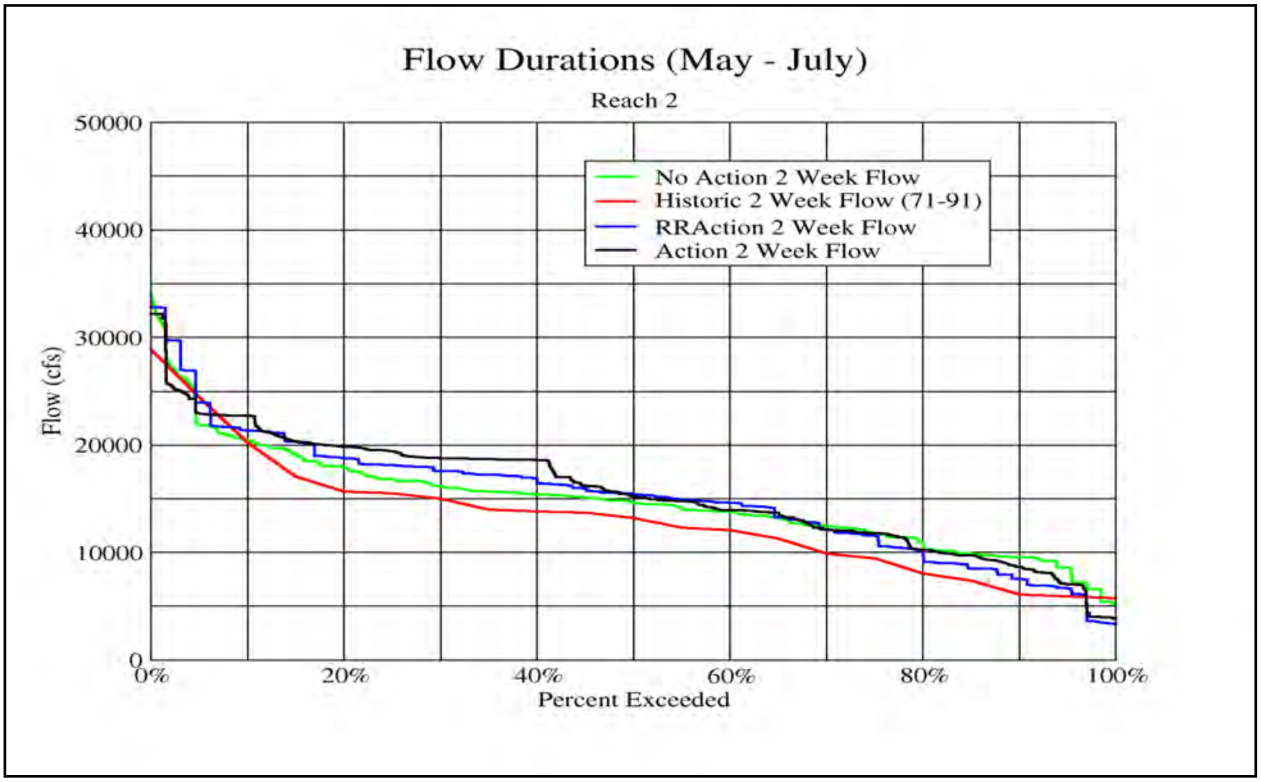

Figure 16.—Distribution of Peak Flows (2-Week Durations) in Reach 2.

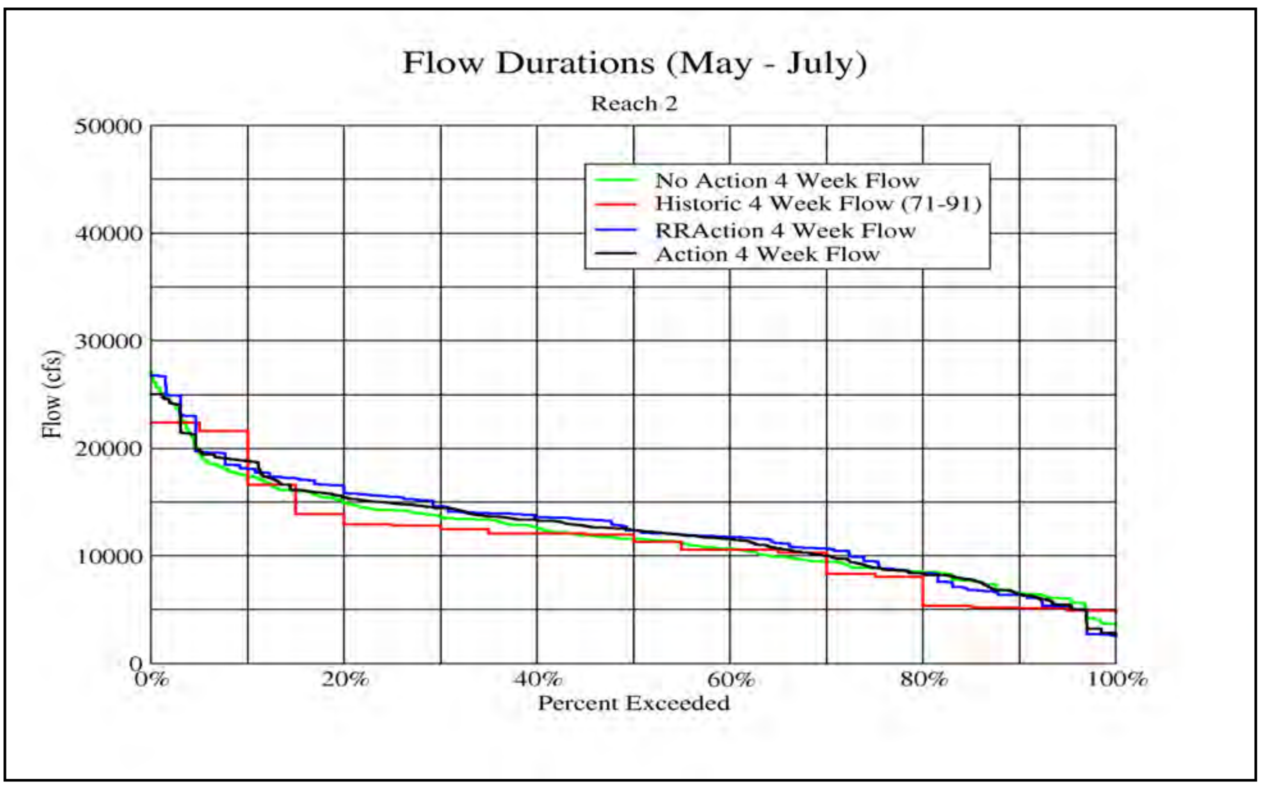

Figure 17.—Distribution of Peak Flows (4-Week Durations) in Reach 2.

REACH 2 BASE FLOW RELEASE RESULTS

Figure 18 shows the distribution of base flows that occurred in Reach 2. Base flow levels were noticeably lower under the "Run of River" approach. As with Reach 1, the difference between the base flow levels for the Action Alternative and the "Run of River" approach can largely be attributed to the difference between the reservoir elevations generated under the respective rulesets. Typically, the "Run of River" ruleset operated Flaming Gorge Dam such that the reservoir elevations were often lower than when the dam was operated under the Action and No Action Alternatives.

SUMMARY

Preliminary analysis of the historic inflows into Flaming Gorge did show that it might be possible to operate Flaming Gorge under a modified "Run of River" approach to achieve the flow objectives of the 2000 Flow and Temperature Recommendations during the spring. However, this analysis did not account for the current levels of consumptive water use that is occurring along the Green River above Flaming Gorge or the fact that this rate of consumptive use is expected to increase in the future. The Flaming Gorge model, on the other hand, does account for current and increasing consumptive use in the future. Currently, about 450,000 acre-feet of Green River water is consumed above Flaming Gorge Reservoir each year. This is about 25% of the mean annual natural inflow into Flaming Gorge Reservoir. More importantly, diversions for

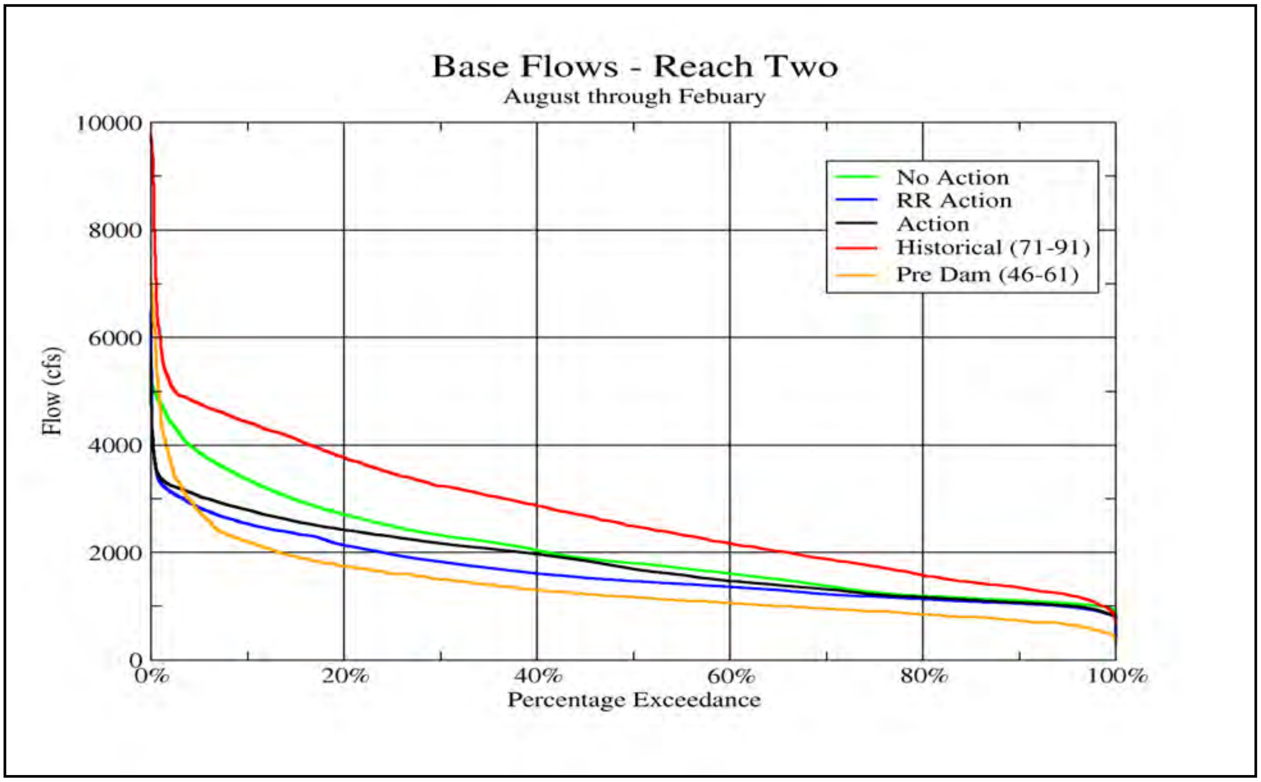

Figure 18.—Exceedance Percentage Flows for Reach 2 Flows During Base Flow Period.

irrigation occur most heavily during the months of May through August. These diversions decrease the unregulated inflow into Flaming Gorge Reservoir during the spring, which in turn, causes the modified “Run of River” methodology to release less water. Water use on the Green River has, and will continue to have, a significant impact on the inflows to Flaming Gorge Reservoir and consequently the impact this increasing use of water will impact the ability of any modified “Run of River” approach to achieving the 2000 Flow and Temperature Recommendations.

While constructing the ruleset for the Action Alternative, it was learned that some of the flow objectives in the 2000 Flow and Temperature Recommendations were more difficult to achieve than others. For example, there are two objectives that call for flows in Reach 2 to be at least 18,600 cfs for a minimum of 2 weeks in at least 40% of all years in one objective, and 18,600 cfs for a minimum of 4 weeks in at least 10% of all years in the other objective. These objectives proved to be the most difficult targets to achieve. To meet this challenge, it was necessary for operational decisions under the Action Alternative to have some input from conditions on the Yampa River. The Action Alternative ruleset assumes that it will be possible to accurately estimate the future flows on the Yampa River given current river flow, snow, temperature, and forecasted temperature conditions in the Yampa River Basin. This assumption allows the Action Alternative ruleset to set releases for the current day such that Reach 2 flows will meet or exceed a target flow objective on the following day within a small degree of error.

Operating Flaming Gorge under the modified “Run of River” methodology, however, does not require information about the Yampa River. Instead, this method relies only on the previous day’s unregulated inflow into Flaming Gorge Reservoir for determining what releases are to be made during the current day. As a result, releases from Flaming Gorge, under the modified “Run of River” methodology, were not controlled such that timing with the Yampa Peak was optimal. For this reason, releases under the modified “Run of River” methodology did not achieve all of the flow objectives of the 2000 Flow and Temperature Recommendations even when the volume of water released from Flaming Gorge Dam were typically greater than that released under the Action Alternative. This proved to be the major drawback of the modified “Run of River” methodology because while release volumes during the spring were much higher than those for the Action Alternative, the spring flow objectives of the 2000 Flow and Temperature Recommendations were not fully achieved. Even when the ruleset was adjusted to release 100% of the unregulated inflow, these duration objectives were still not fully achieved. Based on these findings, the modified “Run of River” Alternative proved not to be a viable alternative that could be included for analysis in the Flaming Gorge Environmental Impact Statement.

DOCUMENTATION OF HOW DAILY INFLOWS WERE CREATED FOR THE MODIFIED RUN OF THE RIVER ALTERNATIVE

The available data for development of the Flaming Gorge daily inflows consisted of the following.

1. Flaming Gorge inflows calculated from releases from Flaming Gorge, delta storage and estimated evaporation.
   Period: October 1, 1962 to December 31, 1985

2. Green River flows measured at the Greendale gauge.
   Period: October 1, 1950 to September 30, 1962
3. Green River flows measured at the Lynnwood gauge.
   Period: October 1, 1928 to September 30, 1950
4. Green River flows measured at the Green River, Utah, gauge less Yampa River flows measured as the sum of the Little Snake River flows measured at the Lily gauge and Yampa River flows measured at the Maybell gauge lagged by 2 days. The adjusted Green River flows were then shifted 2 days to account for travel time between Greendale and Green River, Utah.
   Period: January 1, 1921 to September 30, 1928.

This dataset is then corrected so that the daily volumes summed to each month match the monthly volume of inflow calculated by the Flaming Gorge monthly model, which accounts for current and increasing future depletions above Flaming Gorge. This correction is done during the model run by multiplying the daily input flow by the ratio of the modeled monthly inflow volume over the sum of the daily input volumes for the given month. This correction adjusts the daily flows that the monthly volumes will match those used in the Flaming Gorge monthly model.

Operation of
Flaming Gorge Dam
Final Environmental
Impact Statement

Effects of Flaming Gorge Operations Under the 1992 Biological Opinion and the 2000 Flow and Temperature Recommendations on Sediment Transport in Green River Technical Appendix

EFFECTS OF FLAMING GORGE OPERATIONS UNDER THE 1992 BIOLOGICAL OPINION AND THE 2000 FLOW AND TEMPERATURE RECOMMENDATIONS ON SEDIMENT TRANSPORT IN GREEN RIVER TECHNICAL APPENDIX

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Effects of Flaming Gorge Operations Under the 1992 Biological Opinion and the 2000 Flow and Temperature Recommendations on Sediment Transport in Green River Technical Appendix

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1. INTRODUCTION

Flaming Gorge Dam is located on the upper main stem of Green River in Utah (figure 1.1). The operation of the dam influences flow and temperature regimes and the ecology of riverine biota including native fish. The U.S. Fish and Wildlife Service in the 1992 Biological Opinion (the 1992 Biological Opinion) on Operation of Flaming Gorge Dam concluded that the continuation of historic operations at Flaming Gorge Dam was likely to further reduce the distribution and abundance of the federally protected fishes found in the Green River system.

In order to mitigate this problem, the Flaming Gorge flow recommendations investigation was conducted beginning in 1992 under the auspices of the Upper Colorado River Endangered Fish Recovery Program.

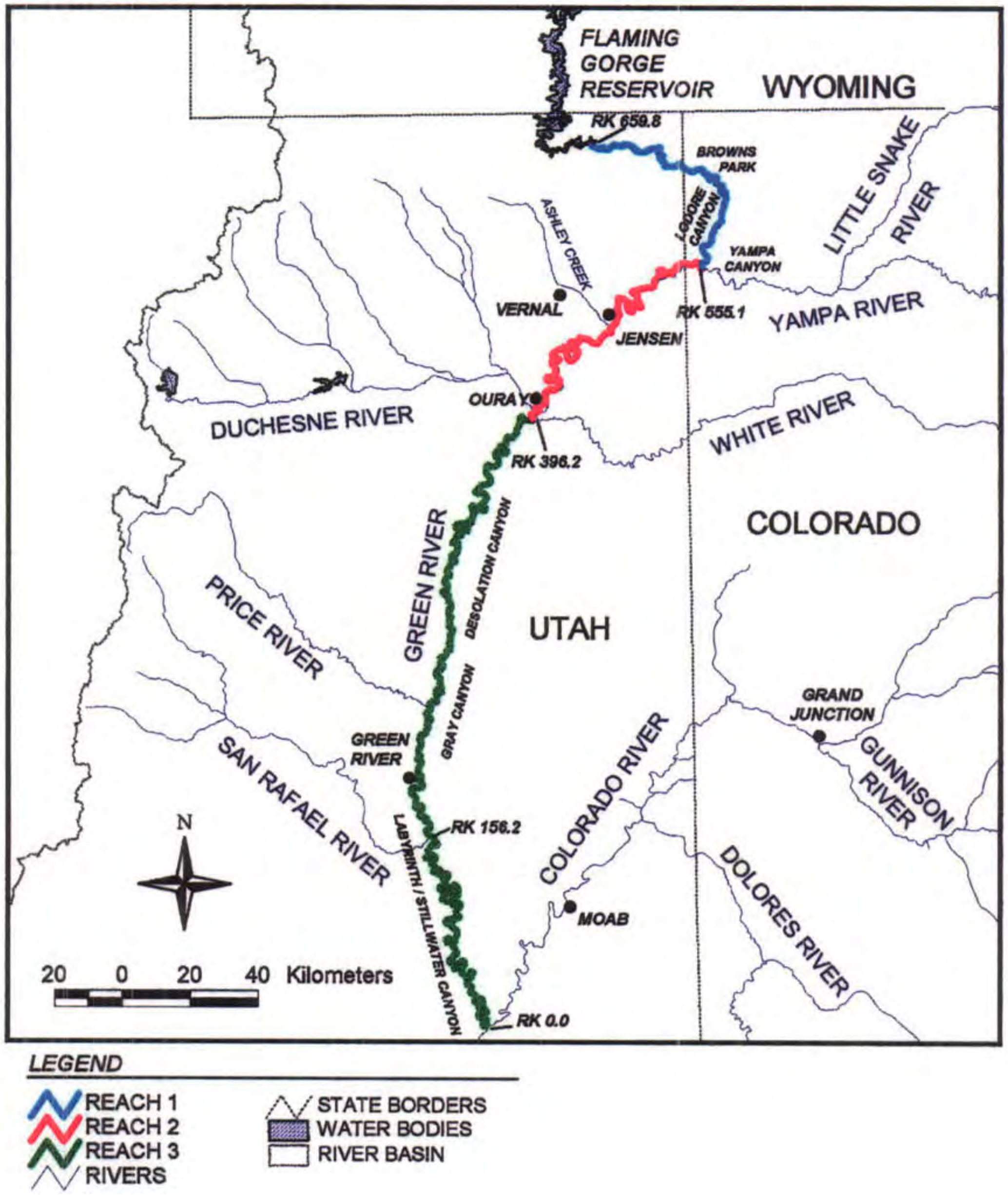

Figure 1.1—The Green River study area.

The 2000 Flow and Temperature Recommendations (the 2000 Flow Recommendations) are documented in a final report by Muth et al. (September 2000).

Clayton and Gilmore (2002) developed the simulation models of reservoir operation and streamflow for the 1992 Biological Opinion, which is referred to as the No Action Alternative, and the 2000 Flow Recommendations, which is referred to as the Action Alternative. The details of the model development and the hydrology results as well as updated flow data are presented in this report and were used to conduct the impact analysis on sediment transport in the Green River downstream from the Flaming Gorge Dam to its confluence with the White River near Ouray in Utah. This portion of the Green River has been divided into three reaches, Reach 1, Reach 2, and Reach 3 (figure 1.1) for impact analysis.

2. STUDY REACHES

The study area for impacts on sediment transport due to differences in flow pattern under the Action and the No Action Alternatives are the three reaches of Green River downstream from the Dam. Reach 1 encompasses the main stem of Green River from Flaming Gorge Dam downstream to its confluence with the Yampa River, and Reach 2 encompasses the mainstream of Green River from its confluence with the Yampa River downstream to the confluence with the White River. Reach 3 encompasses the mainstem of Green River from its confluence with the White River downstream to the confluence with the Colorado River. Long term sediment transport quantities, in terms of sand load and total load are determined for these two reaches by using available sediment rating curves and the flows for the Action and the No Action Alternatives.

3. HYDROLOGY

The hydrology of the Green River below Flaming Gorge Dam for the Action and the No Action Alternatives are presented in *Flaming Gorge Draft Environmental Impact Statement Hydrologic Modeling Report* by R. Clayton and A. Gilmore (February 26, 2002) and supplemental hydrology estimates prepared for Reach 3. The hydrologic modeling results presented in the report are used to evaluate the impacts on sediment transport under the two alternatives. The details of the hydrology model are presented in the report. The average monthly flows for Reach 1 for the Action and the No Action Alternatives are shown in figure 3.1 (all figures are located at the end of this appendix) and the average monthly flows for Reach 2 for the two alternatives are shown in figure 3.2. Figure 3.3 contains the average monthly flow estimates for Reach 3 for the two alternatives. These three figures show the differences in monthly flows for the alternatives. The flow values are also presented in tables 1 and 2 for Reach 1, table 3 for Reach 2, and table 4 for Reach 3.

Table1

Average Monthly and Annual Total Load and Flows for Reach 1

22-Jul-02
Green River Reach 1
Comparison of Alternatives
Using Sed. Rating Curve, Qs=0.000047068*Qw^2.009

Month	Action Qw	Action Qs	No Action Qw	No Action Qs	Qw Action - No Action B6-D6	Qs Action - No Action C6-E6	Percent Qw Action - No Action B6/D6	Percent Qs Action - No Action C6/E6	Action Qs (Tons)	No Action Qs(Tons)	Action Qw (ac-ft)	No- Action Qw(ac-ft)
Jan	1237.45	91.25154	1661.07	181.2136	-423.62	-89.96	74.50%	50.36%	2828.798	5617.622	76087.83	102135.2
Feb	1106.75	73.41528	1423.97	142.6705	-317.22	-69.26	77.72%	51.46%	2055.628	3994.775	61465.79	79083.07
Mar	1268.05	93.29734	1479.83	119.0108	-211.78	-25.71	85.69%	78.39%	2892.217	3689.335	77969.23	90990.95
Apr	1902.90	254.6294	2196.61	288.621	-293.71	-33.99	86.63%	88.22%	7638.883	8658.629	113230.4	130707.1
May	3227.16	789.4469	3477.64	763.5541	-250.48	25.89	92.80%	103.39%	24472.85	23670.18	198430.1	213831.7
Jun	3805.55	1100.887	2703.22	659.3657	1102.33	441.52	140.78%	166.96%	33026.61	19780.97	226446	160852.8
Jul	2247.38	416.7469	983.21	57.42264	1264.17	359.32	228.58%	725.75%	12919.15	1780.102	138186	60455.01
Aug	1620.32	142.1238	1236.71	81.59045	383.60	60.53	131.02%	174.19%	4405.836	2529.304	99629.29	76042.36
Sep	1646.83	148.5881	1370.47	98.32665	276.36	50.26	120.17%	151.12%	4457.643	2949.8	97993.19	81548.53
Oct	1479.81	124.4873	1650.36	146.1216	-170.55	-21.63	89.67%	85.19%	3859.107	4529.768	90989.66	101476.5
Nov	1398.20	114.3954	1958.98	243.9822	-560.78	-129.59	71.37%	46.89%	3431.861	7319.466	83198.68	116567.4
Dec	1329.40	105.035	1893.38	231.0781	-563.98	-126.04	70.21%	45.45%	3256.084	7163.422	81741.62	116419.6
Annual Total									105244.7	91683.37	1345368	1330110
May	3227.16	789.4469	3477.64	763.5541	-250.48	25.89	92.80%	103.39%	24472.85	23670.18	198430.1	213831.7
Jun	3805.55	1100.887	2703.22	659.3657	1102.33	441.52	140.78%	166.96%	33026.61	19780.97	226446	160852.8
Jul	2247.38	416.7469	983.21	57.42264	1264.17	359.32	228.58%	725.75%	12919.15	1780.102	138186	60455.01
Summer Total									70418.62	45231.25	563062.1	435139.5

Table2
Average Monthly and Annual Suspended Load and Flows for Reach 1

26-Jul-02
Green River Reach 1
Comparison of Alternatives
Using Sed. Rating Curve, Qs=0.0000002704*Qw^2.5781

Month	Action Qw	Action Qs	No Action Qw	No Action Qs	Qw Action - No Action B6-D6	Qs Action - No Action C6-E6	Percent Qw Action - No Action B6/D6	Percent Qs Action - No Action C6/E6	Action Qs (Tons)	No Action Qs(Tons)	Action Qw (ac-ft)	No- Action Qw(ac-ft)
Jan	1237.45	35.73213	1661.07	89.79638	-423.62	-54.06	74.50%	39.79%	1107.696	2783.688	76087.83	102135.2
Feb	1106.75	27.5201	1423.97	69.9981	-317.22	-42.48	77.72%	39.32%	770.5628	1959.947	61465.79	79083.07
Mar	1268.05	36.19474	1479.83	46.61334	-211.78	-10.42	85.69%	77.65%	1122.037	1445.013	77969.23	90990.95
Apr	1902.90	143.705	2196.61	152.803	-293.71	-9.10	86.63%	94.05%	4311.149	4584.089	113230.4	130707.1
May	3227.16	642.7417	3477.64	561.4013	-250.48	81.34	92.80%	114.49%	19924.99	17403.44	198430.1	213831.7
Jun	3805.55	963.7196	2703.22	536.3671	1102.33	427.35	140.78%	179.68%	28911.59	16091.01	226446	160852.8
Jul	2247.38	298.4767	983.21	21.30011	1264.17	277.18	228.58%	1401.29%	9252.779	660.3034	138186	60455.01
Aug	1620.32	58.53207	1236.71	28.90967	383.60	29.62	131.02%	202.47%	1814.494	896.1998	99629.29	76042.36
Sep	1646.83	62.50678	1370.47	35.90564	276.36	26.60	120.17%	174.09%	1875.203	1077.169	97993.19	81548.53
Oct	1479.81	50.92449	1650.36	60.32419	-170.55	-9.40	89.67%	84.42%	1578.659	1870.05	90989.66	101476.5
Nov	1398.20	46.60669	1958.98	127.7456	-560.78	-81.14	71.37%	36.48%	1398.201	3832.367	83198.68	116567.4
Dec	1329.40	42.38784	1893.38	120.3333	-563.98	-77.95	70.21%	35.23%	1314.023	3730.333	81741.62	116419.6
Annual Total									73381.38	56333.61	1345368	1330110
May	3227.16	642.7417	3477.64	561.4013	-250.48	81.34	92.80%	114.49%	19924.99	17403.44	198430.1	213831.7
Jun	3805.55	963.7196	2703.22	536.3671	1102.33	427.35	140.78%	179.68%	28911.59	16091.01	226446	160852.8
Jul	2247.38	298.4767	983.21	21.30011	1264.17	277.18	228.58%	1401.29%	9252.779	660.3034	138186	60455.01
Summer Total									58089.36	34154.76	563062.1	435139.5

Table 3
Average Monthly and Annual Sand Load and Flows for Reach 2

5-Sep-03
Green River Reach 2
Comparison of Alternatives
Using Sed. Rating Curve, Qs=0.0000204*(Qw)^2.16 (Sand Load)

Month	Action Qw	Action Qs	No Action Qw	No Action Qs	Qw Action - No Action	Qs Action - - No Action	Percent Qw Action - No Action	Percent Qs Action - No Action	Action Qs (Tons)	No Action Qs(Tons)	Action Qw (ac-ft)	No- Action Qw(ac-ft)
		(Tons/day)		(Tons/day)	B6-D6	C6-E6	B6/D6	C6/E6				
Jan	1600.26	202.0075	2078.81	393.78564	-478.55	-191.78	76.98%	51.30%	6262.233	12207.35	98396.14	127821.2
Feb	1565.57	192.3703	1871.683	318.18166	-306.11	-125.81	83.65%	60.46%	5386.367	8909.086	86947.54	103948
Mar	2303.39	468.0288	2498.78	522.01375	-195.39	-53.98	92.18%	89.66%	14508.89	16182.43	141630.2	153644.3
Apr	5583.25	3462.457	5931.27	3737.021	-348.03	-274.56	94.13%	92.65%	103873.7	112110.6	332226.2	352935.2
May	12099.85	17185.09	12413.10	17693.026	-313.25	-507.93	97.48%	97.13%	532737.9	548483.8	743990.8	763251.5
Jun	11547.95	16068.19	10329.70	13242.874	1218.25	2825.32	111.79%	121.33%	482045.8	397286.2	687150.8	614659.6
Jul	3928.9424	2084.568	2636.43	827.90293	1292.51	1256.66	149.03%	251.79%	64621.6	25664.99	241581.3	162107.7
Aug	2081.61	339.8265	1697.02	216.88671	384.59	122.94	122.66%	156.68%	10534.62	6723.488	127993.3	104345.9
Sep	1944.14	294.1442	1645.227	194.82317	298.92	99.32	118.17%	150.98%	8824.327	5844.695	115684.6	97897.8
Oct	1933.23	291.4628	2109.61	334.42373	-176.38	-42.96	91.64%	87.15%	9035.346	10367.14	118869.5	129714.8
Nov	1854.49	268.0437	2404.08	504.55128	-549.59	-236.51	77.14%	53.13%	8041.31	15136.54	110349.8	143052.6
Dec	1730.25	237.8592	2296.61	469.55755	-566.36	-231.70	75.34%	50.66%	7373.636	14556.28	106388.9	141213.2
Annual Total									1253246	1173473	2911209	2894592
May	12099.85	17185.09	12413.10	17693.026	-313.25	-507.93	97.48%	97.13%	532737.9	548483.8	743990.8	763251.5
Jun	11547.95	16068.19	10329.70	13242.874	1218.25	2825.32	111.79%	121.33%	482045.8	397286.2	687150.8	614659.6
Jul	3928.9424	2084.568	2636.43	827.90293	1292.51	1256.66	149.03%	251.79%	64621.6	25664.99	241581.3	162107.7
Summer Total									1079405	971435	1672723	1540019

Table 4
Average Monthly and Annual Sand Load and Flows for Reach 3

20-Aug-03
Green River Reach 3
Comparison of Alternatives
Using Sed. Rating Curve, Qs=0.00(

Month	Action Qw	Action Qs	No Action Qw	No Action Qs	Qw Action - No Action B6-D6	Qs Action - No Action C6-E6	Percent Qw Action - No Action B6/D6	Percent Qs Action - No Action C6/E6	Action Qs (Tons)	No Action Qs(Tons)
Jan	2347	166	2841	319	-494.50	-153.03	82.60%	52.09%	5156.914	9900.859
Feb	2682	453	3032	614	-349.11	-161.42	88.48%	73.72%	12679.46	17199.3
Mar	3951	1286	4193	1427	-241.15	-141.53	94.25%	90.08%	39861.34	44248.89
Apr	6405	4708	6647	4806	-242.59	-97.25	96.35%	97.98%	141252.1	144169.5
May	13882	41336	14292	41491	-410.02	-154.56	97.13%	99.63%	1281430	1286221
Jun	16201	59368	15189	52639	1012.41	6729.00	106.67%	112.78%	1781051	1579181
Jul	5842	6161	4522	3314	1320.14	2846.84	129.19%	185.91%	190979.9	102727.8
Aug	3030	469	2638	342	391.33	127.50	114.83%	137.29%	14551.24	10598.8
Sep	2824	396	2523	309	300.53	87.65	111.91%	128.39%	11890.99	9261.445
Oct	2992	390	3101	409	-109.10	-18.43	96.48%	95.49%	12096.56	12667.95
Nov	2879	312	3411	539	-532.59	-227.37	84.39%	57.82%	9349.808	16170.78
Dec	2490	211	3079	421	-589.33	-209.80	80.86%	50.14%	6541.229	13044.93
Annual Total									3506840	3245392
May	13882	41336	14292	41491	-410.02	-154.56	97.13%	99.63%	1281430	1286221
Jun	16201	59368	15189	52639	1012.41	6729.00	106.67%	112.78%	1781051	1579181
Jul	5842	6161	4522	3314	1320.14	2846.84	129.19%	185.91%	190979.9	102727.8
Summer Total									3253460	2968130

4. SEDIMENT TRANSPORT ANALYSIS

The change of streamflow pattern from the No Action Alternative to the Action Alternative has impacts on the quantity of sediment transported by the Green River. The magnitude of the difference in sediment transport for the two alternatives was determined using flow duration data for each month of the year and available sediment rating curves for the three reaches of the river for each alternative.

The flow duration curves for Reach 1 are presented in figure 4.1 through 4.12, and the flow-duration curves for Reach 2 are presented in figures 4.13 through 4.24. The flow duration curves are based on daily flows presented in the hydrologic modeling report by Clayton and Gilmore (February 2002). Flow duration for Reach 3 is patterned after the modeled results for Reach 2 and historic tributary inputs in Reach 3.

Four sediment rating curves, two for Reach 1, one for Reach 2, and one for Reach 3, are used to quantify the impacts on sediment transport due to change in flow pattern in the river. Between the two rating curves for Reach 1, one is for determining total load transport and one is for suspended load transport. The one sediment rating curves for Reach 2 is for sand load transport only. The one sediment rating curve for Reach 3 is for sand load transport only.

The sediment rating curves are as follows:

Reach 1:

a) Total load rating curve by Martin et al. (1998)

$$Qs = 4.707\times10^{-5}\,Q^{2.01}$$

b) Suspended load rating curve by Martin et al. (1998)

$$Qsb = 2.704\times10^{-7}\,Q^{2.58}$$

Where Qs = total load, tons/day

Qsb = suspended load, tons/day

Q = water discharge, cfs

Reach 2:

Sand load rating curve by Andrews (1986) for USGS gauge Jensen, UT

$$Qsl = 2.04\times10^{-5}\,Q^{2.16}$$

Where Qsl = sand load, tons/day

Q = water discharge, cfs

Reach 3:

Sand load rating curve by Andrews (1986) for USGS gauge Green River, UT

$$Qsl = 2.06\times10^{-8}\,Q^{2.90}$$

Where Qsl = sand load, tons/day

Q = water discharge, cfs

The above sediment rating curves and the flow-duration curves presented in figures 4.1 through 4.24 are used in computing the sediment transport quantities for each month by utilizing the method presented in Table 2 of Strand and Pemberton (1982).

4.1 Sediment Transport Quantities for Reach 1

The total load transport quantities determined by the total load rating curve for the reach are shown in figure 4.1.1. Figure 4.1.1 shows the month-by-month total load transported by using the rating curve presented in Martin et al. (1998). The greatest difference in total load transport between the alternatives occurs in the month of July in which total load transported in the Action Alternative is more than seven times the No Action Alternative. The smallest difference in total load transport between the two alternatives is in the month of May when total load transported in Action Alternative is about 103 percent of the total load transported in the No Action Alternative.

During the peak runoff season, May through July, the Action Alternative transported about 70,000 tons of total load compared to nearly 45,000 tons transported by the No Action Alternative (a difference of 55 percent). The flow volume during the peak runoff season was about 536,000 acre-feet under the Action Alternative and about 435,000 acre-feet under the No Action Alternative (a difference of 23 percent).

On an annual basis total load transport in reach 1 is nearly same under both of the alternatives. The annual total load transported in the Action Alternative is about 105,000 tons compared to 92,000 tons transported in the No Action Alternative. This annual difference is about 14 percent. The annual modeled flow volumes were about 1,345,000 acre-feet under the Action Alternative and about 1,330,000 acre-feet under the No Action Alternative. This difference in modeled flow volumes in Reach 1 is about 1 percent. The month by month and the annual quantities of total load transported under the two alternatives and the flow values are shown in table 1.

Martin et al. (1998) also presented a suspended load rating curve for Reach 1. Their suspended load rating curve was used to compare suspended load transport quantities under the two alternatives in Reach 1. The monthly suspended loads computed by using Martin et al. (1998) rating curve is presented in figure 4.1.2. The greatest difference in suspended load transport between the two alternatives was similar to the differences noted for total load transport (figure 4.1.1). During July, suspended load transported in the Action Alternative was 14 times greater than the No Action Alternative. The smallest difference in the transport of suspended load between alternatives occurs in April when flows under the No Action Alternative carried only 6 percent more suspended load than flows under the Action Alternative.

On an annual basis, the Action Alternative carried about 73,000 tons of suspended load compared to roughly 56,000 tons carried by the No Action Alternative, a difference of about 30 percent. The monthly suspended loads along with the annual total suspended load for Reach 1 are presented in Table 2.

4.2 Sediment Transport Quantities for Reach 2

The sand load transport quantities determined for Reach 2 are shown in figure 4.2.1. Figure 4.2.1 shows the month-to-month sand load transport quantities determined by the sand load rating curve by Andrews (1986). The greatest difference in sand load transport between the two alternatives is in the month of July. The Action Alternative carried about 2.5 times more sand load than the No Action Alterative during July. The smallest difference in sand load transport occurs during April, in which the No Action Alternative transported 7 percent more sand load than the Action Alternative.

During the peak runoff season, May through July, the Action Alternative transported about 1,079,000 tons of suspended load compared to roughly 971,000 tons transported by the No Action Alternative, a difference of about 11 percent. The flow volume during the peak runoff season was nearly 1,673,000 acre-feet under the Action Alternative and about 1,540,000 acre-feet under the No Action Alternative, a difference of nearly 9 percent.

On an annual basis the difference in sand load transport between the two alternatives is small. The Action Alternative carried about 1,253,000 tons compared to roughly 1,173,000 tons carried by the No Action Alternative, a difference of about 7 percent. The modeled annual flow volumes were about 2,911,000 acre-feet under the Action Alternative and nearly 2,895,000 acre-feet under the No Action Alternative; a difference of less than one percent. The monthly and annual sand loads for Reach 2 along with the flow values are presented in Table 3.

4.3 Sediment Transport Quantities for Reach 3

The monthly sand load transport quantities determined for Reach 3 are shown in figure 4.3.1. These month by month sand load estimates were determined using the sand load rating curve for Green River at Green River, Utah USGS gauge. Flow information for Reach 3 was estimated from the Flaming Gorge Model (described in the Hydrology Appendix) results for Reach 2 and estimated tributary inflows within Reach 3.

5. CONCLUSIONS

Flow-duration comparisons for May, June and July show that flows greater than power plant capacity (4,600 cfs) occur more frequently under Action Alternative conditions than under No Action Alternative conditions. Martin et al. (1998) documented increased active channel area in reach 1 following a series of special research flow releases greater than 4,600 cfs from Flaming Gorge dam. The maximum mean daily release from Flaming Gorge during this period was 8,420 cfs.

The sediment transport quantities for Reach 1, whether considering suspended load or total load show variation between the Action and the No Action Alternatives on a month-to-month basis. This variation is greatest during the summer month of July. There is difference in monthly total load transport for the two alternatives. Relative to conditions under the No Action Alternative, implementing the Action Alternative will likely result in some additional channel deposition and erosion in the reach during May through September. Additional channel deposition in the reach is likely during October through April under the Action Alternative in comparison to the No Action Alternative. On an annual basis, sediment transport in reach 1 will be slightly greater under the Action Alternative relative to the No Action Alternative. The net result of greater frequency of flows in excess of 4,600 cfs and increased sediment transport associated with these higher flows will be greater active channel area under the Action Alternative relative to conditions under the No Action Alternative.

For Reach 2, there are some differences in monthly sand load discharge between the two alternatives although on an annual basis the difference is small. No total load rating curve is available for Reach 2. Assuming sand load transport to be proportional to total load, sediment deposition will likely occur from October through May in Reach 2 under Action Alternative conditions relative to the conditions under the No Action Alternative. From June through September, sediment will tend to be removed from Reach 2 under the Action Alternative relative to the No Action Alternative. However, on an annual basis, the difference in sediment transport between Alternatives will most likely be small in Reach 2.

For Reach 3, the trends in sand load transport are likely to be similar to those discussed for Reach 2. Annual differences in sediment transport in Reach 3 under the two Alternatives will likely be small.

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Figure 3.1
Green River Reach 1: Average Monthly Flows

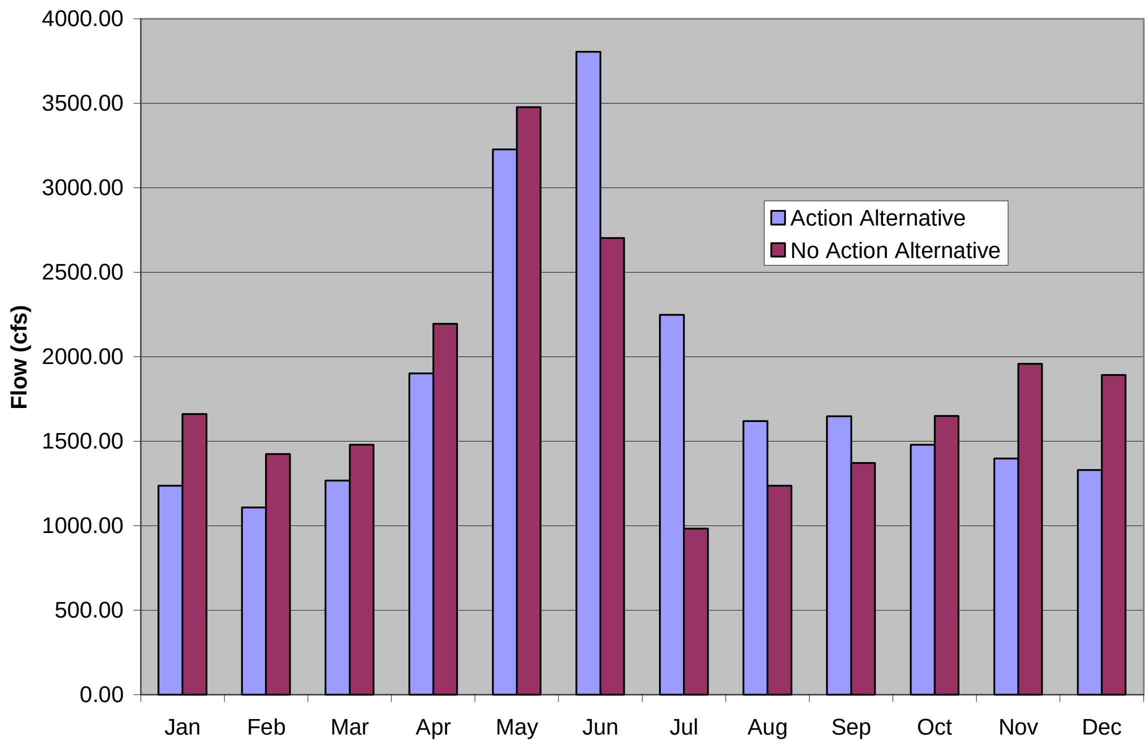


Figure 3.2
Green River Reach 2: Average Monthly Flows

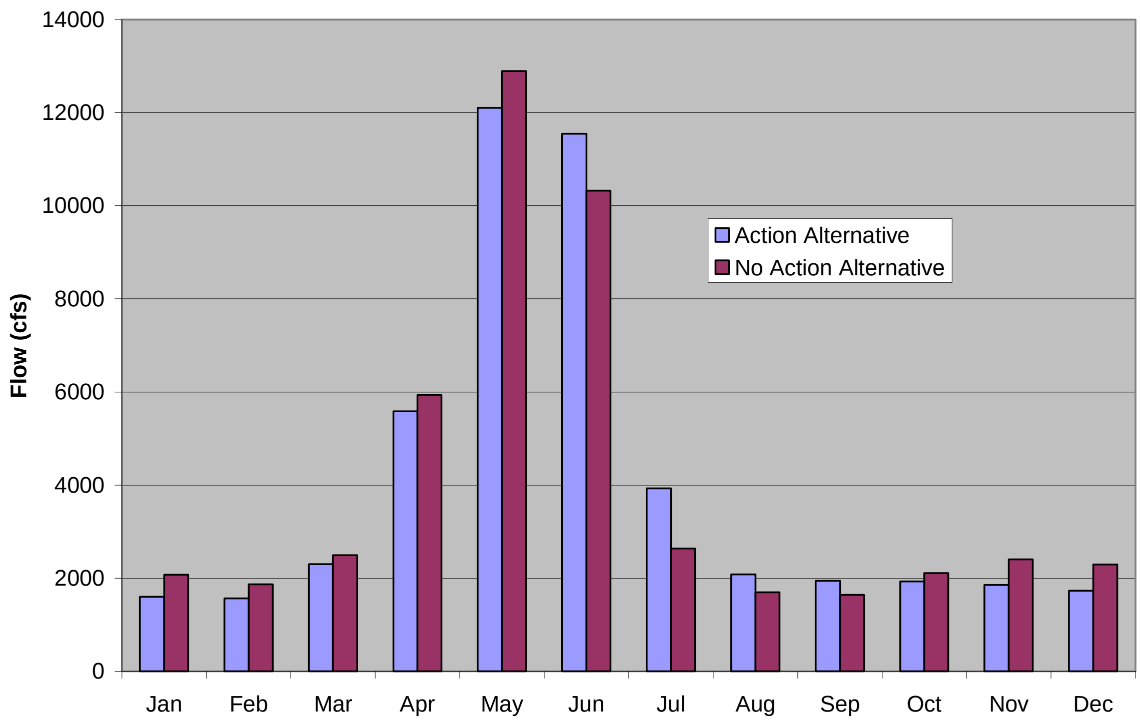


Figure 3.3
Green River Reach 3: Average Monthly Flows

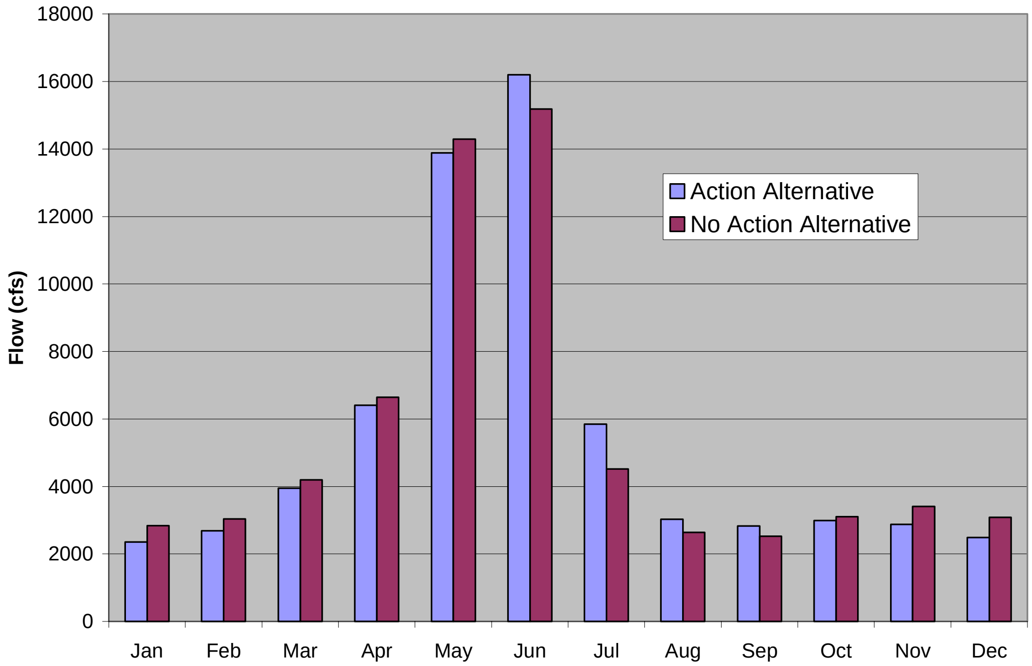


Figure 4.1:Reach One Flows in January

Modelled vs. Historic

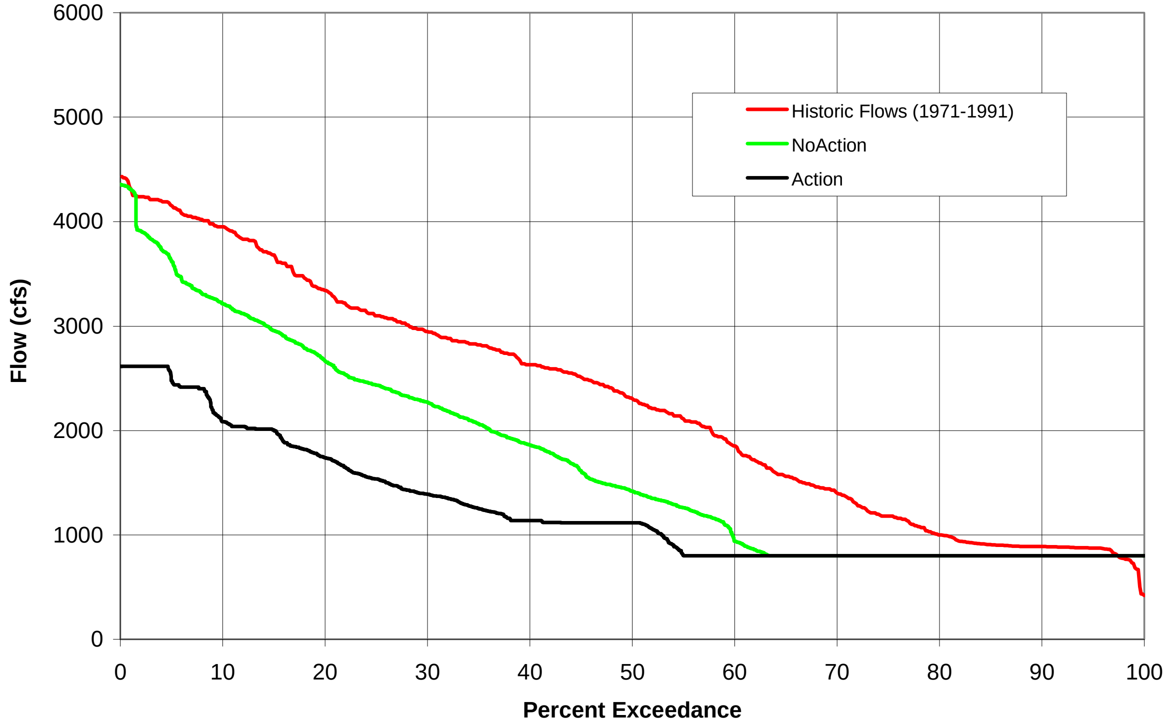


Figure 4.2: Reach One Flows in February

Modelled vs. Historic

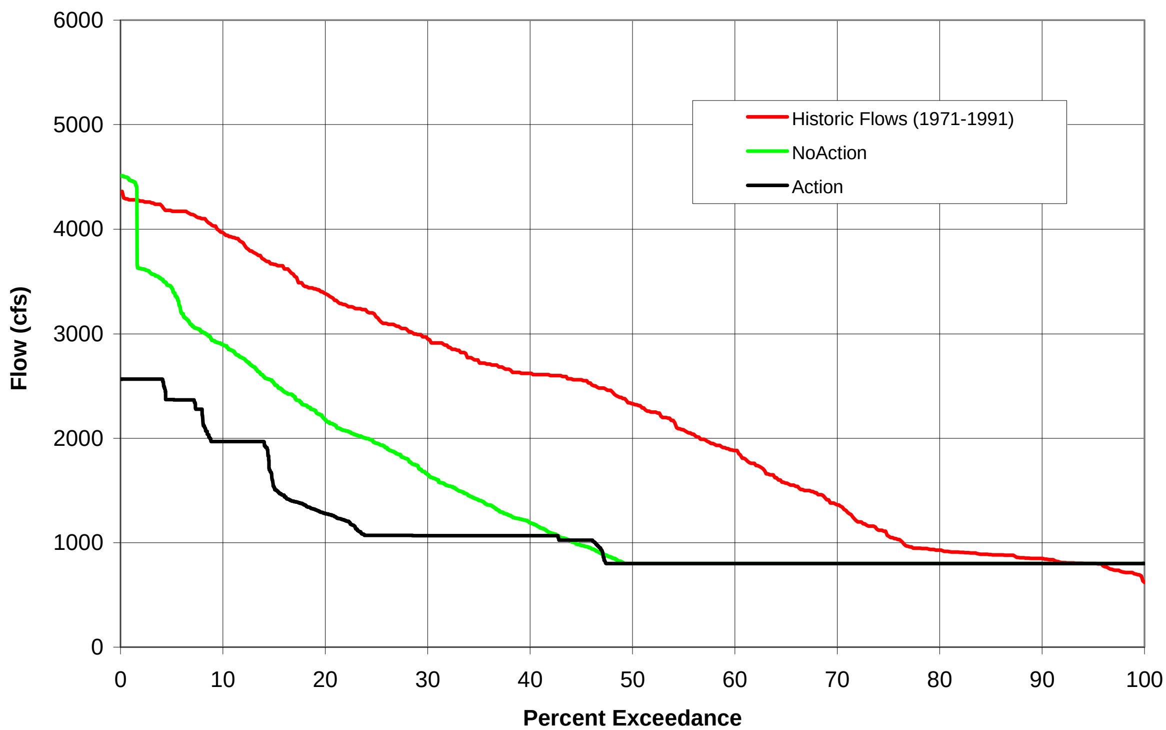


Figure 4.3: Reach One Flows in March

Modelled vs. Historic

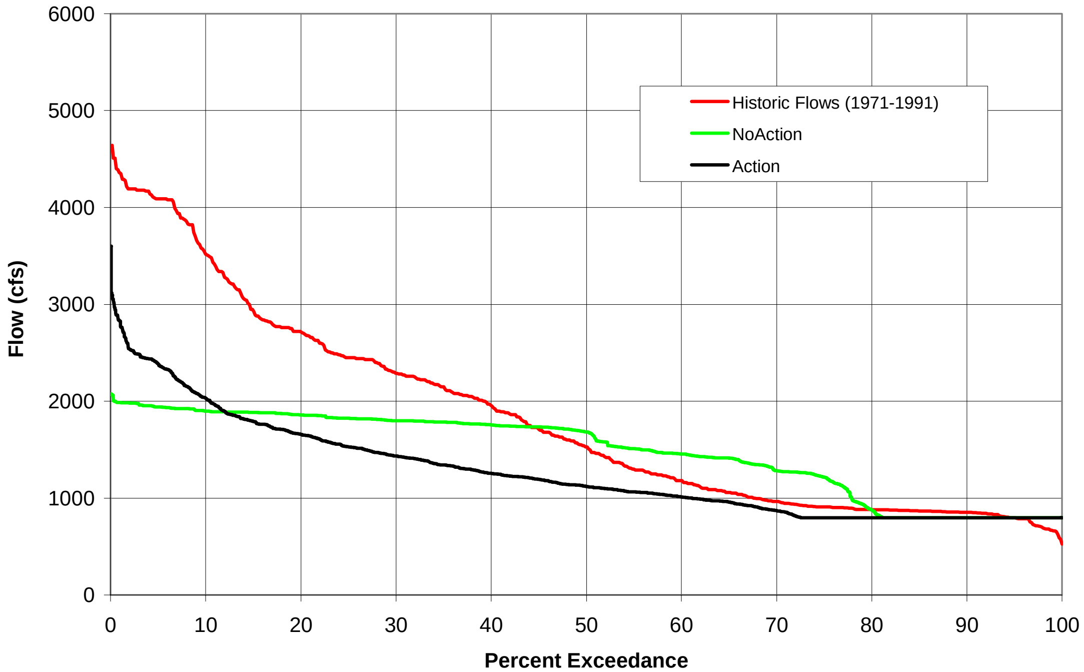


Figure 4.4: Reach One Flows in April

Modelled vs. Historic

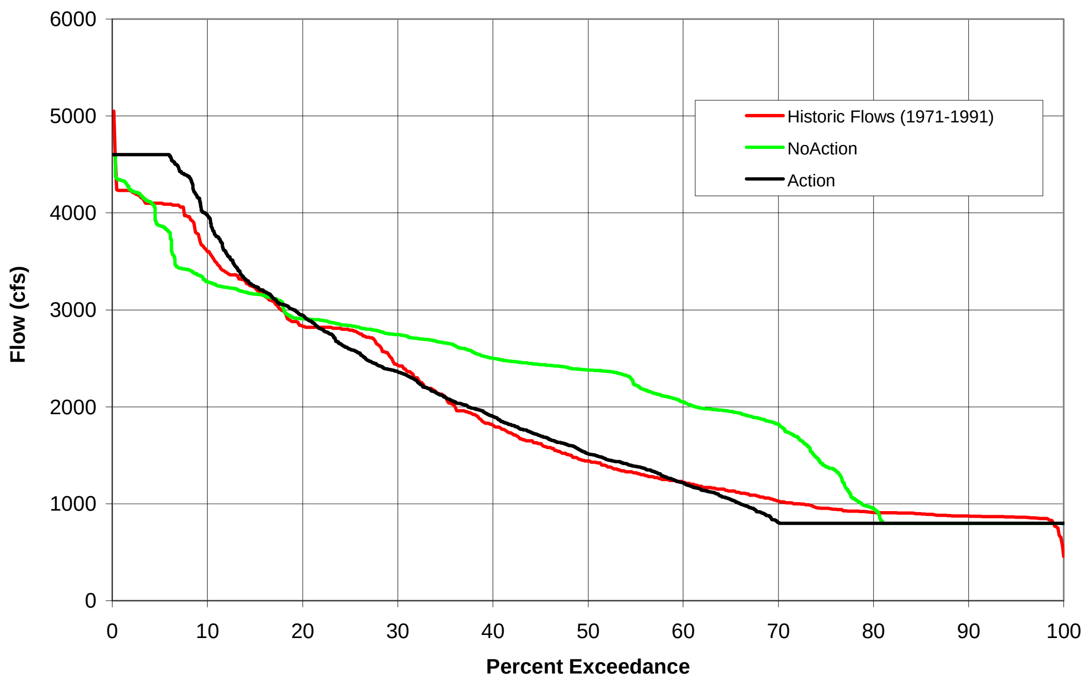


Figure 4.5: Reach One Flows in May

Modelled vs. Historic

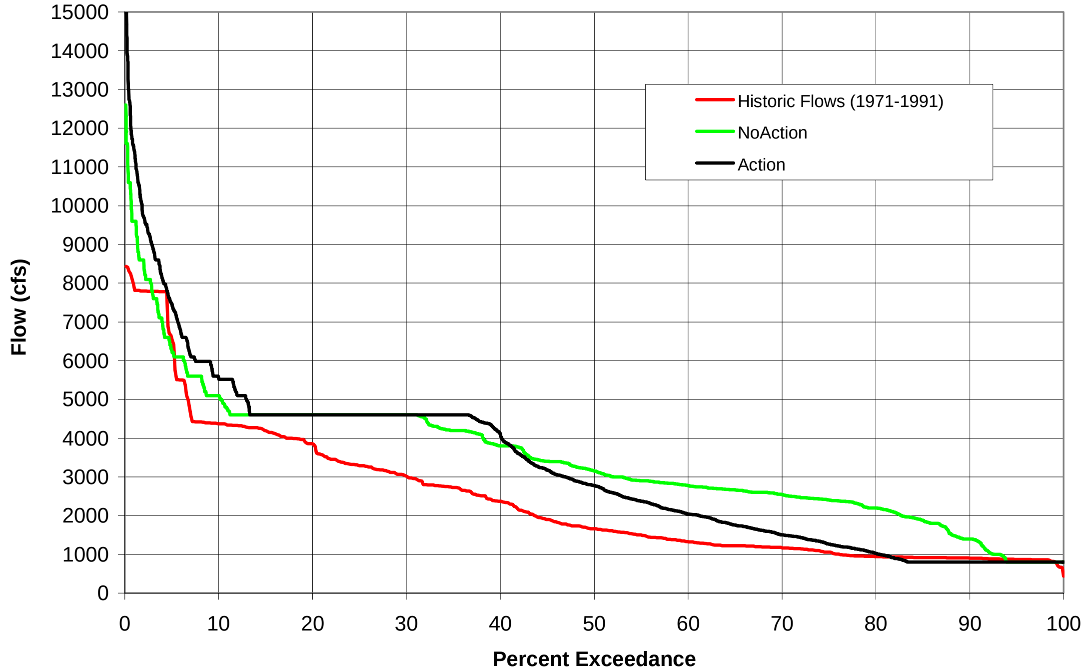


Figure 4.6: Reach One Flows in June

Modelled vs. Historic

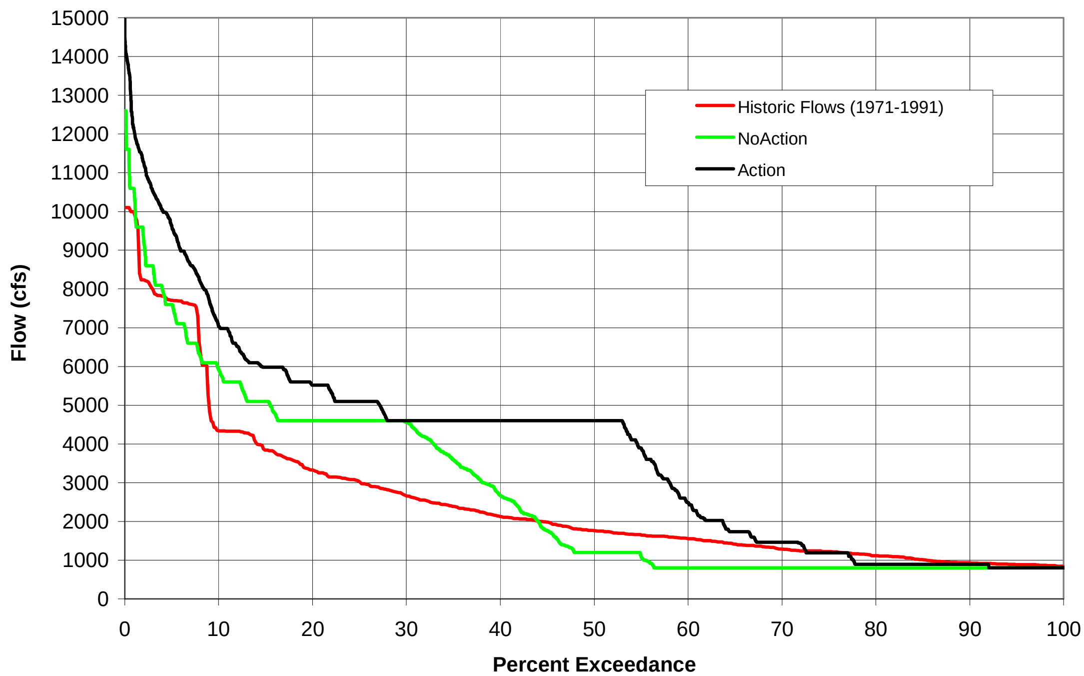


Figure 4.7: Reach One Flows in July

Modelled vs. Historic

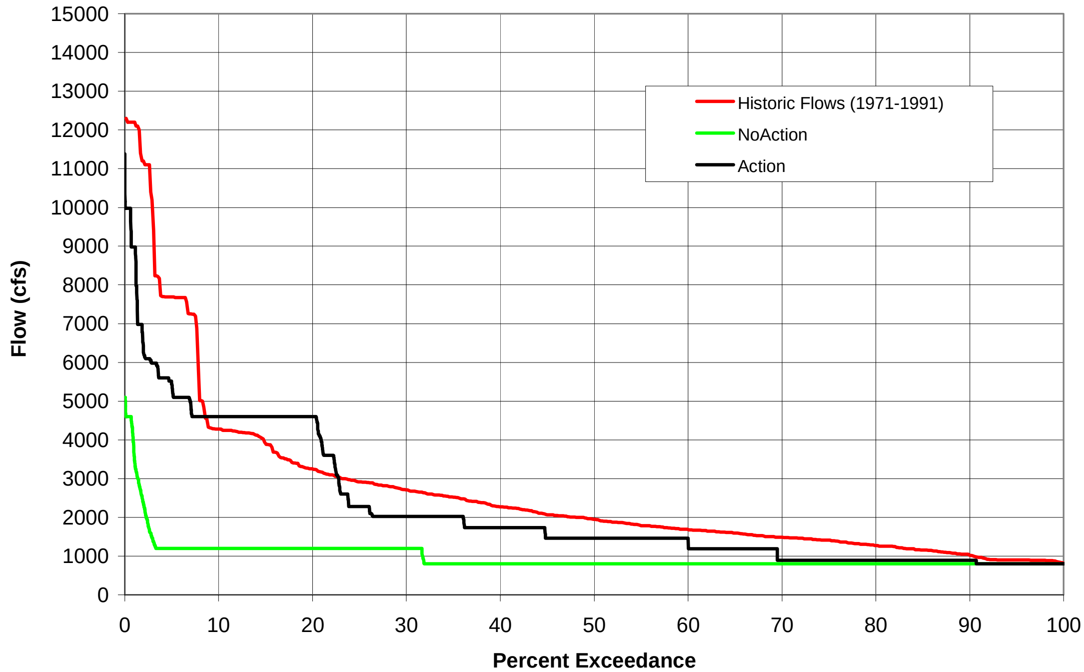
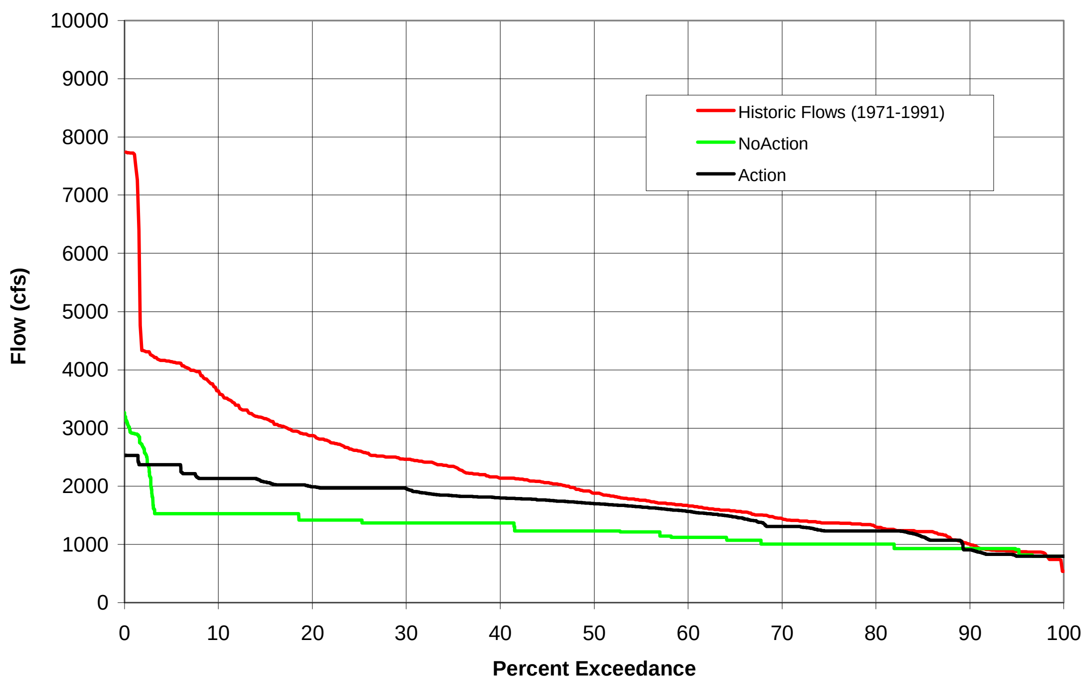


Figure 4.8: Reach One Flows in August

Modelled vs. Historic



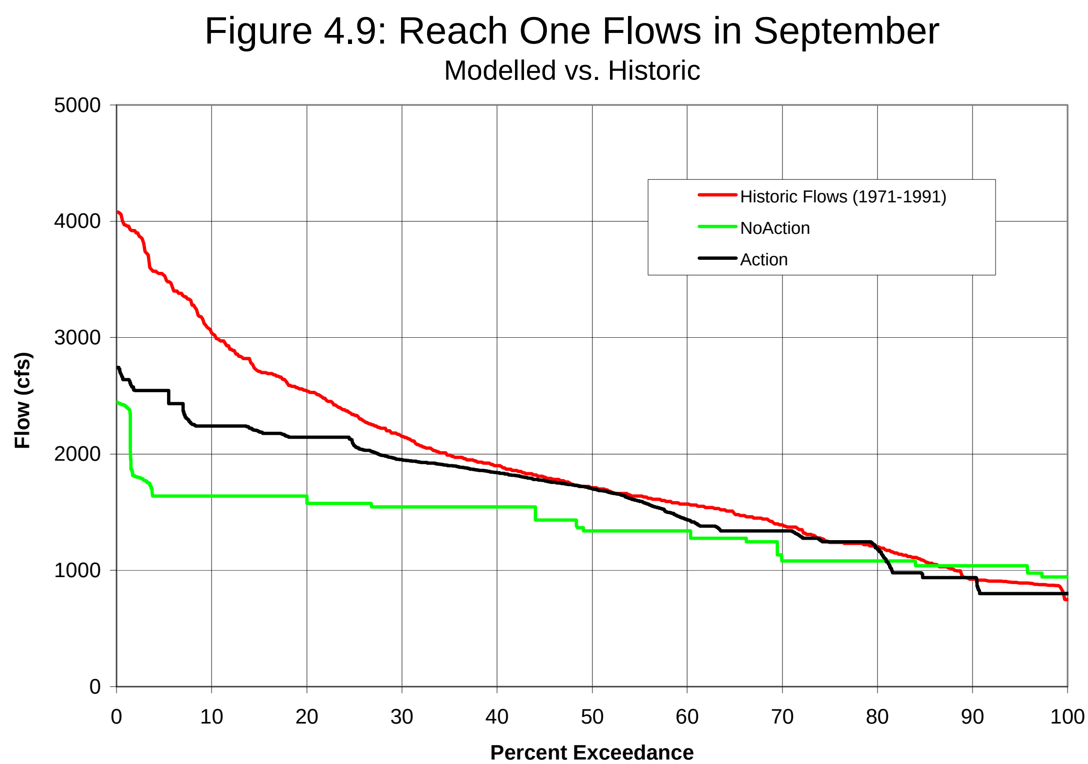


Figure 4.9: Reach One Flows in September
Modelled vs. Historic
Flow (cfs)
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Percent Exceedance
Historic Flows (1971-1991)
NoAction
Action

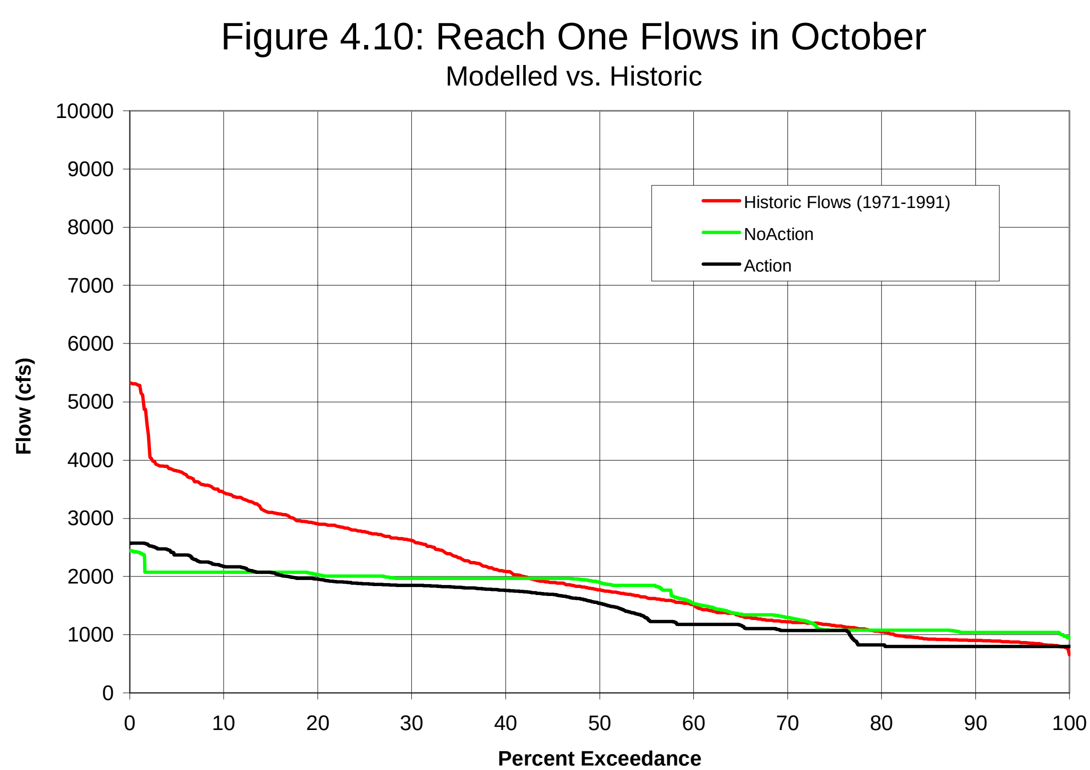


Figure 4.10: Reach One Flows in October
Modelled vs. Historic
Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Percent Exceedance
Historic Flows (1971-1991)
NoAction
Action

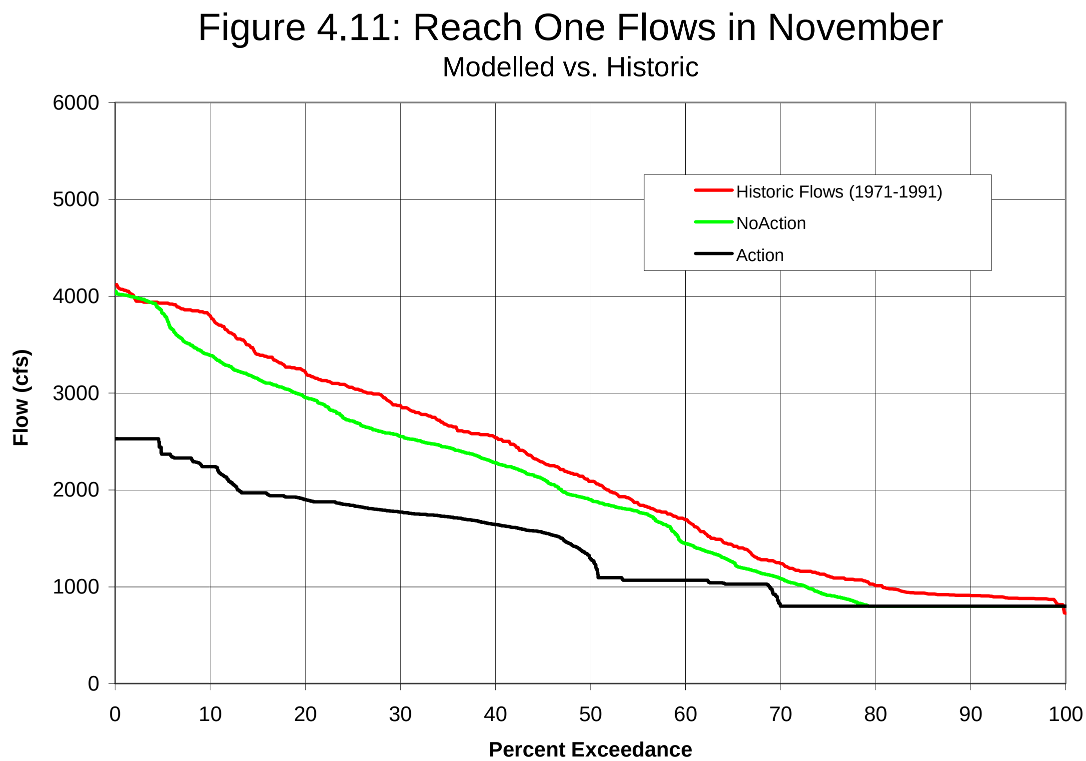


Figure 4.11: Reach One Flows in November
Modelled vs. Historic
Flow (cfs)
Percent Exceedance
Historic Flows (1971-1991)
NoAction
Action
0
1000
2000
3000
4000
5000
6000
0
10
20
30
40
50
60
70
80
90
100

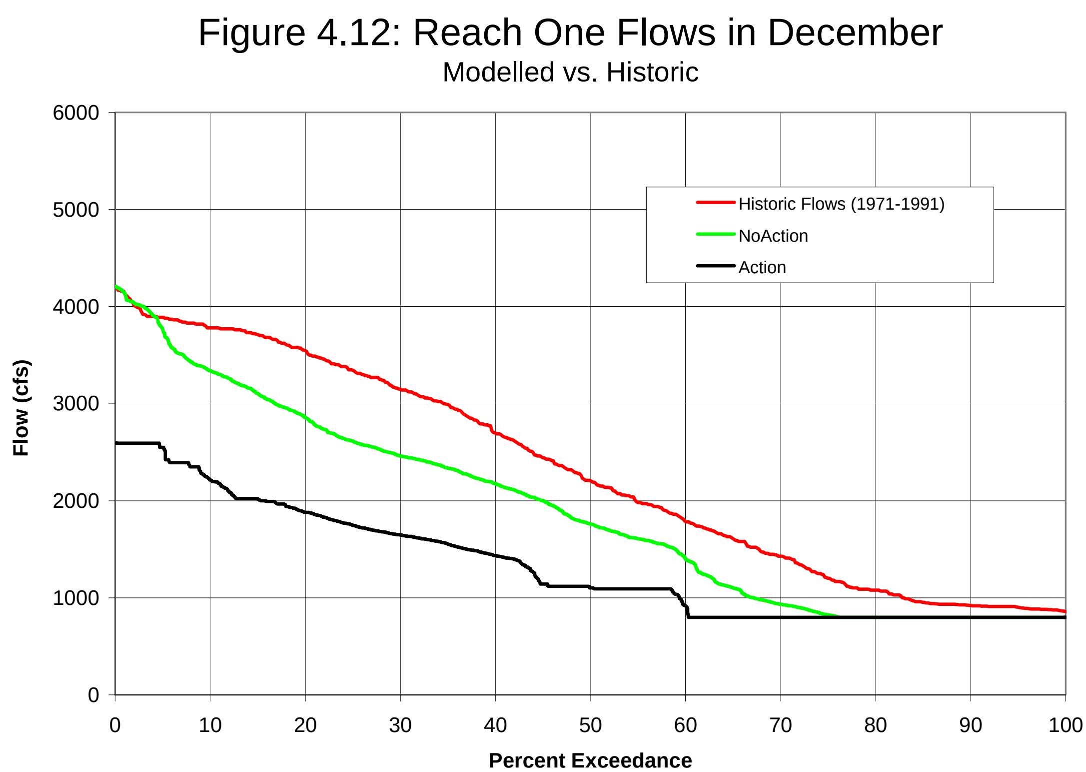


Figure 4.12: Reach One Flows in December
Modelled vs. Historic
Flow (cfs)
Percent Exceedance
Historic Flows (1971-1991)
NoAction
Action
0
1000
2000
3000
4000
5000
6000
0
10
20
30
40
50
60
70
80
90
100

Figure 4.13: Reach Two Flows in January

Modelled vs. Historic

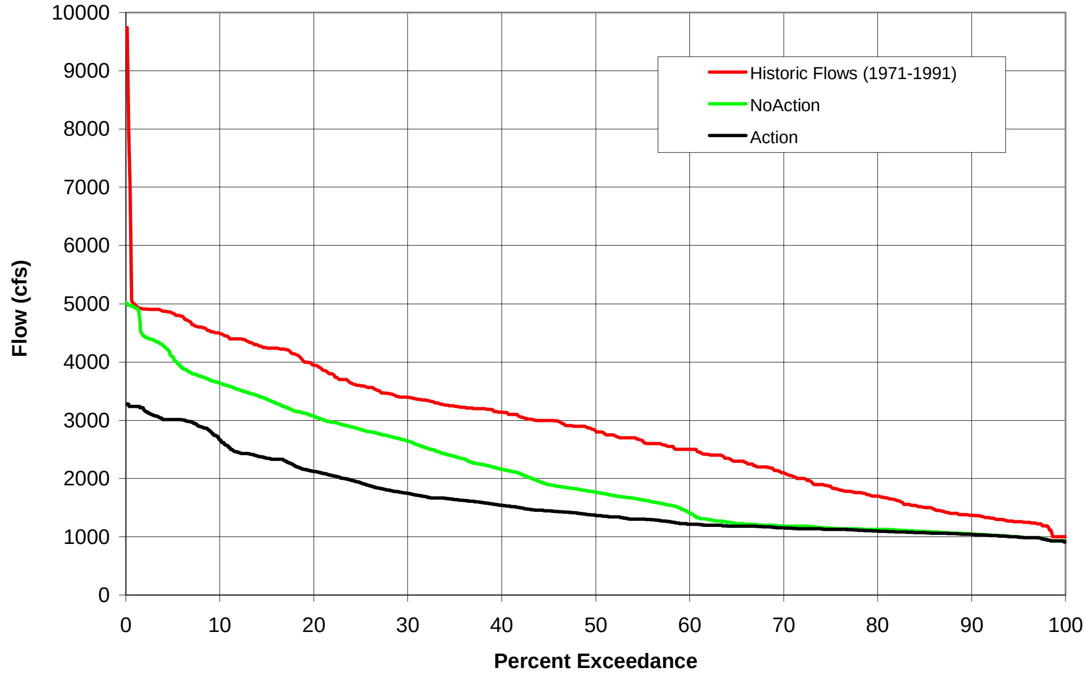


Figure 4.14: Reach Two Flows in February

Modelled vs. Historic

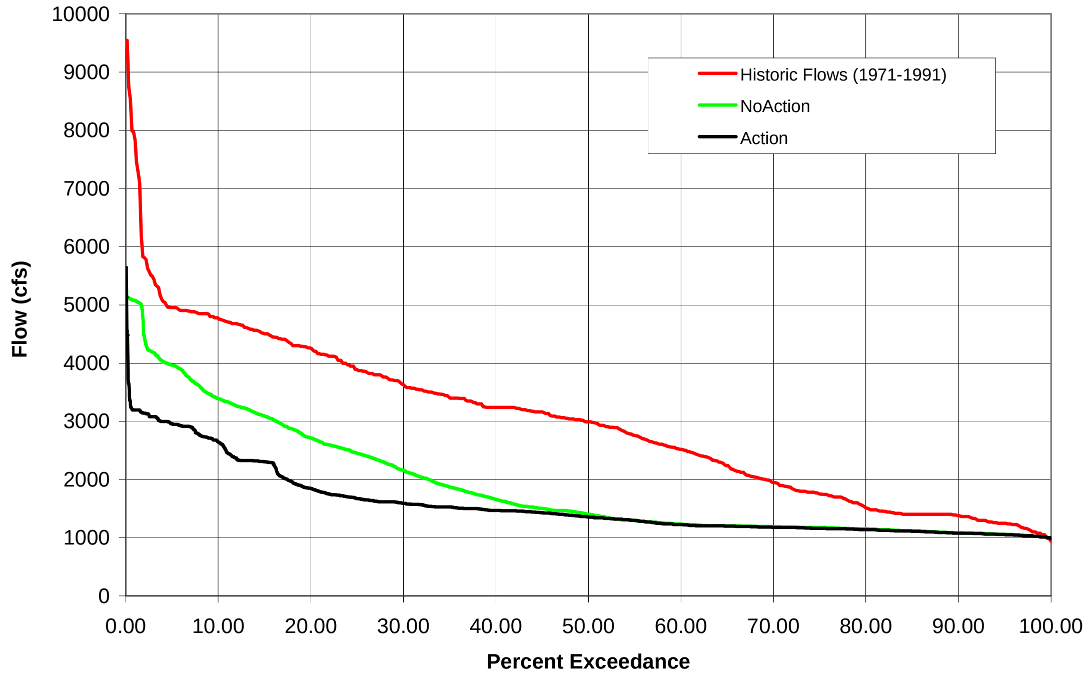


Figure 4.15: Reach Two Flows in March

Modelled vs. Historic

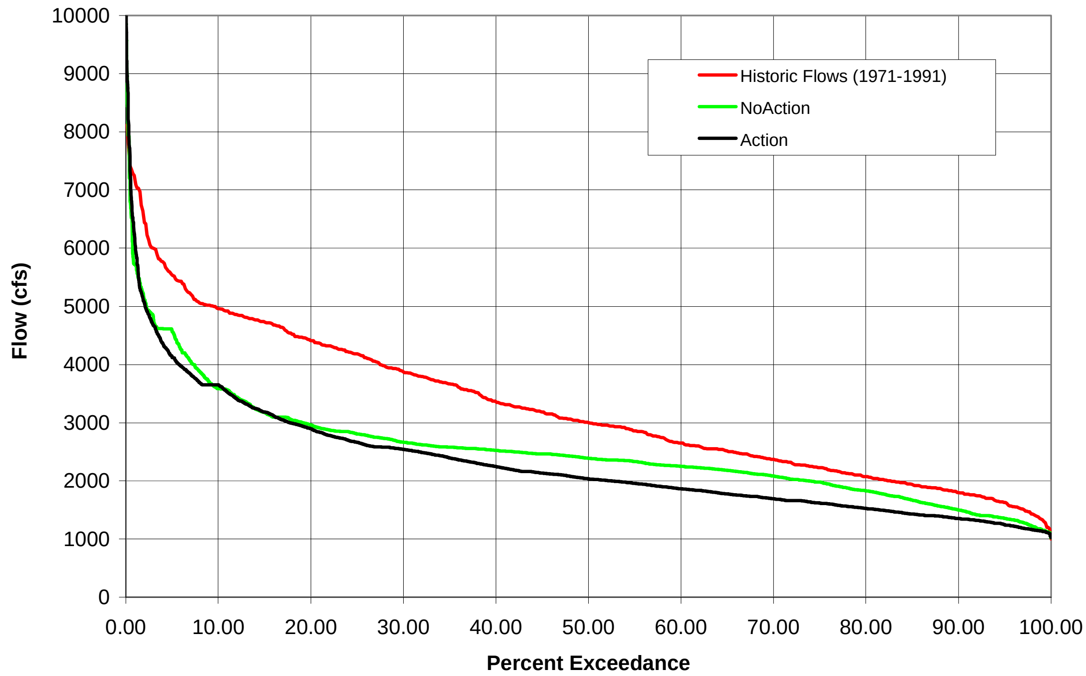


Figure 4.16: Reach Two Flows in April

Modelled vs. Historic

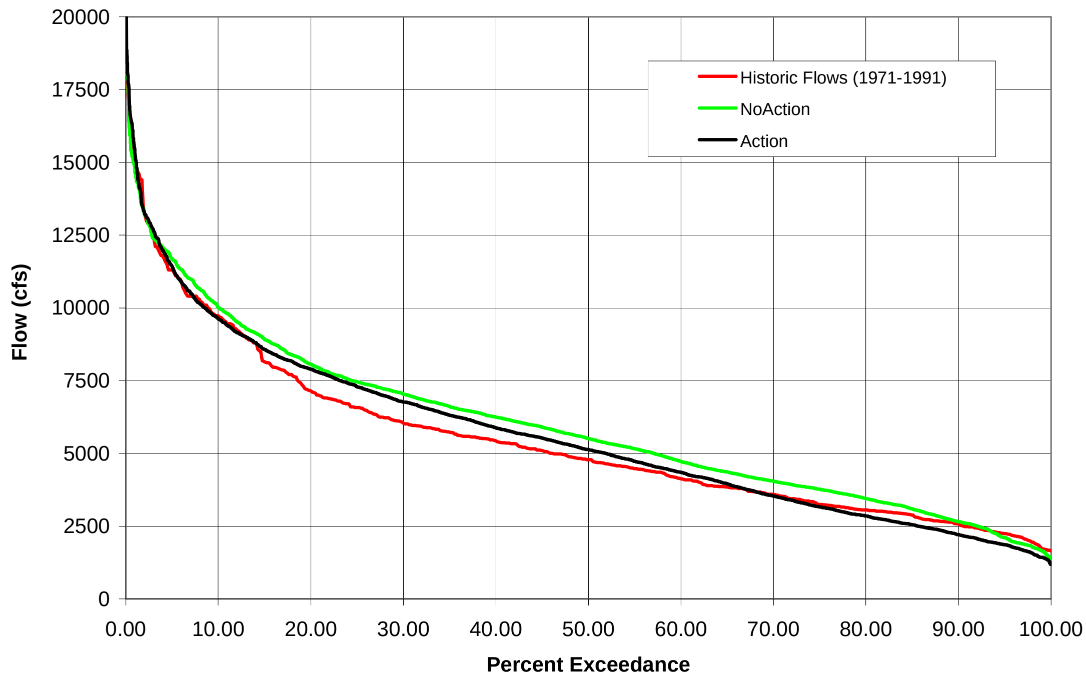


Figure 4.17:Reach Two Flows in May

Modelled vs. Historic

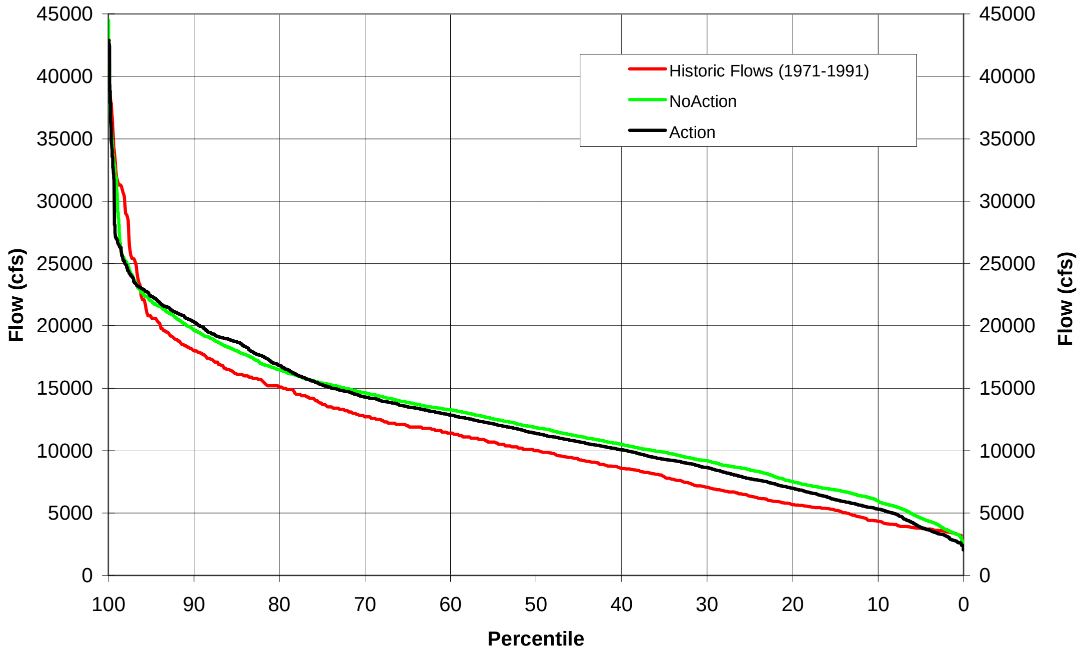
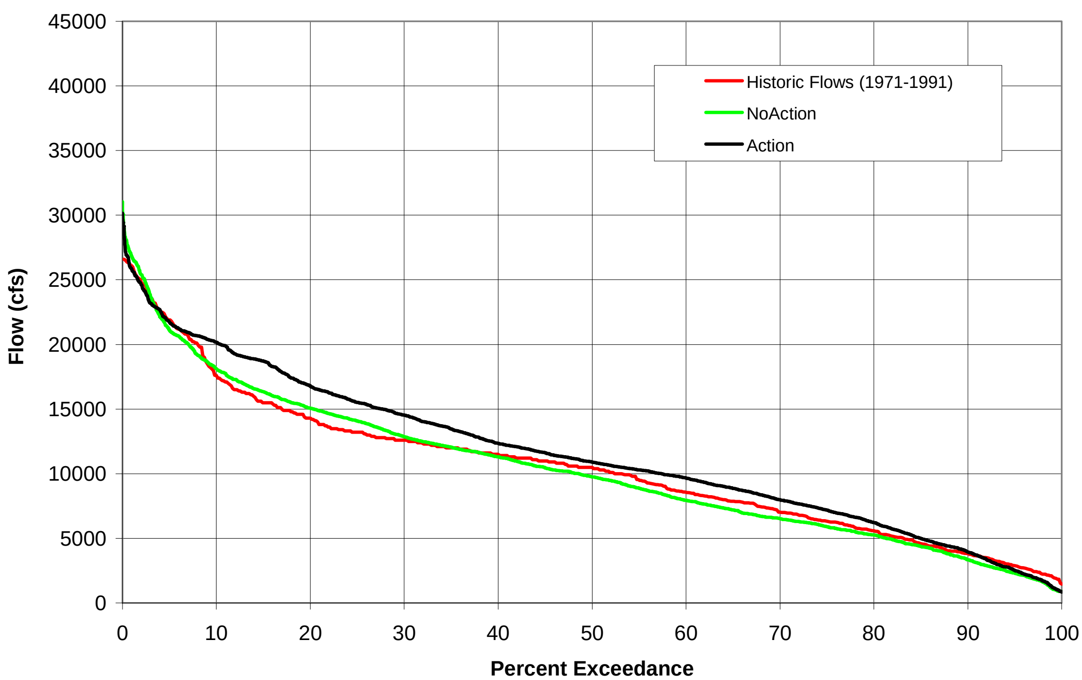


Figure 4.18: Reach Two Flows in June

Modelled vs. Historic



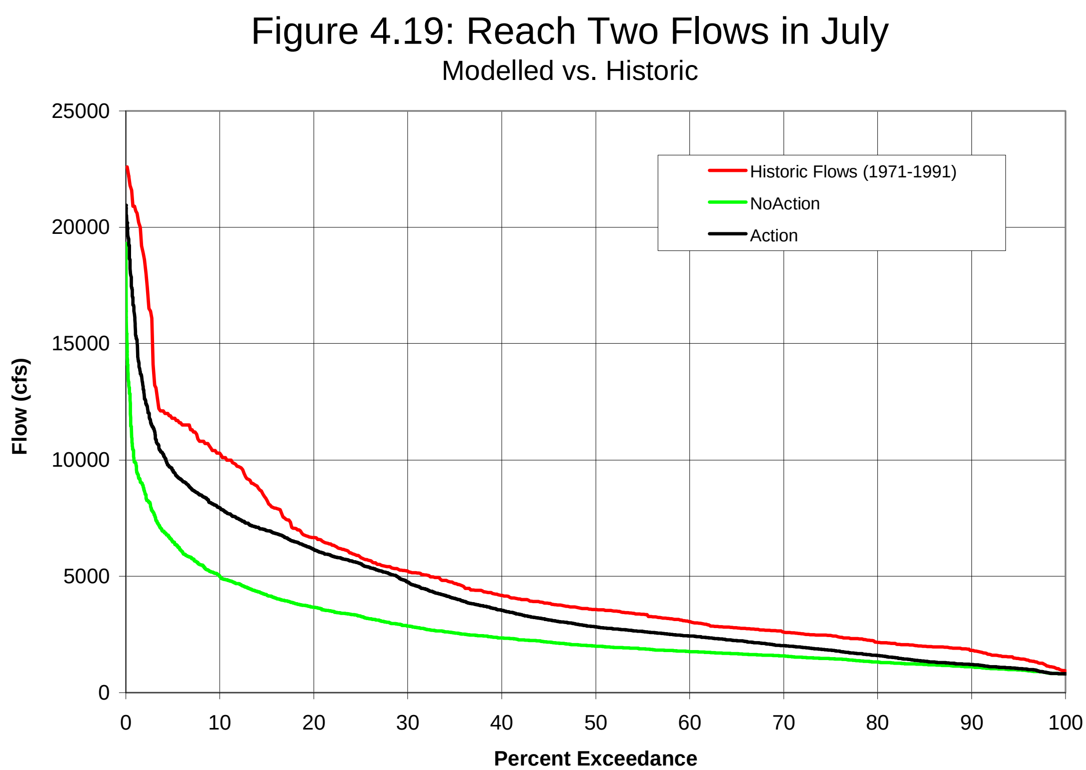


Figure 4.19: Reach Two Flows in July
Modelled vs. Historic
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Flow (cfs)
Percent Exceedance
Historic Flows (1971-1991)
NoAction
Action

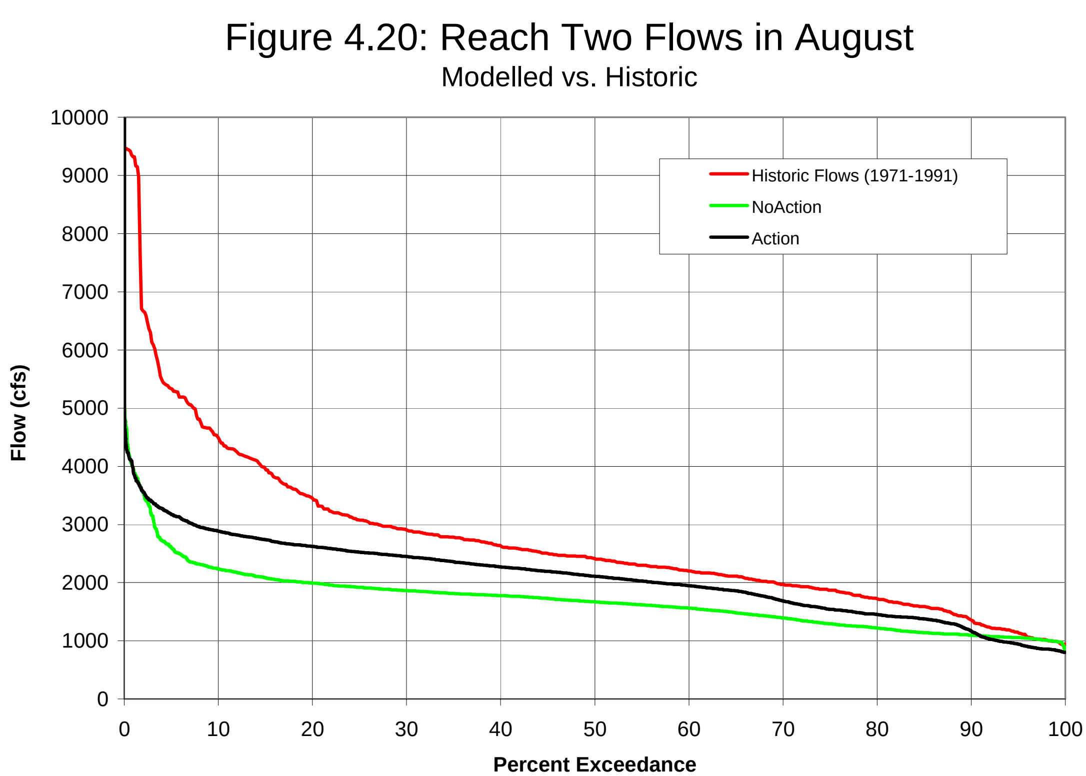


Figure 4.20: Reach Two Flows in August
Modelled vs. Historic
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Flow (cfs)
Percent Exceedance
Historic Flows (1971-1991)
NoAction
Action

Figure 4.21: Reach Two Flows in September

Modelled vs. Historic

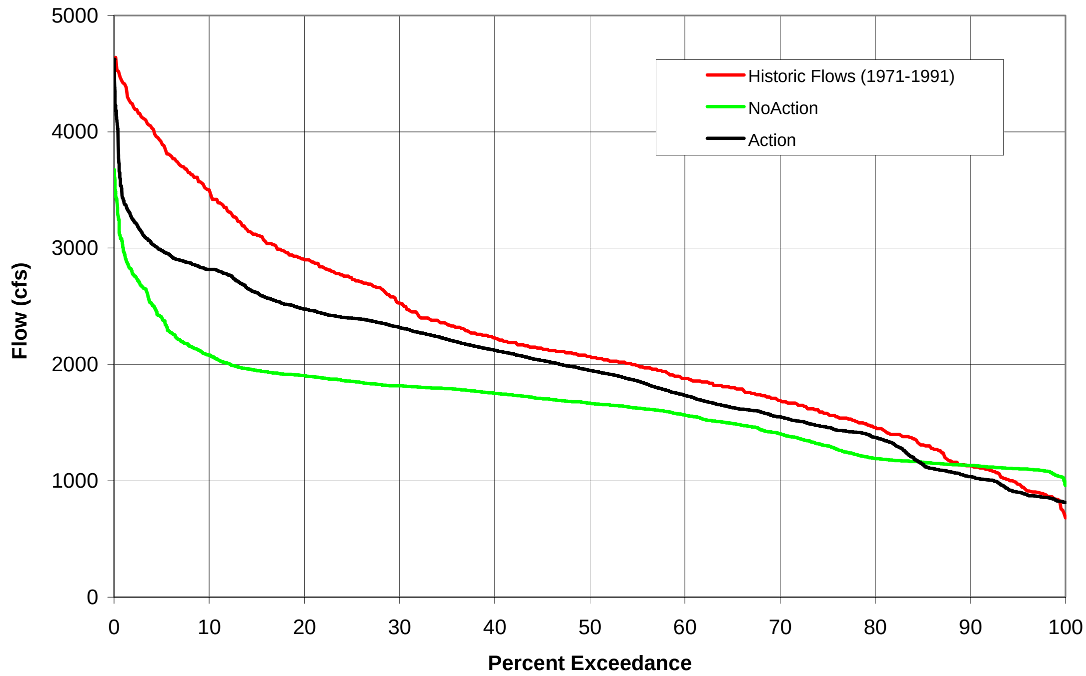


Figure 4.22: Reach Two Flows in October

Modelled vs. Historic

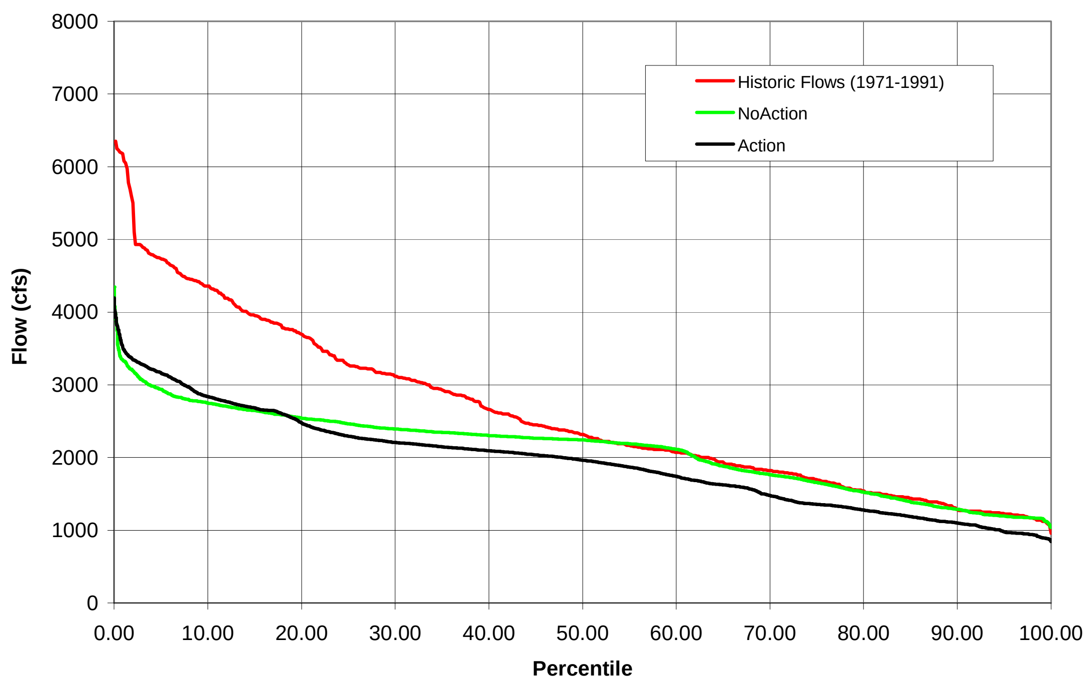


Figure 4.23: Reach Two Flows in November

Modelled vs. Historic

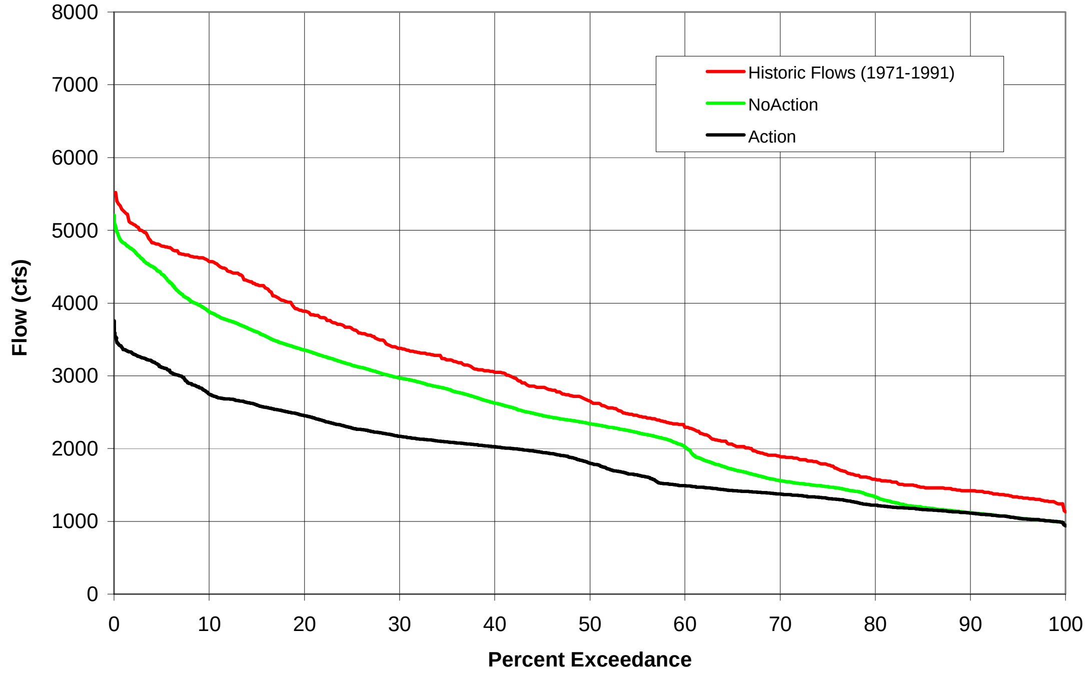
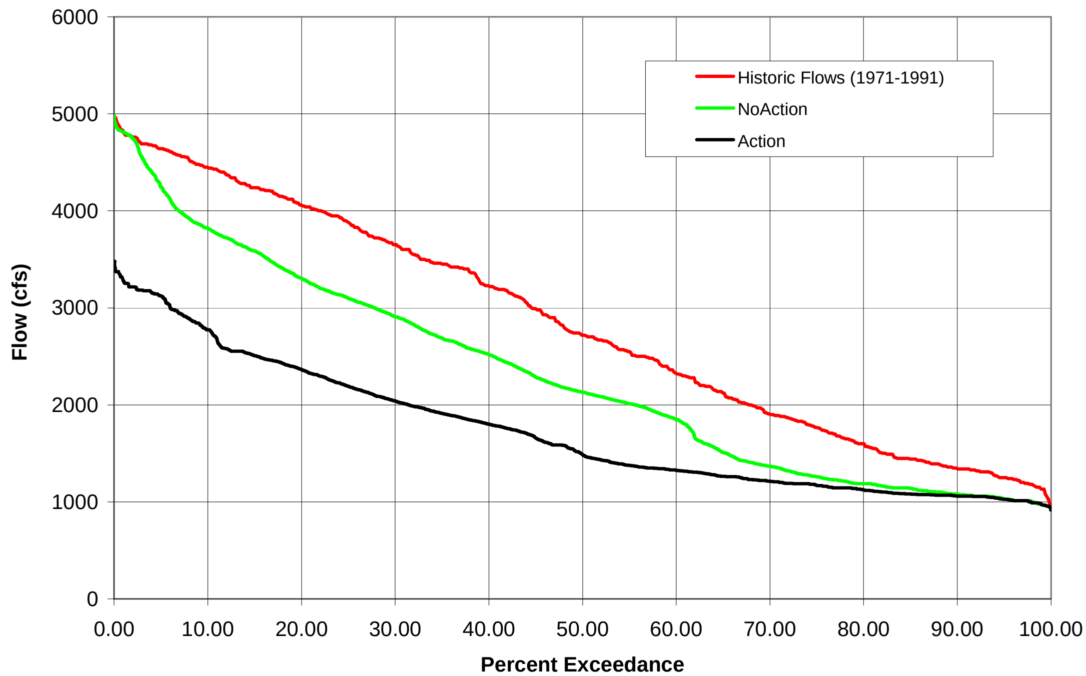


Figure 4.24: Reach Two Flows in December

Modelled vs. Historic



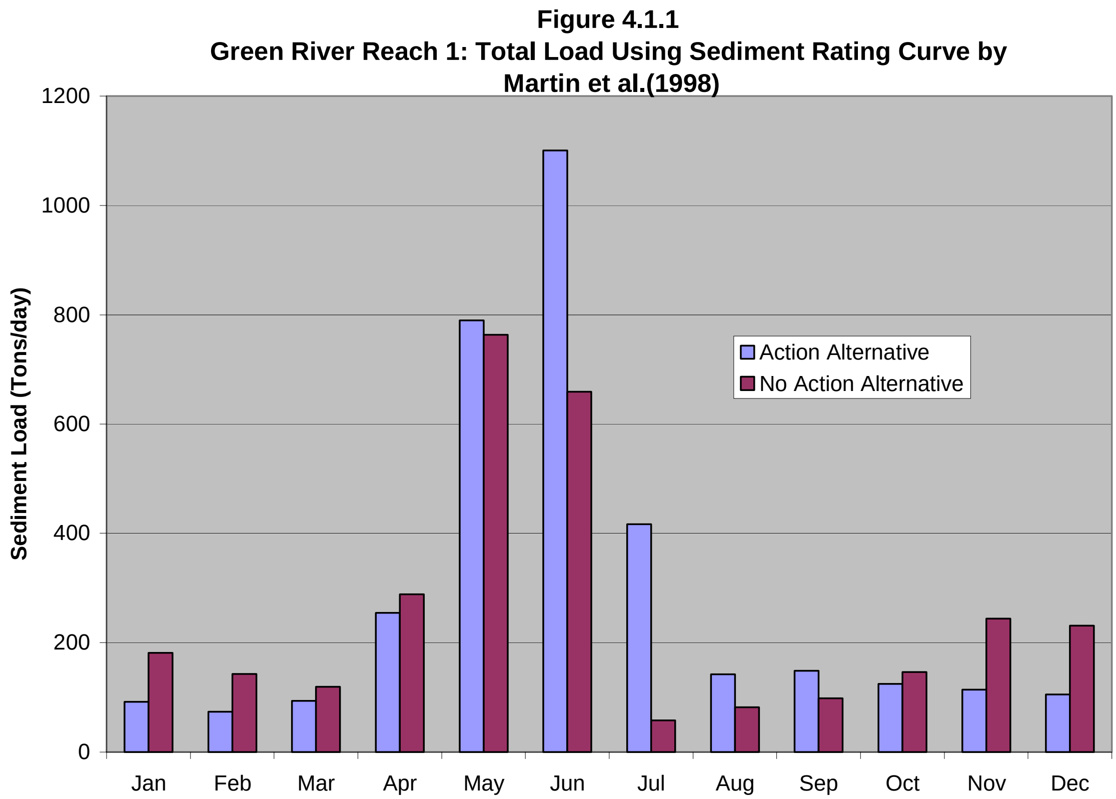


Figure 4.1.1
Green River Reach 1: Total Load Using Sediment Rating Curve by Martin et al.(1998)
Sediment Load (Tons/day)
0
200
400
600
800
1000
1200
Action Alternative
No Action Alternative
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

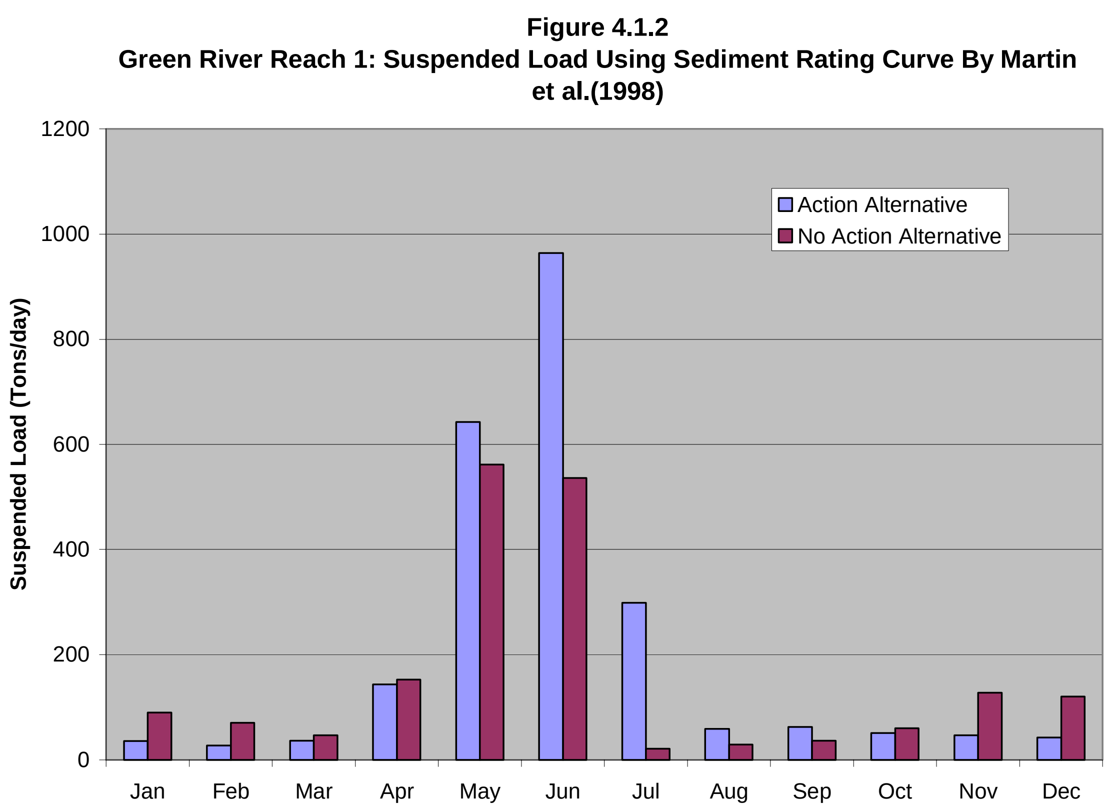


Figure 4.1.2
Green River Reach 1: Suspended Load Using Sediment Rating Curve By Martin et al.(1998)
Suspended Load (Tons/day)
0
200
400
600
800
1000
1200
Action Alternative
No Action Alternative
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Figure 4.1.3
Green River Reach 2: Sand Load Using Sediment Rating Curve by Andrews (1986)

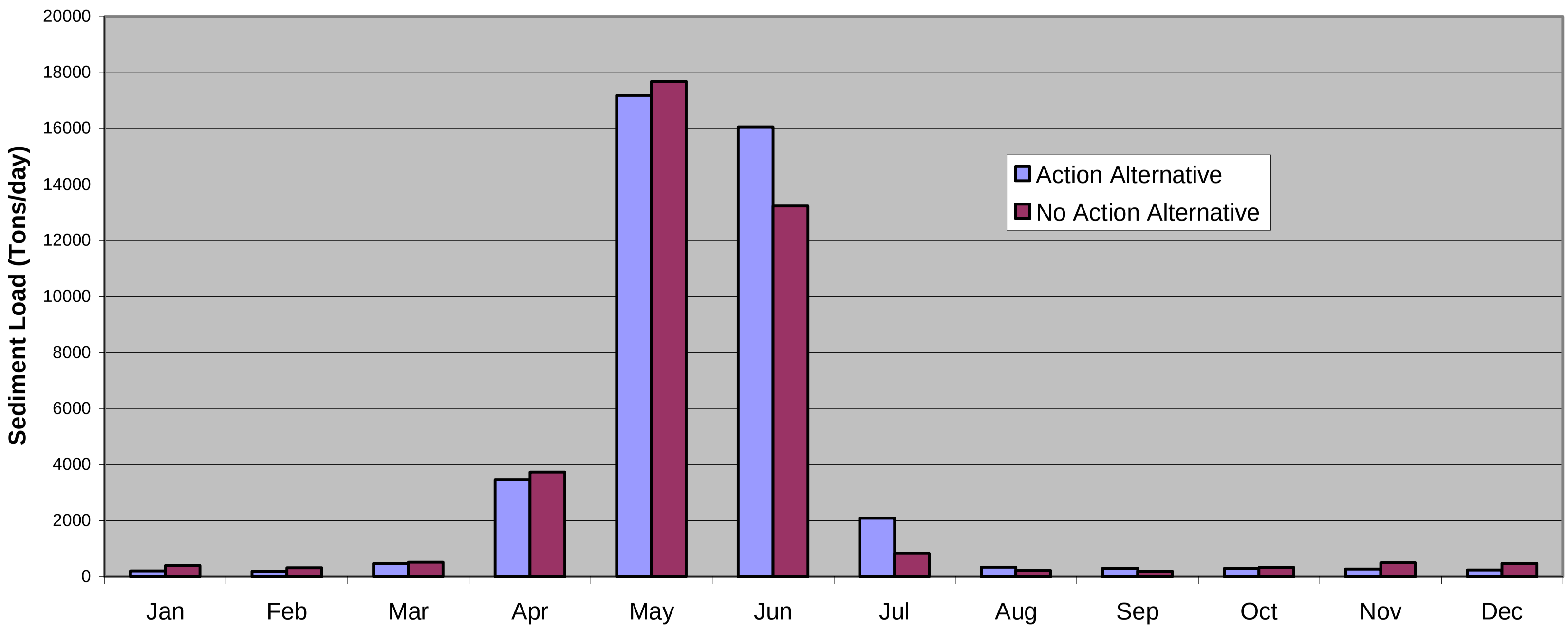
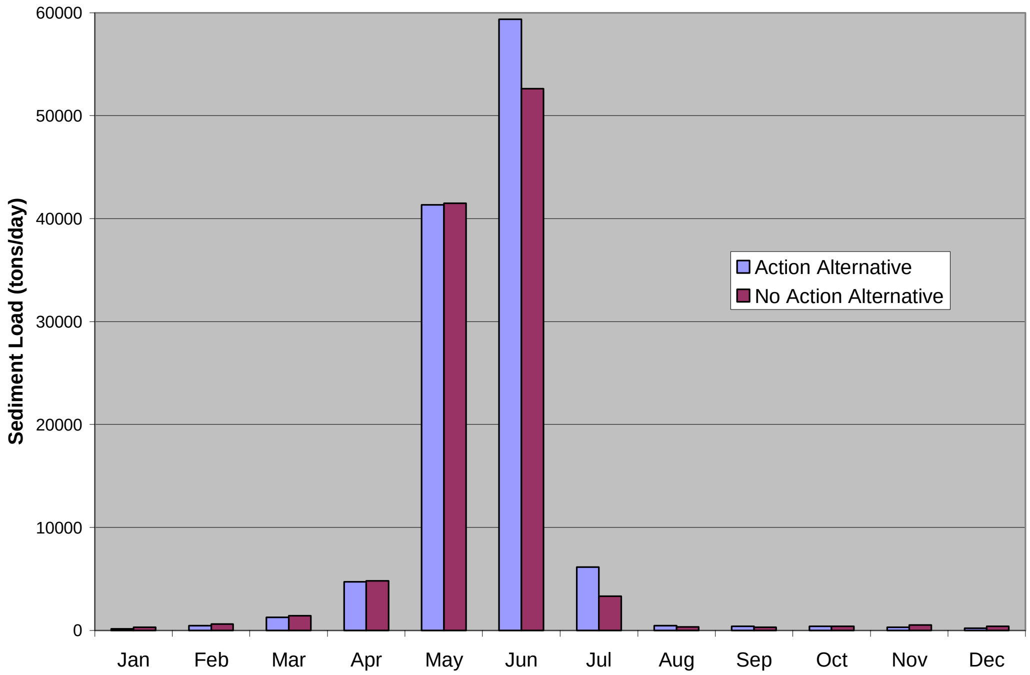


Figure 4.1.4
Green River Reach 3: Sandload Using Sediment Rating Curve by Andrews (1986)



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Power System Analysis Technical Appendix

POWER SYSTEM ANALYSIS TECHNICAL APPENDIX

Page No.

ACKNOWLEGEMENTS

The Bureau of Reclamation funded this project, and its staff provided valuable technical information and advice throughout the conduct of the study. The authors of this report thank several Bureau of Reclamation staff members, including Beverley Heffernan for her leadership role in the Flaming Gorge Environmental Impact Statement and review of critical modeling assumptions as they pertain to hydropower system operations and economic evaluations. Robert Hamilton organized and led meetings for the Flaming Gorge Environmental Impact Statement Power Systems Working Group. Dave Harpman provided power system analysts with equations that describe the Flaming Gorge powerplant and reservoir. He also supplied analysts with spot market price forecasts from the Aurora model. Larry Anderson provided technical information and advice on the operation and physical limitations of the Flaming Gorge Dam, powerplant, and turbines. Andrew Gilmore, Richard Clayton, and Thomas Ryan informed power system analysts about the Green River and RiverWare models. They also gave technical advice on how to apply Flaming Gorge model results to power system simulations. In addition, Andrew Gilmore and Richard Clayton made all of the Flaming Gorge model runs for this study and selected the representative hydrology trace. Jane Blare reviewed draft power systems methodology reports. Flaming Gorge operators Warren Blanchard and Milo McPherson provided information about current powerplant operations. Clayton Palmer from the Western Area Power Administration supplied information concerning key modeling assumptions regarding institutional constraints imposed on the operations of the Flaming Gorge Dam. Kirk Lagory from Argonne National Laboratory helped power system analysts interpret various aspects of environmental impact statement alternatives, and both Vladimir Koritarov and Michael North reviewed and provided comments on this report. The authors also thank members of the Colorado River Energy Distributors Association including Cliff Barrett, Leon Pexton, and Ted Pampton for their participation in the Flaming Gorge Environmental Impact Statement Power Systems Working Group.

NOTATION

The following is a list of the acronyms and abbreviations (including units of measure) used in this document.

ACRONYMS AND ABBREVIATIONS

Argonne	Argonne National Laboratory
BPA	Bonneville Power Administration
CRSP	Colorado River Storage Project
CRSS	Colorado River Simulation System
CSC	Customer Service Center
EIS	Environmental Impact Statement
EOM	end of month
FGEIS	Flaming Gorge Environmental Impact Statement
GenOpt	Generation Optimization
GTMax	Generation and Transmission Maximization
NPV	net present value
PO&M-59	Power Operations and Maintenance
Reclamation	Bureau of Reclamation
SLCA/IP	Salt Lake City Area Integrated Projects
SSARR	streamflow synthesis and reservoir regulation
USFWS	U.S. Fish and Wildlife Service
Western	Western Area Power Administration
WL	water lag
WLF	water lag factor
WSCC	Western Systems Coordinating Council

UNITS OF MEASURE

AF	acre-feet
cfs	cubic-feet per second
ft	foot (feet)
GWh	Giga-watt hour(s)
hr	hour(s)
HP	horsepower
lbs	pound(s)
MW	Mega-watt
MWh	Mega-watt hour(s)
TAF	thousand-acre-feet

Power System Analysis Technical Appendix

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October 2002

ABSTRACT

This report describes the methods that were used to simulate the hourly operations of the Flaming Gorge Dam and powerplant that meet environmental flow constraints at a downstream gauge located near Jensen, Utah. Operations are simulated under two alternative sets of flow constraints that include current limitations and a new set of flow recommendations formulated by the Fish and Wildlife Service. The methodology is also used to estimate the total economic benefits of powerplant electricity generation. This report documents these economic benefits and compares the two alternatives. Economic benefits are also estimated for a Cumulative Impact Scenario in which there are no environmental restrictions imposed on powerplant operations. Simulated operations and economic estimates are in support of the Bureau of Reclamation's Flaming Gorge Environmental Impact Statement.

1. INTRODUCTION

The Bureau of Reclamation (Reclamation) has been studying the potential effects on endangered species in the Green River below Flaming Gorge Dam and reservoir. These studies are in response to their obligations under Section 7 of the Endangered Species Act and have included close coordination with the U.S. Fish and Wildlife Service (USFWS), as well as numerous other agencies and interested members of the public. The USFWS has formulated flow recommendations for endangered fish species downstream from Flaming Gorge Dam and Reclamation is addressing impacts to other resources in the Green River related to such flow recommendations in an Environmental Impact Statement (EIS).

This report describes various aspects of the Flaming Gorge Environmental Impact Statement (FGEIS) that will affect powerplant operations at the dam. It also provides a detailed description of the methodology that was used to simulate dam and powerplant operations under two FGEIS alternatives. The analyses conducted under this power systems study provide an estimate of the economic impacts of EIS alternatives over a 25-year period from 2002 though 2026, inclusive. Cumulative impacts of all operational restrictions at Flaming Gorge are estimated by comparing the economic benefits of power production at Flaming Gorge to a scenario that has no environmental restrictions. Economic estimates are based on the quantity of energy produced by Flaming Gorge and spot market prices. Benefit calculations are performed on an hourly basis. Restrictions specified by each of the alternatives have to some degree an affect on the economic value of the Flaming Gorge hydropower resource.

2. FLAMING GORGE DAM AND POWERPLANT OVERVIEW

The Flaming Gorge Dam is part of the Colorado River Storage Project (CRSP) that was authorized by a Congressional Act of April 11, 1956. It is located on the Green River in northeastern Utah about 32 miles downstream from the Utah/Wyoming border. The concrete thin-arch structure that was built by Reclamation has a maximum height of 502 feet and a crest length of 1,285 feet. Flaming Gorge Reservoir has a total capacity of 3,788,700 acre-feet (AF) at a reservoir water elevation of 6040 feet above sea level. The reservoir has an active capacity of 3,515,700 AF and a surface area of 42,020 acres. Construction of the Flaming Gorge Dam began in October 1956 and the reservoir was topped out in late 1962 ***(Flaming Gorge Flow Recommendations Document, Section 3.2, Page 56)***. To the extent possible the dam has been operated at near-full reservoir levels while attempting to avoid spills.

The powerplant began commercial operation in 1963 with three generating units. Each unit originally had a capacity of 36 Mega-watt (MW) for a plant total of 108 MW. Since that time, the three units were upgraded to approximately 50.65 MW thereby increasing the total installed capacity to 151.95 MW (***Form PO&M-59)***. However, due to turbine limitations the operable capability of the powerplant is approximately 141.0 MW. On average, the Flaming Gorge Dam powerplant generates about 528.9 Giga-watt-hours (GWh) of electricity annually.

The Western Area Power Administration's (Western) CRSP Management Center markets CRSP power resources, including Flaming Gorge, and hydroelectric powerplants of the Collbran and Rio Grande projects. Energy and capacity from these projects, collectively referred to as the Salt Lake City Area Integrated Projects (SLCA/IP), are marketed to more than 140 customers in six western states on both a long-term and short-term firm basis (***ANL/DIS/TM-10)***. Generation from the Flaming Gorge powerplant also serves the energy requirements of special project uses such as irrigation and can be used to fulfill utility system requirements for spinning reserves and area load control. Electricity is also sold on the spot market when available energy exceeds firm contractual obligations. Spot market activities also include purchasing energy at relatively low prices during off-peak hours and using the stored energy for sale when spot market prices are high. This hydro-shifting activity allows Western to maximize the economic value of hydropower resources.

The FGEIS power systems methodology focuses on the operations of the Flaming Gorge Dam subject to environmental flow constraints at a critical downstream reach on the Green River. Power generation from

Flaming Gorge is injected into the transmission grid. The economic value of this generation is based on the market price of electricity at the Four Corners delivery point.

3. EIS ALTERNATIVES

The FGEIS contains two alternatives. The first is referred to as the No Action Alternative. It assumes that Green River flow constraints established under the 1992 Biological Opinion will continue through the end of the study period. The dam is currently operated to meet flow limitations specified by this alternative. The second is referred to as the Action Alternative. It assumes that Flaming Gorge Dam operations will comply with a new set of USFWS flow recommendations. The Action Alternative requires monthly and hourly water release patterns from the Flaming Gorge Dam that differ from those established by the 1992 Biological Opinion.

The economic impacts of altering generation patterns to meet new flow requirements under the Action Alternative are estimated in this analysis. Most of the facets of the Action Alternative that affect the economic value of the power system are precisely documented. However, there is a set of rules that will be assumed under both alternatives that is not based on written documentation, but rather on verbal agreements and current operational practices. Essentially, these are temporary agreements made among various institutions that are assumed to continue throughout the study period. However, these unwritten rules may or may not continue in the future. Tables 3.1 and 3.2 show key operational elements and gauge flow constraints contained in the two alternatives that will affect the economic value of the Flaming Gorge power resource.

3.1 Green River Flow Constraints

The FGEIS defines three reaches shown on figure 3.1 Flaming Gorge Flow Recommendations Document, P. 2-2. For the power systems analysis conducted in this study, the only flow constraints considered are at reach 2 as measured at the Jensen Gauge. Reach 2 begins at the confluence of the Green and Yampa Rivers; that is, about 65.1 miles downstream from Flaming Gorge Dam. Reach 2 extends for about 98.8 miles downstream from the Yampa to the confluence of the White River. The Jensen Gauge is located nearly 28.6 miles downstream of the Yampa confluence. Therefore, a Flaming Gorge water release must travel about 93.7 miles (i.e., 65.1 + 28.6) before it registers at the Jensen Gauge.

Jensen Gauge flows are primarily a function of Flaming Gorge releases and Yampa inflows. Since Yampa inflows are not controlled, releases from Flaming Gorge must be regulated such that flows are in compliance with Jensen Gauge requirements. However, water releases from Flaming Gorge are not required by EIS alternatives to compensate for large and unpredictable changes in Yampa inflows. On the other hand, FGEIS alternatives require that the general pattern of Yampa inflows be accounted for when scheduling Flaming Gorge releases.

Green River flow constraints under the No Action Alternative are based on four time periods that includes a spring spike, a summer season, a winter season and a post-winter flow period. Each of these periods is listed in tables 3.1 and 3.2 for the No Action and Action Alternatives, respectively.

Except for the post-winter period, time period designations are identical for both alternatives. The post-winter period for the Action Alternative begins 1 month earlier than in the No Action Alternative.

The No Action Alternative requires that flows at the Jensen Gauge remain within 12.5 percent of the daily average flow during the summer and autumn seasons. This allows for a maximum daily fluctuation of

Table 3.1. Assumptions for the No Action Alternative (1992 Biological Opinion)

<table>
<tr><th>Spring Flows (Spike)</th><th>Summer</th><th>Winter</th><th>Post-Winter</th></tr>
<tr><td>Period of spike, inclusive</td><td>Day after end of spike to Oct 31, inclusive</td><td>Nov 1 to Apr 31, inclusive</td><td>May 1 until the start of spike, inclusive</td></tr>
<tr><td>No gauge constraints</td><td colspan="2">Requires Jensen Gauge flows to remain within a 12.5% of the daily average</td><td>No gauge constraints</td></tr>
<tr><td></td><td colspan="2">Jensen Gauge flows limits are constant among all days of a month.</td><td></td></tr>
<tr><td colspan="4">Restrict daily water releases from Flaming Gorge</td></tr>
<tr><td></td><td>Daily average gauge flows range from 31 to 51 m^3/s</td><td>Daily average gauge flows range from 31 to 68 m^3/s</td><td></td></tr>
<tr><td></td><td></td><td>Ice cap issues not considered</td><td></td></tr>
<tr><td colspan="4">Assumed that Yampa flows are constant throughout a month</td></tr>
<tr><td colspan="4">Operational rules: 800 cfs minimum flows,
800 cfs maximum up-ramp rate,
800 cfs maximum down-ramp rate,
single hump per day.</td></tr>
</table>

Table 3.2. Assumptions for the Action Alternative (2000 Flow and Temperature Recommendations)

<table>
<tr><th>Spring Flows (Spike)</th><th>Summer</th><th>Winter</th><th>Post-Winter</th></tr>
<tr><td>Period of spike, inclusive</td><td>Day after end of spike to Oct 31, inclusive</td><td>Nov 1 to February 28 (29), inclusive</td><td>March 1 until the start of spike, inclusive</td></tr>
<tr><td>No gauge constraints</td><td colspan="2">Jensen Gauge stage flows limited to an intra-day change of 0.1 meters</td><td>No gauge constraints</td></tr>
<tr><td colspan="4">Restrict daily water releases</td></tr>
<tr><td rowspan="3"></td><td colspan="2">3% daily average gauge constraint does not apply</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Consistent with the Flaming Gorge model daily average gauge flows are between 26 to 85 m^3/s</td></tr>
<tr><td colspan="2">Consistent with the Flaming Gorge model will not utilize 40%/25% variation around year mean flows</td></tr>
<tr><td colspan="4">Assumed that Yampa flows are constant throughout a month</td></tr>
<tr><td colspan="4">Operational rules: 800 cfs minimum flows,
800 cfs maximum up-ramp rate,
800 cfs maximum down-ramp rate,
single hump per day.</td></tr>
</table>

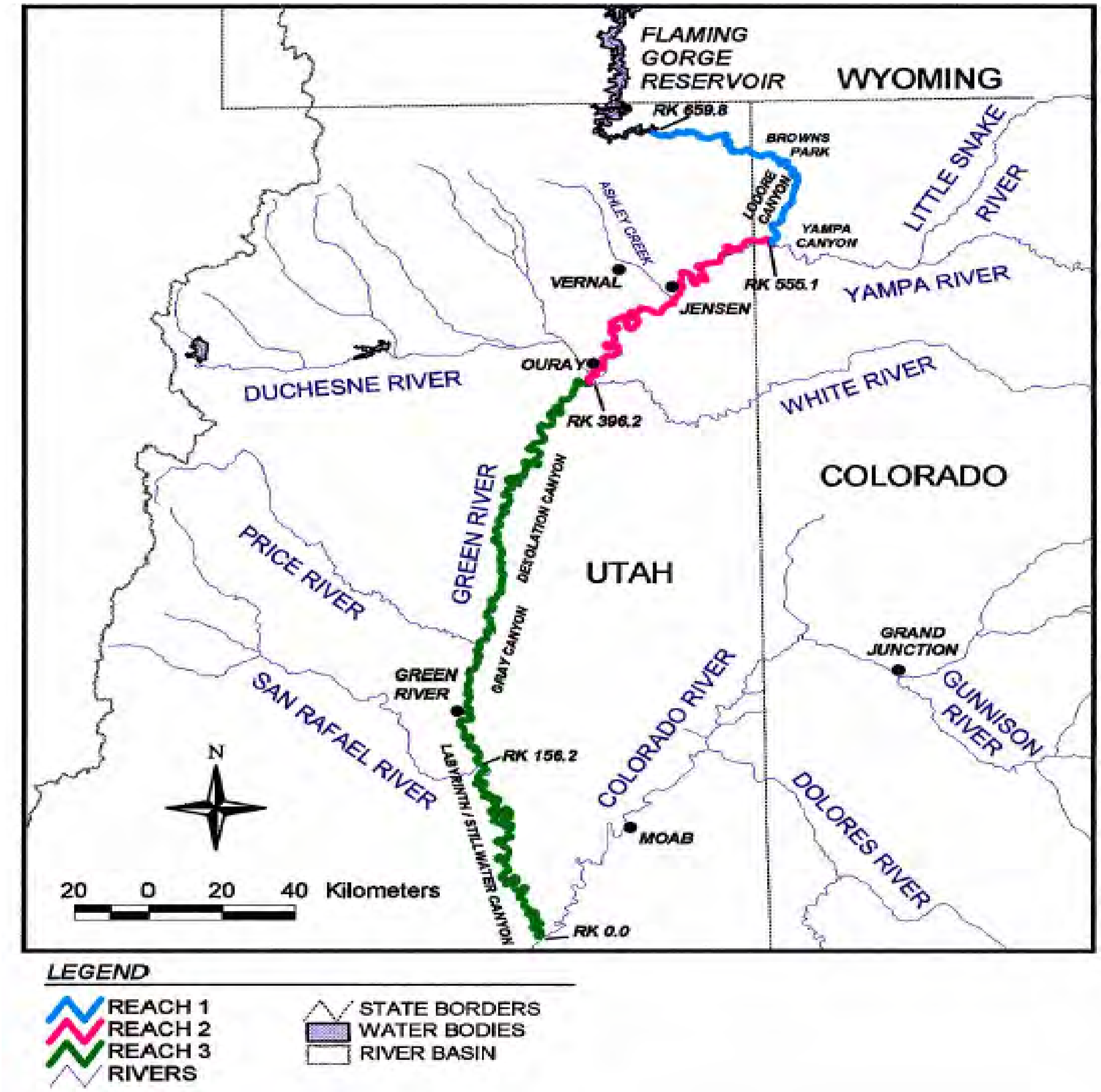

Figure 3.1. Critical Reaches Downstream From the Flaming Gorge Dam.
Source: 2000 Flow and Temperature Recommendations Report.

25 percent; that is, 12.5 percent higher than the average and 12.5 percent lower than the average. Although it is not specified by the No Action Alternative, for this study it is assumed that the 25-percent maximum daily fluctuation requirement will also constrain dam operations in the winter season. This is consistent with historic short-term verbal agreements and current operational practices. This agreement may or may not continue in the future and operations may change.

The Action Alternative specifies Jensen Gauge flow constraints in terms of Green River stage change. The intra-day stage change is limited to 0.1 meters (i.e., 0.328 feet) from the average stage. Figure 3.2 shows the relationship between the stage and flow rates at the Jensen Gauge Data Source: Email from Richard Clayton on September 16, 2002 with attached files jesu.q$15 & jesu.xls.

As shown in figure 3.3, when the 0.1-meter gauge constraint (i.e., Action Alternative) is expressed in terms of percent change, the Action Alternative is more stringent than the No Action Alternative over the entire range of the gauge flows. However, the difference is significantly smaller at lower gauge flows. Table 3.4 shows a comparison of the two alternatives at the lower flow rates. At 800 cubic feet per second (cfs), the Action Alternative has approximately a 23-percent flow range; that is, a range that is 2 percent less than the No Action Alternative. Unlike the No Action Alternative that has a 12.5-percent allowable flow range both above and below the daily average, these percentages are asymmetrical for the Action Alternative. At a stage of 3.1 ft a 9.9-percent flow decrease below the daily average is allowed for the Action Alternative while an 11.6-percent increase above the daily average sets the upper flow bound. This occurs since flow stages as shown in figure 3.2 are non-linear.

Although the Action Alternative is more restrictive, the lower flow rates are expected to occur more frequently than higher flow rates. Difference in the gauge flow flexibility between the two scenarios is usually from 2 percent to 4 percent. Figure 3.4 shows the flow rate exceedance curve for the Action Alternative for all days of the 25-year study period. The curve is based on Flaming Gorge model projections of daily Flaming Gorge releases and inflows from the Yampa Data Source: Email from Andrew Gilmore with attached files RepresentativeTraceAction.xls. The figure shows that the range for the Action Alternative drops to 21.2 percent at 2,060-cfs flow rate. Daily average flows are less than 2,060 cfs about 50 percent of the time.

The No Action Alternative requires the daily average flow at the Jensen Gauge to remain constant over a period (e.g., season). While the range of allowable flows at the Jensen Gauge under the No Action Alternative remains constant, the window of allowable flows at the Jensen Gauge under the Action Alternative can change from one day to the next by up to 3 percent. The intent of this daily change allowance is to permit Reclamation to adjust water releases in response to unpredicted changes in the system hydrology. Therefore, for the purpose of modeling power system operations, water releases from Flaming Gorge are not permitted to change from one day to the next.

3.2 Flaming Gorge Operational Rules

The hourly average water release from the Flaming Gorge Dam must be at least 800 cfs as mandated in 1967 Flaming Gorge Flow Recommendations Document, P. 3-6. This directive was given in order to establish and maintain tailwater trout fisheries. Over a period of one week, the 800 cfs minimum release accounts for approximately 11.1 thousand acre-feet (TAF). Weekly water releases above this level can be used at the discretion of dispatchers within other dam operational and downstream flow constraints. Typically a dispatcher releases this water through the turbines when it has the highest economic value as indicated by spot market prices.

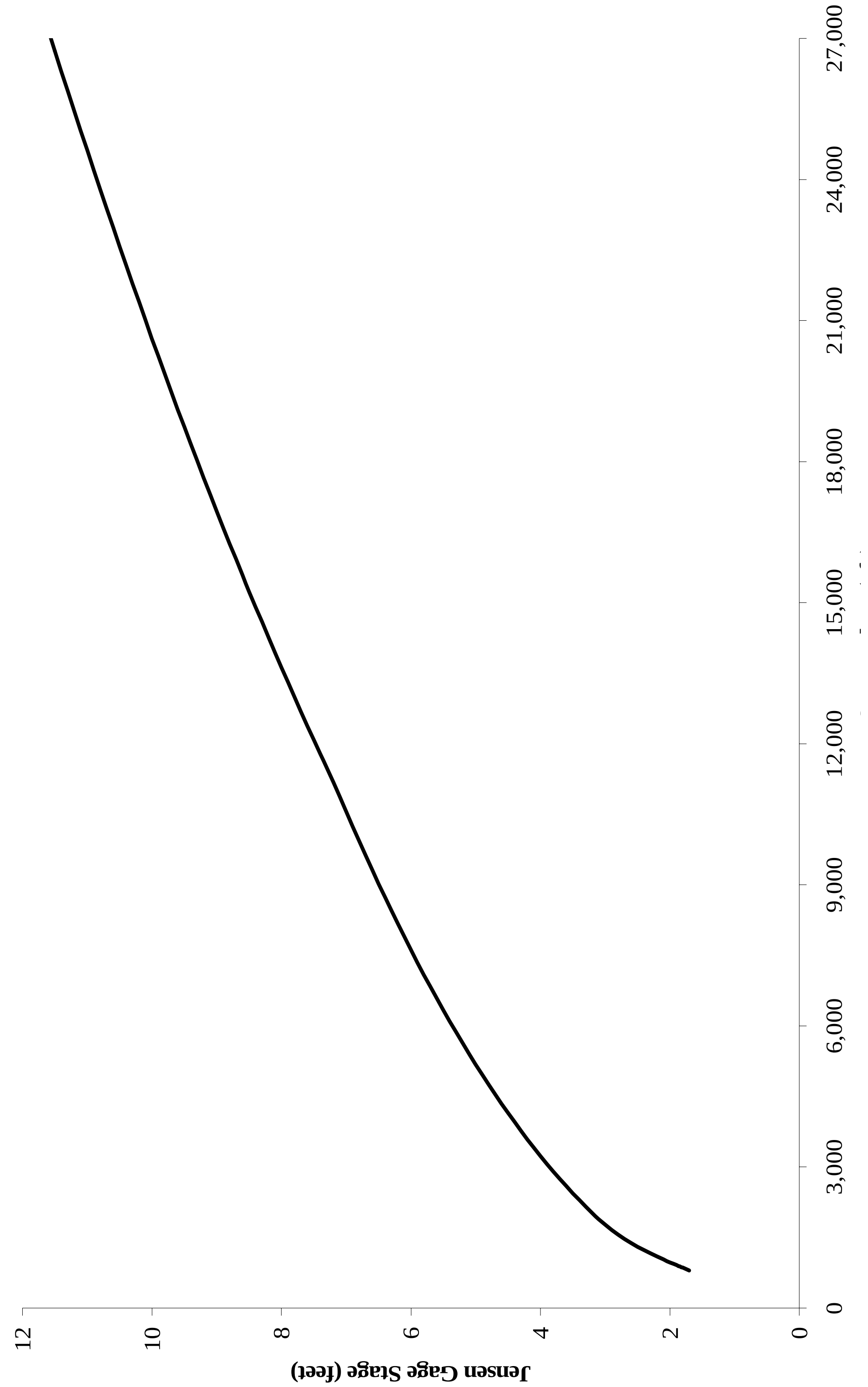

Figure 3.2. Green River Stage as a function of Flow Rate at the Jensen Gauge.

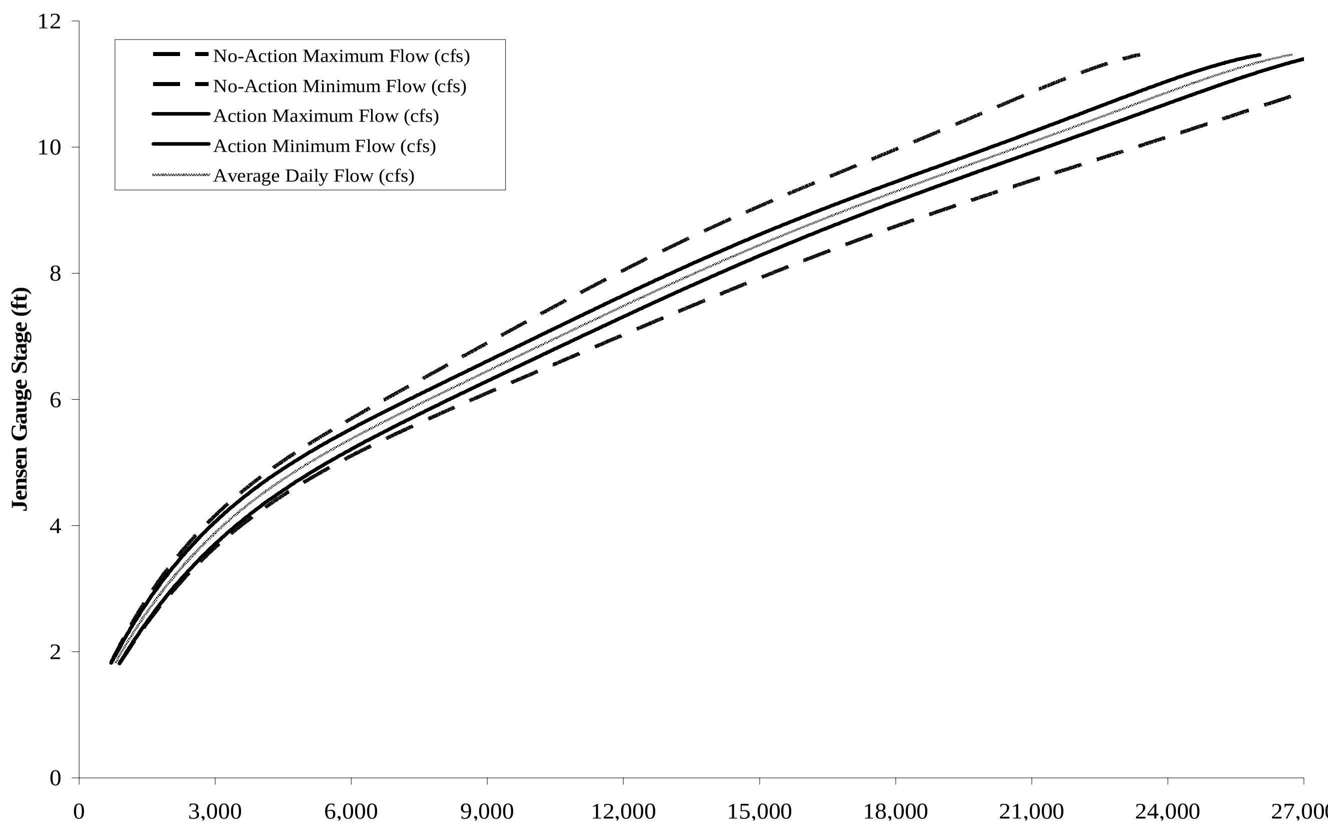

Figure 3.3. Allowable Flow Range for the No Action and Action Alternatives.

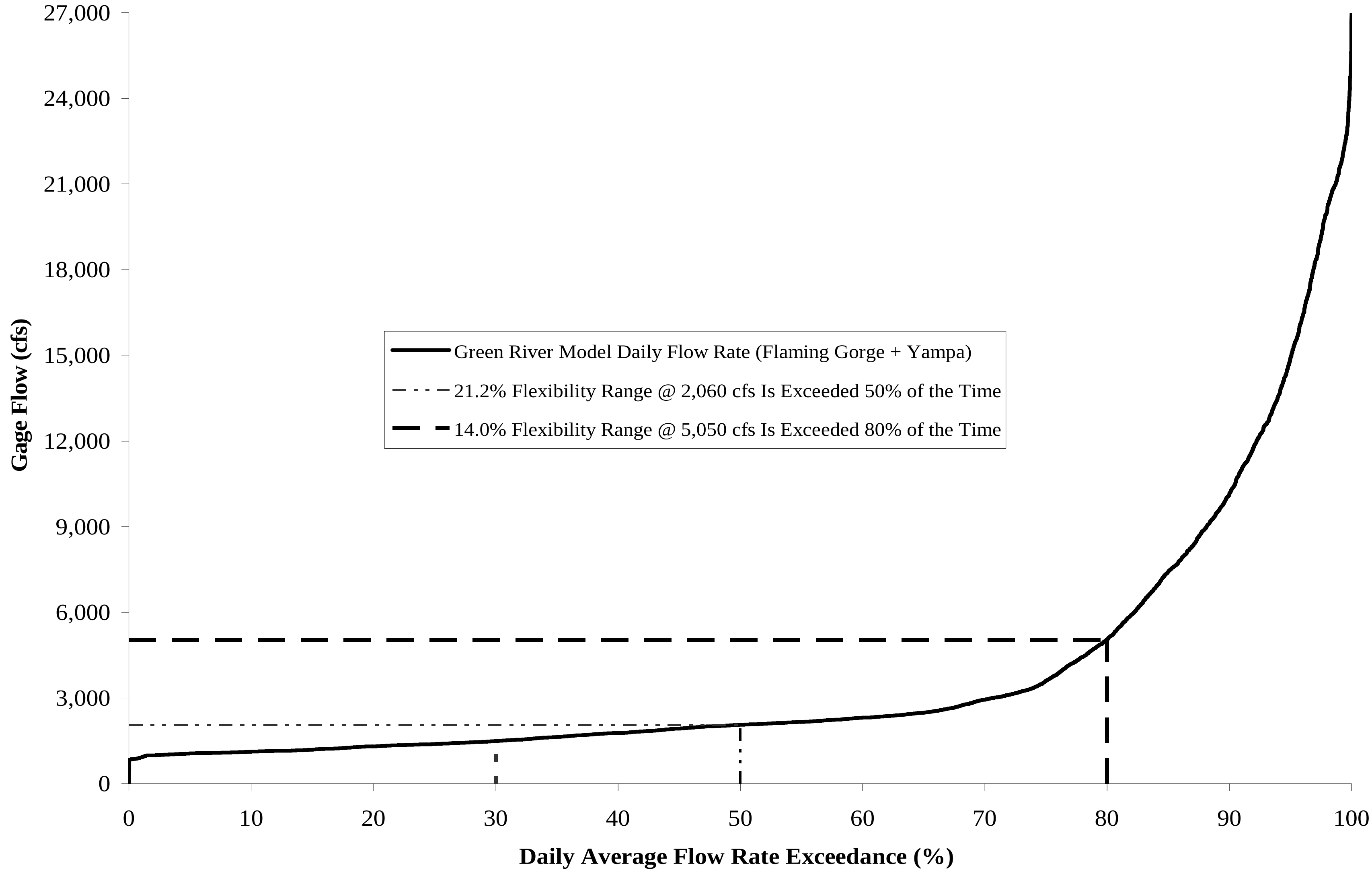

Figure 3.4. Projected Daily Average Flow Rate Exceedance Curve at the Jensen Gauge for the Action Alternative.

Table 3.3. Spike Period Dates and Duration

Year	No Action Alternative			Action Alternative		
	Start Date	End Date	Duration (days)	Start Date	End Date	Duration (days)
2002	24-May	22-Jun	30	30-May	09-Jul	41
2003	15-May	05-Jun	22	19-May	12-Jun	25
2004	08-May	31-May	24	13-May	10-Jun	29
2005	10-May	31-May	22	12-May	27-May	16
2006	15-May	09-Jun	26	22-May	05-Jun	15
2007	06-May	28-Jun	54	07-May	08-Jun	33
2008	09-May	31-May	23	10-May	25-May	16
2009	13-May	26-Jun	45	17-May	28-Jun	43
2010	01-May	29-Jun	60	12-May	18-Jun	38
2011	01-May	31-May	31	10-May	05-Jun	27
2012	15-May	26-Jun	43	24-May	18-Jul	56
2013	29-May	19-Jun	22	02-Jun	07-Jul	36
2014	11-May	11-Jun	32	04-May	27-Jun	55
2015	13-May	04-Jun	23	18-May	18-Jun	32
2016	08-May	04-Jul	58	28-May	23-Jun	27
2017	15-May	03-Jul	50	30-May	26-Jun	28
2018	15-May	05-Jun	22	16-May	25-Jun	41
2019	10-May	20-Jun	42	01-Apr	28-Jun	89
2020	28-May	03-Jul	37	02-Jun	25-Jul	54
2021	19-May	20-Jun	33	21-May	21-Jul	62
2022	27-May	20-Jun	25	02-Jun	16-Jun	15
2023	29-May	24-Jun	27	07-Jun	31-Jul	55
2024	18-May	08-Jun	22	22-May	16-Jun	26
2025	15-May	20-Jun	37	21-May	28-Jun	39
2026	18-May	09-Jun	23	22-May	09-Jun	19
Minimum			22			15
Average			33.3			36.7
Maximum			60			89

Table 3.4. Comparison of Alternative Gauge Constraints at Low Flow Rates

Stage (feet)	Average Flow (cfs)	No Action Alternative			Action Alternative		
		Minimum Flow (cfs)	Maximum Flow (cfs)	Range (%)	Minimum Flow (cfs)	Maximum Flow (cfs)	Range (%)
1.70	800	700	900	25.0	708	892	23.0
1.80	856	749	963	25.0	764	949	21.7
1.90	913	799	1,027	25.0	820	1,011	20.9
2.10	1,032	903	1,161	25.0	934	1,137	19.6
2.30	1,160	1,015	1,305	25.0	1,055	1,275	18.9
2.50	1,300	1,138	1,463	25.0	1,185	1,435	19.2

There are two other operational rules that are not written, but have been agreed upon by Reclamation and Western for near-term system operations. These include up- and down-ramp rate limits of 800 cfs per hour and a daily one-hump restriction.

The hourly ramp rate restriction limits the change in water release rates from one hour to the next. For example, if the water release from Flaming Gorge is 2,400 cfs at noon, then releases at 1 PM must remain within a band that ranges from 1,600 to 3,200 cfs. From the beginning of 1992 through April 8, 2001, the 800-cfs ramp rate restriction has been violated less than 1% of the time based on HourlyReleaseInspection.xls file. Figure 3.5 shows the ramp rate exceedance curve for 1996, a typical ramping year.

As agreed upon by the two institutions for near-term operations, releases are currently limited to a single "hump" per day. When restricted to a single daily hump, dam releases are permitted to change the ramp direction only twice per day—once in the up direction and once in the down direction. Flat flow periods in between the up and down ramp rate phases are allowed. This includes periods when flows are constant or continuously ramp either up or down throughout a day. Releases typically ramp up from a low rate at night to a higher one during the daytime and then back down to a lower release rate during the following night. After March of 1993 through the present, the single hump restriction has been part of the Flaming Gorge operational regime. However, there were situations in the past when very minor zigzag patterns of increasing and decreasing flows were embedded into a larger single-hump pattern. Figure 3.6 shows an example of 1 day when this zigzag pattern occurred. The one-hump restriction reduces the economic value of the hydropower resources and does not allow plant operators to send pulses of water down the Green River to meet gauge constraints.

4. POWER SYSTEM MODELING

One objective of this study is to simulate operations at the Flaming Gorge Dam such that it maximizes the value of the hydropower resource while complying with both operational limitations and flow constraints at the Jensen Gauge. Several models are used to perform these simulations. Some models simulate the hydrology of the Green River and others are used to optimize the hourly operations of the hydropower resource. The set of modeling tools that were selected to perform these tasks was integrated into a modeling system referred to as the Flaming Gorge Power Modeling Package. Model integration, as depicted in figure 4.1, enables data and information to be exchanged among package components.

4.1 Flaming Gorge Model

The Flaming Gorge model provides long-term simulations of the Flaming Gorge Dam. It was written by Reclamation to simulate reservoir operations on the Green River and the requirements specified under FGEIS alternatives. The model is based on the same philosophy and principles as the RiverWare modeling software and its predecessor, the Colorado River Simulation System (CRSS). RiverWare and CRSS have been used by Reclamation for numerous long-term policy studies including the Glen Canyon Dam EIS and the Power Marketing (***EIS Salt Lake City Area Integrated Projects Electric Power Marketing Final Environmental Impact Statement U.S. DOE Western Area Power Administration Jan 1996)***. The Flaming Gorge model projects the operations of Flaming Gorge including monthly and daily water release volumes from the dam. It also predicts reservoir elevations and volumes on a monthly basis.

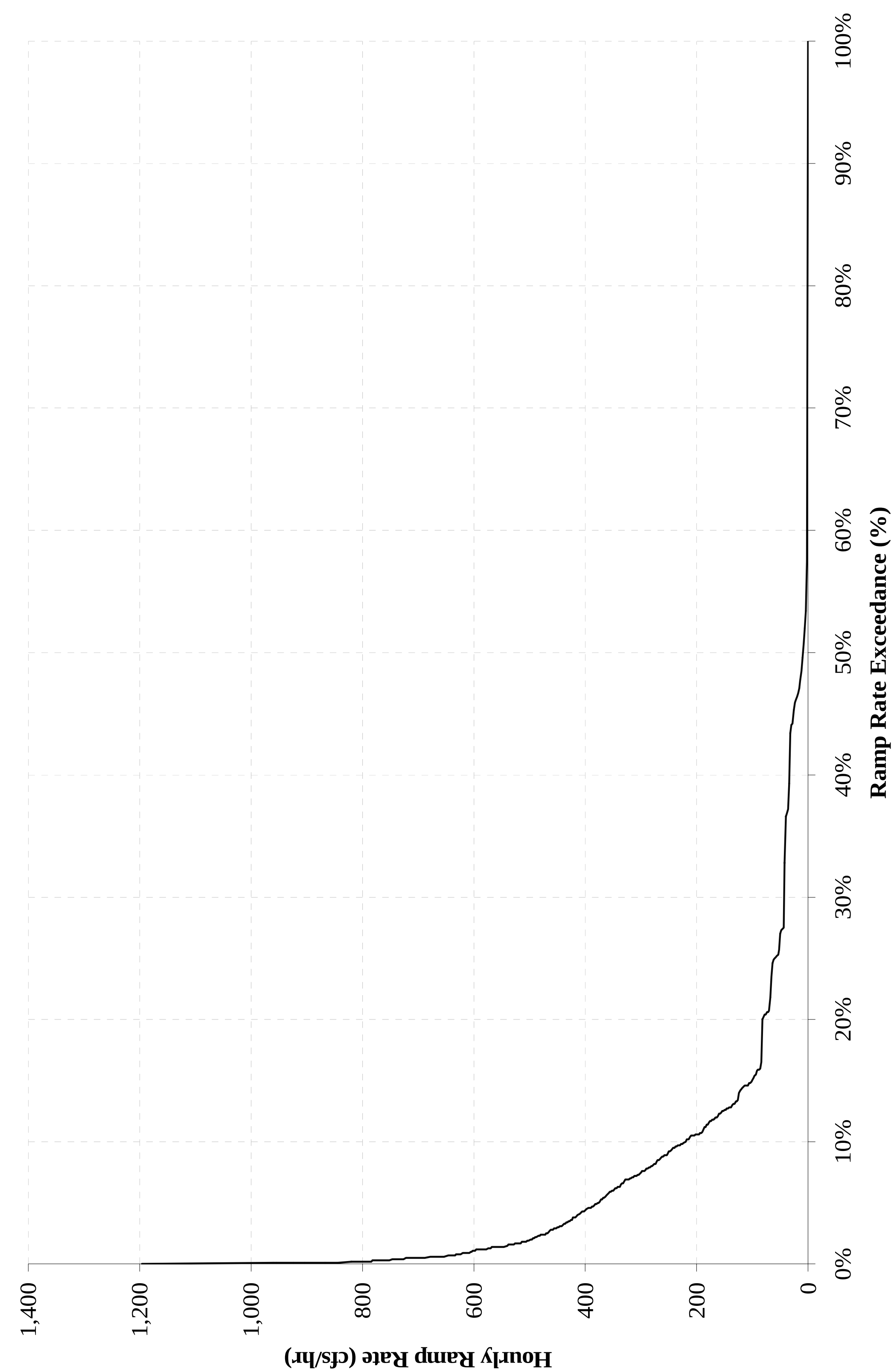

Figure 3.5. Ramp Rate Exceedance Curve for 1996.

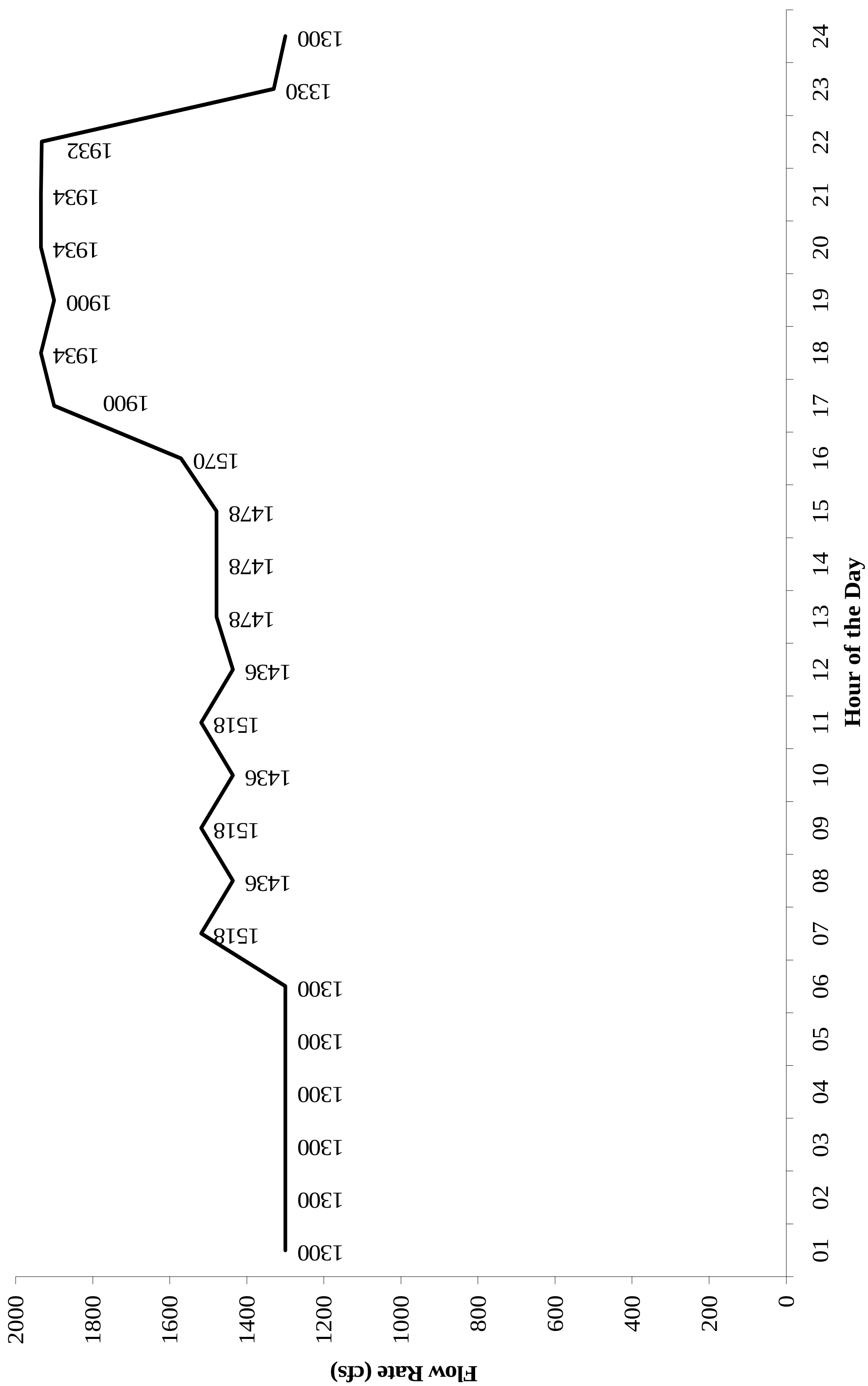

Figure 3.6. Minor Violation of Single Daily Hump Agreement on August 16, 1996.

The Flaming Gorge model contains a database of historical inflows. Since future inflows beyond the near future (i.e., 2 to 6 months) are largely unpredictable, these historic inflows are used to predict numerous possible outcomes. The hydrologic inflows from 1921 through 1985 were adjusted for upstream regulation, projected consumptive uses, and losses at inflow points in the basin. The first year that Yampa data were collected is 1921, marking the beginning of the historical sequence, and 1985 is the last year that reliable and consistent data were compiled.

The Flaming Gorge model simulated Flaming Gorge for the period from January 2002 through December 2040 using the state of the reservoir at the end of December 2001 as the initial condition. To assess future hydrologic uncertainty, the model was run in an “index sequential mode.” In this mode, the model is run multiple times, where each run is based on a different hydrologic trace extracted from the historic record (***Labadie, et al., 1990)***. The first trace uses the adjusted historic sequence in which 1921 hydrology is assumed to occur in 2002 and hydrology for 1922 is used to represent 2003. These hydrology assignments continue sequentially through 2040 in which it is assumed that 1960 hydrology will be repeated. The second trace is similar to the first except that historic hydrology assignment begins with 1922 data instead of 1921. Therefore, 2002 is assigned 1922 hydrology data and 2003 is assigned 1923 data.

Using the index sequential method, a total of 65 possible monthly and daily futures were projected for each alternative. It is assumed that any one of these historical inflow sequences may be repeated in the future and that each trace has an identical probability of occurrence in the future.

Since the Flaming Gorge model contains a database with known inflow traces (i.e., it contains a perfect forecast of the future), it would be unrealistic to use that information to simulate Flaming Gorge Dam operations. Therefore, forecast errors are computed and subtracted from the perfect inflow forecast to produce a more realistic simulation of the future. In the model, dam operators make decisions based on the imperfect forecast, but the unadjusted inflows (i.e., inflows with no errors) occur. Errors resulting from imperfect forecasts propagate to subsequent months since it is assumed that each month’s forecast error is correlated to the previous month’s error. Reclamation staff developed equation 4.1, a hydrology forecast error equation.

$$E_i = a_i x_i + b_i E_{(i-1)} + c_i + z_r d_I \qquad (4.1)$$

where

E_i = the error in the forecast for the current month in million acre-feet;

$E_{(i-1)}$ = the forecast error for the previous month;

x_i = the natural inflow into the Flaming Gorge Reservoir for the current month through July;

z_r = a randomly determined mean deviation taken from a normal distribution; and

d_i = the standard error of the estimate for the regression equation.

The regression coefficients a_i, b_i, and c_i are based on a multiple linear regression analysis of actual inflows and forecasted values over the 1965 to 1999 time period.

The Flaming Gorge model operates the system using the forecast trace and a set of system operator rule sets. The rules that are input into the model are consistent with the restrictions specified by a FGEIS alternative. Errors associated with the forecast incorporate uncertainty into the model and help to facilitate the simulation of operator decisions with inflow uncertainty. Based on the forecast, the Flaming

Gorge model simulates operations at the Flaming Gorge Dam such that it will usually comply with alternative specifications. However, forecasted flows do not always come to fruition and the model will at times violate one or more FGEIS alternative flow requirements; that is, there is some probability that there will be a flow violation at the Jensen Gauge.

It is impractical from a computational standpoint to perform detailed economic analyses for all 65 possible hydrologic traces; therefore, Reclamation staff selected the 37th hydrological trace (i.e., run 36) as a representative sequence of future inflows. This trace was selected since inflow volumes for the first 20 years is the closest to the mean inflow volume of all 65 traces. The trace is used in this analysis to simulate powerplant operations and to estimate the economic benefits associated with the alternatives.

4.2 SSARR Model

The Streamflow Synthesis and Reservoir Regulation (SSARR) model is a numeric model of the hydrology of a river basin system SSARR User Manual. It was initially developed by the U.S. Army Corps of Engineers North Pacific Division to assist hydrological systems analysts for the planning, design, and operation of water control works. The SSARR model was further developed for operational river forecasting and river management activities in connection with the Cooperative Columbia River Forecasting unit, sponsored by the National Weather Service, U.S. Corps of Engineers, and the Bonneville Power Administration. Numerous river systems in the U.S. and abroad have been modeled with SSARR by various agencies, organizations, and universities.

SSARR is comprised of a generalized watershed model and a stream flow and reservoir regulation model. The watershed model simulates rainfall-runoff, snow accumulation, and snowmelt-runoff. Algorithms are included for modeling snow pack cold content, liquid water content, and seasonal conditioning for melt. Interception, evapotranspiration, soil moisture, base flow infiltration, and routing of runoff into system streams are accounted for. The river system and reservoir regulation model routes stream flows from upstream to downstream points through channel and lake storage, and reservoirs under free flow or controlled-flow modes of operation.

The basic routing method used in the watershed and river models is a “cascade of reservoirs” technique, wherein the lag and attenuation of the flood wave is simulated through successive increments of lake-type storage. A channel is represented as a series of small “lakes” that represent the natural delay of runoff from upstream to downstream points.

In this analysis, SSARR is used to forecast the hourly flows at the Jensen Gauge. SSARR is given both hourly Flaming Gorge water releases as determined by the Generation Optimization (GenOpt) model and Yampa inflow data from the Flaming Gorge model. Upon completion of a SSARR simulation, the resulting gauge flows are examined to determine if Flaming Gorge water releases will result in a violation at the Jensen Gauge. If any violation is found, then the GenOpt model is run again with a revised set of input data. This process is repeated until an acceptable solution is found.

4.3 AURORA Model

Electricity generated from the Flaming Gorge powerplant is injected into the power grid to serve system loads. Since utility systems are connected via transmission lines, the value of this energy is a function of system dynamics and constraints over a large geographical area; that is, the Western Systems Coordinating Council (WSCC) region. The economic value of Flaming Gorge energy is set equal to the spot price of energy times the quantity of electricity injected into the grid.

Projections of future spot prices for this analysis are based on AURORA model simulations. This model has been used in the past to simulate the WSCC region for the Bonneville Power Administration (BPA). AURORA uses fundamentals of competitive markets to forecast hourly electric prices (***http://www.epis.com/products/AURORA/aurora.htm)***. The pricing structure used by AURORA satisfies the requirements of both supply and customer demand in a dynamically changing competitive energy market. In AURORA, the hourly pricing of energy is determined by the economic dispatch of regional resources to meet regional energy requirements. The model incorporates hourly information on demand, supply, fuel costs, transmission costs, and availability. The hourly dispatch of resources is based on the lowest cost resource available to meet customer demand. The energy price at any time is the cost of the last resource that is dispatched into each market area. Spot prices vary among market areas and energy delivery points to reflect regional production costs, transportation costs, and transmission line constraints. Price projections also reflect numerous assumptions concerning the future such as delivered utility fuel prices, electricity demand growth rates, changes in hourly electricity consumption patterns, and advancements in generation technologies.

Since AURORA model simulations span many years, additional capacity must be constructed in the future to meet the growing demand for electricity. The model projects a capacity expansion path based on an open utility market structure. Spot prices reflect these new capacity additions and their impact on the market.

Flaming Gorge energy injections into the grid are very small compared to total WSCC loads. Therefore, it is assumed that power injections into the grid for both alternatives will not change regional electricity prices.

4.4 GENOPT Model

The GenOpt model optimizes the economic value of electricity generated at Flaming Gorge while complying with all powerplant operational constraints. The model uses the same approach as the Generation and Transmission Maximization (GTMax) model that was used for a number of studies conducted by Western and Argonne to evaluate the economic value of power resources in the CRSP system. GenOpt was constructed to customize the mathematical formulation of the problem for the purposes of the FGEIS. Also, the customization streamlined the modeling process and significantly decreased simulation runtime.

The Flaming Gorge powerplant in GenOpt is modeled as a single generating entity. Under this representation, the three units at the plant turn on and off as many times as necessary during a simulated period in order to maximize the economic value of the hydropower resource. This may entail turning a turbine on and off several times in a single day.

The model's objective function, shown in equation 4.2, is to maximize the value of water releases from the Flaming Gorge Dam. The value of the plant power is maximized when the plant's limited water potential is used to generate energy when market prices are the highest.

$$\text{Max} \sum_{h} Gen_h \times SP_h, \qquad (4.2)$$

where

Gen_h = Generation in Mega-watt hours (MWh) during hour *h;* and

SP_h = spot market price ($/MWh) during hour *h*.

The spot price of electricity, SP_h, in the above equation is a model input and for this study is based on AURORA model projections.

Water that is released through the turbines is converted to electricity and sold to the market. As shown in equation 4.3, the amount of water and associated generation is based on block-level conversion factors. These conversion factors are a function of both the reservoir elevation level and the designation of powerplant block.

$$TR_h = \sum_b BGEN_{b,h} / CF_{b,e}, \quad \text{where} \tag{4.3}$$

TR_h = turbine water release (cfs) during hour h, for power block b;

$BGEN_{b,h}$ = generation from powerplant block b during hour h; and

$CF_{b,e}$ = power conversion factor (MWh/cfs) for powerplant generating block b at reservoir elevation e.

Each generation block has a defined limit that is specified in equation 4.4. The block limits are a function of several factors such as reservoir elevation level, maximum turbine flow rates, and turbine efficiencies. These limits and associated power conversion factors are input into the model. The procedure used to determine values for these parameters is described in section 5.

$$BGEN_{b,h} \leq BLOCKMAX_{b,e}, \tag{4.4}$$

where

$BLOCKMAX_{b,e}$ = maximum power output (MW) for block b.

Except for the second block, all other blocks in GenOpt must have a lower conversion factor than the one loaded before it; for example, block 3 must be more efficient than block 4. As discussed in section 5.1, this simplifying assumption may result in minor errors when estimating powerplant output levels; that is, errors are less than 3 MW.

Blocks and associated conversion factors are defined such that the first block is the amount of power that is generated at the minimum mandatory release rate. As specified in equation 4.5, the minimum average hourly release for all hours is 800 cfs. This minimum release rate applies to both alternatives.

$$800 = BGEN_{1,h} / CF_{1,e} \tag{4.5}$$

Electricity that is sold at spot market prices in equation 4.1 is computed by summing up the generation levels for all blocks as shown in equation 4.6.

$$GEN_h = \sum_b BGEN_{b,h}, \tag{4.6}$$

As formulated in equation 4.7, total dam water releases are a function of both turbine and non-turbine releases. Under certain wet hydrological conditions and spike flows it may be necessary to release some water through the dam’s bypass tubes and spillways. Typically, the GenOpt model will only spill water when the powerplant is generating at its maximum capability during all hours of a simulated period or as required to simulate a spring spike. Note that non-power water releases are not associated with generation in equation 4.3 and therefore do not increase the objective function value given in equation 4.2.

$$DR_h = TR_h + NTR_h, \tag{4.7}$$

where

DR_h = water release (cfs) from the Flaming Gorge Dam in hour *h*; and

NTR_h = non-turbine water release (cfs) from Flaming Gorge through bypass tubes and spillways in hour *h*.

The average water release rate during a day is computed by equation 4.8. It equals the sum of all hourly releases in a day divided by 24 hours.

$$ADR_d = \sum_{h=1,24} DR_h / 24, \tag{4.8}$$

where

*ADR*d = average daily water release (cfs) from the Flaming Gorge powerplant during day *d*.

Maximizing the economic value of water releases is subject to powerplant operational constraints. One such constraining factor limits the amount of water that can be released during a specific time period. For the No Action and Action Alternatives during a spike release period, the average daily flow must equal the amount that is specified by the Flaming Gorge model. This restriction also applies to both alternatives (refer to table 3.1). It is represented in the model by equation 4.9. To maximize the value of the hydropower resource, the GenOpt model releases as much water as possible through turbines when spot market prices are the highest. During low priced periods water releases are at a minimum.

$$ADR_d = GRDR_d, \tag{4.9}$$

where

$GRDR_d$ = average daily Flaming Gorge water release (cfs) from Flaming Gorge model.

As shown in equation 4.10 water releases in GenOpt over a multiple-day period must equal the total amount that is specified by Flaming Gorge model simulations. Typically this multi-day period equals one week.

$$\sum_d ADR_d = \sum_d GRDR_d \tag{4.10}$$

Equations 4.11 and 4.12 restrict the change in hourly water releases from the dam. Water releases from one hour to the next for both increasing levels and decreasing levels cannot differ by more than 800 cfs. The GenOpt model starts multi-hour ramping periods such that it can obtain maximum generation levels when prices are the highest and relatively low generation when electricity prices are inexpensive.

$$DR_h - DR_{h+1} \leq 800 \tag{4.11}$$

$$DR_{h+1} - DR_h \leq 800 \tag{4.12}$$

The single daily hump restriction is assured by equations 4.13 and 4.14. It is assumed that the lowest release rate (i.e., generation level) of the day will occur during hour, *h*, that has the lowest spot price; that is the minimum daily $SP_{h.}$ On the other hand, release rates are the fastest during the hour of the day with the highest spot prices.

$$DR_{h-1} - DR_h \geq 0 \tag{4.13}$$

for hours, *h*, of the day that are from midnight to the hour with the lowest daily spot price, SP_h, and also for hours of the day from the highest spot price until the last hour of the day.

$$DR_h - DR_{h-1} \geq 0 \tag{4.14}$$

for hours, *h*, of the day that are from the hour with the lowest daily spot price to the hour with the highest spot price.

GenOpt also includes equation 4.15 that relates Flaming Gorge releases and Yampa inflows to flows at the Jensen Gauge. These flows are calculated only when there are gauge constraints as specified in tables 3.1 and 3.2.

$$JF_h = AYF_m + \sum_{p=\min l, \max l} \mathrm{DR}_{h-p} \mathrm{WLF}_p , \tag{4.15}$$

where

JF_h	= GenOpt estimate of stream flow (cfs) at the Jensen Gauge in hour *h*;
AYF_h	= average inflows from the Yampa (cfs) during month *m*;
WLF_p	= fraction of Flaming Gorge water that reaches the Jensen Gauge *p* hours after it has been released from the dam;
minl	= the minimum time, in hours, that a Flaming Gorge water release takes to travel to the Jensen Gauge; and
maxl	= the maximum time, in hours, that a Flaming Gorge water release takes to travel to the Jensen Gauge.

The water lag factors, *WLF*, in equation 4.15 represent the relationship between water releases from the Flaming Gorge reservoir and water flows at the gauge. As a wave of water travels downstream from the Flaming Gorge Dam it attenuates or flattens out as it travels downstream. This attenuation becomes more pronounced the farther the wave travels downstream from the dam. Also, the farther downstream a given point (e.g., a gauge) is from the dam, the longer it takes for the wave of water to reach it. It usually takes a minimum of about 20 to 25 hours for a water release from Flaming Gorge to register at the Jensen Gauge.

Figure 4.2 shows a model run in which water releases are constant in all but the first hour of a SSARR simulated period. During the first hour a relatively high volume of water (i.e., wave of water) is released. The SSARR model projects that 24-hours (i.e., *minl*) after the pulse release from Flaming Gorge, water flows at the Jensen Gauge begin to increase above the base level. About 35 hours after the high volume release, the flow rate at the Jensen Gauge is at a peak and after 50 hours (*maxl*) water flow rates return to the base level.

A *WLF* relates the fractional amount of water from a Flaming Gorge release that will pass the Jensen Gauge in a one-hour time period and the time that it takes that portion of the water to travel to the gauge. As shown in figure 4.3, about 9.9 percent of the wave's water volume flows past the gauge during the 35th hour after the water was released from the dam. Hours both prior to and after the 35-hour lag time have smaller amounts of water that flow past the gauge.

The *WLF*s roughly form a bell-shaped distribution. Typically this distribution is skewed to the left toward shorter travel times. The sum of the water lag factors equals 1.0; that is, it is assumed that all of the water released from the Flaming Gorge Dam flows past the Jensen Gauge at some time in the future.

In addition to operational constraints at the dam, the GenOpt model also restricts Jensen Gauge flows. Equation 4.16 is used to compute the daily average flow at the gauge.

$$AJF_d = \sum_{h=1,24} JF_h / 24, \qquad (4.16)$$

where

AJF_d = average daily flow rate (cfs) at the Jensen Gauge.

For the No Action Alternative all daily average flows at the gauge are constant from one day to the next over a multi-day period; that is, a month period or from the end of the spike period through the end of the month. Equation 4.17 ensures that daily average flows passing the gauge are identical.

$$AJF_d - AJF_{d+1} = 0 \qquad (4.17)$$

Both the No Action and Action Alternatives also restrict gauge flows within a day. Equation 4.18 restricts the intra-day hourly flows.

$$AJF_d \times (1 - LGL_d) \le JF_h \le AJF_d \times (1 + UGL_d) \qquad (4.18)$$

where

UGL_d = gauge upper flow limit (fraction) for day *d* (e.g., 0.125 for the No Action Alternative); and

LGL_d = gauge lower flow limit (fraction) for day *d* (e.g., 0.125 for the No Action Alternative).

As described in section 3.1, Jensen Gauge flows are limited to 12.5 percent of the daily average for the No Action Alternative. The lower and upper gauge limits for the Action Alternative are based on 0.1-meter stage change. The daily average flow rate along with the river stage plot shown in figure 3.3 are used to express the limits in terms of a fraction.

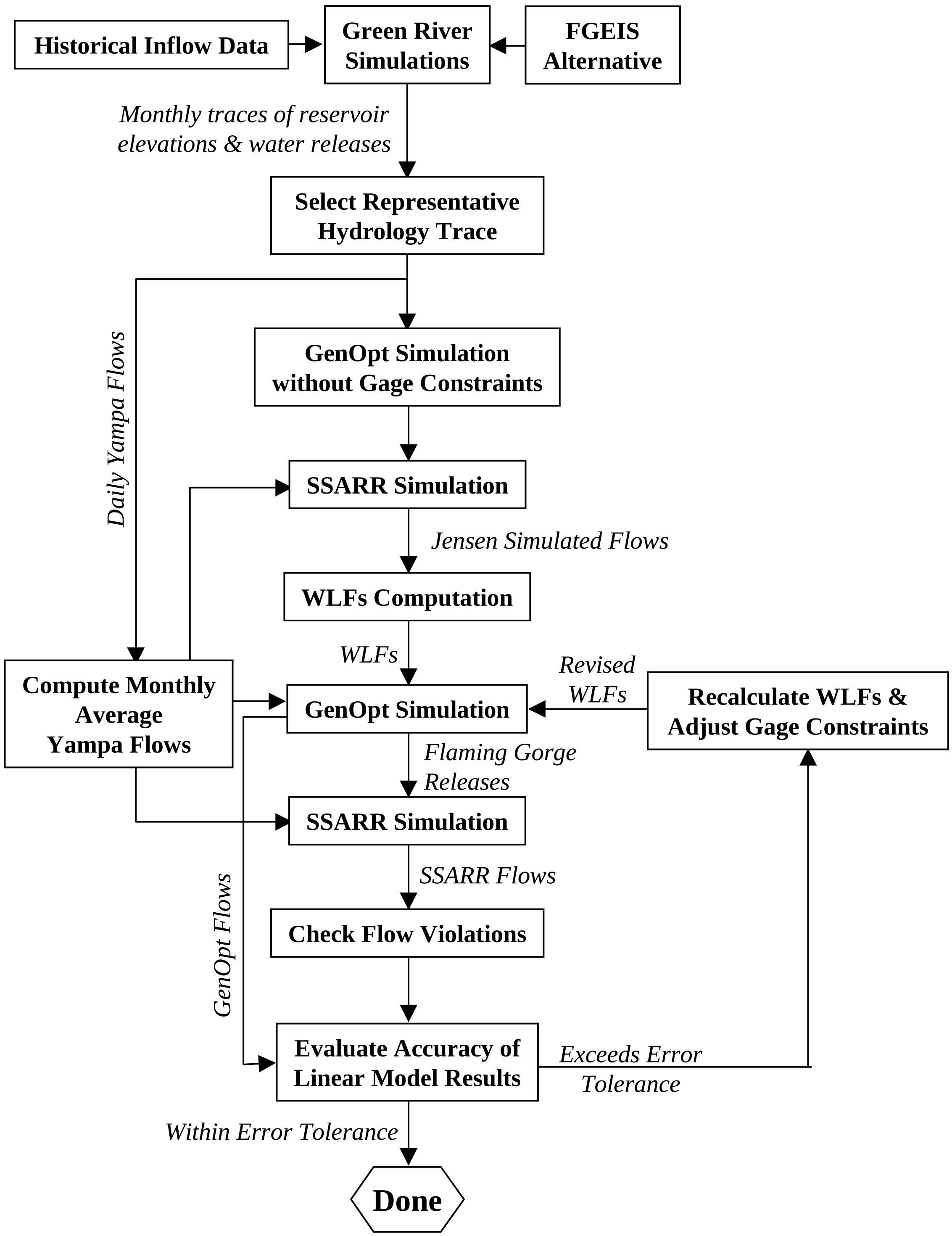

Figure 4.1. Overview of the Flaming Gorge Power Modeling Package.

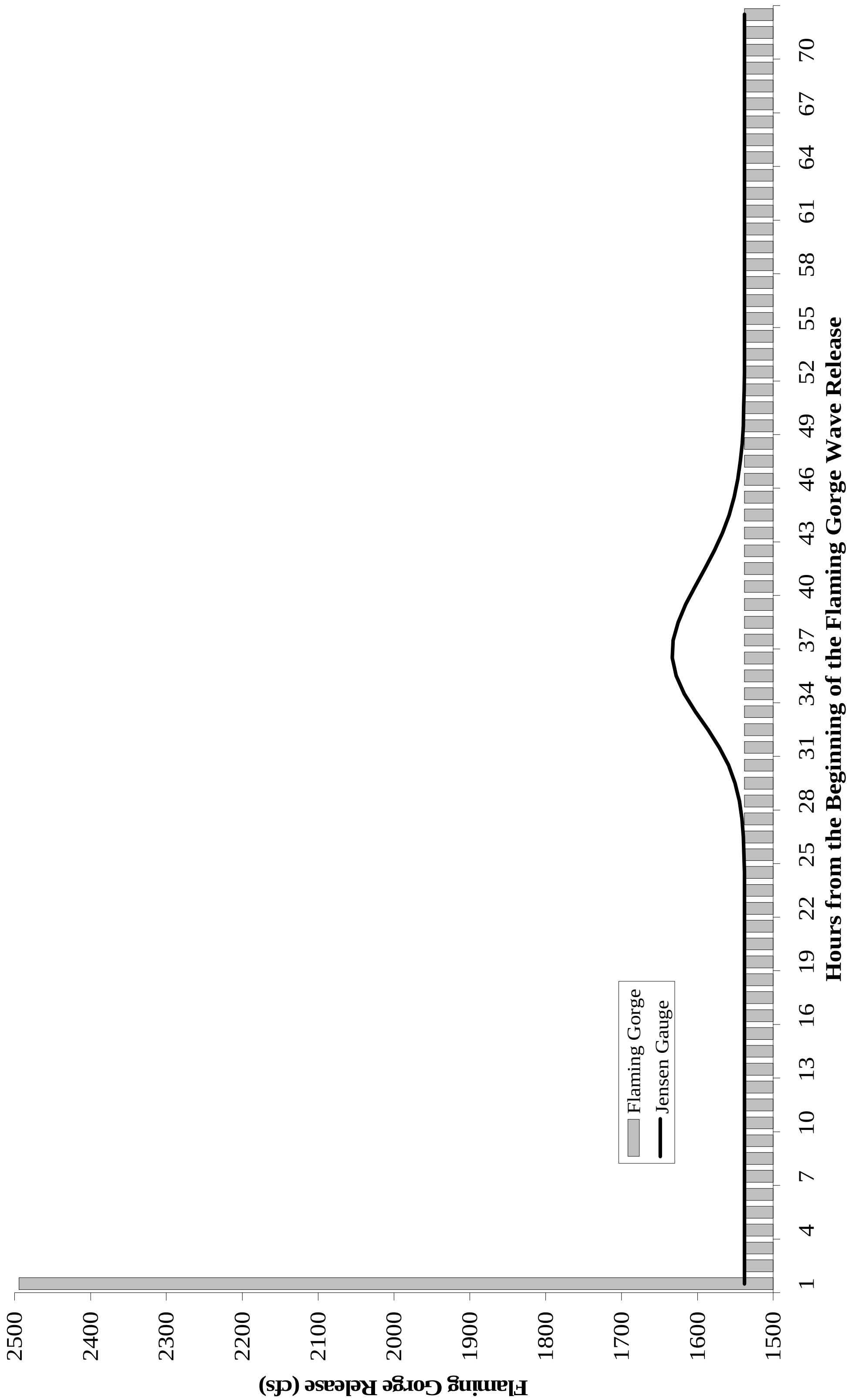

Figure 4.2. Travel Time for a Wave of Water Released From Flaming Gorge to the Jensen Gauge.

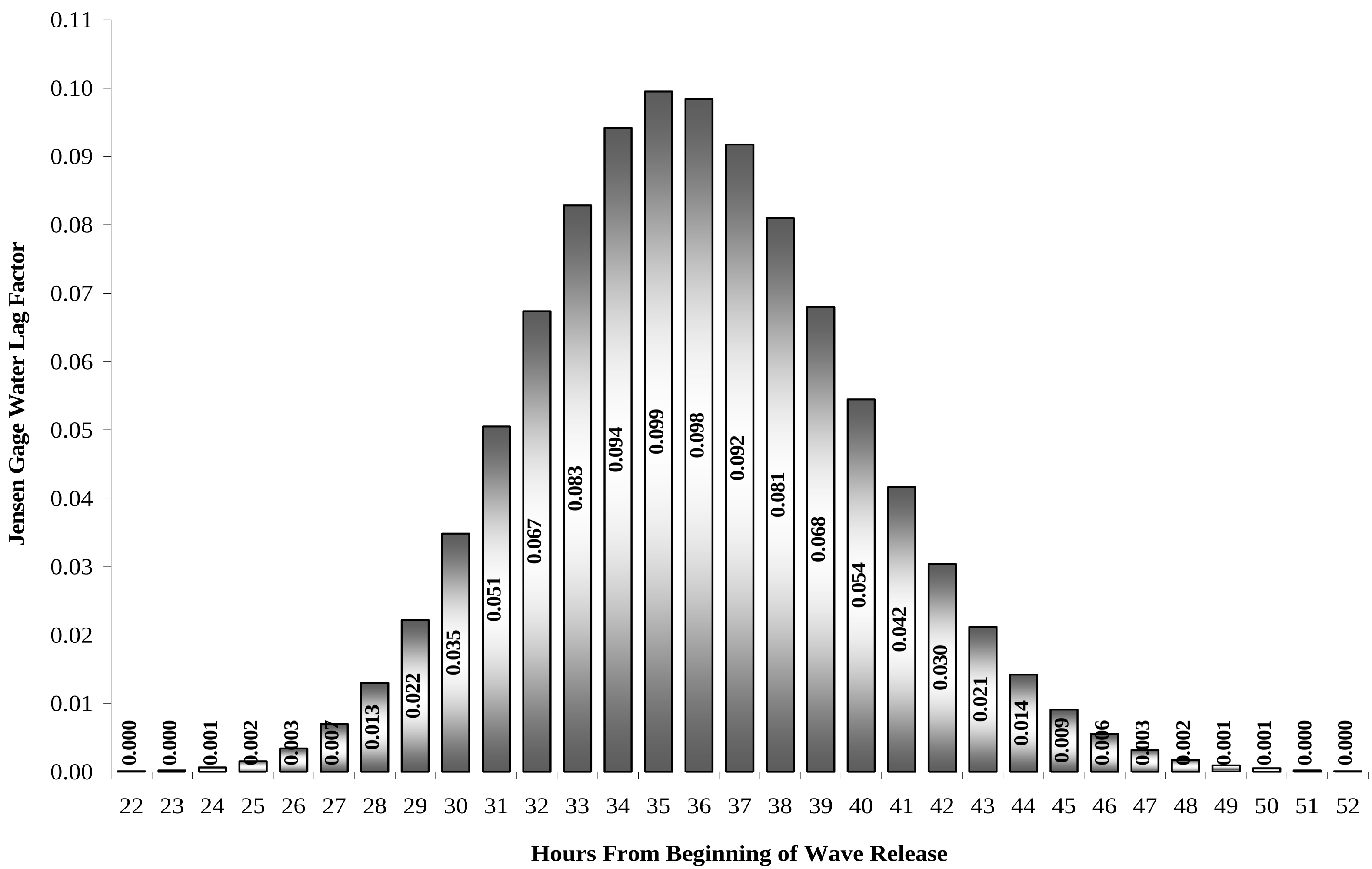

Figure 4.3. Water Release Lag Factors for Flaming Gorge Travel to the Jensen Gauge.

4.5 WL Algorithm

The Water Lag (WL) algorithm computes *WLF*s based on SSARR simulations of Green River flows at the Jensen Gauge. The objective of the model, shown in equation 4.19, is to compute a set of *WLF*s that minimizes gauge flow differences estimated by equation 4.15 and those estimated by SSARR.

$$\text{Min} \sum_{h} ABS(SJF_h - JF_h), \tag{4.19}$$

where

SJF_h = stream flow (cfs) at the Jensen Gauge estimated by SSARR.

The *WLF*s are based on a known set of water releases and Yampa inflows that are identical to the ones used as input into the SSARR model. The WL algorithm computes Jensen Gauge flows using equation 4.20. Both Yampa inflows and Flaming Gorge releases are known and the algorithm solves for *WLF*.

$$JF_h = AYF_M + \sum_{p=\min l, \max l} SDR_{h-p} WLF_p, \tag{4.20}$$

where

SDR_{h-p} = Flaming Gorge releases that are input into the SSARR model.

*WLF*s are subject to constraints provided in equations 4.21 and 4.22 that ensure that the shape of the *WLF*s follows a bell shaped curve as shown on figure 4.3. When the lag time, *p,* is less than the lag hour with the largest *WLF* (i.e., lag hour with the peak influence on the gauge), equation 4.21 requires that the *WLF* for the previous lag hour be less than the next lag hour. For example in figure 4.3, all *WLF*s for lags of 24 hours to 35 hours (i.e., hour with the largest value or 0.099) must be greater than or equal to the previous lag value.

$$WLF_{p+1} - WLF_p \geq 0 \tag{4.21}$$

For lag hours greater than the one with the largest *WLF*, equation 4.22 is used.

$$WLF_p - WLF_{p+1} \geq 0 \tag{4.22}$$

The lag time with the maximum *WLF* value is determined by running the SSARR model for numerous combinations of Flaming Gorge Dam releases and Yampa inflows. These runs were used to create the surface shown in figure 4.4. For example, when Yampa inflows are zero and 800 cfs is released from the Flaming Gorge Dam, the Jensen Gauge will have the highest *WLF* for lag hour 44.

As the release from Flaming Gorge increases from 800 cfs to approximately 3,500 cfs, the lag time to the maximum *WLF* (i.e., peak influence on the gauge) decreases from about 44 hours to about 28 hours. As

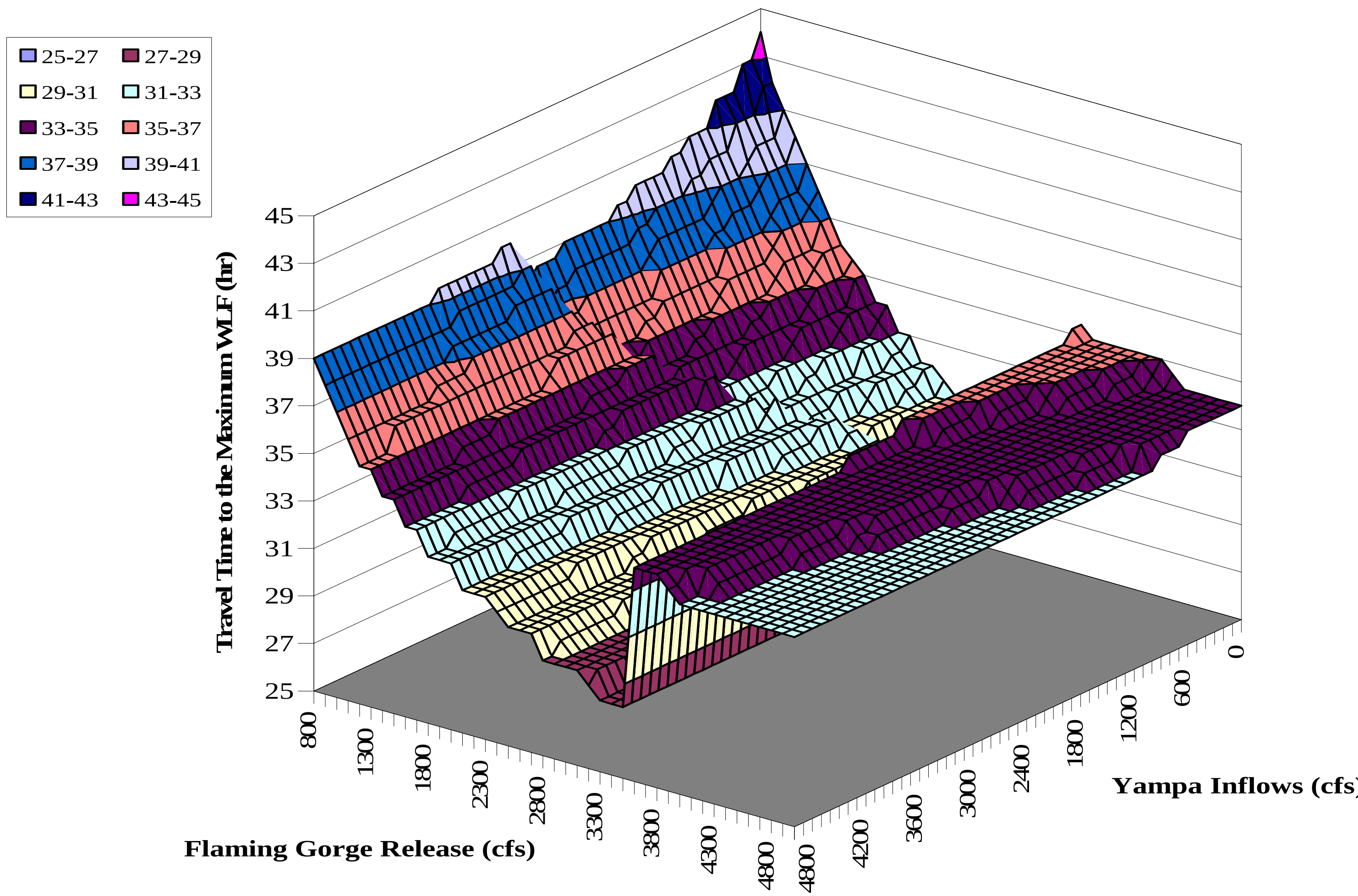

Figure 4.4. Travel Times for the Maximum WLF to Reach the Jensen Gauge as a Function of Flaming Gorge Releases and Yampa Inflows.

release rates increase beyond this level the lag time to the maximum *WLF* abruptly increases to about 35 hours. At higher release rates water spills out of the main river channel and the flow rate decreases. Flow rates above the 3,500 cfs level slowly shorten lag times.

Although less dramatic, a similar pattern is observed with Yampa inflows. Note in figure 4.4 for a Flaming Gorge release of 800 cfs that the lag time to the maximum *WLF* abruptly increases when Yampa inflows are greater than 2,500 cfs.

Based on Flaming Gorge model results for Flaming Gorge daily releases and Yampa inflows, the lag time with the largest *WLF* value was approximated. This lag time and the ones surrounding it are separately run through the WL algorithm. The GenOpt model uses the set of *WLF*s that yields the smallest error.

4.6 Model Integration

The main advantages of using equation 4.15 in the GenOpt model are that the equation is based on SSARR simulations and that the mathematical problem can be quickly solved. Also, since the equation is linear it can be directly incorporated into the GenOpt model making it possible to simultaneously maximize the economic value of hourly reservoir operations while complying with downstream flow restrictions. However, the linear representation of Jensen Gauge flows is only an approximation of the complex behavior of Green River flows. Despite these shortcomings, the linear representation in GenOpt produces flow estimates that are very similar to the ones output from SSARR provided that *WLF*s are estimated for a specific hydrological condition.

The determination of *WLF*s in the WL algorithm poses a problem since it requires a set of known Flaming Gorge releases, Yampa inflows, and SSARR flow simulation results for the Jensen Gauge. The GenOpt model can approximate Flaming Gorge releases, but equation 4.15 requires an estimate of *WLF*s as input data. This is a classic "chicken-and-egg" problem. As shown in the flow chart on figure 4.1, an iterative method is used to solve it. First, an initial GenOpt model is run with the assumption that there are no gauge constraints. In this simulation, equation 4.15 and gauge constraint equations 4.16 through 4.18 are not considered.

Next, the SSARR model is run with GenOpt's initial estimates of Flaming Gorge releases. As shown in figure 4.5, this first SSARR simulation typically results in a gauge flow violation. Simulated flows for the No Action Alternative are about 200 cfs above the maximum limit and about 50 cfs below the minimum limit. Flaming Gorge water releases follow the spot market price trends with minimum releases at night when prices are the lowest and significantly higher releases during the day when prices peak. Daytime releases are almost 3.5 times higher than the minimum release rate.

Based on initial Flaming Gorge releases and SSARR results, the WL algorithm is then run to produce an initial set of *WLF*s. These *WLF*s are then input into GenOpt and the model optimizes Flaming Gorge releases such that both dam operational and Jensen Gauge constraints are not violated. The GenOpt model also estimates gauge flows. However, since the GenOpt gauge flow simulation is only a linear approximation, actual flows may violate gauge constraints based on the more detailed SSARR simulation. As shown in figure 4.6, gauge flows estimated by SSARR using the revised set of Flaming Gorge releases are about 30 to 40 cfs higher than the maximum limit during each day. Low flows, however, never violate the limit. Since the initial set of *WLF*s is based on Flaming Gorge releases without gauge constraints, the GenOpt model under- predicts peak gauge flows. However, compared to the initial simulation, gauge violations for the second GenOpt run are significantly smaller.

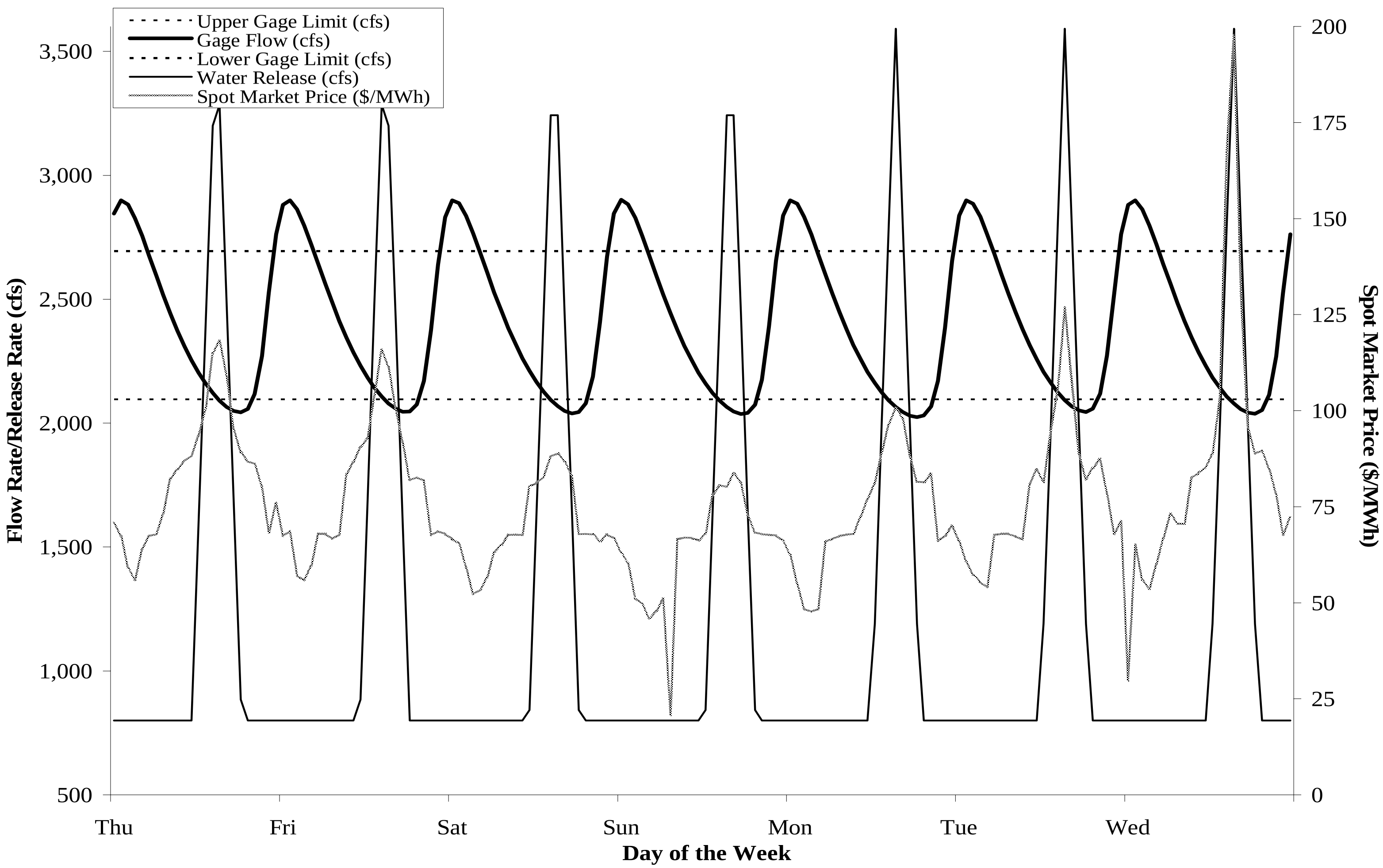

Figure 4.5. Flaming Gorge Releases and Simulated Jensen Gauge Flows Assuming No Gauge Constraints.

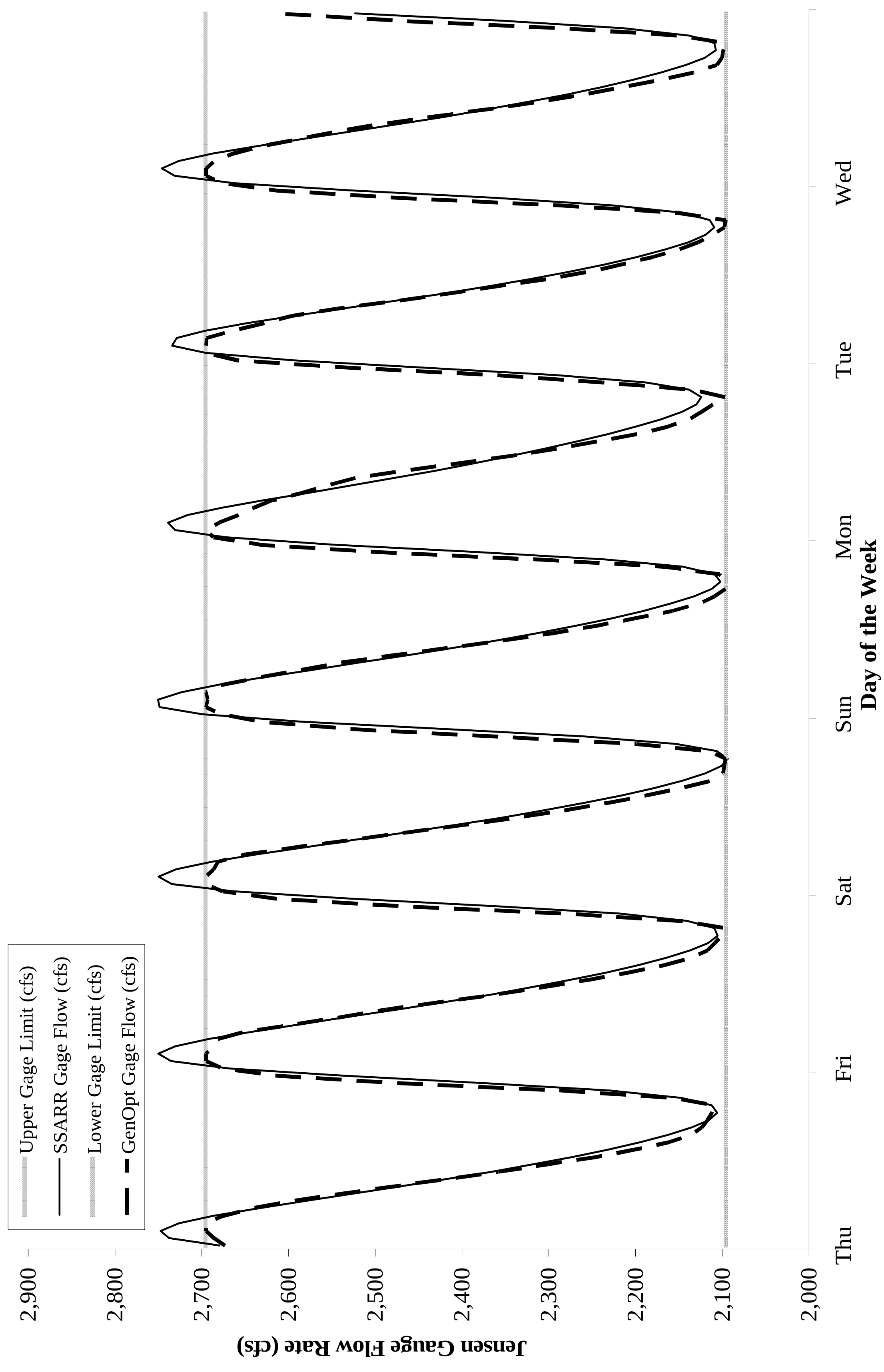

Figure 4.6. Comparison of Jensen Gauge Flow Estimated by the GenOpt and SSARR Models for the First Iteration.

Compared to the initial run without gauge constraints, peak releases from Flaming Gorge are lower; that is, from about 35,000 cfs to 29,000 cfs. As shown on figure 4.7, water releases during the peak hours were shifted to the less valuable shoulder hours. This shifting of water decreases peak Jensen Gauge flows and increases the lower flows.

The updated dam releases from GenOpt along with the new SSARR results are input into the WL algorithm to update estimates of *WLF*s. Since the *WLF*s are based on a set of Flaming Gorge releases that are closer to compliance than the initial set, the linear representation of Jensen Gauge flows improves.

The new *WLF*s are input into the GenOpt model and Flaming Gorge releases are recomputed. The SSARR model is also run again. Figure 4.8 shows that violations estimated by SSARR for the second iteration are very small; that is, about 5 to 25 cfs during peak flows. Also, compared to the first iteration, estimates of gauge flows by the GenOpt model are closer to SSARR simulations. As shown on figure 4.9, the lower violation level was the result of shifting more water from peak release periods to shoulder hours.

The process of sequentially running GenOpt, SSARR, and the WL algorithm continues in an iterative process until there are no gauge violations based on SSARR simulations. Figure 4.10 shows that results for the final iteration have no gauge violations as simulated by the SSARR model. Peak releases from Flaming Gorge are much lower than the initial run without gauge constraints and less water is released when it has the highest value.

Updating the *WLF*s via the iteration process may never achieve compliance in some situations since the linear representation produces results that do not always exactly match SSARR projections. In these situations a successive relaxation method is used to adjust the gauge limits input into GenOpt.

When compliance is not achieved after a user specified number of iterations, a gauge limit input into GenOpt is adjusted such that it is slightly more stringent than the one specified by an alternative. For example, if SSARR gauge flow simulations are over the limit by a maximum of 0.2 percent for the No Action Alternative, then the upper gauge flow limit input into GenOpt is lowered from 12.5 percent to 12.4 percent. That is, the gauge limit given to GenOpt is reduced by one-half of the violation level as expressed in equation 4.23 where the adjustment parameter, *UAP*, is set equal to 0.5.

$$AUGL_{i,d} = AUGL_{i-1,d} - (UAP_d \times UVL_d), \tag{4.23}$$

where

$AUGL_d$ = adjusted gauge upper flow limit (fraction) for day d and iteration i, where $AUGL_{1,d}$ is set equal to UGL_d;

UAP_d = upper flow limit adjustment parameter (fraction) for day d and iteration i; and,

UVL_d = maximum violation above the upper flow limit in day d (fraction).

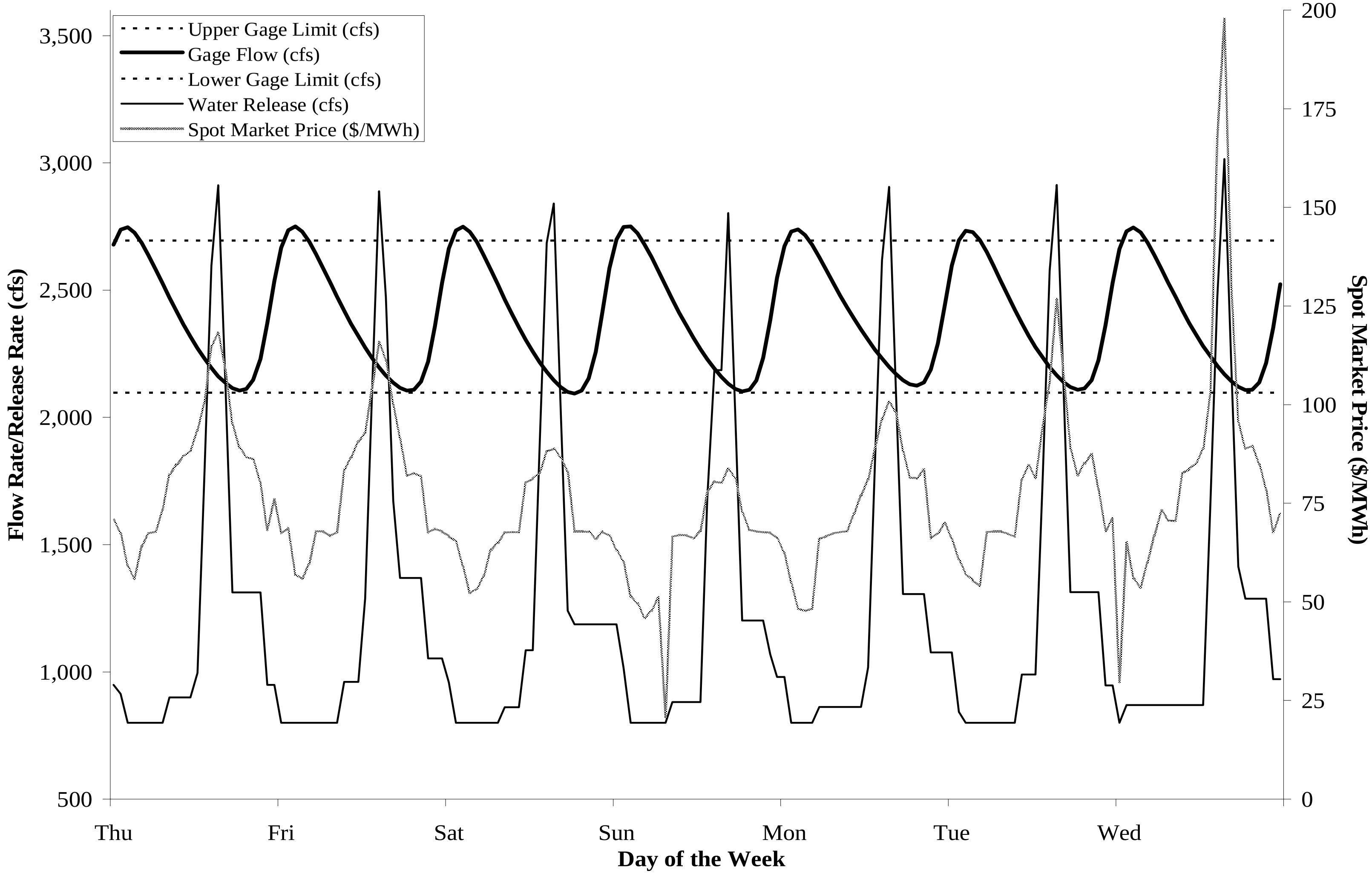

Figure 4.7. Flaming Gorge Releases and Simulated Jensen Gauge Flows for the First Iteration.

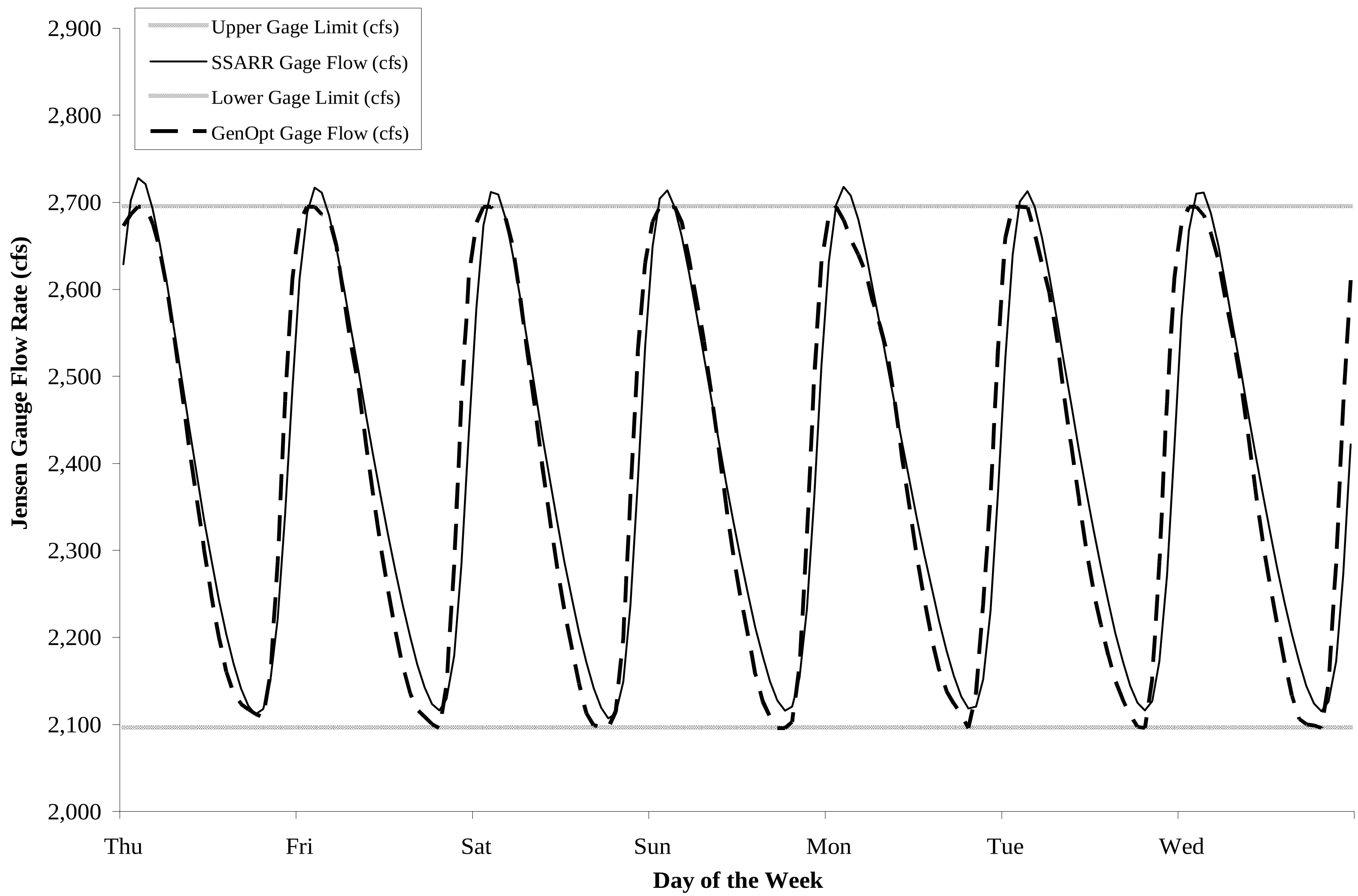

Figure 4.8. Comparison of Jensen Gauge Flow Estimated by the GenOpt and SSARR Models for the Second Iteration.

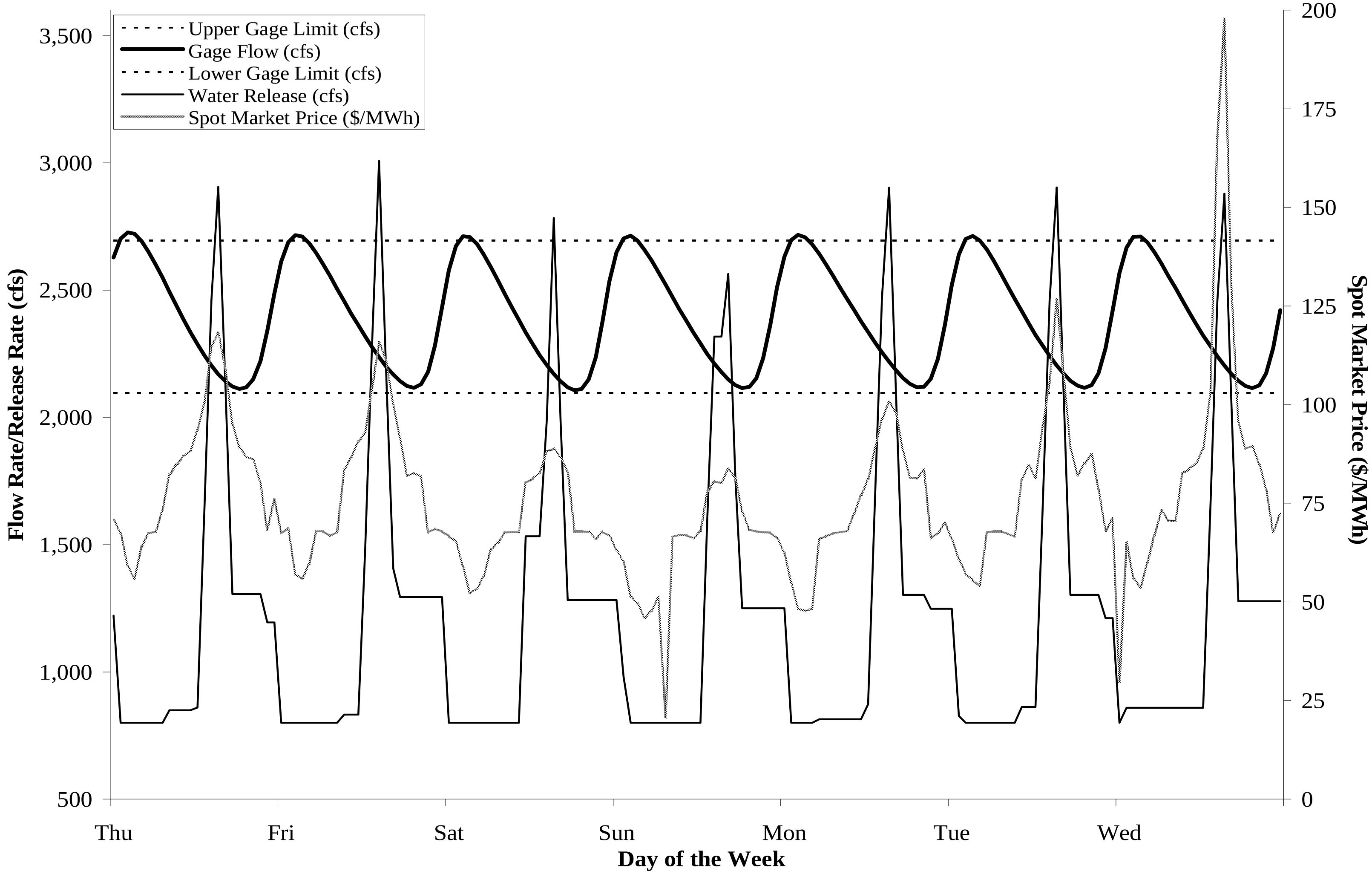

Figure 4.9. Flaming Gorge Releases and Simulated Jensen Gauge Flows for the Second Iteration.

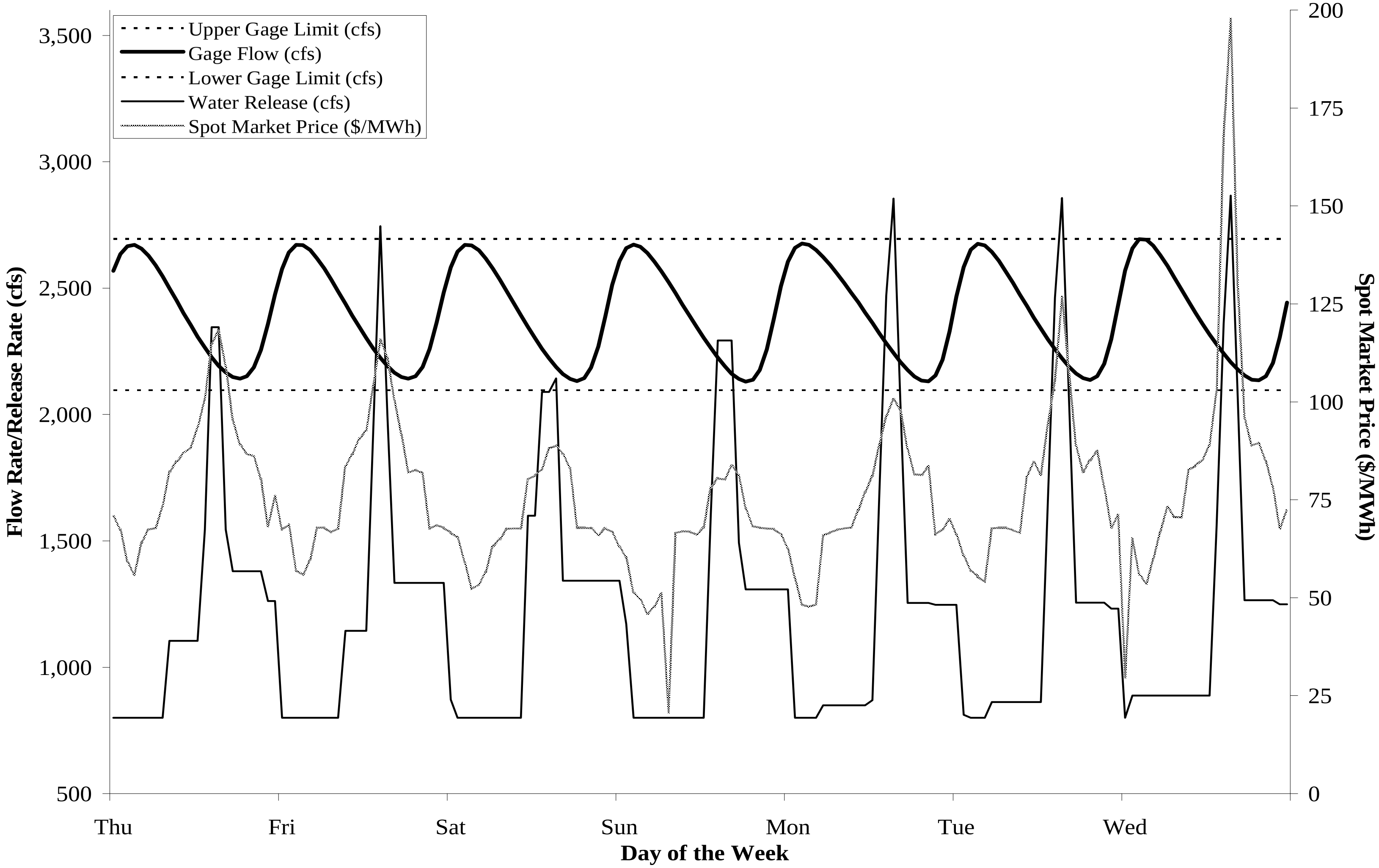

Figure 4.10. Flaming Gorge Releases and Simulated Jensen Gauge Flows for the Final Iteration.

The violation level, *VL*, can be either positive or negative. A positive value indicates a violation while a negative value indicates that the GenOpt model is over complying with gauge flow limits. Over compliance occurs when the difference between SSARR model simulated flow and the limit is greater than a user specified tolerance level and slack values for gauge constraint equations from GenOpt results are zero.

The adjustment parameter, *LAP*, changes or adapts among iterations. The number assigned to it is based on a set of rules that track the parameter's value relative to its previous assigned value and the number of directional changes (i.e., from + to – or vice-versa) of the violation, *LVL*, in all previous iterations. The rule set also places bounds on the adjustment parameter, *AP*, under various situations to ensure that the search space remains within a feasible region and to guide the convergence process.

Lower gauge limits are adjusted using a similar process in equation 4.24

$$ALGL_{i,d} = ALGL_{i-1,d} - (LAP_d \times LVL_d), \tag{4.24}$$

where

$ALGL_d$ = adjusted gauge upper flow limit (fraction) for day d and iteration *i*, where $ALGL_{1,d}$ is set equal to LGL_d;

LAP_d = upper flow limit adjustment parameter (fraction) for day *d* and iteration *i*; and,

LVL_d = maximum violation above the upper flow limit in day *d* (fraction).

This heuristic process does not guarantee an optimal result since the linear representation of Jensen Gauge flows is imperfect. However, it is well within the range of SSARR simulation error and future uncertainties such as spot market prices and hydrology forecasts. For the purposes of the FGEIS, the modeling process provides a good measure of the operational constraints that are required at Flaming Gorge to meet downstream flow requirements and the associated economic impacts on power systems.

4.7 Compatibility Issues and Boundary Conditions

GenOpt, SSARR, and WL algorithm runs are performed on a monthly basis whereby each month was assumed to be independent of the months that precede and follow it. This assumption was made since in some cases it is impossible to comply with Jensen Gauge constraints given the daily water releases from Flaming Gorge projected by the Flaming Gorge model. In each of these cases, the compliance problem was due to an abrupt increase or decrease in daily releases between two consecutive days that were in two different months; for example, June 30, 2003 and July 1, 2003. Similarly, Flaming Gorge model results also contained cases with abrupt Yampa inflow changes. These abrupt inflow changes between months also created gauge compliance problems.

By treating each month as an independent model run, the boundary problem between two successive months was alleviated. Other boundary conditions stemming from the long lag time between Flaming Gorge water releases and Jensen Gauge flows were also addressed. When these boundary conditions are not considered, Flaming Gorge releases at the beginning of a simulated month do not recognize water releases from the dam that occurred prior to the simulation month. These prior releases will affect gauge flows in the current period. Likewise, releases at the end of the month will affect gauge flows in the next month.

To deal with this boundary condition, monthly simulations were extended by 2 days. Yampa inflows and Flaming Gorge releases for the last day of the month were assumed to continue throughout the 2-day extension period. However, spot market price projected for the 2 days following the current simulation month were used. This assumption preserves weekly spot price patterns and resultant generation patterns. Conceptually the boundary condition at the beginning of a simulation month is treated in a similar manner except that the model includes a 2-day period prior to the current simulation month. These 2 days are assumed to have characteristics that are identical to the last 2 days of the first week in the month. GenOpt model results are only considered for the simulated month; that is, extension period results are not used.

Non-compliance problems also occurred in the modeling of Flaming Gorge releases when Yampa inflows change rapidly over a short time period. Therefore, the Yampa flows input into the model are based on monthly averages. This assumption is compatible with FGEIS alternatives that do not require Flaming Gorge operations to compensate for unpredictable Yampa inflows.

Another issue that arose during the modeling process involved Green River inflow forecast errors. Jensen Gauge flow constraints that specify a daily minimum and maximum level shown in tables 3.1 and 3.2 were not input into the GenOpt model for either alternative. Projected daily releases from the Flaming Gorge model did not always comply with this requirement. Since the Flaming Gorge model includes an inflow-forecast error, non-compliance events will occur. In most of these cases it is impossible for the GenOpt model to allocate a daily water release volume among hours of the day such that there are no violations at the Jensen Gauge.

5. FLAMING GORGE POWERPLANT CHARACTERISTICS

This section describes the methods that were used to estimate GenOpt input values for the Flaming Gorge powerplant. These characteristics are used by GenOpt to estimate the powerplant's generation capability and power conversion factors. As described in detail below, the powerplant's maximum generation level and conversion of turbine water releases (i.e., kinetic energy) to electricity are dynamic and change as a function of both reservoir elevation level and powerplant operations.

5.1 Powerplant Capacity and Capability

The Flaming Gorge Powerplant has three generating units each with an installed capacity of 50.65 MW for a total of 151.95 MW (***Form PO&M-59)***. However, due to turbine limitations the operable capability of the powerplant is approximately 141 MW; that is 47.0 MW per turbine **(*Larry Andersen, Email sent on 7/10/2002*).** Figure 5.1 shows the installed capacity and maximum recorded generation in a month as reported in PO&M 59. Prior to unit rewinds that began in March 1991, the powerplant's maximum generation level routinely exceeded the installed capacity. At that time, the powerplant was able to operate with overload factors of 25 percent without adversely affecting the turbines or generators. Once rewinds were completed in April 1992, maximum hourly generation levels did not increase significantly.

The capability of the powerplant is not only a function of the installed capacity and turbine limits, but also of several other factors. Some of these include:

(1) number of turbines in operation,
(2) turbine efficiency level,
(3) turbine overload capability,
(4) the maximum turbine flow rate,
(5) plant's power factor,

(6) reservoir elevation level, and
(7) tail water elevation.

This analysis uses equation 5.1 to estimate the capability of the Flaming Gorge Powerplant; that is, the maximum continuous generation level that the plant can sustain without adverse effects on the equipment.

$$PCAP_h = \text{Min}\{47.0 \times NT_h, FML_h\}, \tag{5.1}$$

where

$PCAP_h$ = powerplant capability (MW) in hour *h*;

NT_h = number of operating turbines in hour *h*; and

FML_h = capability (MW) limited by the turbine's maximum flow rate in hour *h*.

The powerplant capability is constrained by the turbine operational limit of 47 MW each and by the maximum flow rate through the turbines.

The maximum flow rate through a turbine and hence the computed value for *FML* in equation 5.1 is a function of the net head. The net head is computed by subtracting the tail water elevation from the reservoir elevation, where the tail water elevation is estimated by equation 5.2. This equation is identical to the one that is in the RiverWare model.

$$TWE_h = 5600.2 + (1.709 \times DR_h) - (0.2039 \times DR_h^{\ 2}) + (0.01147 \times DR_h^{\ 3})\}, \tag{5.2}$$

where

TWE_h = tail water elevation (ft) in hour *h*; and

DR_h = water release (cfs) including both turbine and non-turbine releases in hour *h*.

As shown in figure 5.2, the tail water elevation level rises as the flow rates from the dam increases. Flows include both turbine and non-turbine releases.

The maximum flow through the Flaming Gorge Powerplant is estimated by equation 5.3. This equation is also contained in the RiverWare model.

$$TRMax_h = [593.8 + (2.222 \times N_h) + (0.0002616 \times N_h^{\ 2})] \times NT_h, \tag{5.3}$$

where

$TRMax_h$ = maximum water release rate (cfs) through operational turbines in hour *h*; and,

N_h = net head (ft) in hour *h*.

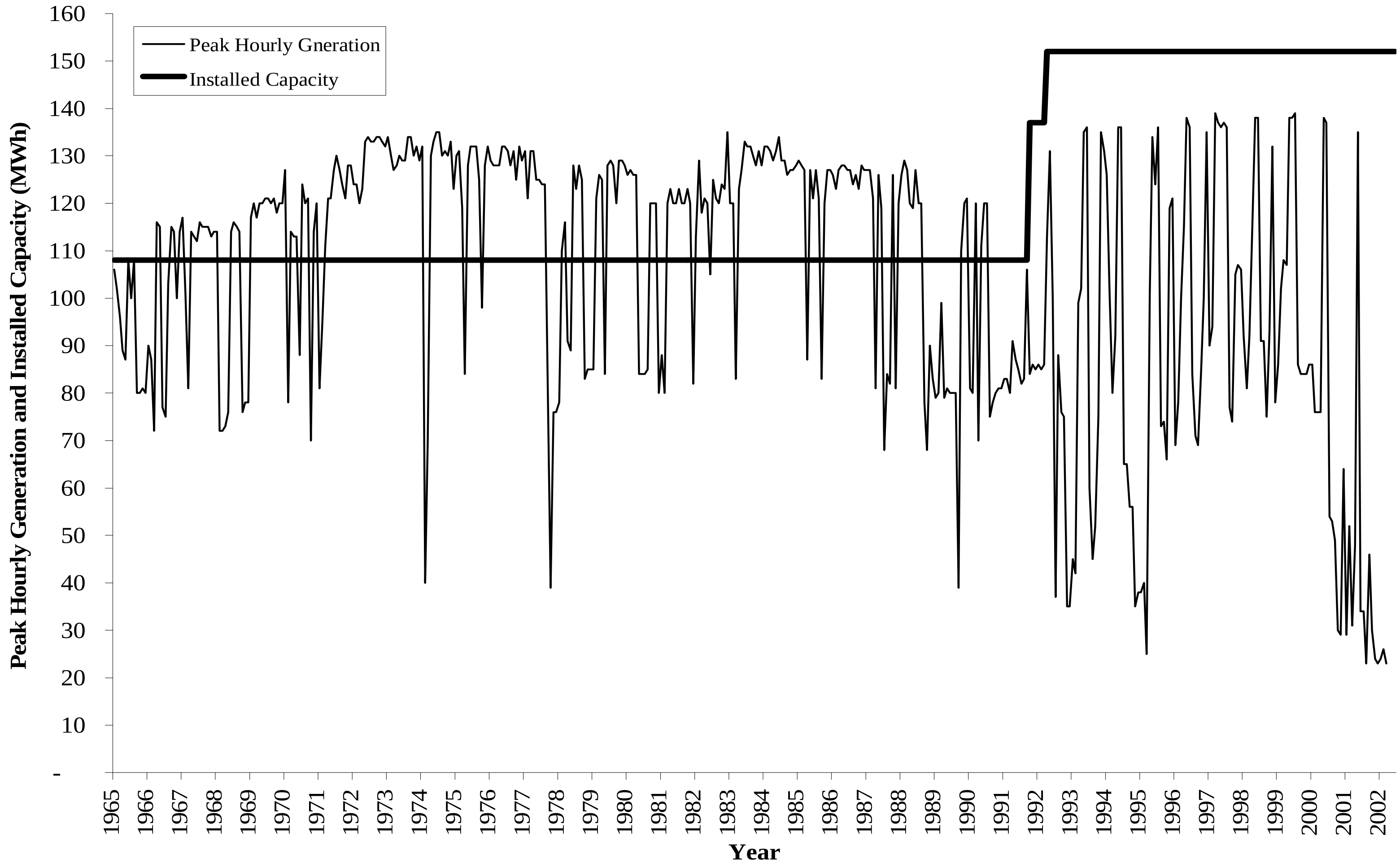

Figure 5.1. Comparison of Capacity and Maximum Recorded Generation in Each Month.

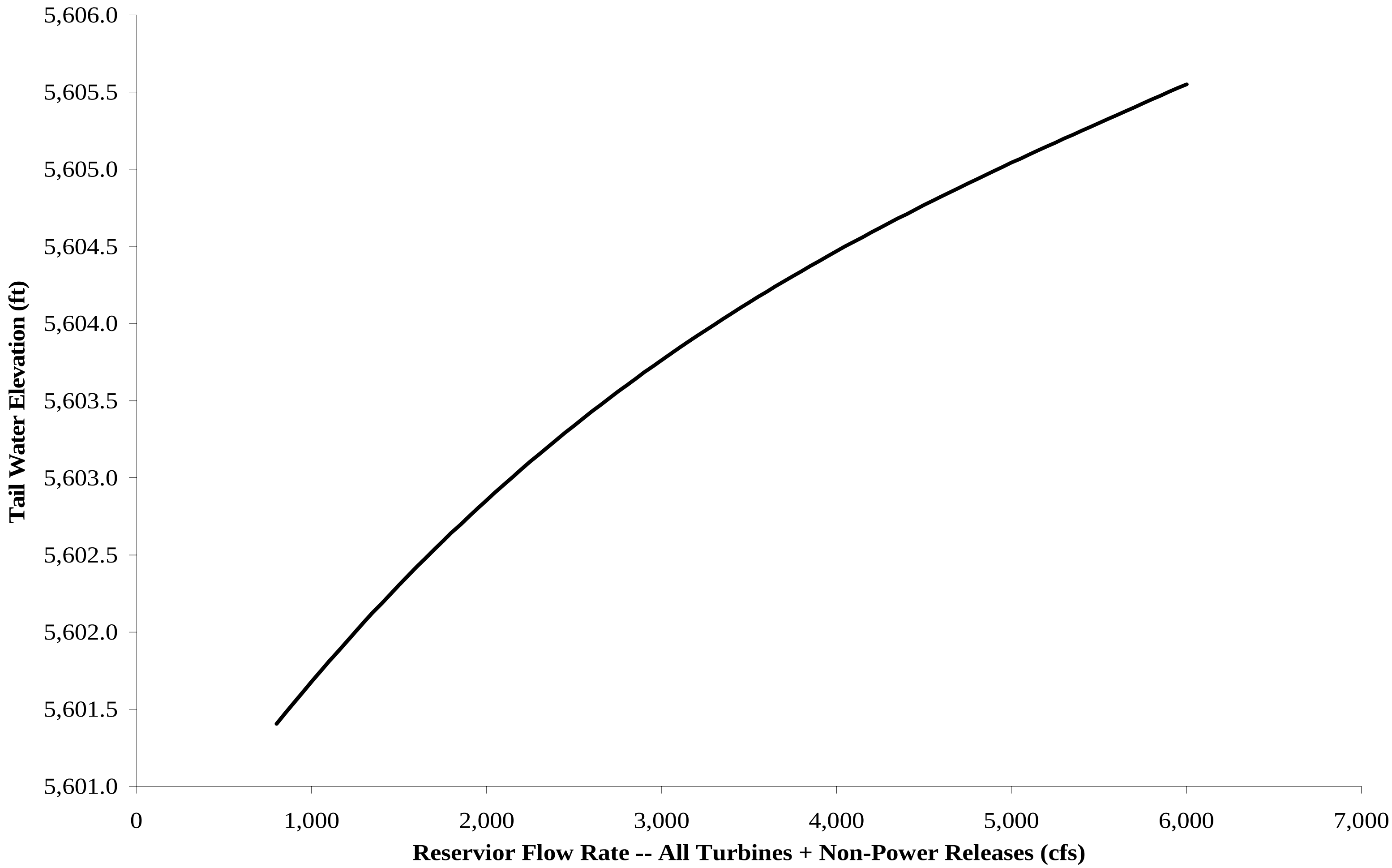

Figure 5.2. Flaming Gorge Tail Water Elevation as a Function of Total Dam Releases.

As shown in figure 5.3, the maximum turbine flow increases with higher heads. However, the turbines are not usually operated at the higher flow rates since it would produce more energy than the powerplant's generating capability (i.e., 47 MW x *NT*) resulting in potential damage to turbines and related power equipment.

Based on the net head and the turbine flow rate limit, the maximum generation level is computed by equation 5.4 (i.e., universal power equation) (***Modeling Hourly Operations at the Glen Canyon Dam GCPS09 version 1.0, September 1996, p. 47)***.

$$FML_h = (SWW \times EFF \times PF \times TRMax_h \times N_h)/(hptokw \times 1000), \qquad (5.4)$$

where

SWW = 62.4, the specific weight of water at 50 degrees Fahrenheit (lb/ft^3);

EFF = turbine efficiency (fraction);

PF = plant's power factor (fraction); and

hptokw = 737.5 conversion factor (kw/ft-lbs).

For this analysis, the plant's power factor, *PF*, is set equal to 0.95. This value is based on historic reactive power requirements (***Personal Communication, Larry Andersen)***.

As shown in figure 5.4, the turbine efficiency parameter is a function of both turbine output level, in terms of horsepower (HP), and net head. Equations 5.5 through 5.7 are used to estimate the turbine efficiency curves for three net head levels that include 400, 420, and 440-feet, respectively. When the reservoir elevation is not at one of these three levels, the turbine efficiency is based on linear interpolation. The equations are based on curves contained in Reclamation's Hydraulic Turbine Data profiles for the Flaming Gorge Powerplant **(No. 2512 4-20-62)**. This profile is provided in Appendix A1.

$$\begin{aligned} EFF400 &= 25.098 + (6.6653 \times PHP) - (0.3259 \times PHP^2) + (8.36312\text{e-}03 \times PHP^3) \\ &\quad - (1.01932\text{e-}04 \times PHP^4) + (4.51414\text{e-}07 \times PHP^5), \end{aligned} \qquad (5.5)$$

where

PHP = powerplant output (HP); and

EFF400 = turbine efficiency for at a net head of 400 feet (fraction).

$$\begin{aligned} EFF420 &= 6.86486 + (8.41418 \times PHP) - (0.39346 \times PHP^2) + (9.5572\text{e-}03 \times PHP^3) \\ &\quad - (1.11467\text{e-}04 \times PHP^4) + (4.83267\text{e-}07 \times PHP^5), \end{aligned} \qquad (5.6)$$

where

EFF420 = turbine efficiency for at a net head of 420 feet (fraction).

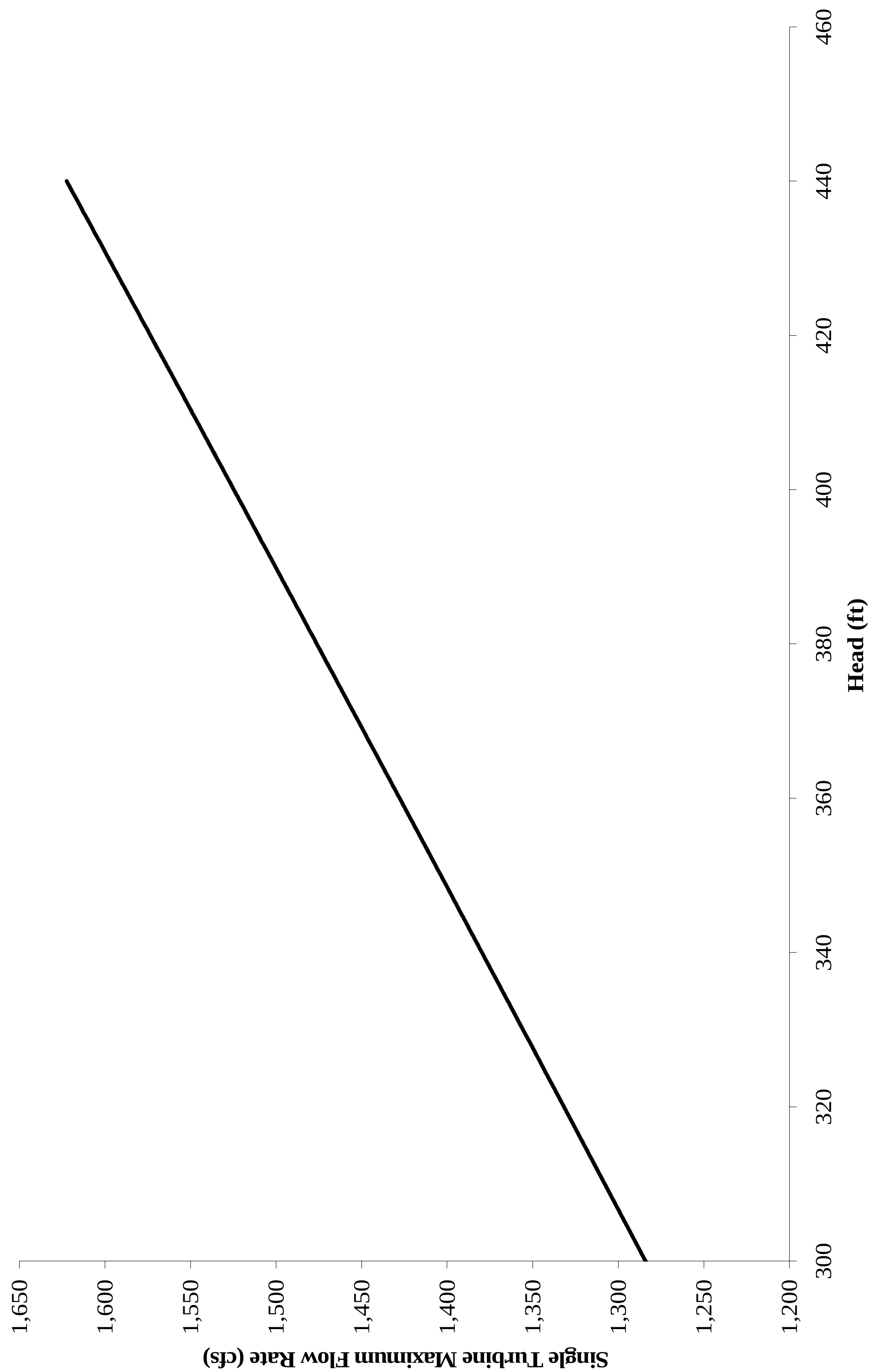

Figure 5.3 Maximum Flow Rate through a Single-Turbine as a Function of Head.

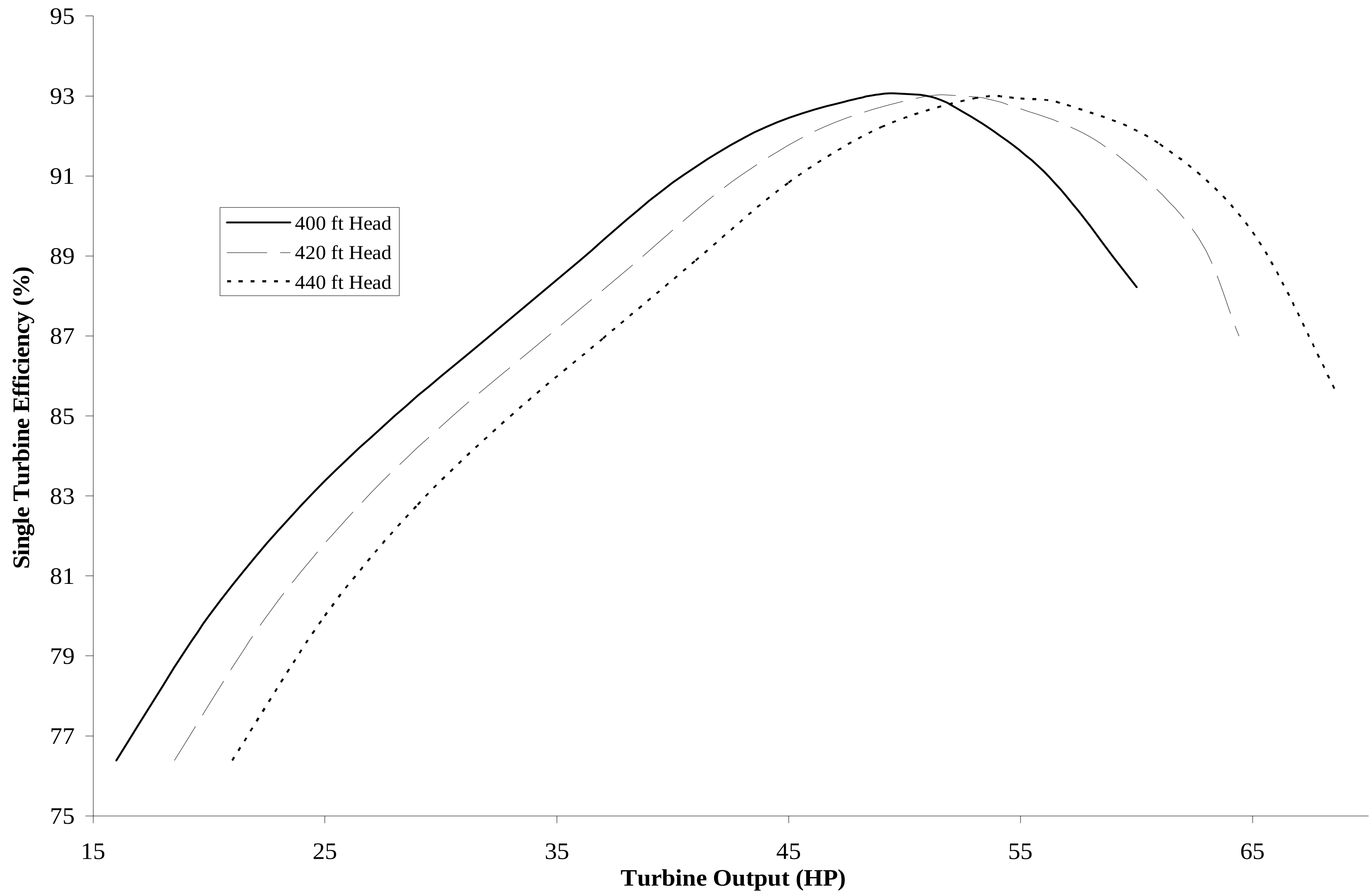

Figure 5.4. Turbine Efficiency as a Function of Flaming Gorge Power Output.

$$EFF440 = -20.69 + (11.1294 \times PHP) - (0.500487 \times PHP^{2}) + (1.15304e\ -02 \times PHP^{3})$$
$$- (1.28141e\ -04 \times PHP^{4}) + (5.35890e\ -07 \times PHP^{5}), \quad (5.7)$$

where

EFF440 = turbine efficiency for at a net head of 440 feet (fraction).

Figure 5.5 shows the results of equation 5.1 and compares it to historical maximum generation levels for the range of reservoir elevations that are projected by the Flaming Gorge model through the year 2026. The figure shows that for a few observations the hourly maximum generation level was slightly higher than the ones computed by equation 5.1. This may have been the result of low reactive power requirements during this time period and therefore a higher power factor than the 0.95 assumed in this study.

The number of turbines operating, *NT*, in equation 5.3 is typically set to 3. However, each unit is taken off-line for approximately 2 weeks annually to perform routine maintenance. For both the No Action and Action Alternatives, most future years have periods when flows are at minimum level (i.e., 800 cfs) for a four-week period or longer. It is assumed that maintenance will be performed during this time since only one unit is typically operated when the dam release level is 800 cfs. However, there is a 4-year period from 2016 through 2019 when the representative trace has daily flows that exceed the minimum all year long. The assumed time periods for scheduling the maintenance during this 4-year period are shown in table 5.1. These maintenance periods were selected since monthly release levels were very low (i.e., barely above the minimum). When daily releases from the dam are similar for 2 or more months, periods that have lower projected spot market prices are selected for the maintenance period.

Table 5.1. Assumed Maintenance Periods

Year	Alternative	
	No Action	Action
2016	Jan 19 - Feb 29	Jan 19 - Feb 29
2017	Feb 18 - Mar 31	Jan 18 - Feb 28
2018	Mar 4 - Apr 14	Feb 1 - Mar 14
2019	Feb 18-Mar 31	Feb 15 - Feb 28 & Dec 4 - Dec 31

5.2 Power Conversion and Generation

The Flaming Gorge Dam has injected more than 20,235 GWh of electricity into the power grid from November, 1963 through the end of June, 2002 (***based on Form PO&M-59 data)***. Between 1964, the first full year of operation, and 2001 the Flaming Gorge Powerplant generated an average of about 528.9 GWh of electricity annually. However, as shown in figure 5.6, the powerplant has historically displayed a large degree of annual variability. Generation levels were as low as 251.6 GWh in 1990 and as high as 877.1 GWh in 1984; that is, generation varied by a factor of almost 3.5.

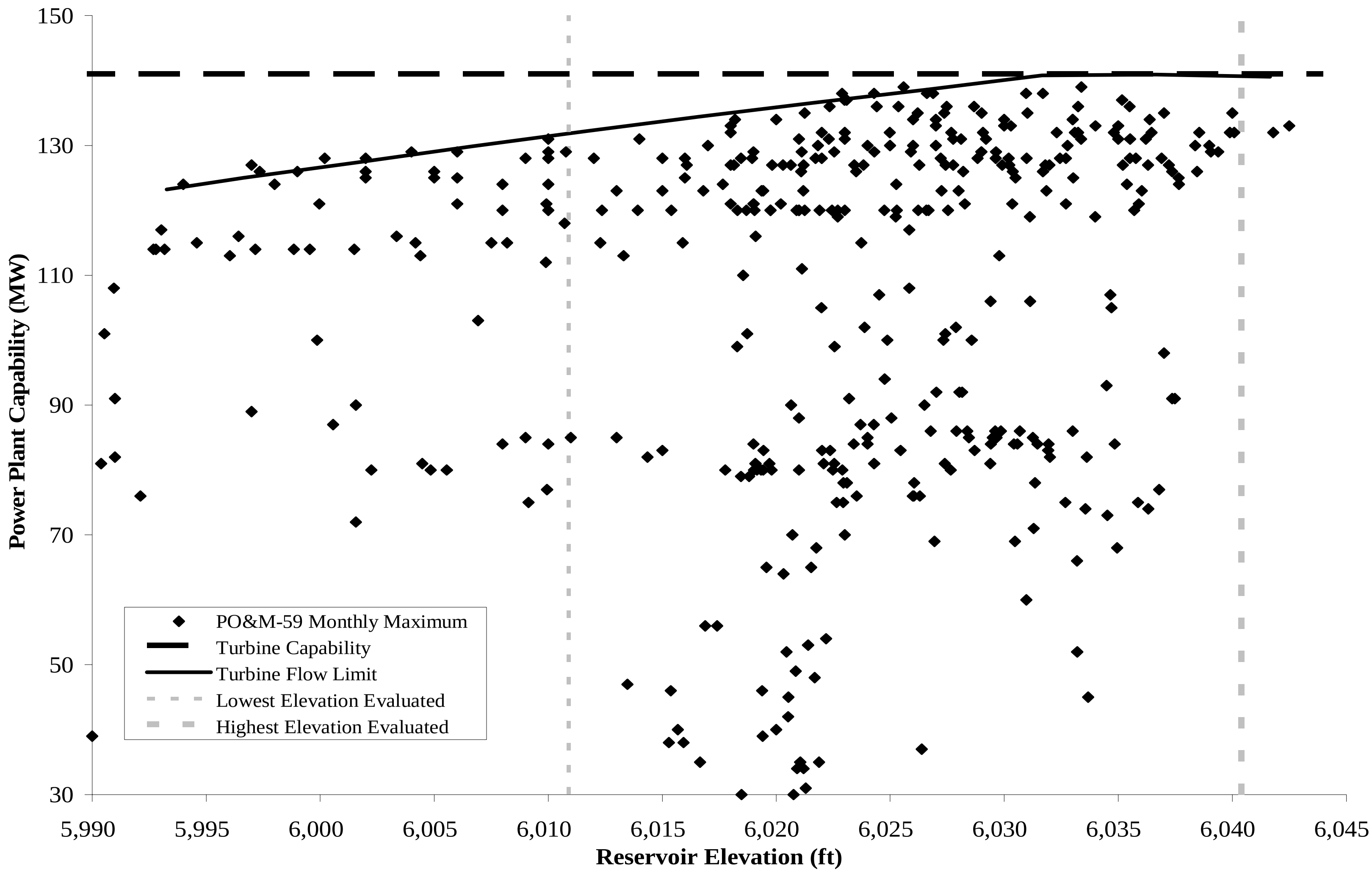

Figure 5.5. Comparison of Historical Monthly Maximum Generation and the Plant Capability Curve.

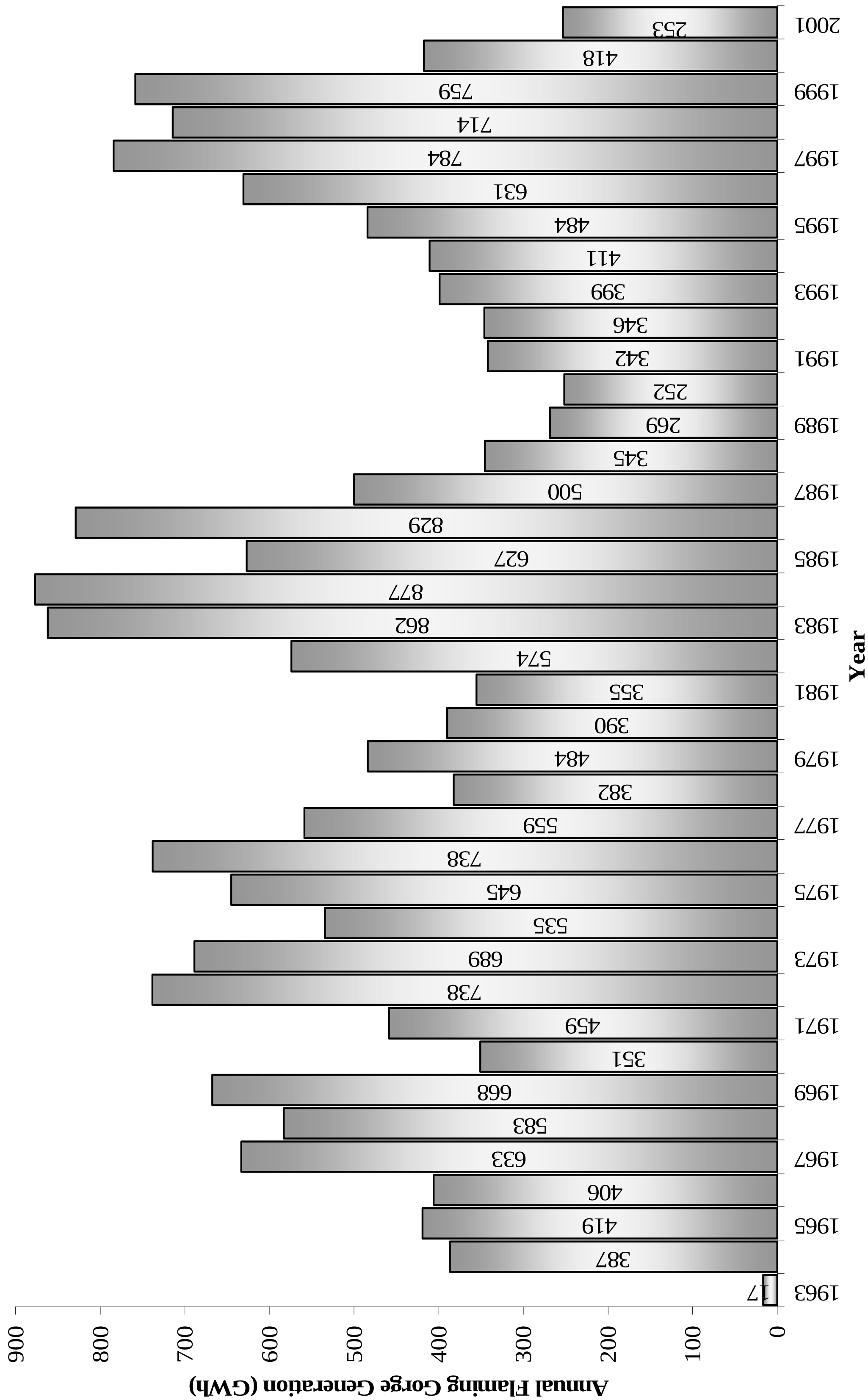

Figure 5.6. Annual Generation from the Flaming Gorge Dam.

Alternatives will affect monthly water release volumes and reservoir elevations at Flaming Gorge. Therefore, operable capability blocks and associated power conversion factors were estimated monthly for each alternative. Estimates are based on the universal power equation, equations 5.2 and 5.3, and equations 5.5 through 5.7. The sum of the capability blocks equals the amount computed by equation 5.1.

Although the powerplant is modeled in GenOpt as a single entity, power conversion factors and capability blocks were based on unit-level computations. An algorithm was written that optimizes generation and water releases through each turbine given a total water release from the dam. The algorithm uses a cellular automata procedure that contains a lattice of three cells (i.e., columns) each of which represent a single turbine. The cellular automata procedure also uses simple rules for allocating water among the three turbines based on the state of the neighboring cell (i.e., turbine) as it proceeds from one discrete step to the next (i.e., rows). Through this process all possible states for allocating a fixed amount of water among turbines are tested in a water volume increment that is specified by the user (***Melanie Mitchell, "An Introduction to Genetic Algorithms").***

Conceptually, the turbines are lined up in a single row. In the initial state all of the water release is allocated to the rightmost turbine (refer to step 1 below). To advance to the next step one increment of water release (e.g., 1 cfs) is reallocated from the rightmost turbine to the turbine (i.e., cell) on the left (step 2 below). If it is not possible to remove water from the rightmost turbine (i.e., zero or minimum turbine flow rate as in step 4 below), then a search is performed to locate the nearest turbine containing a non-zero water release. An increment of water is then reallocated from this non-zero release turbine to the turbine on the left. The remaining turbine water is then reallocated to the rightmost one (step 5 below). The final step occurs when all of the water is allocated to the leftmost turbine (step 10 below).

An example pattern for a dam with three turbines and a total flow of 3 cfs is as follows:

Step 1: [0-0-3]

Step 2: [0-1-2]

Step 3: [0-2-1]

Step 4: [0-3-0]

Step 5: [1-0-2]

Step 6: [1-1-1]

Step 7: [1-2-0]

Step 8: [2-0-1]

Step 9: [2-1-0]

Step 10: [3-0-0]

For each step, the amount of water that is shifted to a non-power release is determined after initial turbine water release allocations have been performed. If a turbine is allocated more water than its physical maximum flow or generation capability, then the excess water is also reallocated to non-power releases. Total powerplant generation is calculated with the equations presented in this section. The step (i.e., combination of turbine releases) with the highest generation is selected as the optimal allocation of water releases.

Results from this algorithm for dam releases ranging from 800 cfs to the maximum powerplant rate are shown in figure 5.7. The graph, which is based on a full reservoir condition (i.e., maximum head), shows that generation as a function of flow rate is non-linear. At low release rates all of the water is routed through a single turbine. However, as the release rate increases to a level that is near the maximum of a single turbine, some of the water is routed through a second turbine. The third turbine is put into operation when doing so will produce higher generation levels than the level that can be achieved by running only two turbines.

Generation levels using the cellular automata procedure and engineering equations described above were compared to actual operations as documented on Western's web site (***site address: http://www.wapa.gov/crsp/operatns/fgSCADAdata.htm).*** Table 5.2 shows that the computed estimates of generation are very similar to the recorded values for a large range of flow rates and reservoir elevation levels. Power equations underestimate generation levels at most by 5 MW and overestimate generation levels by as much as 4 MW. This difference can be attributed to a number of factors including measurement errors at the powerplant, power factor errors (i.e., actual value may not be 0.95), equation coefficient inaccuracies, and powerplant operators who allocate water among turbines differently from the cellular automata routine. Also, the tail water equation has a tendency to underestimate the tail water elevation by about 1 ft as compared to the recorded value.

As described in section 4.4, the GenOpt model separates the powerplant into generation blocks. Block level generation capabilities and incremental power conversion factors for full-reservoir conditions were estimated from the curve in figure 5.7. The first block is set equal to the power that is produced at the minimum release rate; that is, 800 cfs. As shown in figure 5.8, the second block is loaded to the point where the incremental conversion factor is at a maximum (i.e., first derivative of the curve is at a

Table 5.2. Comparison of Recorded Generation Levels and Computed Estimates

Power Release (cfs)	Date	Hour	Reservoir Elevation (ft)	Tail Water Elevation (ft)	Head (ft)	Recorded Generation (MW)	Estimated Generation (MW)	Generation Difference (MW)
800	07/02/01	4 AM	6013.5	5602.6	410.9	22	23	1
970	12/31/00	6 PM	6020.3	5602.8	417.5	28	30	2
1,030	09/04/00	3 AM	6021.3	5602.9	418.4	30	32	2
1,560	03/09/00	3 AM	6026.2	5603.4	422.8	44	46	2
1,700	01/10/00	4 AM	6027.4	5603.5	423.9	49	51	2
1,910	08/03/99	10 PM	6033.5	5603.8	429.7	62	59	-3
2,000	12/21/99	8 AM	6028.4	5603.9	424.5	60	62	2
2,120	08/04/99	12 PM	6033.5	5604.0	429.5	65	67	2
2,400	12/09/98	1 AM	6032.7	5604.3	428.4	74	77	3
2,470	12/26/99	4 PM	6028.1	5604.3	423.8	75	78	3
2,780	12/25/99	7 PM	6028.2	5604.4	423.8	86	86	0
2,820	02/19/99	7 PM	6028.6	5604.4	424.2	86	87	1
3,250	07/15/99	8 AM	6032.5	5605.0	427.5	100	99	-1
3,320	02/21/99	9 PM	6028.5	5605.2	423.3	101	96	-5
3,500	04/12/99	1 PM	6024.9	5605.3	419.6	106	110	4
3,500	04/03/99	6 AM	6025.6	5605.3	420.3	107	110	3
4,450	07/04/99	3 AM	6031.6	5605.6	426.1	135	136	1
4,550	05/17/99	7 AM	6025.4	5605.7	419.7	135	135	0

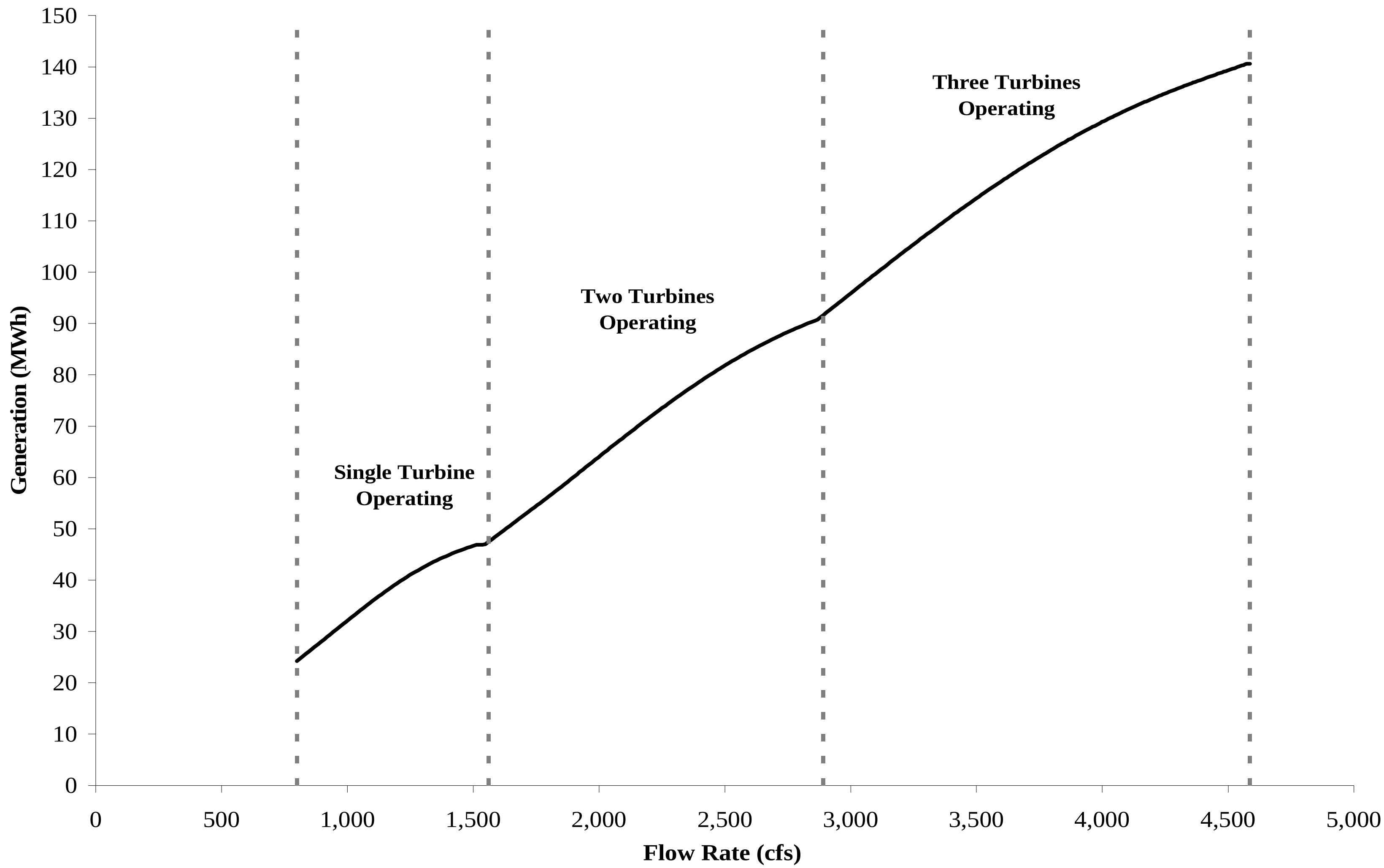

Figure 5.7. Optimal Unit Loading and Generation Level as a Function of Flaming Gorge Release Rate.

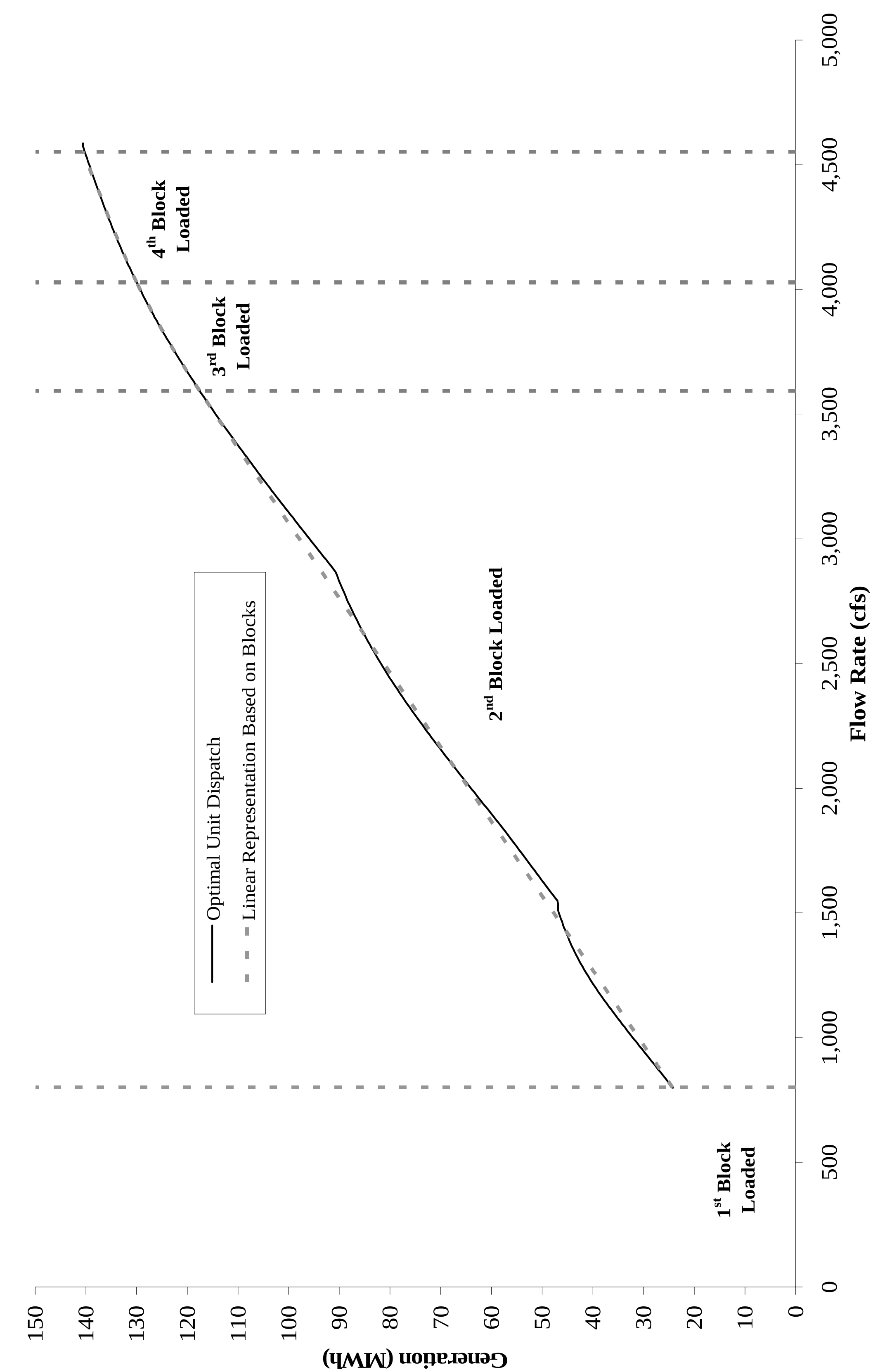

Figure 5.8. Power Block Representation for the Flaming Gorge Powerplant.

maximum). The fourth block ends at the generating capability of the plant and extends backwards to approximately the midpoint between the plant capability and the end of the second block. The third block lies between the second and the fourth. Using this approach, incremental block conversion factors decrease after the second block. The advantage of the blocked capability approach is that it can easily be represented in the GenOpt modeling framework. However, it can lead to computational errors. Figure 5.8 shows that the optimal unit dispatch curve and the piecewise-linear curve based on blocked capabilities are very similar. The maximum generation error of about 2 MW is at point where a second turbine is brought into operation. An error of approximately the same magnitude occurs at the point where the third turbine is brought on-line.

Power production estimates for three operational turbines similar to the one in figure 5.7 were made for 10 Flaming Gorge reservoir elevations that span the range projected by the Flaming Gorge model. Block-level generation capabilities and associated power conversion factors associated with these 10 reservoir elevation levels are shown in table 5.3. When the reservoir elevation for a month is not at one of these levels, block capabilities and incremental power conversion factors are estimated by linear interpolation.

Since units are put into maintenance, power production for the 10 reservoir elevation levels were also made for two other conditions; namely, one turbine in operation and two turbines in operation.

Table 5.3. Capability Blocks and Associated Conversion Factors

	Block 1		Block 2		Block 3		Block 4	
Reservoir Elevation (ft)	Incremental Capability (MW)	Incremental Conversion Factor ($MWh/10^3$ cfs)	Incremental Capability (MW)	Incremental Conversion Factor ($MWh/10^3$ cfs)	Incremental Capability (MW)	Incremental Conversion Factor ($MWh/10^3$ cfs)	Incremental Capability (MW)	Incremental Conversion Factor ($MWh/10^3$ cfs)
5993	21.9	27.3	80.3	29.6	12.1	25.0	9.0	18.6
5997	22.0	27.6	81.0	29.9	12.5	25.1	9.6	19.3
6002	22.3	27.9	82.0	30.3	13.1	25.2	10.0	19.6
6007	22.6	28.2	83.4	30.7	13.5	25.4	10.3	19.9
6012	22.8	28.5	85.2	31.0	13.7	25.7	10.5	19.7
6017	23.1	28.8	86.7	31.4	14.5	26.0	10.3	19.3
6022	23.3	29.1	88.5	31.8	14.6	26.3	10.2	18.7
6027	23.6	29.4	90.0	32.2	15.0	26.4	10.1	22.3
6032	23.8	29.7	91.1	32.6	14.4	27.0	11.5	18.6
6037	24.0	30.0	92.2	33.0	13.7	27.7	11.0	18.6
6042	24.3	30.3	93.3	33.4	12.5	28.6	10.6	20.2

Block-level generation capabilities and associated power conversion factors for both of these combinations of turbine outages were also derived and input in the GenOpt model.

The conversion factors generated by the methodology described above were compared to historical values. Figure 5.9 shows historical power conversion factors as computed from PO&M–59 data. It also shows calculated conversion factors as a function of reservoir elevation at minimum flows and at the point of highest efficiency.

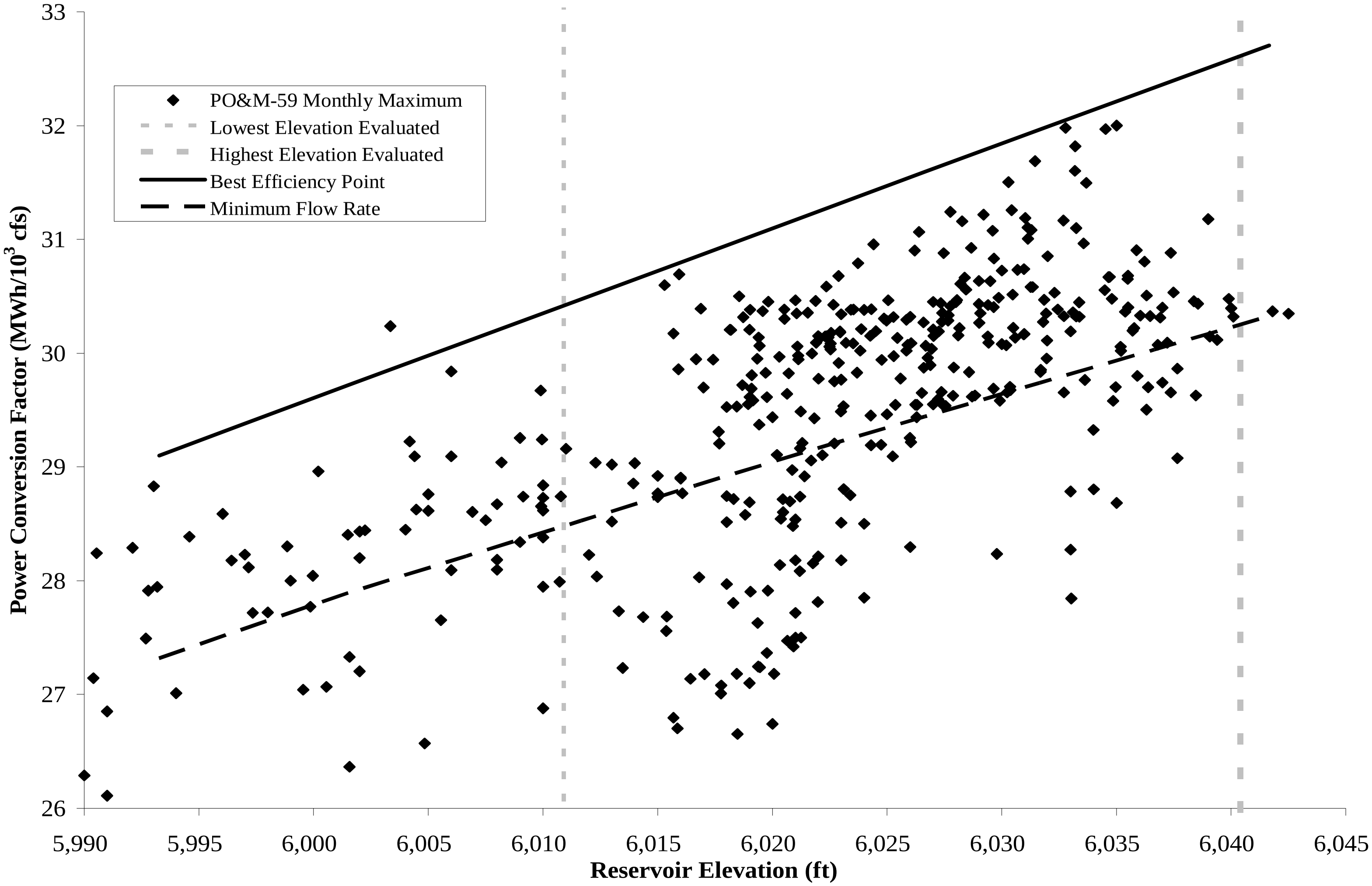

Figure 5.9. Comparison of Historical Power Conversion Factors and Computed Efficiency Curves.

6. PROJECTED SPOT MARKET PRICES

The projected economic value of electricity generated from the Flaming Gorge powerplant is closely tied to the estimated price of electricity on the spot market. The AURORA Model was used to estimate spot prices for various delivery points into the WSCC grid. For this analysis, AURORA spot price forecasts for Four Corners were used to compute the economic value of Flaming Gorge energy. It was assumed that the operations of Flaming Gorge would not affect spot market prices. This assumption is generally true since it makes a very small contribution to the total supply of the WSCC system.

6.1 Average Annual and Seasonal Prices

Average annual spot market prices for the Four Corners delivery point in nominal dollars are shown in figure 6.1 The figure shows that the average price is expected to decrease from the year 2002 through 2005. Prices increase thereafter through 2020, the last AURORA projection year. From 2020 through 2026 it was assumed that spot prices would remain constant. The maximum spot price during a year typically occurs during the summer months when electricity demands are the highest. As shown in the figure, peak spot prices can be more than 10 to 20 times the annual average. On the low price side, projected spot prices are about one-fourth of the average. These lower prices typically occur during the night and very early morning hours.

Prices not only change annually over time, but also have a very distinct seasonal pattern. Figure 6.2 shows average monthly prices used in this analysis. Averages are based on hourly values from the 2002 to 2026 time period. Prices are typically the highest in July and August with relatively low prices in the springtime. A secondary peak price season occurs during the wintertime. As described in section 7, this seasonal variation in spot prices along with the amount of water that is released in each month has a significant impact on the projected economic value of the Flaming Gorge power resource.

6.2 Daily Spot Market Price Patterns

Spot market prices not only change as a function of year and season but also by the time of the day and by the type of day. Figure 6.3 shows projected average hourly prices in January 2005 for weekdays and weekends. The price pattern is typical for the wintertime with relatively high prices in the morning and evening hours. Prices dip during midday hours and are the lowest during the nighttime. Weekend prices typically follow the same pattern as the weekday but are noticeably lower during peak demand hours. The one-hump release restriction at Flaming Gorge will not allow dispatchers to respond to the winter two-hump price pattern.

Projected spot market prices for April 2005 are generally less expensive and have less volatility compared to other times of the year. Demand is relatively low and energy is typically supplied by resources with low production costs such as hydro powerplants, nuclear units, and coal-fired steam generators. The two-hump price pattern that is characteristic of the wintertime continues in the springtime but it is less pronounced. Weekend prices are relatively flat ranging from about 20 to 26 $/MWh.

During the summer months the projected price pattern changes to a one-hump pattern that peaks in the late afternoon. Figure 6.5 shows that in July 2005 spot market prices are projected to peak at 4 PM during both weekdays and weekends. Flaming Gorge can follow this price pattern more easily than the wintertime two-hump pattern. Since demands are typically lower on the weekend, spot prices are expected to be significantly lower. Figure 6.6 shows hourly average prices projected by the AURORA model for October 2005. Relative to the summer, prices in October are significantly lower, but remain somewhat higher than prices in the springtime.

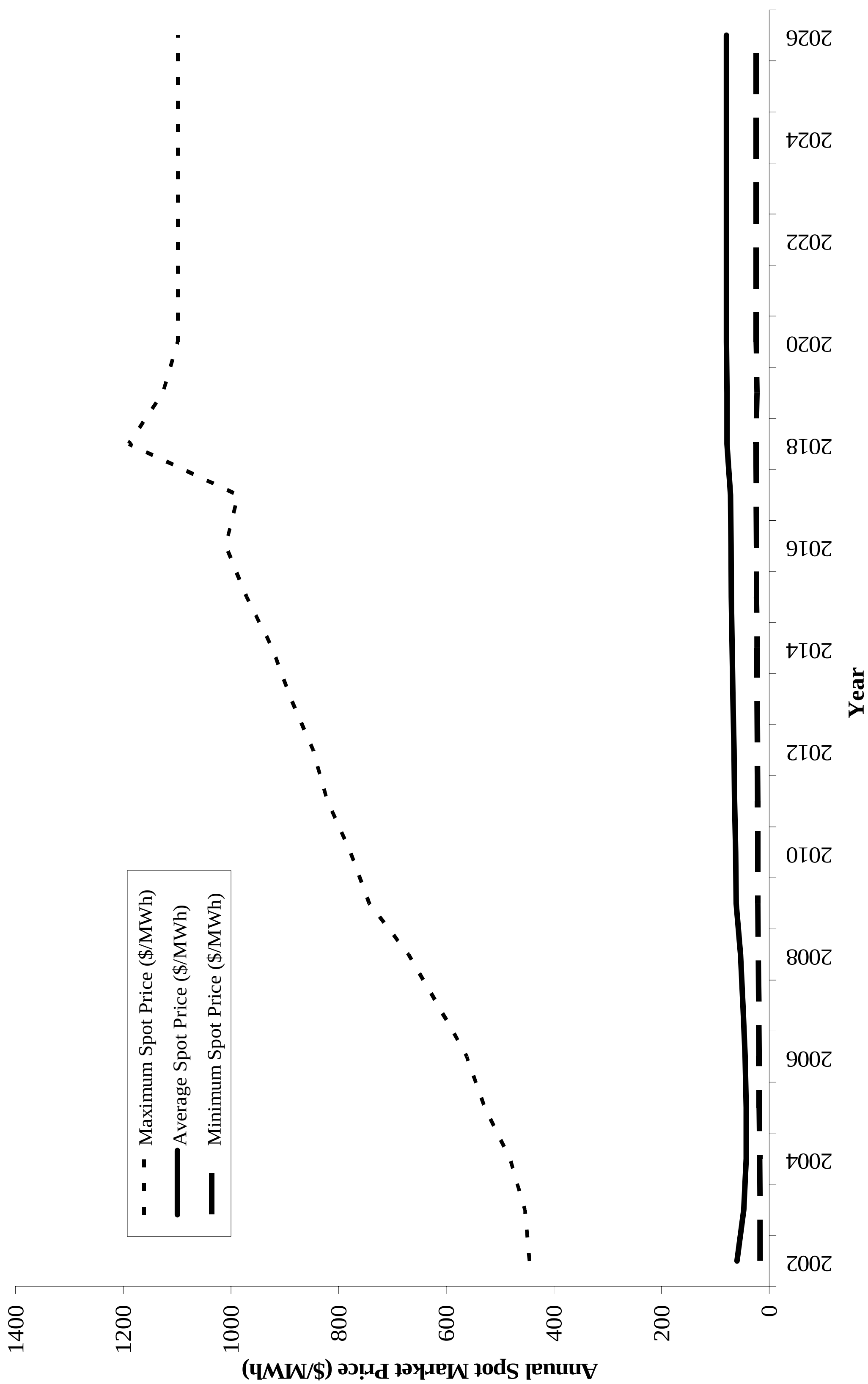

Figure 6.1. Average Annual Spot Market Prices Projected by the AURORA Model.

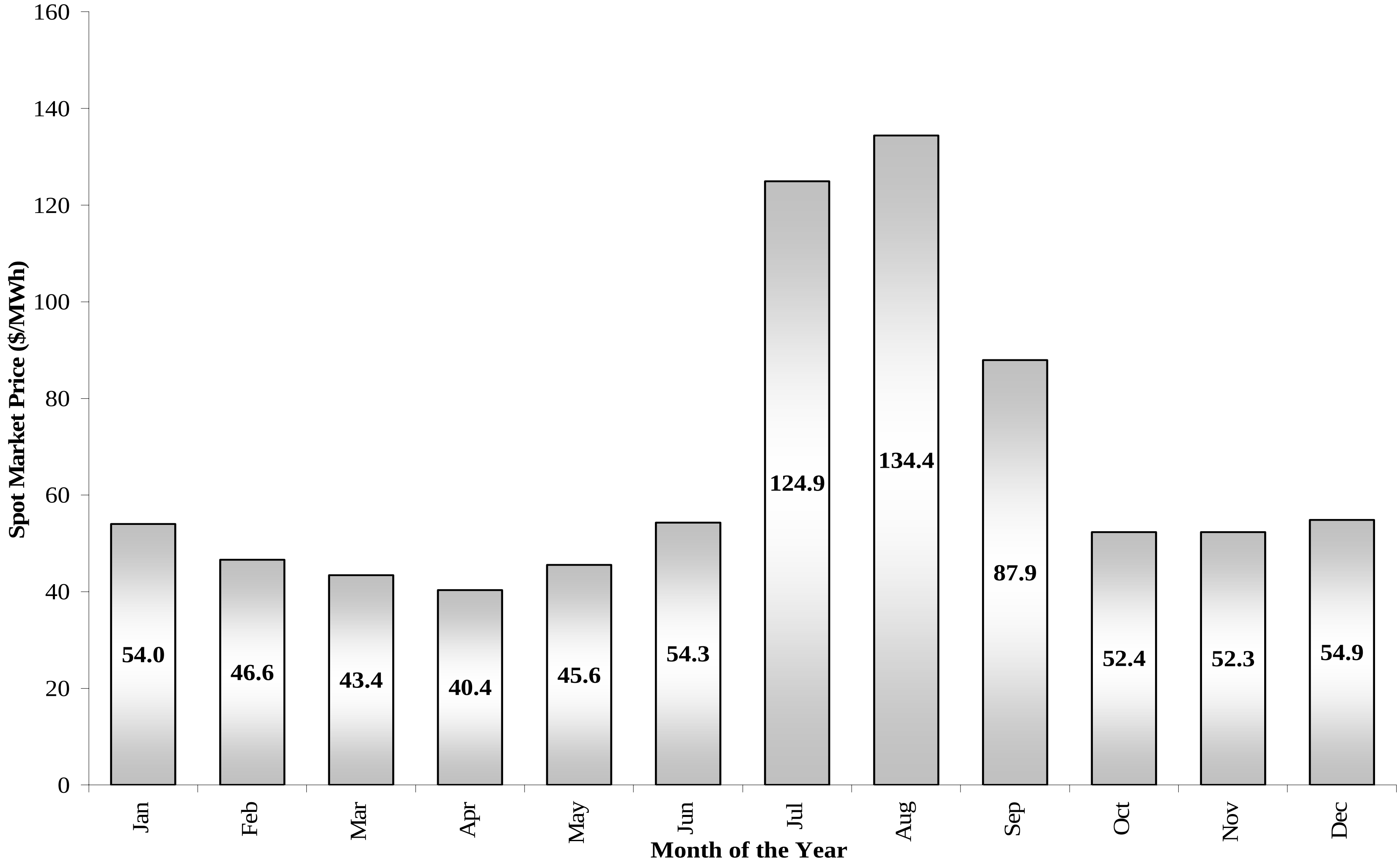

Figure 6.2. Average Monthly Spot Market Prices Over the Study Period.

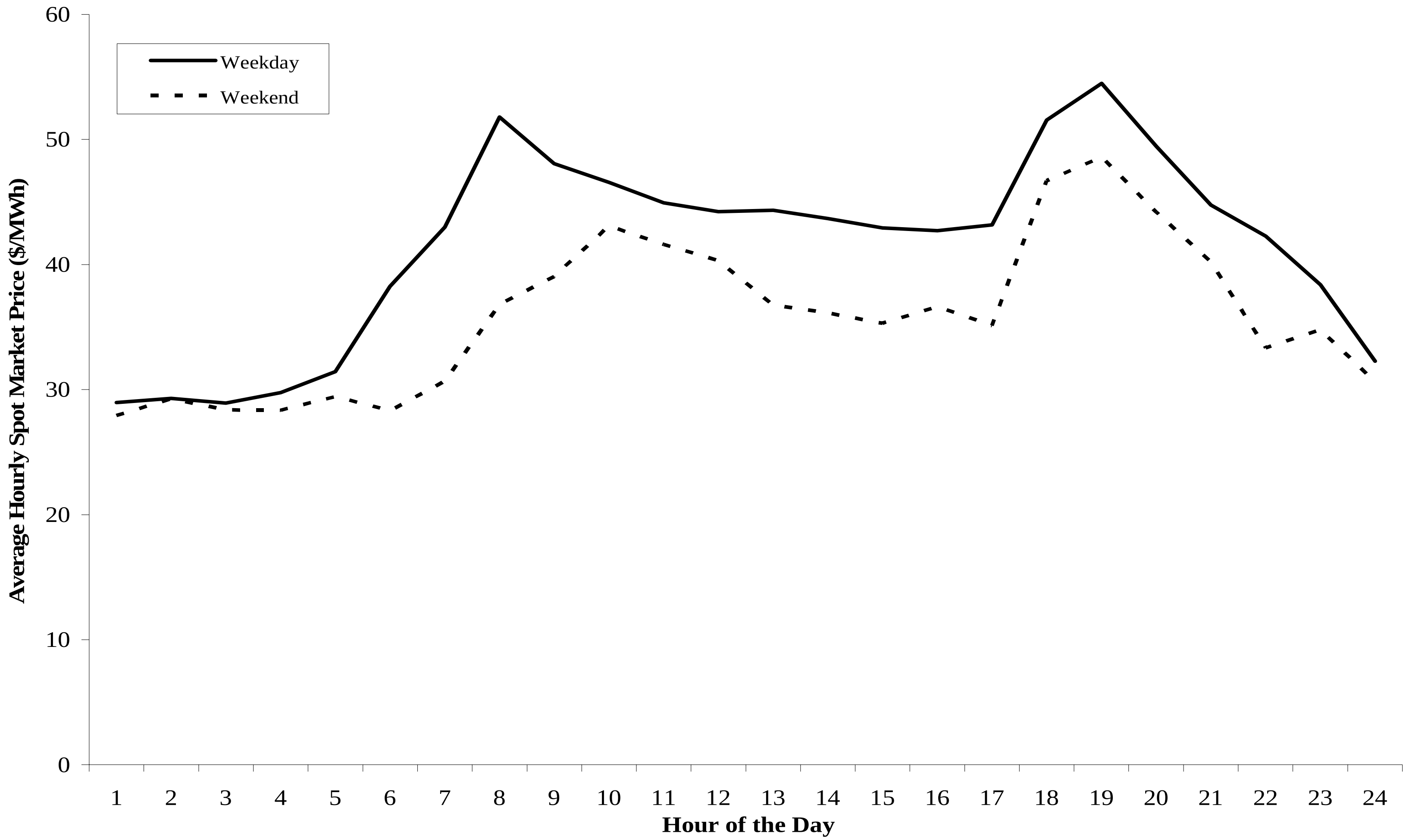

Figure 6.3. Projected Average Spot Market Prices for a Weekday and Weekend in January.

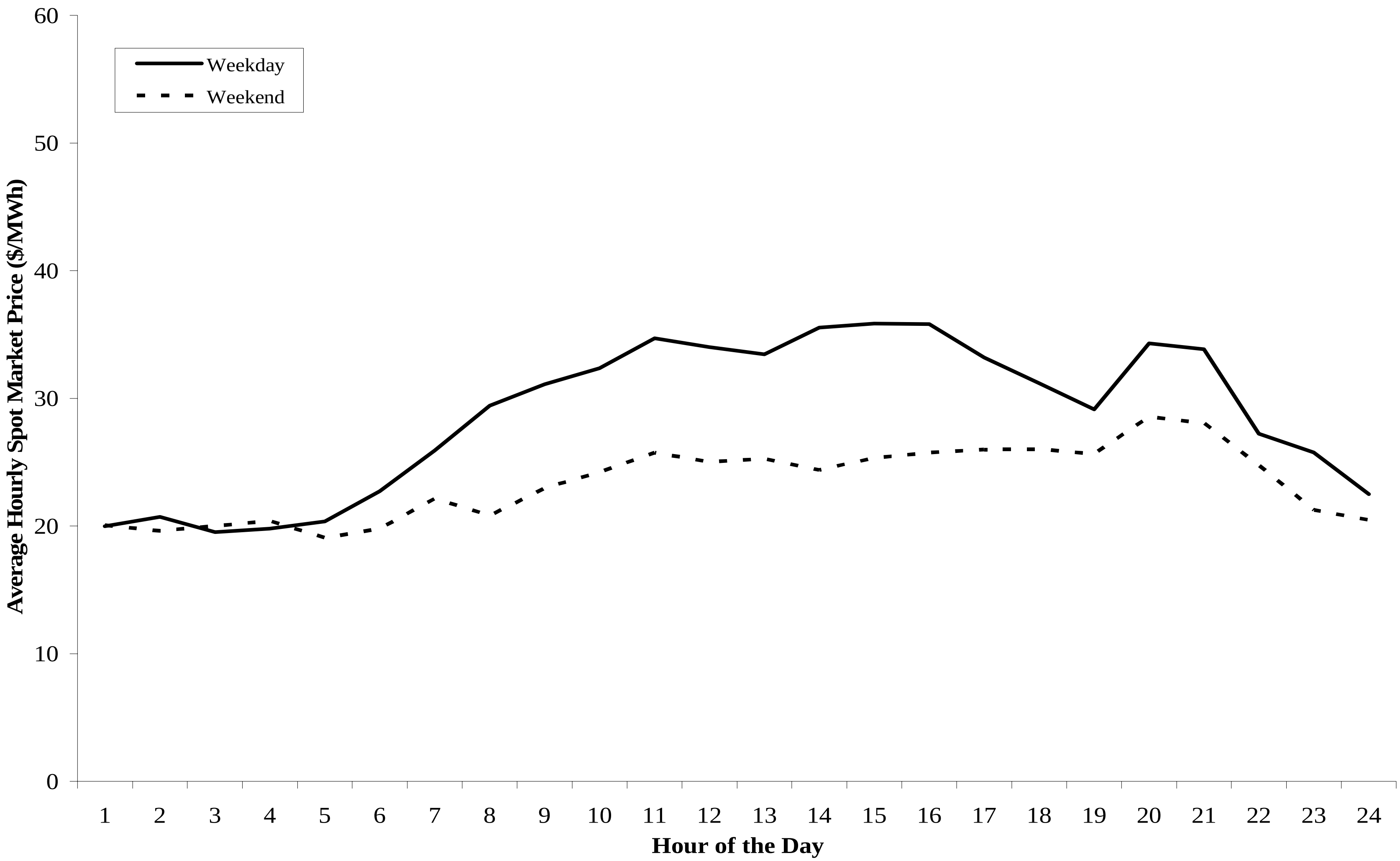

Figure 6.4. Projected Average Spot Market Prices for a Weekday and Weekend in April.

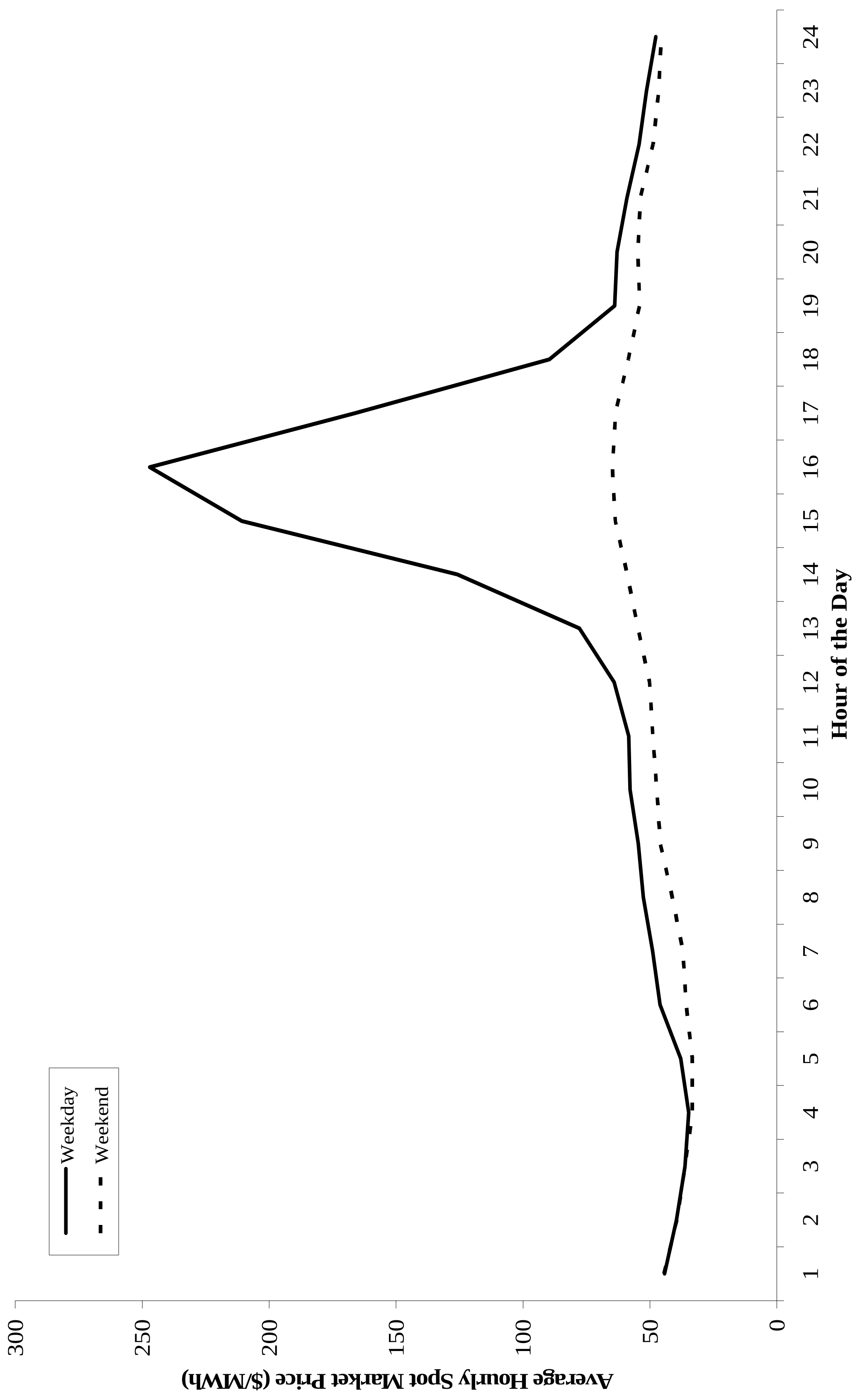

Figure 6.5. Projected Average Spot Market Prices for a Weekday and Weekend in July.

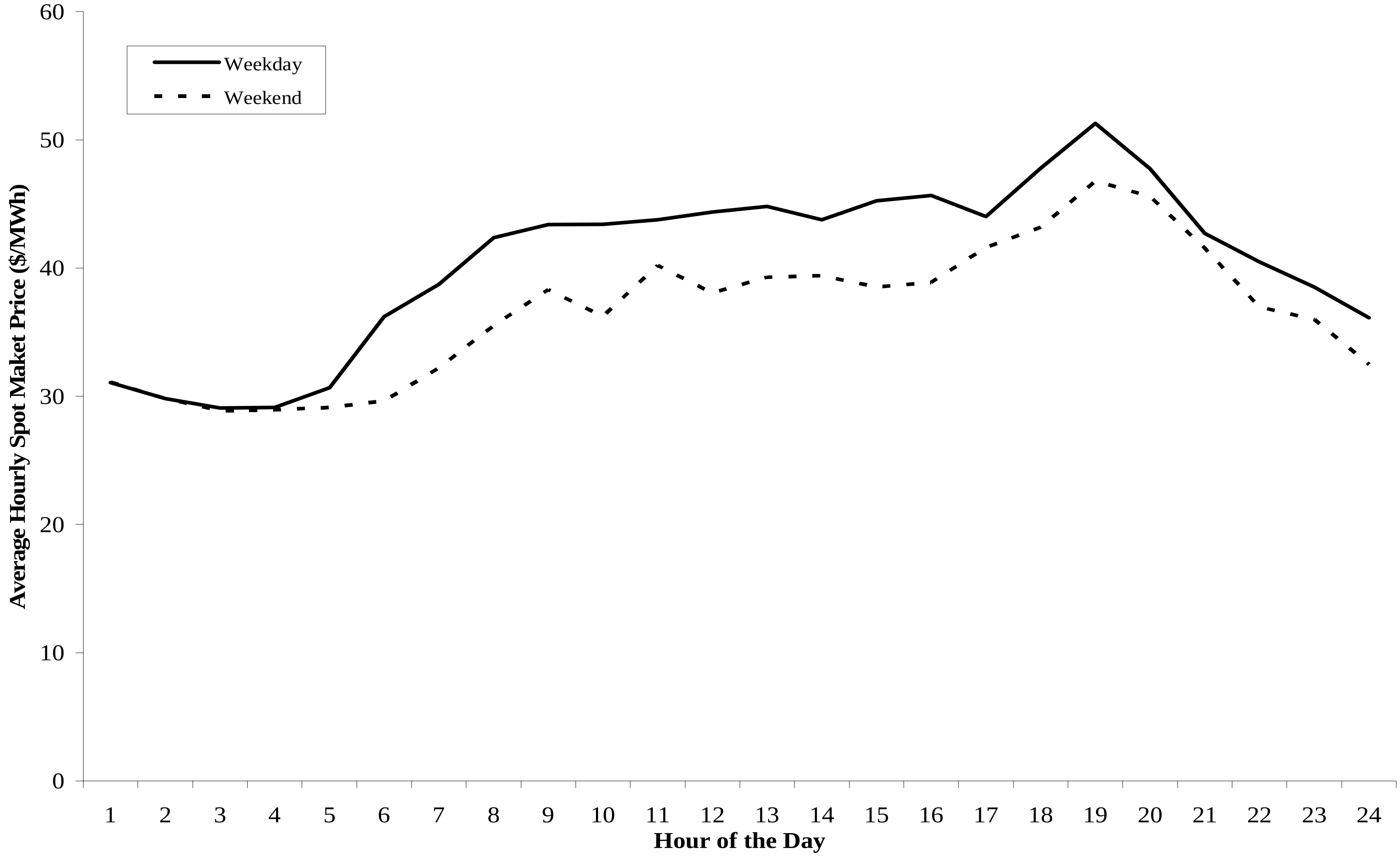

Figure 6.6. Projected Average Spot Market Prices for a Weekday and Weekend in October.

Spot market prices during the past 2 years in the WSCC have been very volatile and were subject to a number of market forces and rule modifications in the California market that heavily influenced WSCC prices. The forecasts presented in this section are much higher than current spot market prices. However, the projections were more consistent with prices at the time the AURORA model runs were performed.

Future prices in the open market may significantly differ from those used for this analysis. Although prices are uncertain, the general seasonal pattern of higher prices in the winter and summer with lower prices in the spring and autumn has persisted in the past and is expected to continue into the future. Also, the daily price patterns that are exhibited in figures 6.3 through 6.6 are reasonable.

Since the same forecast is used for both alternatives the relative differences between the two alternatives in terms of percentage is a more robust measure of the economic impacts of the alternative than the absolute dollar values.

7. MONTHLY FLAMING GORGE OPERATIONS AND YAMPA INFLOWS

The Flaming Gorge model simulates water releases from the Flaming Gorge Dam on a daily basis and estimates the reservoir elevation level at the end of each month. Both water releases and reservoir elevations influence the economic value of the Flaming Gorge power resource. To a large extent daily water releases dictate the amount of energy that will be generated. For the No Action Alternative, the sum of the daily water releases in a month constrains monthly generation levels. The reservoir elevation level directly influences both the generation capability and power conversion factors.

7.1 Flaming Gorge Reservoir Elevations

Forecasts of end-of-month (EOM) Flaming Gorge reservoir elevations for the representative trace for both the No Action and Action Alternatives are shown in figure 7.1. The average EOM reservoir elevation level over the 25-year study period is about 6026 feet above sea level for both alternatives. However, the No Action Alternative has a higher range of elevations from 6010.9 to 6040.4 feet versus a range of 6015.6 to 6037.4 feet for the Action Alternative.

The higher degree of reservoir variability is also evident by comparing the annual minimum and maximum elevation levels shown in figures 7.2 and 7.3 for the No Action and Action Alternatives, respectively. These two figures also show that the annual average reservoir elevation has a higher degree of variability under the No Action Alternative.

Reservoir elevation levels predicted under both alternatives are well within historical extremes after full operations began in November 1967 (***Flow Recommendations Report, Pages 3-4)***. In April 1970, the reservoir elevation reached a low at approximately 5967 feet and in June 1983 the reservoir elevation was over 6042 feet (***PO&M-59)***.

7.2 Flaming Gorge Water Releases

The Flaming Gorge model also projects a high degree of variability for monthly water releases. Figure 7.4 shows average monthly water release rates in terms of cfs for both alternatives. Average water releases

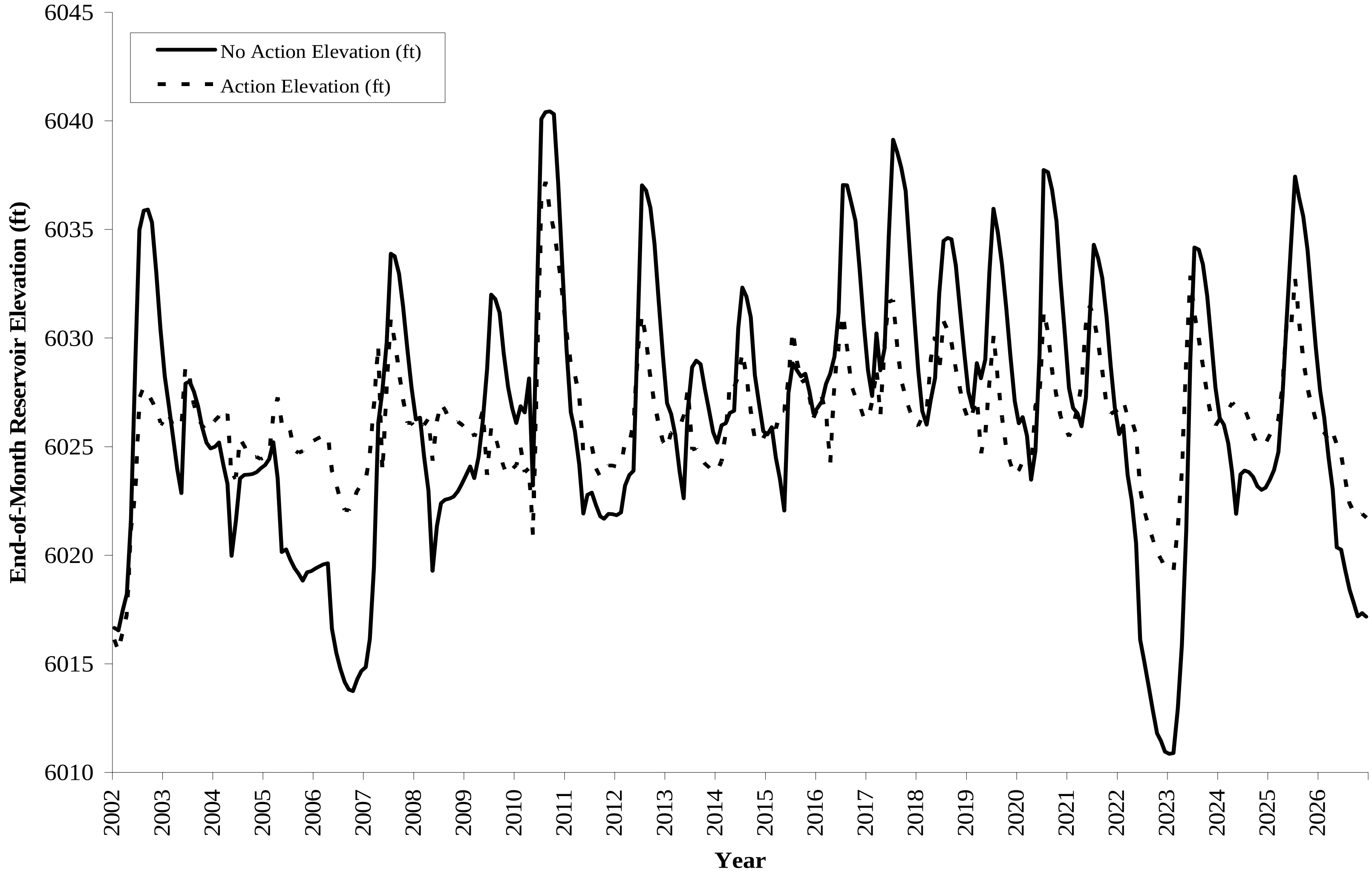

Figure 7-1. Monthly Reservoir Elevations Projected by the Flaming Gorge Model for the No Action and Action Alternatives (Representative Trace – Run 36).

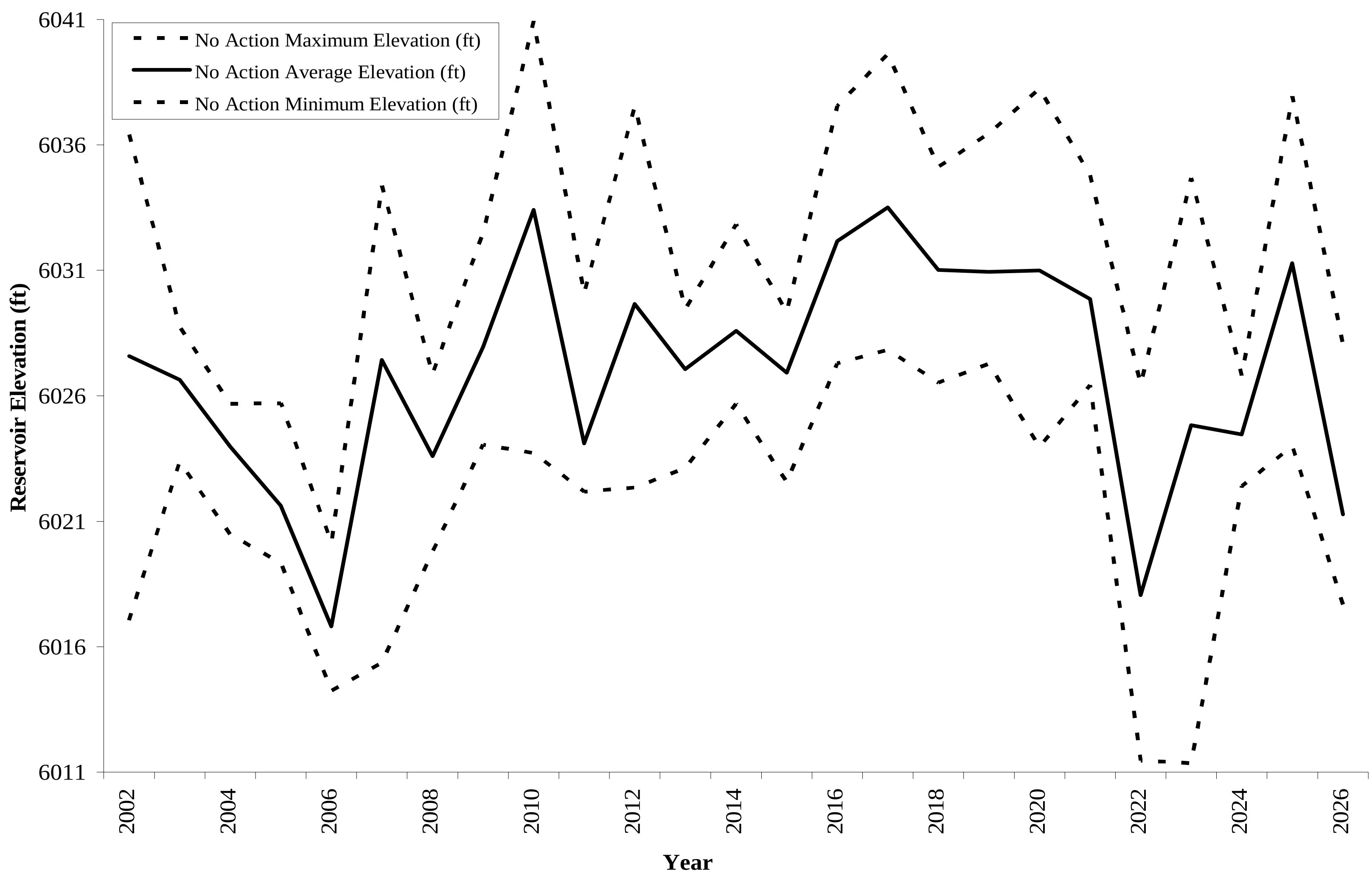

Figure 7-2. Average and Range of Monthly Reservoir Elevations Projected by the Flaming Gorge Model for the No Action Alternative (Representative Trace — Run 36). Alternatives (Representative Trace – Run 36).

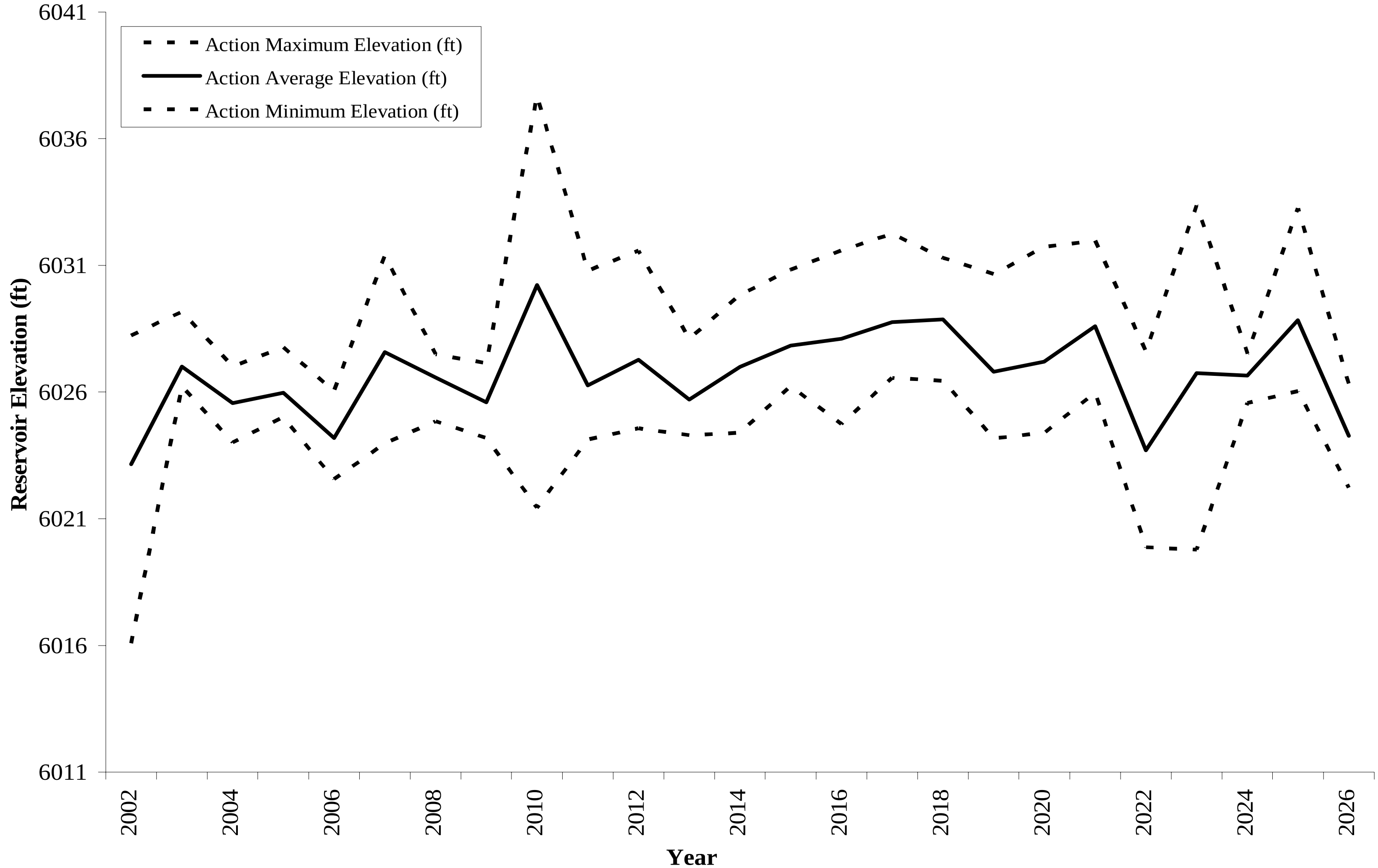

Figure 7-3. Average and Range of Monthly Reservoir Elevations Projected by the Flaming Gorge Model for the Action Alternative (Representative Trace — Run 36). Alternatives (Representative Trace – Run 36).

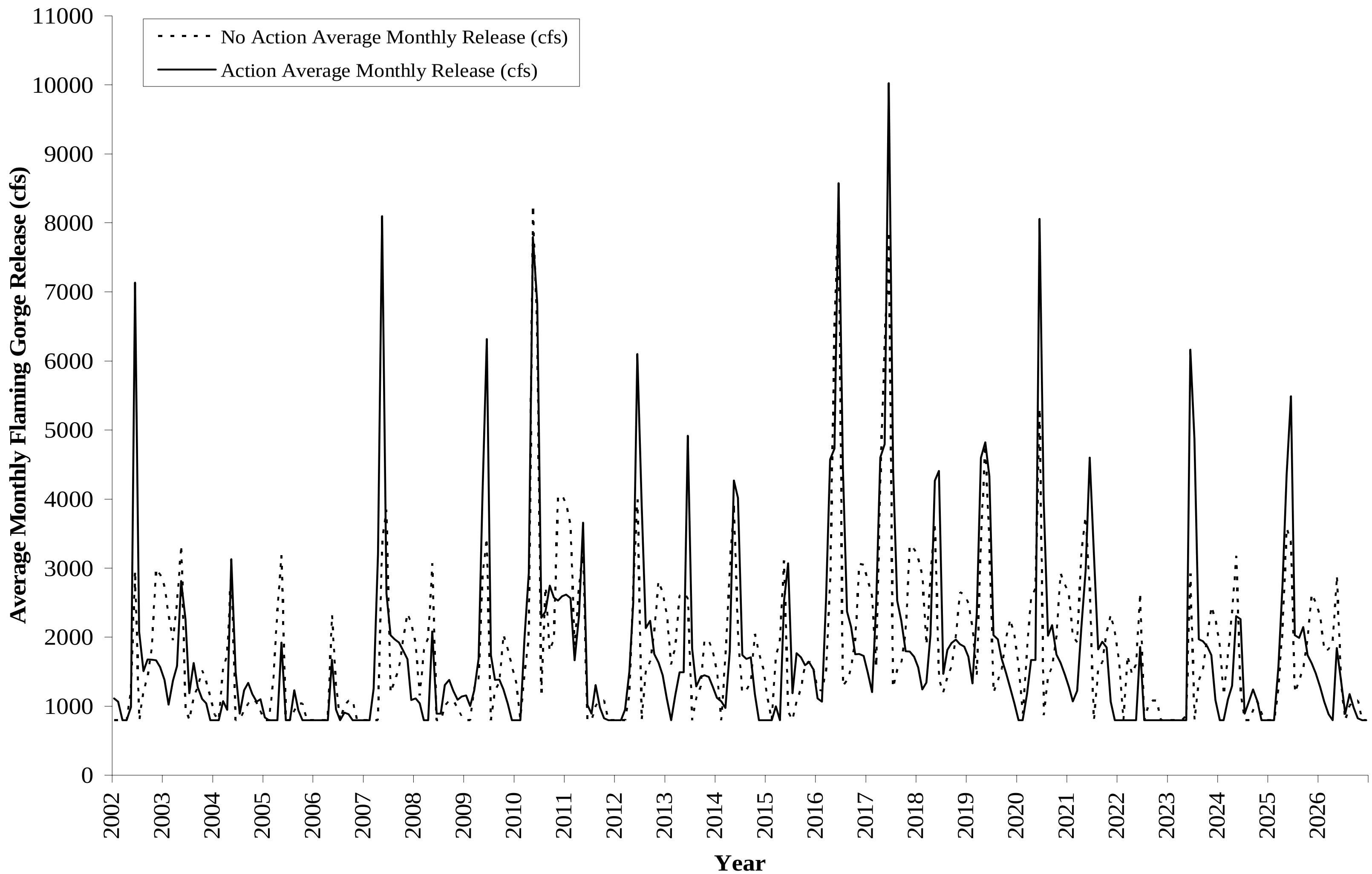

Figure 7-4. Monthly Releases from Flaming Gorge Projected by the Flaming Gorge Model for the No Action and Action Alternatives (Representative Trace – Run 36).

over the study period are nearly identical for the alternatives at about 1,840 cfs. For the Action Alternative, monthly water releases range from 800 to 15,000 cfs. Monthly releases for the No Action Alternative range from 800 cfs to 11,500 cfs. Since the maximum powerplant release is less than 5,000 cfs, it is projected that both alternatives will have non-power water releases. Most of these spills occur during spring spike periods.

During periods of low releases when the release level is 800 cfs, the powerplant has very little operational flexibility since this equals the minimum flow requirement. The only flexibility that the operator has is to decide which turbine(s) to release the water through. There is no operational flexibility during very high release periods when all of the turbines are operated at the maximum flow rate. Under both extreme cases there are no differences between the two alternatives. The largest economic and operational differences occur when releases are at a more moderate level.

Figures 7.5 and 7.6 show average water releases and the range of flows by month over the study period for the No Action and Action Alternatives, respectively. For both alternatives, the lowest average monthly flow rates are about 800 cfs. Only 2 months, September and October, under the No Action Alternative have minimum flow rates that slightly exceed 800 cfs. The highest flow rates occur during May and June under both alternatives. These high maximum flow rates extend into July under the Action Alternative. In general, the range of flow rates is highest during the late spring and early summer period.

On average the Action Alternative releases more water during times of the year when power generation has the greatest value. Table 7.1 shows that during the 3 months with the highest spot market prices (i.e., July, August, and September) the Action Alternative has significantly higher water releases. This is most noticeable for the month of July when releases for the Action Alternative are on average more than twice those of the No Action Alternative. On the other hand, releases for the Action Alternative are on average lower during the other months of the year when spot prices are less expensive.

Table 7.1 Average Monthly Spot Market Prices and Water Release Rates from the Flaming Gorge Dam for the No Action and Action Alternatives

Month	No Action Average Release Rate (cfs)	Action Average Release Rate (cfs)	Average Spot Market Price ($/MWh)
Jan	1,675	1,108	54
Feb	1,350	1,006	47
Mar	1,493	1,286	43
Apr	2,153	1,900	40
May	3,445	3,213	46
Jun	2,884	4,223	54
Jul	937	2,054	125
Aug	1,267	1,650	134
Sep	1,357	1,633	88
Oct	1,668	1,444	52
Nov	1,970	1,328	52
Dec	1,862	1,205	55
Average	1,838	1,838	66

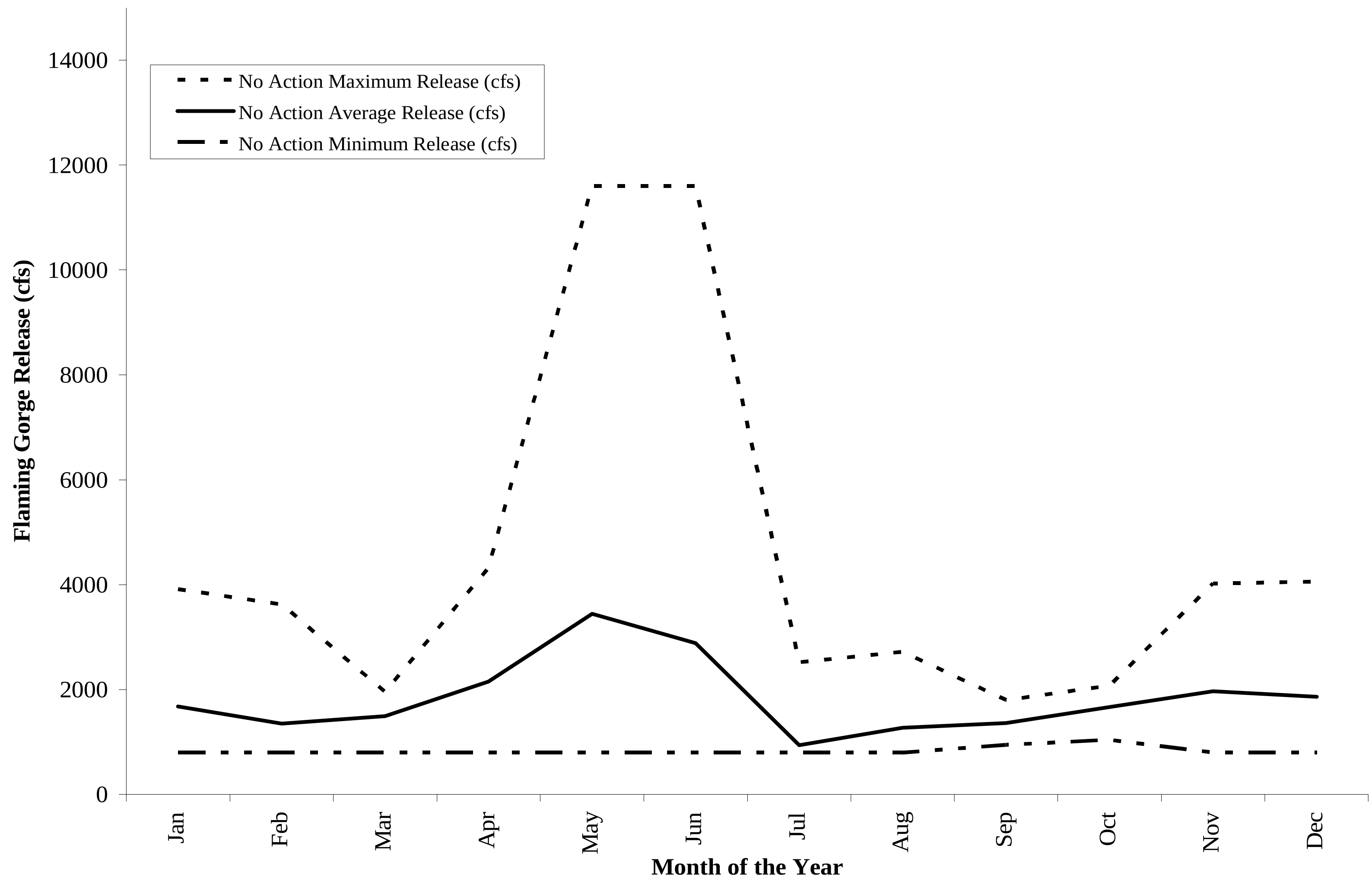

Figure 7-5. Average and Range of Monthly Releases Projected by the Flaming Gorge Model for the No Action Alternative (Representative Trace – Run 36).

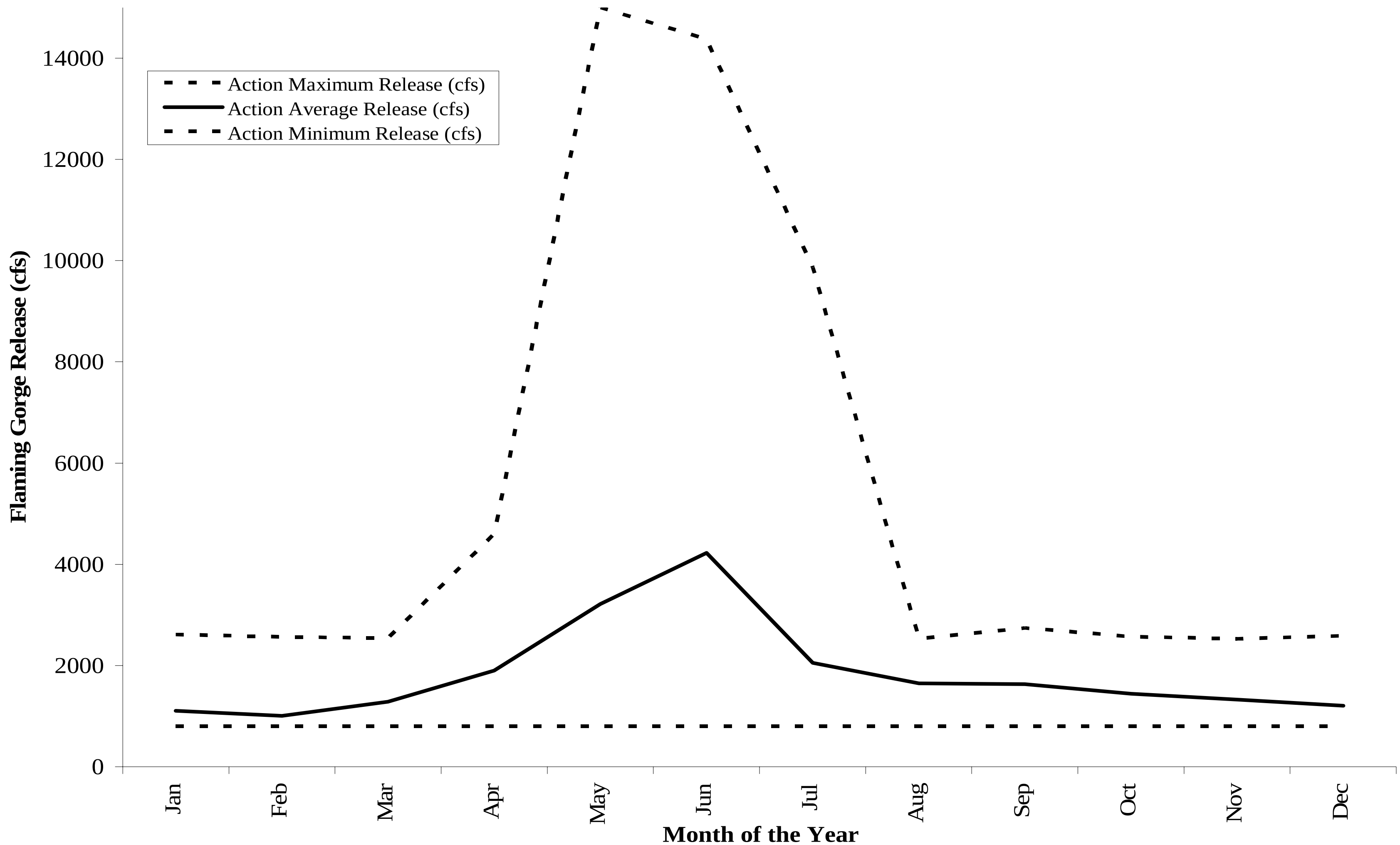

Figure 7-6. Average and Range of Monthly Releases Projected by the Flaming Gorge Model for the Action Alternative (Representative Trace – Run 36).

7.3 Yampa Inflows

Figure 7.7 shows monthly Yampa inflows for the 2002 through 2026 study period. Inflows are highly cyclical with large inflows during the late spring and early summer and very low inflows during the rest of the year. Although this strong cyclical pattern exists, the figure also shows that annual peak inflows vary significantly among years.

The cyclical pattern and annual variability are highlighted in figure 7.8. In the month of May, Yampa inflows range from about 1,800 cfs to more than 21,700 cfs. In contrast the inflow range in January is from about 110 to 700 cfs. Yampa variability is very high largely due to the fact that it is not regulated (i.e., there are no dams) and that it carries significant amounts of snowmelt from the mountains.

8. ECONOMIC COMPUTATIONS AND RESULTS

The economics of the No Action and Action Alternatives are based on net present value (NPV) calculations of the hourly value of Flaming Gorge generation over the 25-year study period. The value of generation is computed by multiplying hourly electricity production by the hourly spot market price. All NPV calculations are based on an annual discount rate of 5.5 percent. The nominal value of Flaming Gorge hourly generation is totaled for a weekly period and discounted to the beginning of the simulation year from the middle of the week. The annual beginning of year revenues are then discounted to January 1, 2002.

The economic impact of implementing flow recommendations under the Action Alternative is measured as the difference in the NPV between the Action and the No Action Alternatives. Table 8.1 shows that operating under Action Alternative constraints will increase the economic value of the Flaming Gorge Powerplant by approximately 5.5 percent above the No Action Alternative. The Action Alternative has a higher economic value despite projected higher non-turbine releases and lower generation levels. Table 8.2 shows that non-power releases for the Action Alternative are projected to be almost twice as much as the No Action Alternative. This is the main factor that leads to a total reduced power output of about 4.5 percent over the 2002-2026 study period.

Table 8.1. Comparison of the Economic Benefits of the Flaming Gorge Powerplant under the No Action and Action Alternatives

	No Action Alternative	Action Alternative	Increase Above the No Action Alternative (%)
Nominal Value (10^6 $)	806	851	5.5
NPV (10^6 $)	403	423	5.0

Table 8.2. Comparison of the Water Release and Generation from the Flaming Gorge Powerplant under the No Action and Action Alternatives

	No Action Alternative	Action Alternative	Increase Above the No Action Alternative (%)
Average Water Release (cfs)	1,839	1,839	0.0
Average Non-turbine Release (cfs)	64	125	94.6
Generation (GWh)	11,904	11,374	-4.5

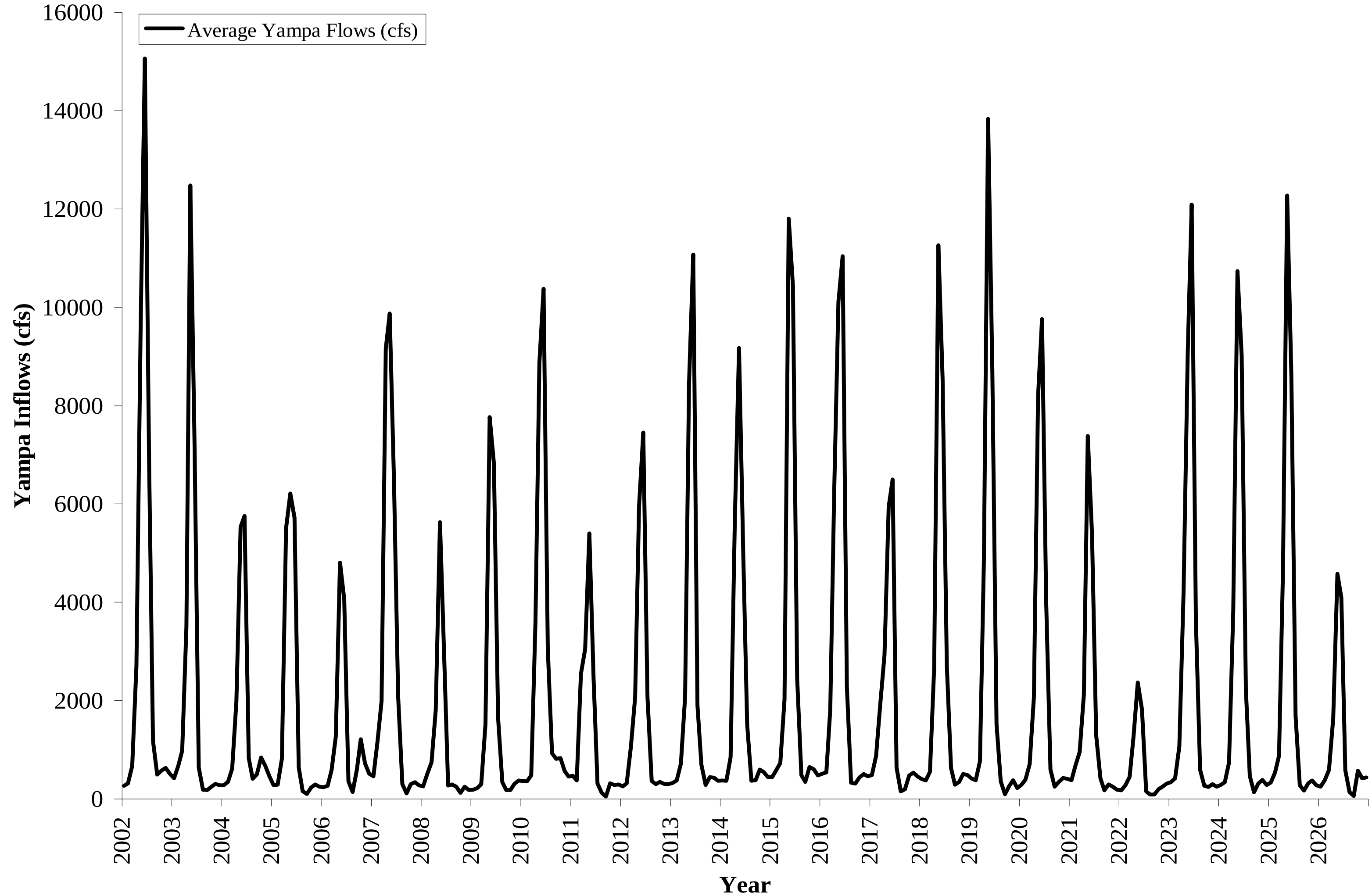

Figure 7-7. Monthly Yampa Inflow Projections from the Flaming Gorge Model (Representative Trace – Run 36).

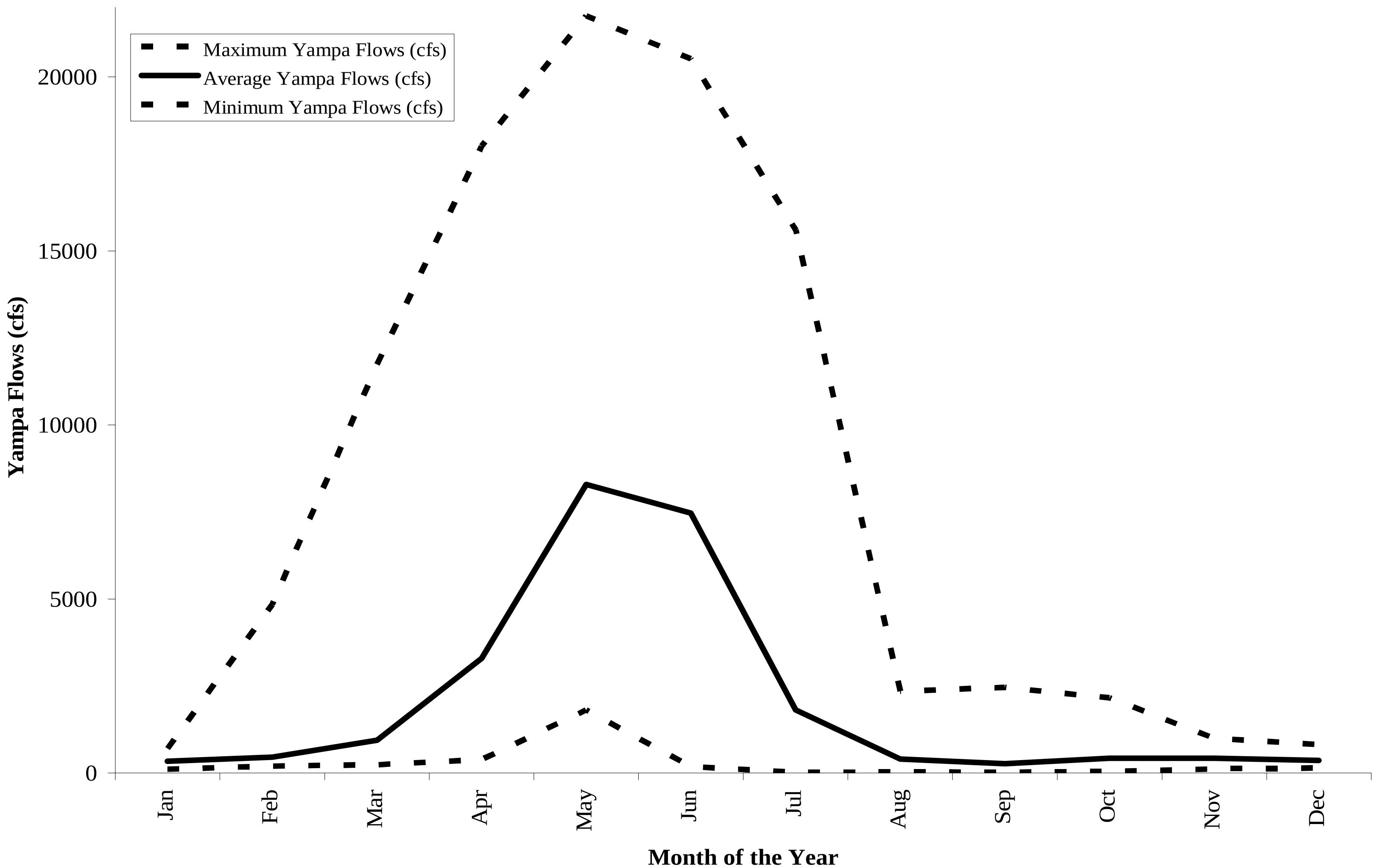

Figure 7-8. Average and Range of Monthly Yampa Inflows Projected by the Flaming Gorge Model for the No Action Alternative (Representative Trace – Run 36).

Although the Action Alternative is projected to have an overall higher economic benefit, there are some years that the benefits are expected to be negative. Table 8.3 shows that the Action Alternative has lower nominal revenues during 10 years of the 25-year study period. In each of these years annual generation for the No Action Alternative is significantly higher than for the Action Alternative.

Table 8.3 Comparison of the Annual Economic Benefits of the Flaming Gorge Powerplant under the No Action and Action Alternatives

		No Action Alternative			Action Alternative				
Year	Average Spot Market Price ($/MWh)	Average Power Release (cfs)	Annual Generation (GWh)	Nominal Value (Millions $)	Average Power Release (cfs)	Annual Generation (GWh)	Nominal Value (Millions $)	Generation Above the No Action Alternative (GWh)	Nominal Value Above the No Action Alternative (Million $)
2002	60.0	1,548	415.8	26.0	1,631	428.9	27.4	13.1	1.5
2003	47.5	1,750	471.0	21.8	1,456	386.3	18.9	-84.8	-2.8
2004	42.6	1,222	321.3	13.5	1,257	330.2	14.5	8.9	1.1
2005	42.7	1,233	322.3	13.3	947	245.8	11.0	-76.5	-2.3
2006	44.9	1,036	264.6	12.3	903	233.0	10.8	-31.6	-1.5
2007	48.6	1,760	470.1	24.2	1,981	530.2	27.2	60.0	3.0
2008	53.3	1,381	366.2	18.9	1,150	304.0	18.1	-62.2	-0.8
2009	61.1	1,619	431.4	25.9	1,674	441.0	29.1	9.6	3.2
2010	62.3	2,540	687.0	46.0	2,452	666.2	45.8	-20.8	-0.2
2011	64.2	1,805	484.0	27.5	1,616	432.7	26.7	-51.3	-0.8
2012	65.4	1,771	476.4	31.5	1,981	526.6	41.1	50.2	9.6
2013	67.6	1,875	506.0	32.3	1,620	427.4	32.6	-78.6	0.3
2014	68.6	1,843	495.6	35.1	1,766	467.5	35.6	-28.0	0.5
2015	70.3	1,467	391.0	27.2	1,510	401.0	32.7	10.0	5.5
2016	70.9	2,327	630.4	44.9	2,739	728.9	56.6	98.5	11.8
2017	71.6	2,793	757.3	51.5	2,812	749.2	58.4	-8.0	7.0
2018	78.5	2,275	622.3	50.2	2,027	545.4	46.7	-76.9	-3.5
2019	78.3	2,272	614.6	48.0	2,372	628.7	50.9	14.2	2.9
2020	79.3	2,138	580.4	46.0	1,985	528.8	50.9	-51.6	4.9
2021	79.4	2,218	602.2	46.6	2,001	534.3	48.6	-68.0	2.0
2022	79.4	1,288	335.8	27.8	887	228.2	18.1	-107.6	-9.7
2023	79.4	1,447	385.9	32.8	1,744	461.3	46.3	75.4	13.5
2024	79.3	1,406	373.5	28.2	1,204	316.7	28.1	-56.8	-0.1
2025	79.4	1,886	509.7	43.7	2,069	556.2	49.5	46.5	5.8
2026	79.4	1,472	389.5	30.9	1,060	275.9	24.9	-113.6	-6.1

The primary reason that the Action Alternative has a higher overall economic value despite lower generation levels is that more power is being generated when it has the highest economic value. As shown on figure 8.1, average weekly generation for the Action Alternative is significantly higher during the high priced summer months as compared to the No Action Alternative. Note that throughout the summer price spike period for weeks 26 through 40 that the average generation level is always higher for the Action Alternative. On the other hand, generation levels during much of the rest of year are lower under the Action Alternative.

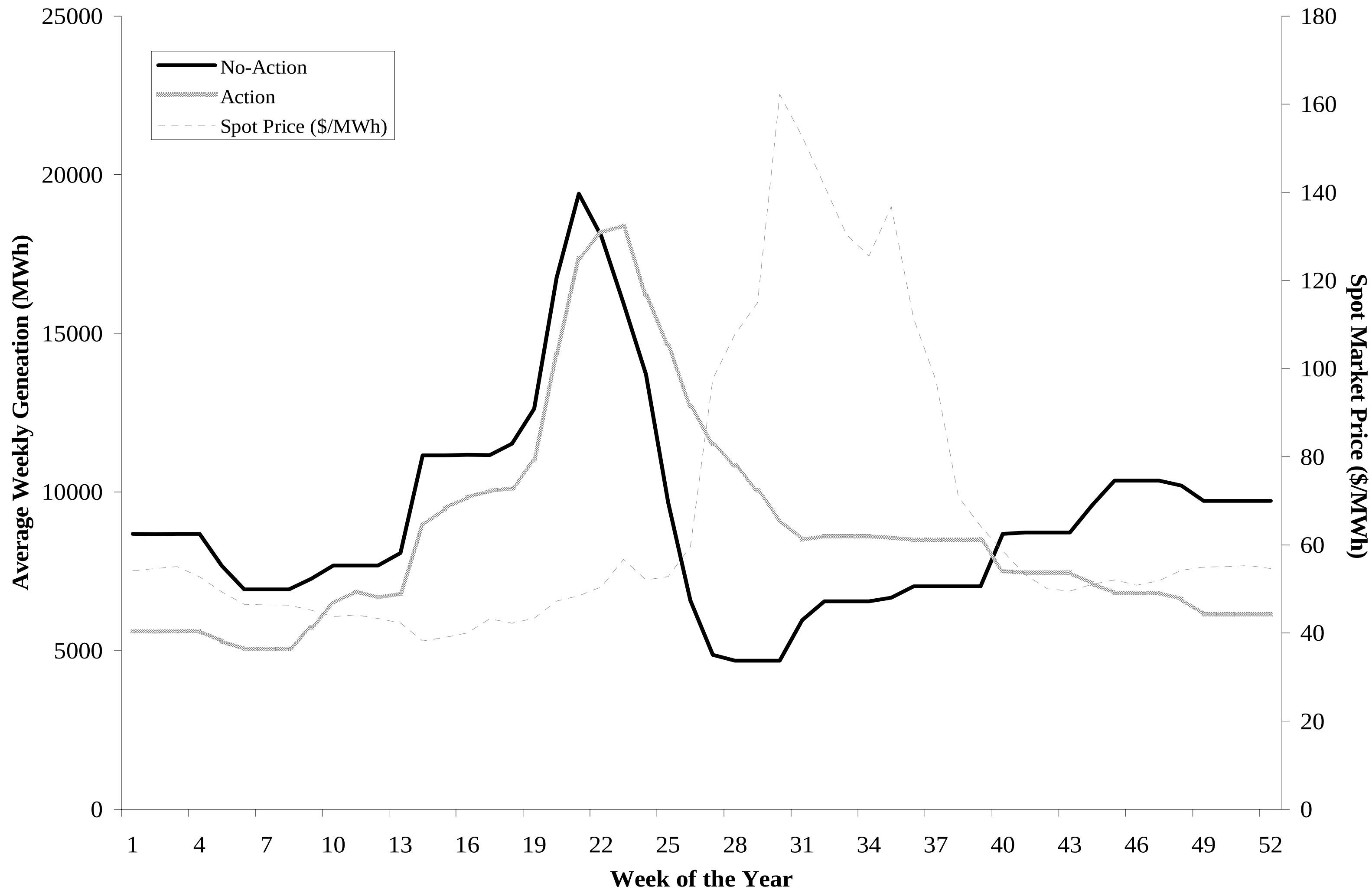

Figure 8-1. Average Weekly Generation Levels and Spot Market Prices for the No Action and Action Alternatives.

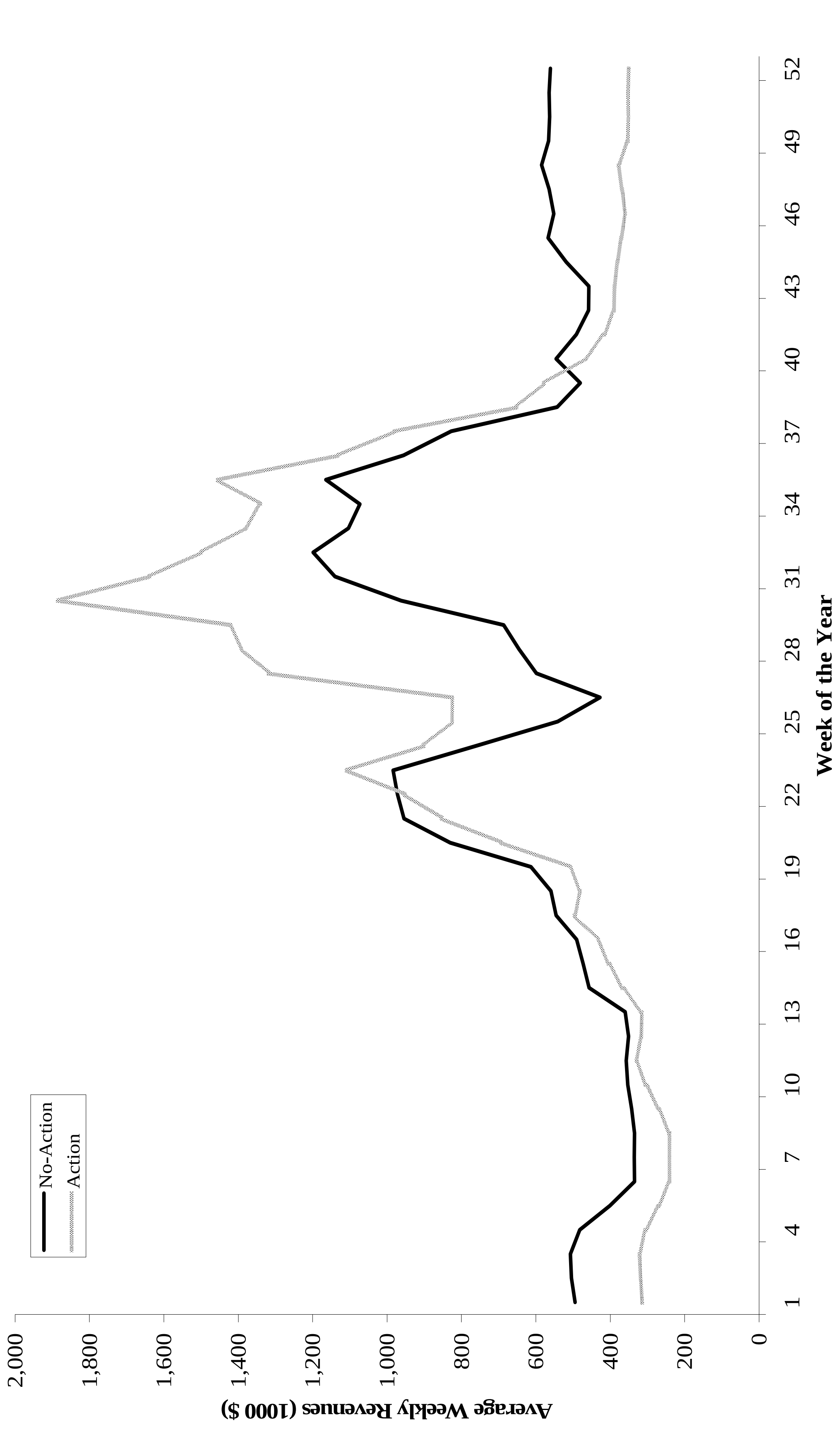

Figure 8-2. Average Weekly Revenues for the No Action and Action Alternatives.

Average nominal revenues for the two Alternatives are shown in figure 8.2. Consistent with the weekly distribution of generation levels and spot market prices, the Action Alternative has much higher revenues during the summer. These gains more than offset lower revenue streams during the other seasons. If price differences among the seasons of the year were projected to be smaller, then the Action Alternative would have a lesser economic advantage relative to the No Action Alternative and under some spot price scenarios an economic disadvantage.

With similar monthly release levels, hourly operations under the two alternatives are alike. Figures 8.3 and 8.4 show Flaming Gorge release patterns and resultant Jensen Gauge flows under average hydropower conditions for the No Action and Action Alternatives, respectively. The figure shows that release patterns and hence generation for both alternatives are able to respond to market price signals. During the most expensive spot market hours water releases are relatively high. In general, however, release levels for the No Action Alternative fluctuate slightly more than for the Action Alternative. This is partially due to a slightly larger average release rate over the week for the No Action Alternative (i.e., 2,722 cfs) compared to the Action Alternative (i.e., 2,370 cfs). Also, the No Action Alternative has a slightly larger Jensen Gauge flow window compared to the Action Alternative.

The upper bounds of the gauge flow window for the No Action Alternative are fixed through the simulated week at +/- 12.5 percent of the average weekly flow rate. As shown in figure 8.4. the gauge flow rate window is somewhat smaller for the Action Alternative

Similar release patterns in response to market prices and gauge constraints are displayed under both wetter and drier hydropower conditions. Figures 8.5 and 8.6 show generation patterns for relatively dry conditions for the No Action and Action Alternatives, respectively. For both alternatives release rates are at the minimum allowable levels (i.e., 800 cfs) when prices are at their lowest levels. Peak dam releases occur during the daytime when prices are high, but ramp rate and the single-hump limitations constrain release levels well below the turbine maximum. Only two of the three turbines would be operated under these conditions.

When hydropower conditions are relatively wet, the powerplant is mainly limited by operational constraints for the No Action Alternative. Figure 8.7 shows that Jensen Gauge flows do not approach either the upper or lower limits during most the simulated week. Instead ramp-rate and the one-hump limitations along with turbine constraints dictate the release pattern. For the Action Alternative, gauge limitations are more constraining, as shown in figure 8.8. However, the economic impact of these limitations is minor since the powerplant is operating at its maximum level most of the time. Releases are only slightly lower during the lowest priced hours.

The hourly Flaming Gorge release patterns presented in this section are based on a relatively complex search routine that seeks to maximize the economic benefits of hydropowerplant operations. In doing so the mathematical algorithms find solutions that are often at the edge of compliance with little or no margin for error. Historically, operators have not used this type of approach and have been more conservative by operating the Flaming Gorge Dam well within the gauge flow limits. Given a more conservative approach the economic difference between the two alternatives may be smaller.

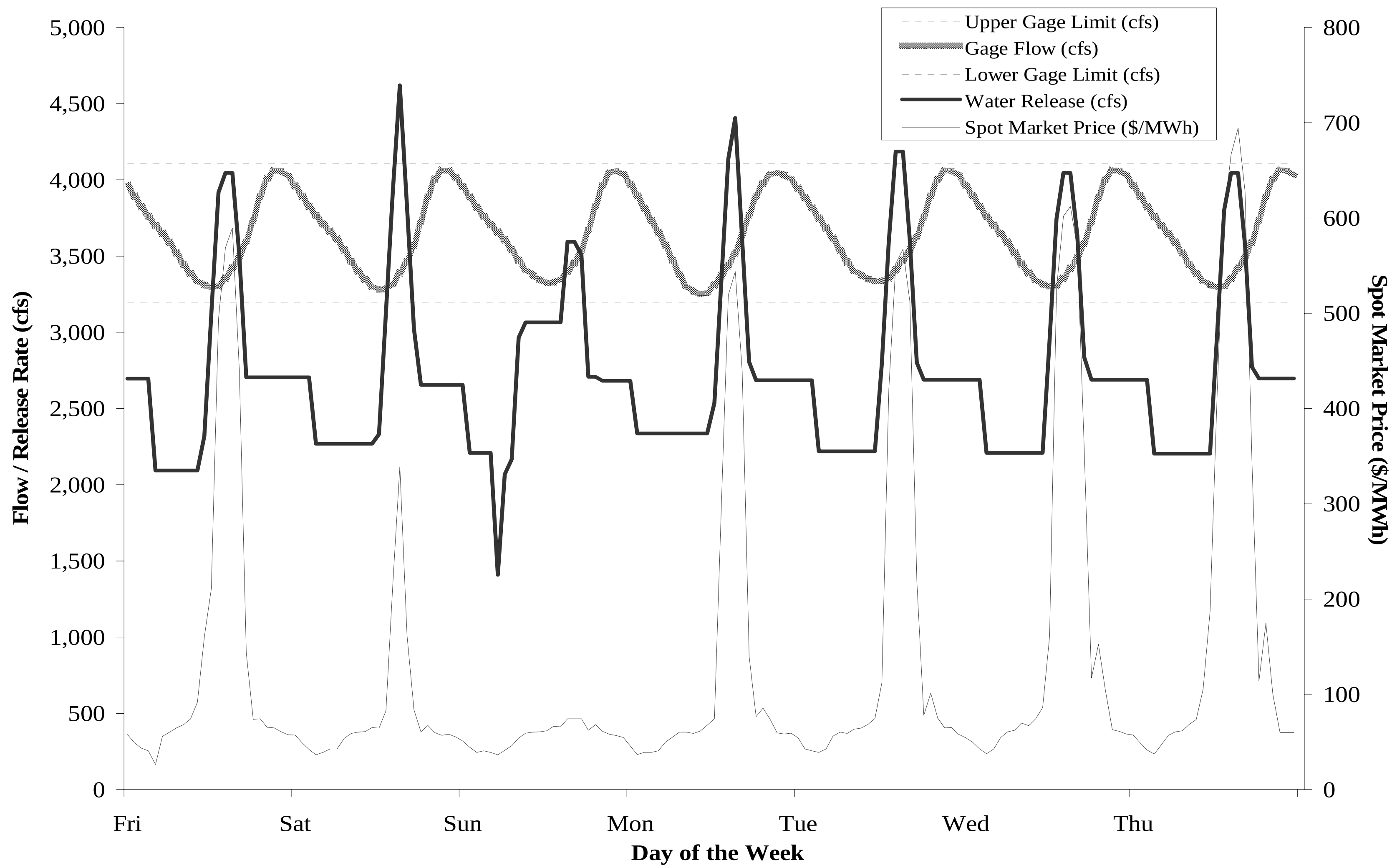

Figure 8-3. Hourly Flaming Gorge Dam Operations and Resultant Gauge Flows for the No Action Alternative Under Average Hydropower Conditions.

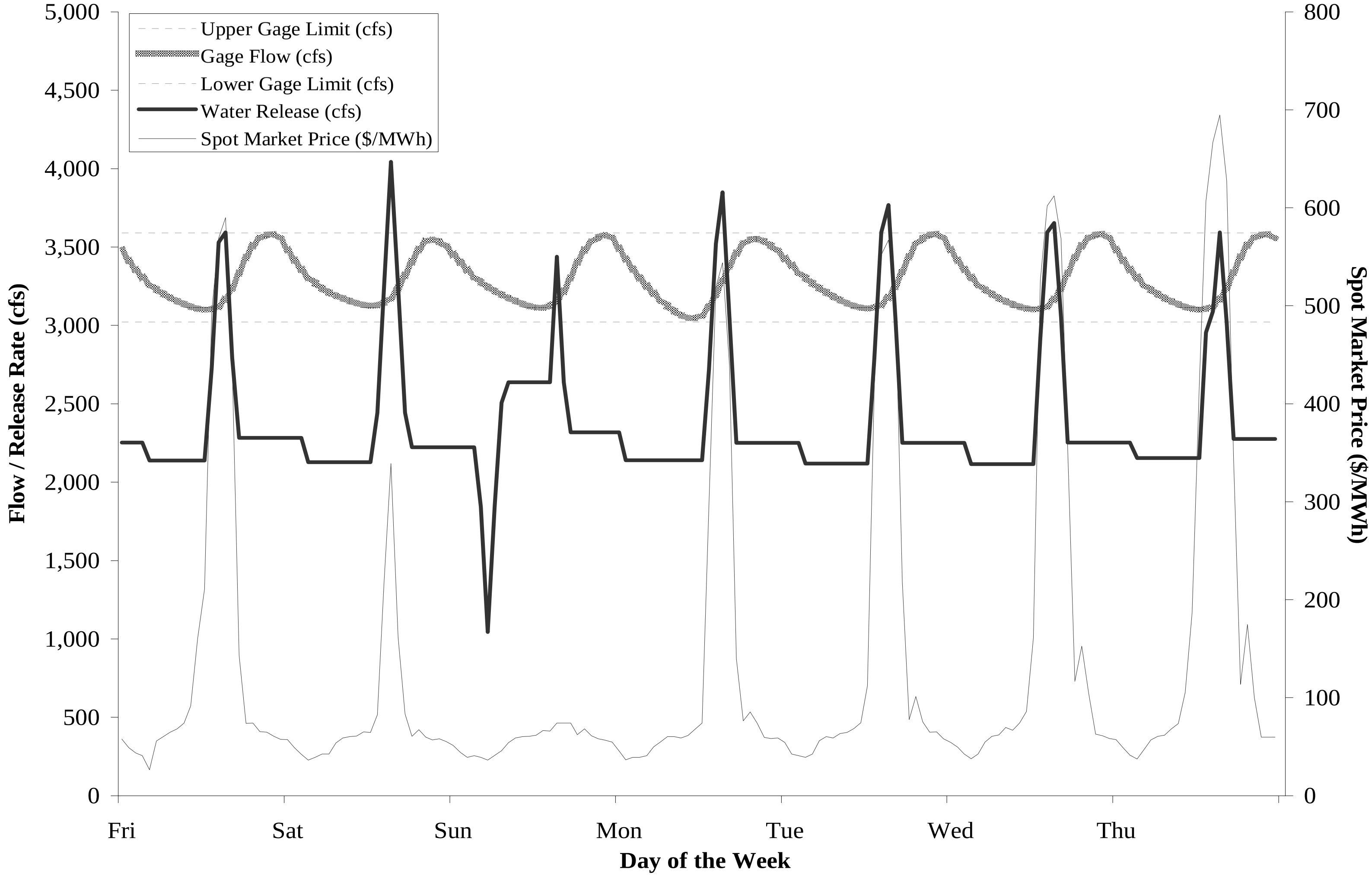

Figure 8-4. Hourly Flaming Gorge Dam Operations and Resultant Gauge Flows for the Action Alternative Under Average Hydropower Conditions.

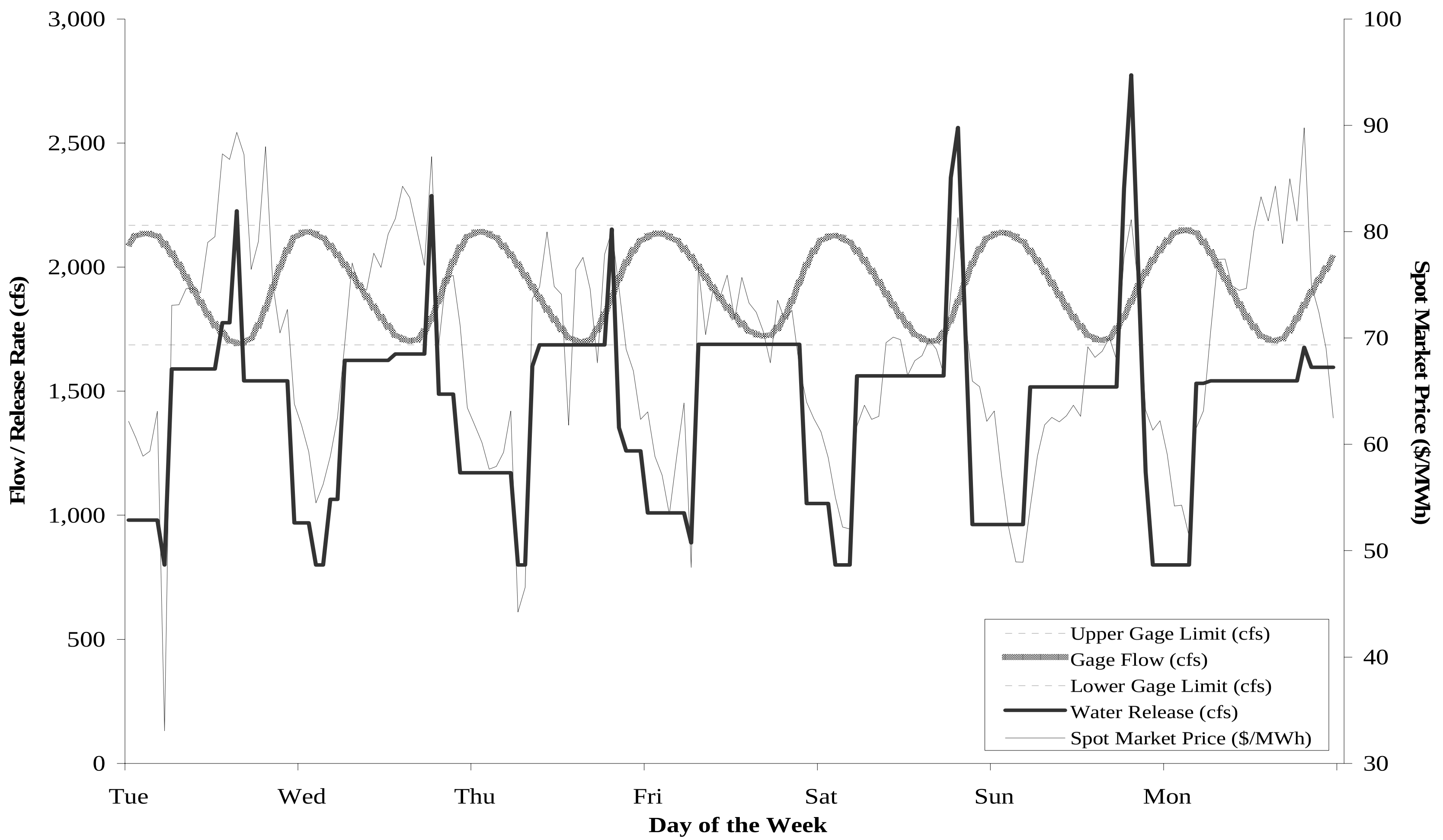

Figure 8-5. Hourly Flaming Gorge Dam Operations and Resultant Gauge Flows for the No Action Alternative Under Relatively Dry Hydropower Conditions.

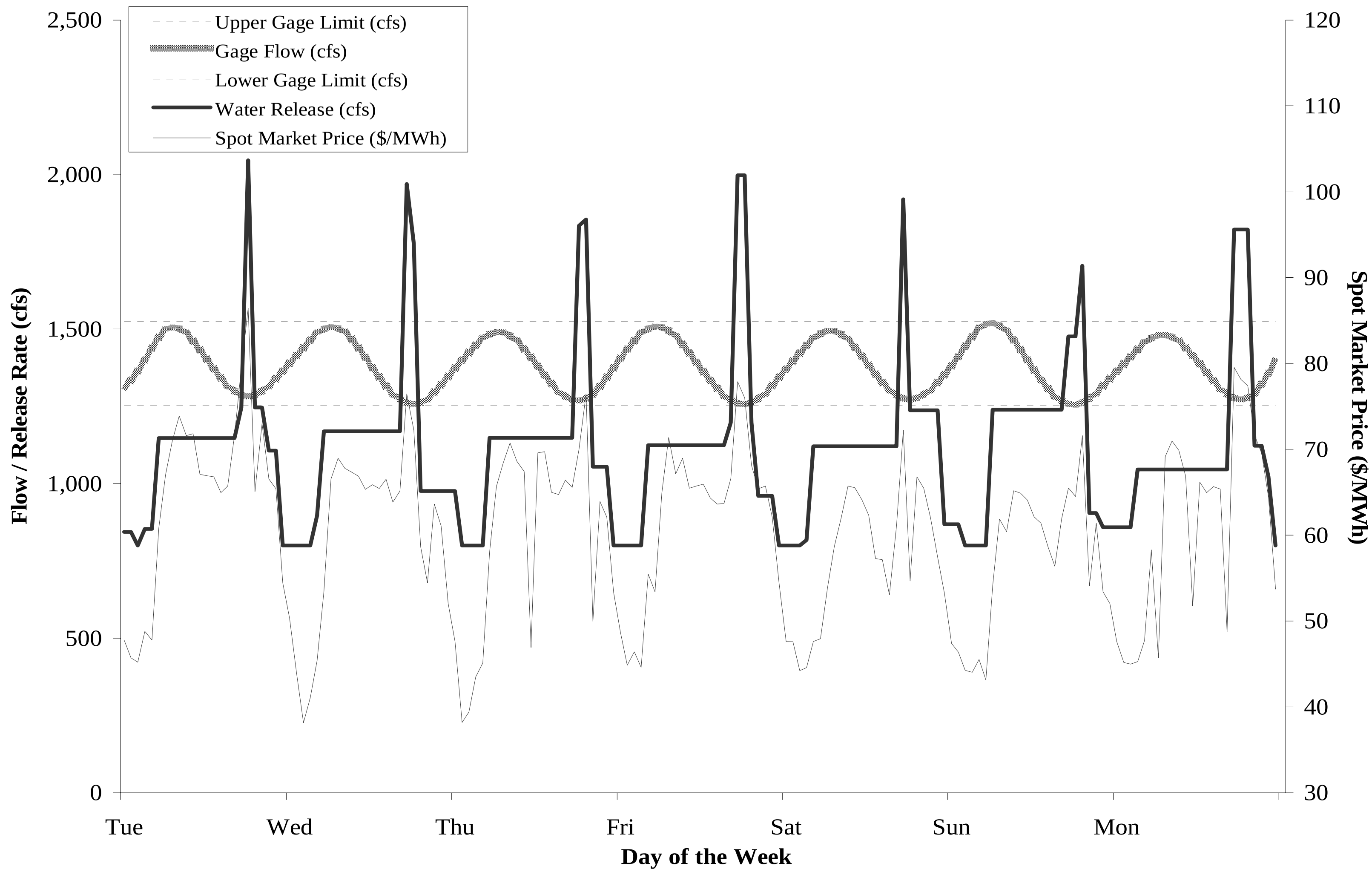

Figure 8-6. Hourly Flaming Gorge Dam Operations and Resultant Gauge Flows for the Action Alternative Under Relatively Dry Hydropower Conditions.

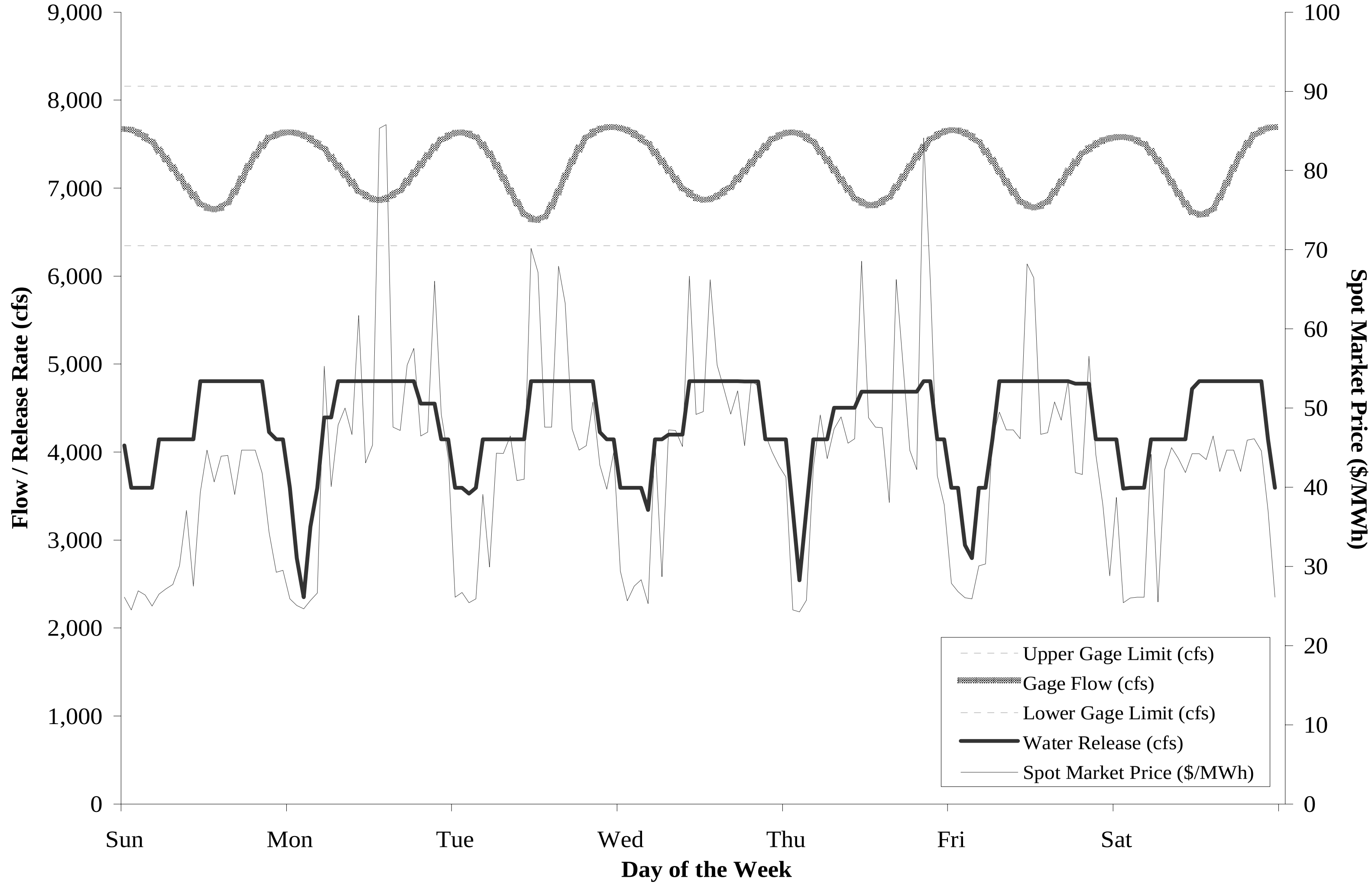

Figure 8-7. Hourly Flaming Gorge Dam Operations and Resultant Gauge Flows for the No Action Alternative Under Relatively Wet Hydropower Conditions.

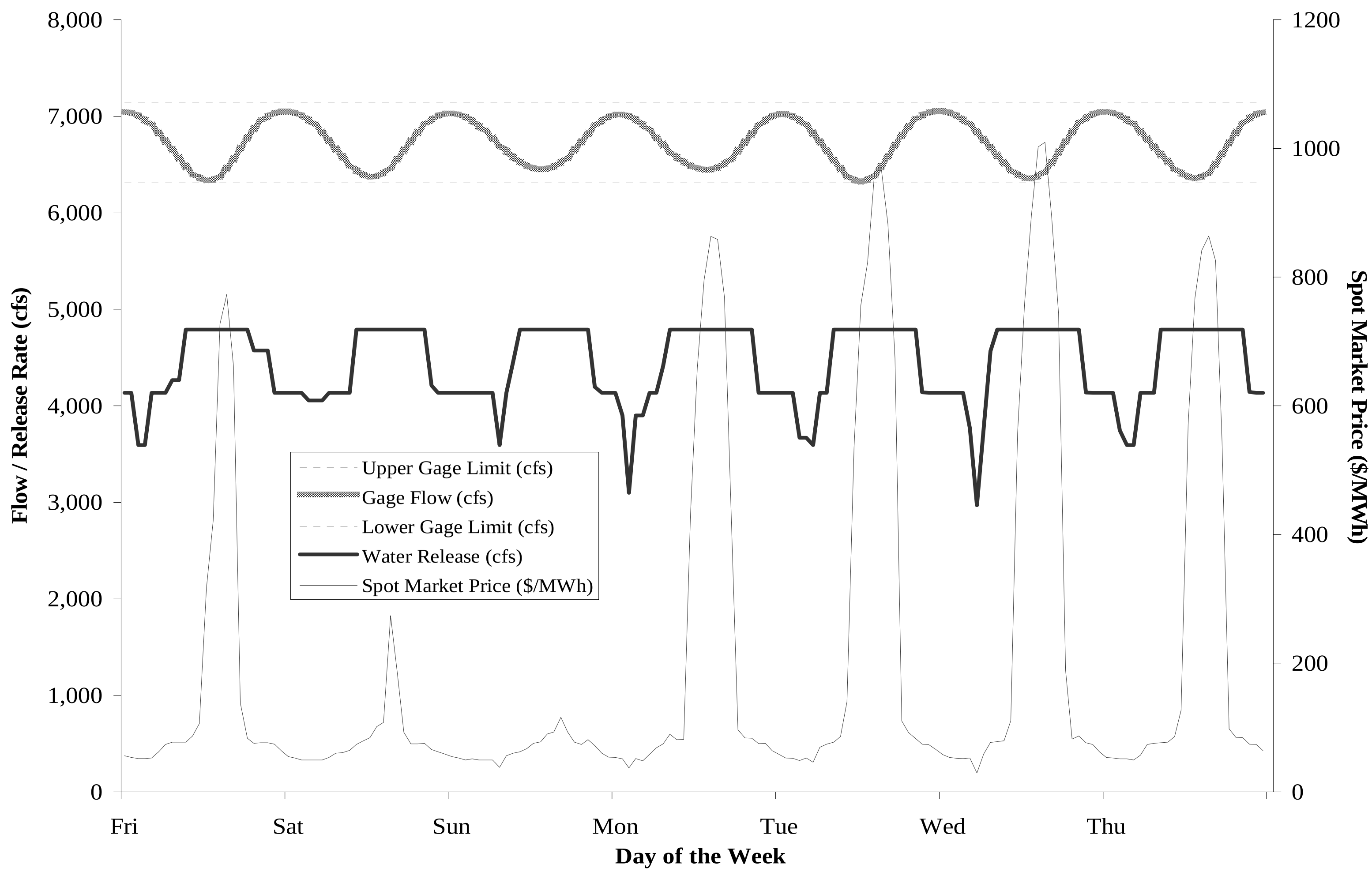

Figure 8-8. Hourly Flaming Gorge Dam Operations and Resultant Gauge Flows for the Action Alternative Under Relatively Wet Hydropower Conditions.

9. CUMULATIVE IMPACT

An additional hydropower analysis was performed to estimate the cumulative economic costs of environmental regulations associated with Flaming Gorge Powerplant operations. The Cumulative Impact Scenario assumes that there are no biological constraints except for the 800 cfs minimum flow requirement. This scenario is for comparison purposes only and is not an alternative under consideration. Instead, it reflects the economic impacts on the economic value of power from environmental constraints enacted since 1973. Power simulations of the Cumulative Impact Scenario are performed using the same model systems approach as the No Action and Action Alternatives. Also, an additional run of the Flaming Gorge model was made to reflect the removal of biological constraints.

9.1 Green River Simulations

Flaming Gorge model simulated monthly water releases volumes for the Cumulative Impact Scenario are guided by a drawdown target that is set to 6,026 ft for April 1st. The fill target for August 1st is set to 6,033 ft. During the spring, forecast errors do not affect decisions regarding operational planning. Therefore, when the forecast is lower than the actual hydrology the elevation will exceed the 6,033 ft. target. On the other hand, a high forecast will result in a lower reservoir elevation on April 1st. During the base flow it is assumed that there are no forecast errors. The outflow is always limited to powerplant capacity except when the spillway gates are in danger of being overtopped. A model parameter is specified such that non-power releases occur when the elevation exceeds 6040 ft. (i.e., the top of the spillway gates). Spills and turbine releases are scheduled such that reservoir elevation is lowered to 6,040 ft.

Average monthly water releases over the study for the Cumulative Impact Scenario and the No Action Alternative are shown in figure 9.1. On average, water releases during the summer months are significantly higher for the Cumulative Impact Scenario. Note that these are the months that have the highest value of electricity. In addition to having higher water releases during the summer months, water releases among days of a simulated month were not restricted; that is, only monthly water volumes constrain powerplant operations. This allows for greater water releases and generation levels during days of the month that have the highest electricity prices.

9.2 Powerplant Operations

Powerplant operations for the Cumulative Impact Scenario not only benefit from larger water releases during the summer months, but there are significantly fewer non-power water releases. Most of the non-power releases for the Alternatives are attributable to spring spike flows. Table 9.1 shows that non-power release for the No Action Alternative is more than five times higher than the Cumulative Impact Scenario. Lower spills and more operational flexibility translate into a 2.7% higher generation level.

Ramp-rate constraints and the single daily hump requirement do not restrict hourly generation patterns for the Cumulative Impact Scenario. Therefore, operations respond more quickly and efficiently to market price signals. Figure 9.2 shows typical operations for a summer day. Generation levels quickly increase from the minimum flow level (i.e., energy produced by 800 cfs) to the point of maximum water-to-power conversion efficiency when prices begin to increase in the morning. When prices spike in the afternoon, generation levels increase to the maximum powerplant capability.

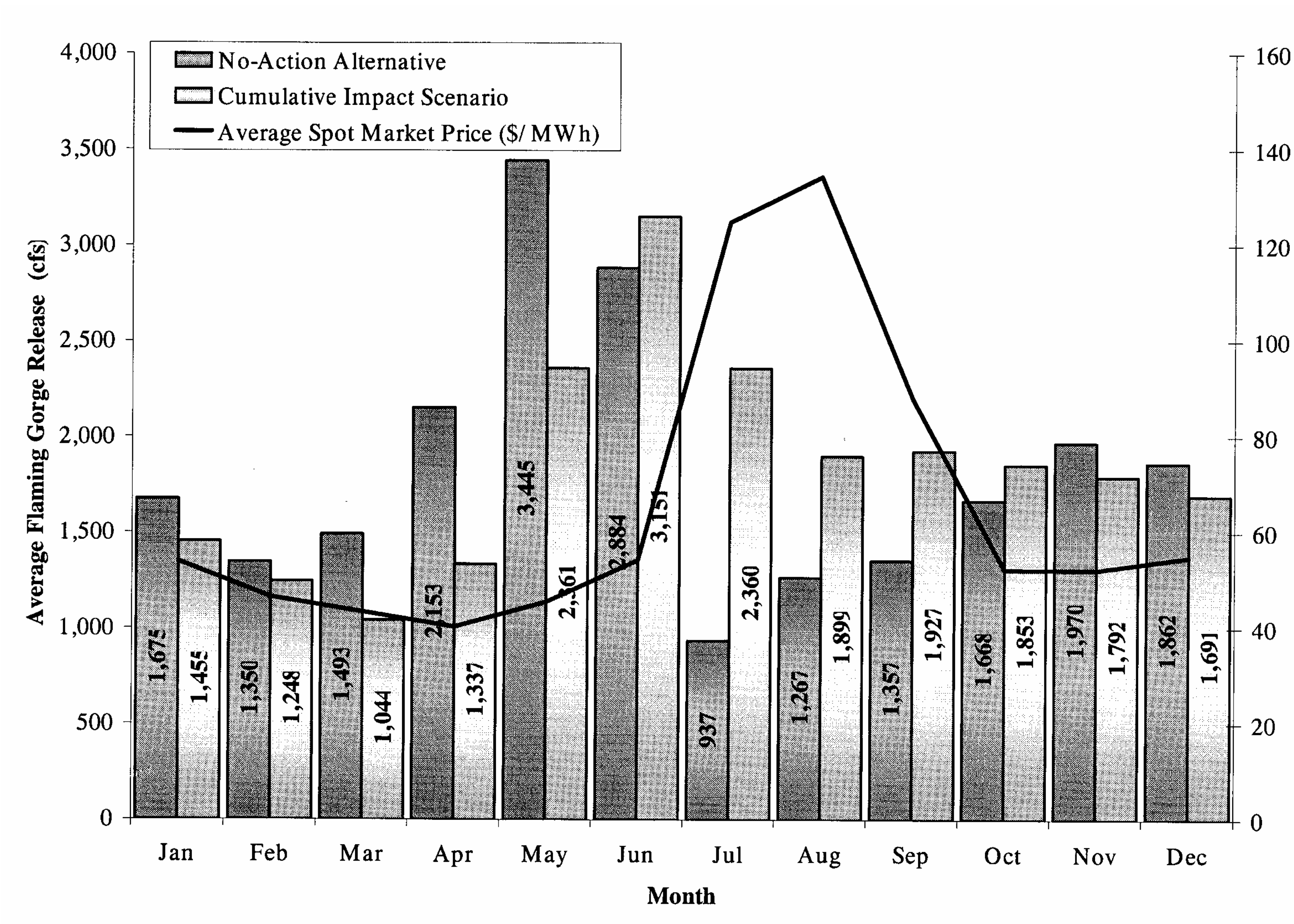

Figure 9-1. Comparison of Monthly Average Water Releases for the No Action Alternative and the Cumulative Impact Scenario.

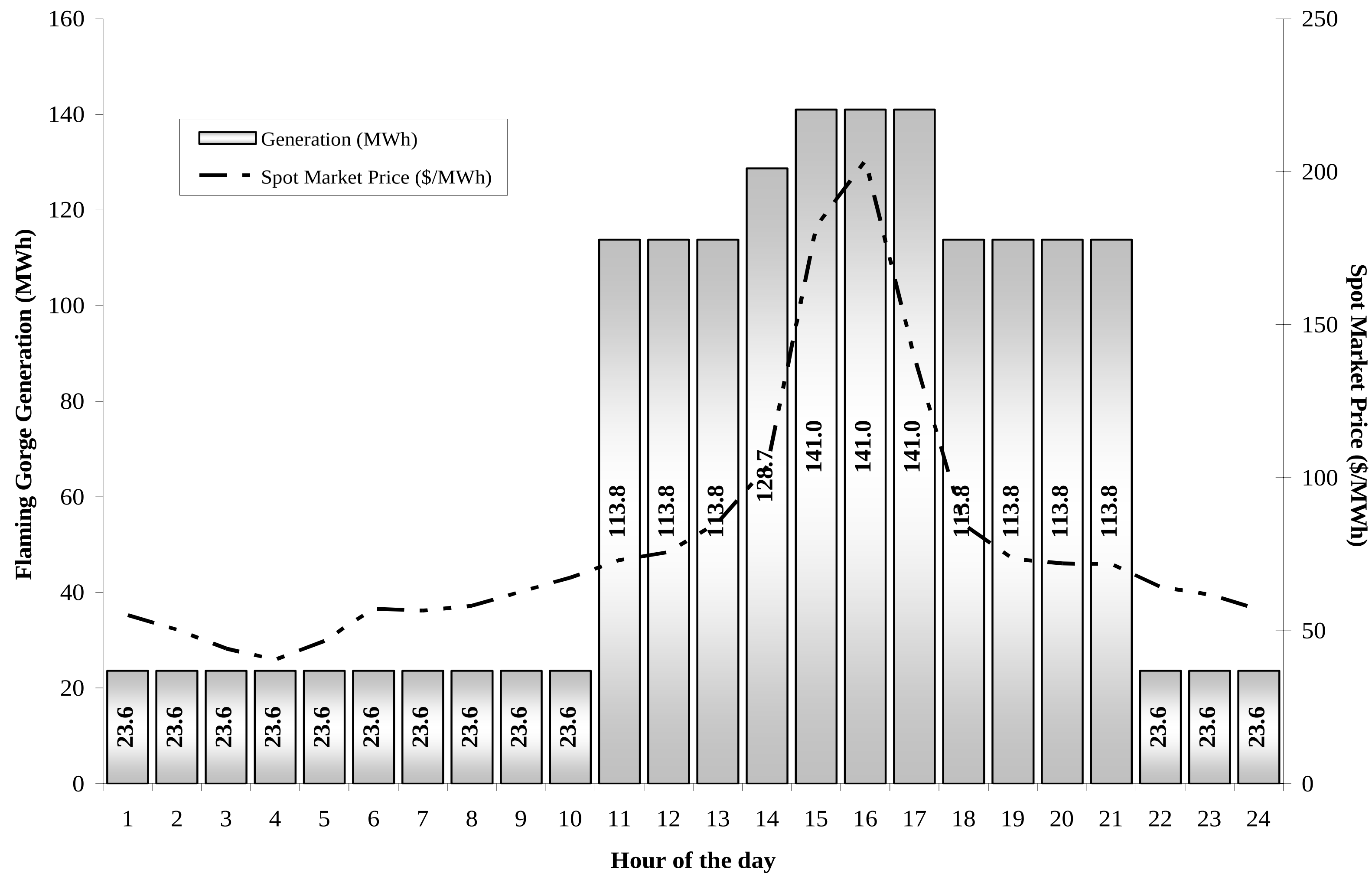

Figure 9-2. Typical Daily Generation Pattern During a Summer Weekday for the Cumulative Impact Scenario.

Table 9.1. Comparison of the Water Release and Generation from the Flaming Gorge Powerplant between the No Action Alternative and the Cumulative Impact Scenario

	No Action Alternative	Cumulative Impact Scenario	Increase Above the No Action Alternative (%)
Average Water Release (cfs)	1,839.2	1,843.7	0.2
Average Non-turbine Release (cfs)	64.4	11.6	-81.9
Generation (GWh)	11,904.1	12,229.7	2.7

With environmental constraints removed, the economic value of power production over the 25-year simulation period is significantly greater as compared to both the No Action and Action Alternatives. As shown in table 9.2, the Cumulative Impact simulation has an economic value that is about 29% higher than the No Action Alternative.

Table 9.2. Comparisons of the Economic Value of EIS Alternatives and the Cumulative Impact Scenario

	No Action Alternative (millions $)	Action Alternative (millions $)	Cumulative Impact (millions $)	Comparison of Cumulative Impact to No Action (%)
Nominal	$806.1	$850.6	$1,065.1	32.1
NPV	$403.1	$423.1	$521.4	29.3

10. References

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Fulp, T., Vickers, B., Williams, B., and King, K., 1996, *Replacement of the Colorado River Simulation System (CRSS)*, Draft Report, in final preparation, Bureau of Reclamation.

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Mitchell, Melanie, *An Introduction to Genetic Algorithms*, The MIT Press, Cambridge, Massachusetts, London, England, Sixth printing, 1999

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United States Army Corps of Engineers, Streamflow Synthesis and Reservoir Regulation Model Users Manual, Draft, August 1987

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Western Area Power Administration Web Site, http://www.wapa.gov/crsp/operatns/fgSCADAdata.htm.

Western Systems Coordinating Council, 1991, 10-Year Coordinated Plan Summary 2001 – 2010 Planning and Operation for Electric System Reliability, August 2001, Loads and Resources Subcommittee

APPENDIX A:

HYDRAULIC TURBINE DATA FOR FLAMING GORGE

FLAMING GORGE POWER PLANT COLORADO RIVER STORAGE PROJECT.
SPECIFICATIONS NO. DS-5263 UNITS 1, 2 AND 3 DATE May 17, 1960
TURBINE NAMEPLATE RATING: H.P. 50,000 ; HEAD 365 FT.; SPEED 240 R.P.M.
GENERATOR RATING IN KV-A 40,000 POWER FACTOR 90 PERCENT.
Turbine mfr. The James Leffel Co. Type Francis
Cost per unit f.o.b. factory $266,183.33 Weight 310,000 lbs.
Cost per h.p. $4.38 Weight per h.p. 5.10 lbs.
Type of scroll case Welded plate steel spiral. Weight heaviest part 50,000 lbs.
Type of draft tube Elbow with plate steel liner–one pier
Weight of runner 21,500 lbs. Weight of rotating parts 45,000 lbs.
Weight of turbine parts including hydraulic thrust to be carried by generator thrust bearing 225,000 lbs. New; 310,000 lbs. Worn rings
Governor capacity in foot-lbs. 105,000 Pipe size 3 inches.
Gov. mfr. Woodward Governor Co. Time element 5 seconds.
Cost per unit f.o.b. factory $39,758.33 Weight 15,550 lbs.
Generator mfr. Westinghouse Electric Corp.
Generator WR^2 7,000,000 lbs. at one foot radius.
Turbine WR^2 160,000 lbs. at one foot radius.
Regulating constant of unit ($\overline{R.P.M.}^2 \times WR^2 \div$ Design H.P.) 6,990,000
n_s of runner 29.9 at 400 ft. design head when delivering 50,000 h.p. (Best eff. gat
N_s of runner 33.1 at 400 ft. design head when delivering 60,800 h.p. (Full gate).
H.P. at 400 ft. (Design head) 60,800 ; at 100 percent of design head; 1530 c.f.s.
H.P. at 440 ft. (Max. head) 69,400 ; at 110 percent of design head; 1620 c.f.s.
H.P. at 260 ft. (Min. head) 30,600 ; at 65 percent of design head; 1190 c.f.s.
H.P. at 350 ft. (Mfrs. Rated Hd.) 50,000 ; at 87.5 percent of design head; 1400 c.f.s.
H.P. at best efficiency equals 82.2 percent of h.p. at full gate.
Runaway speed at 440 ft. hd. 445 r.p.m. equals 185 percent of normal speed.

DIMENSIONS OF TURBINE:

Unit spacing 36.0 ft.
Max. dia. of runner 8.50 ft.
Dia. of gate circle 9.75 ft.
Height of distributor case 1.6'5 ft.
Dia. at scroll case inlet flange 8.00 ft.
Outside radii of stay vanes 6.92 to ft.
Dia. of shaft 26 inches.
Dia. of cover plate 12.05 ft.
Number of wicket gates 20
Number of stay vanes 19
Dia. at top of draft tube 7.80 Ft=D_3
Distributor ℄ Elev. 5601 Ft.
Distance from center line of distributor to top of draft tube 2.29 ft.
Depth of draft tube 22.5 ft. equals 289 percent of dia. D_3.
Length of draft tube 31.58 ft. equals 405 percent of dia. D_3.
Width of draft tube 29.00 ft. equals 372 percent of dia. D_3.
Distance from center line of turbine to center line of scroll case inlet 11.25 ft.
Distance from center line of distributor to minimum tailwater, (Elev. 5601.6 ft.) (One unit operating at full load) −0.6 ft.
Pressure regulator mfr. None Type Size inches.
Cost per unit f.o.b. factory Weight lbs.
REMARKS:
Placed in operation

Figure A.1. Listing of Turbines, Generator, and Related Equipment Characteristics at the Flaming Gorge Powerplant.

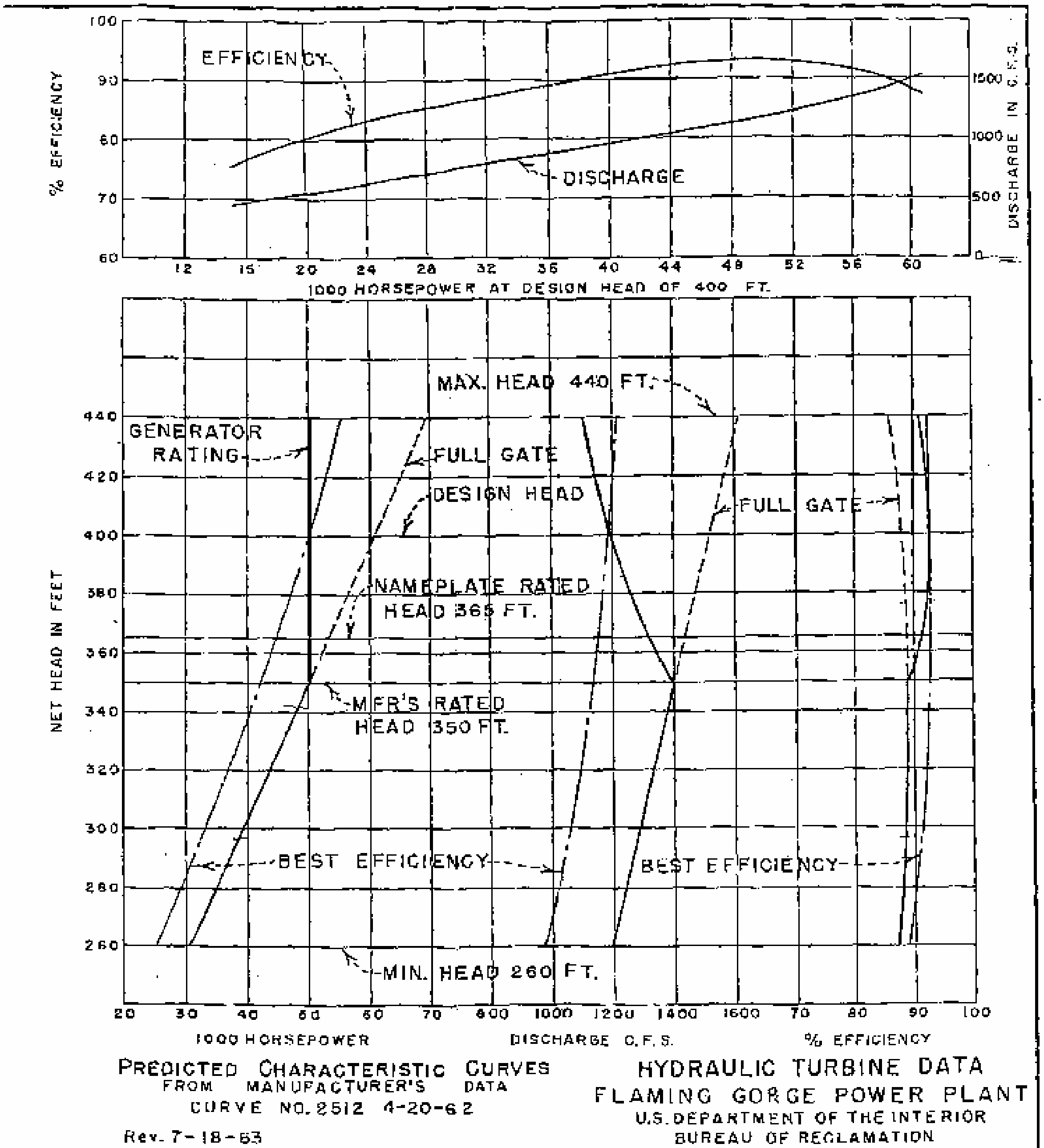


Figure A.2. Predicted Characteristic Curves and Hydraulic Turbine Data for the Flaming Gorge Powerplant.

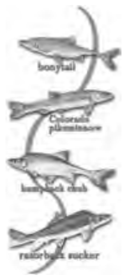
Operation of Flaming Gorge Dam Final Environmental Impact Statement

Cultural Resources Technical Appendix

CULTURAL RESOURCES TECHNICAL APPENDIX

Page No.

Cultural Resources Technical Appendix



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COLORADO HISTORICAL SOCIETY

The Colorado History Museum 1300 Broadway Denver, Colorado 80203-2137

August 30, 2002

Kerry Schwartz
Chief, Environmental Group
Bureau of Reclamation
302 East 1860 South
Provo, UT 84606-7317

Re: Flaming Gorge Dam Operation

Dear Ms. Schwartz

This office has reviewed the information contained in your correspondence of August 22, 2002 concerning the project listed above.

5MF605, 5MF2357.3 and 5MF2357.2 are listed in the National Register of Historic Places. 5MF2399 and 5MF2388 have officially been determined not eligible to the National Register.

We concur that sites 5MF3668, 5MF1238, 5MF3669 and 5MF1230 are not eligible due to the lack of subsurface deposits, diagnostic artifacts and features. 5MF1233, an historic trash scatter, could not be relocated and is therefore not eligible.

5MF1234, 5MF840 and 5MF67 need additional data in order to make a determination of eligibility. The only information we have in house on site 5MF67 is a 1965 form. This site needs to be recorded according to today's standards.

We concur that rock art sites 5MF2964, 5MF2966 and 5MF2968 are eligible to the National Register.

The proposed work at sites 5MF605, 5MF688, 5MF840, 5MF1232 and 5MF1234 is adequate. We would also recommend that recording 5MF67 be added to the work being done for this project.

If we may be of further assistance please contact Jim Green at 303-866-4674.

Sincerely,

Georgianna Contiguglia
State Historic Preservation Officer

GC/WJG

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March 28, 2003

Beverley Hefferman
Chief, Environmental Group
Bureau of Reclamation
302 East 1860 South
Provo, UT 84606-7317

Re: Flaming Gorge Dam Operation EIS, Browns Park Area

Dear Ms. Hefferman:

This office has reviewed your March 24, 2003 correspondence and the cultural resource report prepared by Alpine Archaeological Consultants for the testing of six sites in the Flaming Gorge Dam flow study, Browns Park National Wildlife Refuge.

Fort Davey Crockett, 5MF605, was listed on the National Register of Historic Places in 1977. Despite impacts from the river, testing determined that buried cultural deposits exist that may increase our knowledge of the Fort and the people who inhabited the region.

5MF688 a rock art site, was determined eligible on August 30, 2002.

Testing at 5MF1232, an early homestead site, turned up a living surface. Further work on the site may yield information on early homesteading in the region.

5MF1234, 5MF3668 and 5MF840 are not eligible. 5MF3668 and 5MF680 no longer exist and 5MF1234 will yield no further information important to history.

It is apparent that wave action from the Green River is severely impacting 5MF605 and in a lesser way 5MF1232. We look forward to working with the agencies involved in this project to formulate a mitigation plan for these sites.

Beverley Hefferman
March 28, 2003
Page 2

If we may be of further assistance please contact Jim Green at 303-866-4674.

Sincerely,

Georgianna Contiguglia
State Historic Preservation Officer

GC/WJG

cc: Rhoda Lewis, F&WS
Mary Barger, WAPA

chael O. Leavitt
Governor
Max J. Evans
Director

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State of Utah

Department of Community and Economic Development
Division of State History
Utah State Historical Society

300 Rio Grande
Salt Lake City, Utah 84101-1182
(801) 533-3500 FAX: 533-3503 TDD: 533-3502
ushs@history.state.ut.us http://history.utah.org

December 10, 2002

Peter Crookston
Acting Chief, Environmental Group
Bureau of Reclamation
Upper Colorado Region – Provo Area Office
302 East 1860 South
Provo UT 84606-7317

RE: Consultation Regarding Determinations of Eligibility and Effect for Flaming Gorge Dam Operation Environmental Impact Statement

In Reply Please Refer to Case No. 02-1790

Dear Mr. Crookston:

The Utah State Historic Preservation Office received the referenced information on December 5, 2002. After consideration of the consultation request in behalf of the Bureau of Reclamation, the Utah Preservation Office provides the following comments per §36CFR800.

1. Eligibility of Sites Within the Reservoir Area of Potential Effects, Table 1: USHPO preservation Office concurs with the determination that Table 1 sites are **Not Eligible, [17 NP]**.

2. Eligibility of Sites in the Reservoir, Table 2, APE Indirectly Affected by the Proposed Undertaking; USHPO concurs with the determination that DA 15 is **Not Eligible** and that DA 11, 12 and 16 are **Eligible**. In addition, USHPO recommends that DA 17 and 497 be considered eligible until evaluation is completed of the sites. **[DOEx5, NPx1]**.

3. Eligibility of Sties in the Downstream Area of Potential Effects, Table 3: USHPO concurs with the determinations that DA 394, 196 are **Eligible**. The site numbers for the Uintah County sites are incomplete in the version of the table our office received, so our office cannot complete consultation without the complete site numbers. For the sites undetermined, USHPO recommends that they be treated as eligible until evaluation is completed of the sites. **[DOEx7]**.

Preserving and Sharing Utah's Past for the Present and Future

4. Eligibility of Sites Downstream Indirectly Affect by River Flows, Table 4: USHPO concurs with the determinations that DA 337, 562, 40, 485, 30, 668; UN 1746, 265, 267 and 271 are **Eligible**. USHPO concurs with the determination that DA 338, 204, 225, 339, 341, 661, 750, 751, 332; UN 1563, 65, and 1600 are **Not Eligible**. For the sites undetermined, USHPO recommends that they be treated as eligible until evaluation is completed of the sites. **[DOEx13, NPx12]**.

5. After review of the site forms in consideration for testing, USHPO understands that a limited testing program for eligibility is considered for DA 203, 342, 488 and 564. Concerning DA 342, unless there has been significant disturbance since recording appears to be eligible with well defined site location, USHPO recommends not testing this site.

6. Assessment of Effects for the Reservoir APE: Table 1, concur **No Historic Properties Affected,** Table 2, concur **No Historic Properties Affected**.

7. Assessment of Effects for the Downstream APE: concur with limited testing for eligibility and potential to be included in the area of potential effect. Concur **No Adverse Effect**.

8. Ethnographic Report: the report will be removed as of 12.16.02 from the public compliance record and put in my files until the document is released by BOR.

This information is provided to assist with Section 106 responsibilities as per §36CFR800. My email address is: jdykman@utah.gov

As ever,

James L. Dykmann
Deputy State Historic
Preservation Officer - Archaeology

JLD:02-1790 BOR/NPx31/DOEx32/NPAx24/NAEx7

c: SWCA Environmental Consultants, 230 South 500 East, Suite 380,
Salt Lake City UT 84102-2015

c: Mary Barger, Western Area Power Administration, 12155 West Alameda Parkway
P. O. Box 281213, Lakewood CO 80228-8213

c: Blaine Phillips, Archaeologist, Bureau of Land Management, Vernal Field Office
170 South 500 East, Vernal UT 84078-2799

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Department of Community and Economic Development

DAVID HARMER
Executive Director

Division of State History / Utah State Historical Society

PHILIP F. NOTARIANNI
Division Director

State of Utah

MICHAEL O. LEAVITT
Governor

OLENE S. WALKER
Lieutenant Governor

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December 29, 2003

Barbara Blackshear
Bureau of Reclamation
302 East 1860 South
Provo UT 84606-7317

RE: Extension of the Analysis Area for the Operation of Flaming Gorge Dam EIS'

In Reply Please Refer to Case No. 02-1790

Dear Ms. Blackshear:

The Utah State Historic Preservation Office received the referenced information on December 19, 2003. After consideration of the consultation request in behalf of the Bureau of Reclamation, the Utah Preservation Office provides the following comments per §36CFR800.

Consultation; concur eligibility determinations, [Table 1, 12.16.2003 consultation letter] and effect determination, No Historic Properties Affected.

This information is provided to assist with Section 106 responsibilities as per §36CFR800. My email address is: jdykman@utah.gov

As ever,

James L. Dykmann
Deputy State Historic
Preservation Officer - Archaeology

JLD:02-1790 OFR/DOEx11/NPx11/NPAx22

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State of Utah

MICHAEL O. LEAVITT
Governor

OLENE S. WALKER
Lieutenant Governor

Department of Community and Economic Development
DAVID HARMER
Executive Director

Division of State History / Utah State Historical Society
PHILIP F. NOTARIANNI
Division Director

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January 13, 2004

Barbara Blackshear
Bureau of Reclamation
302 East 1860 South
Provo UT 84606-7317

RE: Archaeological Determination, Testing and Assessment of Four Sites for the Operation of Flaming Gorge Dam Environmental Impact Statement

In Reply Please Refer to Case No. 02-1790

Dear Ms. Blackshear:

The Utah State Historic Preservation Office received the referenced information on January 7, 2004. After consideration of the consultation request in behalf of the Bureau of Reclamation, the Utah Preservation Office provides the following comments per §36CFR800.

Consultation; concur No Adverse Effect.

This information is provided to assist with Section 106 responsibilities as per §36CFR800. My email address is: jdykman@utah.gov

As ever,

James L. Dykmann
Deputy State Historic
Preservation Officer - Archaeology

JLD:02-1790 OFRNAE

300 South Rio Grande, Salt Lake City, UT 84101 • telephone (801) 533-3500 • facsimile (801) 533-3503 • www.history.utah.gov

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State of Utah

OLENE S. WALKER
Governor

GAYLE F. McKEACHNIE
Lieutenant Governor

Department of Community and Economic Development

DAVID HARMER
Executive Director

Division of State History / Utah State Historical Society

PHILIP F. NOTARIANNI
Division Director

RECEIVED
MAY 10 '04

May 5, 2004

Barbara Blackshear
Bureau of Reclamation
302 East 1860 South
Provo UT 84606-7317

RE: Flaming Gorge EIS - Effects on Desolation Canyon National Historic Landmark

In Reply Please Refer to Case No. 02-1790

Dear Ms. Blackshear:

The Utah State Historic Preservation Office received the referenced information on April 29, 2004. After consideration of the consultation request in behalf of the Bureau of Reclamation, the Utah Preservation Office provides the following comments per §36CFR800.

Section 106 Consultation; Concur No Historic Properties Affected, 36 CFR §800.10 Consultation, National Landmark.

This information is provided on request to assist with Section 106 responsibilities as specified in §36CFR800. My email address is: jdykman@utah.gov

As ever,

James L. Dykmann
Deputy State Historic
Preservation Officer - Archaeology

JLD:02-1790 BOR

300 South Rio Grande, Salt Lake City, UT 84101 • telephone (801) 533-3500 • fax (801) 533-3503 • www.history.utah.gov

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WYOMING

DEPARTMENT OF STATE PARKS & CULTURAL RESOURCES
STATE HISTORIC PRESERVATION OFFICE

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Barrett Building
2301 Central Ave.
Cheyenne, WY 82002

(307) 777-7697
FAX (307) 777-6421

Nov 19, 2002

Ms. Beverley Heffernan
Acting Chief, Environmental Group
Provo Area Office
Bureau of Reclamation
302 East 1860 South
Provo, Utah 84606-7317

Re: Flaming Gorge Dam Operation Environmental Impact Statement (SHPO File # 0902SES016)

Dear Ms Heffernan:

Sara Sheen of our staff has received information concerning the aforementioned project. Thank you for allowing us the opportunity to comment.

We have reviewed the project report and find the documentation meets the Secretary of the Interior's Standards for Archaeology and Historic Preservation (48 FR 44716-42).

We concur that the proposed action will have no effect on the historic porperties located at or near (one-quarter mile or less) of the high elevation of Flaming Gorge Reservoir as your office does no expect there to be any changes in the fluctuations of the water levels from what has been considered normal. However, we recognize there is potential for unusual drawdowns on Flaming Gorge to occur which would potentially affect cultural properties located at or near the shoreline of the Reservoir. We recommend that the Bureau of Reclamation conduct an annual monitor of the historic properties listed by your office as located near the high elevation of the Reservoir. We also recommend an annual report, due by December 31 of each year, be submitted to our office documenting the results of the monitor.

We recommend the Bureau of Reclamation allow the project to proceed in accordance with state and federal laws subject to the conditions stipulated in this letter and the request for comment and the standard stipulation that if any cultural materials are discovered during the proposed action, work in the area should halt immediately and the Bureau of Reclamation staff and SHPO staff must be contacted. Work in the area may not resume until the materials have been evaluated and adequate measures for their protection have been taken.

This letter should be retained in your files as documentation of our conditional determination that no historic properties will be affected by this project.

Jim Geringer, Governor   John T. Keck, Director

Please refer to SHPO project control number 0902SES016 on any future correspondence dealing with this project. If you have any questions, contact Sara Sheen at 307-777-7498 or me at 307-777-6311.

Sincerely,

Judy K. Wolf
Review and Compliance Program Manager

ORIGINAL COPY

United States Department of the Interior
NATIONAL PARK SERVICE
INTERMOUNTAIN REGION
Intermountain Support Office
12795 West Alameda Parkway
PO Box 25287
Denver, Colorado 80225-0287

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JUL 9 '04

H3417 (IMDE-ONR) NHL

JUL 2 2004

Memorandum

To: Beverly C. Heffernan, Chief, Environmental Group, Bureau of Land Management, Provo Area Office, 302 East 1860 South, Provo, Utah 84606-7317

From: Lysa Wegman-French, Historian, National Park Service, Heritage Partnership Program

Subject: Consultation on Desolation Canyon for Operations of Flaming Gorge Dam Environmental Impact Statement (EIS)

Thank you for providing us with the material on the proposed implementation of the Action Alternative described in the above referenced EIS, which is an undertaking in relation to Desolation Canyon National Historic Landmark (NHL). As stated in 36 CFR Part 800.10 (c), federal agencies are required to notify the Secretary of the Interior (delegated to the National Park Service) of any consultation involving an undertaking at a National Historic Landmark.

That same paragraph in Code of Federal Regulations specifies that the agency will invite the Secretary to participate in the consultation where there may be an adverse effect. Based on your letter, and the letter that you enclosed from the Utah State Historic Preservation Office (SHPO), your agencies concur that the undertaking will not result in an adverse effect.

Your letter also asks us to concur with the finding of no adverse effect, or no effect, on the NHL. It is not within the statutory authority of the National Park Service to concur on effects.

As a result of these two points, we have no comments on the proposal.

Thank you for informing us about this undertaking, and we appreciate your interest in preserving our nation's historic resources. If you have any questions, please contact call me at (303) 969-2842.

Sincerely,

for Thomas G. Keohan

Lysa Wegman-French, Historian
Heritage Partnerships

cc:
Bureau of Land Management, Attn: Garth Portillo, Post Office Box 45155, Salt Lake City, Utah 84145-0155
Utah State Historic Preservation Office, Salt Lake City

TAKE PRIDE IN AMERICA

Attachment #9

C...GINAL COPY

THE HOPI TRIBE

Wayne Taylor, Jr.
CHAIRMAN

Phillip R. Quochytewa, Sr.
VICE-CHAIRMAN

July 17, 2000

Bruce C. Barrett, Area Manager
Bureau of Reclamation
Upper Colorado Region
Provo Area Office
302 East 1860 South
Provo, Utah 84606-7317

Dear Mr. Barrett,

This letter is in response to your correspondence dated July 10, 2000 regarding the Bureau of Reclamation publication of a notice of intent to draft a Flaming Gorge Dam Operations Environmental Impact Statement. The Hopi Tribe appreciates your solicitation of our input and your efforts to address our concerns.

Without waiving our rights under the National Historic Preservation Act, the Native American Graves Protection and Repatriation Act, and all other relevant legislation and executive orders, the Hopi Tribe defers consultation on this proposed project to the Unitah and Ute Nations, whose lands lie within the potential project area, and other interested American Indian tribes.

Thank you for your consideration.

Respectfully,

Leigh J. Kuwanwisiwma, Director
Cultural Preservation Office

P.O. BOX 123 — KYKOTSMOVI, AZ. — 86039 — (520) 734-3000

ORIGINAL

Kaibab Band of Paiute Indians

Attachment #7

August 29, 2000

Mr. Bruce C. Barrett, Area Manager
U.S. Department of the Interior
Bureau of Reclamation, Provo Area Office
302 East 1860 South
Provo, Utah 84606-7317

Re: Flaming Gorge EIS

Dear Mr. Barrett:

We are in receipt of the correspondence and maps of the Flaming Gorge Environmental Impact Statement and want to express to you that in matters related to the Inadvertent Discovery of Human Remains, and Cultural Resource concerns, we will be satisfied that the Uintah/Ouray Ute Tribe take the lead in monitoring and deciding what course of action to take in these matters. Thus, with the Ute Tribe taking the lead, the government-to-government relationship and consultation, will be completed in a timely manner.

Thank you for notifying us and considering our participation.

Sincerely,

Jake

VIVIENNE-CARON JAKE
Director, Environmental Program

cc: File

Tribal Affairs
HC 65 Box 2
Pipe Spring, Arizona 86022
Phone (520) 643-7245
Fax (520) 643-7260

The Great Seal of The Ute Indian Tribe
Uintah and Ouray Reservation

COPY

UTE INDIAN TRIBE
P.O. Box 190
Fort Duchesne, Utah 84026
Phone: (435) 722-5141 • Fax: (435) 722-5072

RECEIVED '04

May 24, 2004

Mr. Peter Crookston
Environmental Protection Specialist
Flaming Gorge EIS Manager
302 E. 1860 South
Provo, Utah 84606

RE: Flaming Gorge PD EIS Draft

Dear Peter:

Upon review of the Comment Analysis and our meeting on April 27, 2004 regarding the Flaming Gorge EIS draft we find there would not be a significant impact on Tribal lands.

Advance notice of peak flows from Reclamation would resolve our issues of oil and gas well development and access. It is our understanding Reclamation will monitor the Yampa River and the Green River for timing of peak flows, and we will given a three day notice prior to peak flows. This advance notice is imperative to curtail any oil and gas activity in the area and also to relocate any cattle in the area.

Contact information:

UTE INDIAN TRIBE

Energy & Minerals
Lynn Becker, Land Manager EMD 435-725-4072,
email address lynnb@utetribe.com
Energy & Minerals Department 435-725-4040,
email address energy_minerals@utetribe.com
Fax # 435-722-9270

Fish and Wildlife
Everett Manning, Director, 435-722-5511, ext. 402, email address emanning@ubta.com
Conrad Reed, Sr., Livestock Manager 453-722-5511, ext. 435, he does not have an email address

Business Committee
Roland McCook, Tribal Business Committee Member, 435-722-4005,
email address rolandm@utetribe.com

BIA
Environment Protection Specialist – will need to contact the BIA for this information

If you need any further information, please call me at 435-725-4072.

Sincerely,

Lynn Becker
Land Manager

cc: Fish and Game
Business Committee

UTE INDIAN TRIBE
UINTAH AND OURAY AGENCY

P.O. Box 190
Fort Duchesne, Utah 84026
Phone (435) 722-5141
Fax (435) 722-5072

TRI - UTE LEADER'S SUMMIT
GRAND JUNCTION, COLORADO
SEPTEMBER 22, 2000

AGENDA

9:00 A.M. COFFEE, JUICES, ROLLS, FRUIT

OPENING:

Welcoming - O. Roland McCook, Sr.
Opening Prayer

SOUTHERN UTE INDIAN TRIBE

Update *John E. Baker, Jr., Chair*

UTE MOUNTAIN UTE INDIAN TRIBE

Update *Ernest House, Sr., Chair*

UTE INDIAN TRIBE

Update *O. Roland McCook, Sr., Chair*

OTHER ITEMS

Dale Bassett - Concern with Council Tree

Barbara Blackshears - Bureau of Reclamation

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PUEBLO OF ZUNI
HERITAGE AND HISTORIC PRESERVATION OFFICE

P.O. BOX 339
ZUNI
NEW MEXICO 87327

TEL: 505 782-4814
782-5558
FAX: 505 782-2393

Attachment # 8

August 1, 2000

Mr. Kerry Schwartz
Co-NEPA Manager
United States Department of the Interior
Bureau of Reclamation
Upper Colorado Region, Provo Area Office
302 East 1860 South
Provo, Utah 84606-7317

Dear Mr. Schwartz:

Pursuant to your request dated 30 June 2000 regarding the draft environmental impact statement (EIS) on the operation of Flaming Gorge Dam, located on the Green River in northeastern Utah, the Zuni Heritage and Historic Preservation Office (ZHHPO) provides the following information with regards to cultural properties. The Zuni Tribe, federally recognized as the Pueblo of Zuni, ascribes cultural and religious significance to historic properties that may be affected by the proposed undertaking

Prior to amendments of the National Historic Preservation Act and other federal laws enacted to protect historic properties, archaeological resources, traditional cultural properties, and places of significance of Native American Tribes, many properties with immense cultural and religious significance were knowingly and unknowingly destroyed. This destruction occurred in areas of ancestral occupations along ancestral migration routes, within aboriginal lands, and even within the current boundaries of Indian reservations through federally assisted undertakings.

While federal laws have been strengthened to provide for the preservation and protection of properties and places as described above, the Zuni Tribe continues to witness such destruction and desecration in areas where it claims affiliation to cultural resources.

The land that will be impacted by this undertaking is outside the boundaries of the Zuni aboriginal land claims. The Zuni Tribe claims cultural affiliation to ancestral Puebloan, and pre-Puebloan archaeological sites, trails, shrines, and other historic properties. Many of these properties should be treated as Traditional Cultural Properties because of their significance to the cultural history of the Zuni Tribe.

The Zuni Tribe also claims cultural affiliation to all Puebloan and pre-Puebloan ancestral burials and associated funerary objects under the provisions of the Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 (Public Law 101-601).

Since it would be impossible to consult with every group of Zuni religious leaders for this undertaking, it is recommended that all historic and traditional cultural properties be avoided. If avoidance cannot be accomplished, it is recommended that comprehensive archaeological and ethnographic studies be implemented to identify affected properties that are important to the Zuni Tribe, and to determine how any impact to the properties may be mitigated. If further consultation is deemed necessary, we will be happy to work with you in establishing the necessary protocol.

Although we acknowledge that according to 36 CFR 800.2 (c) (3), the Pueblo of Zuni is a *consulting party* for properties that may be affected by the proposed undertaking, we do not wish at this time to participate as a consulting party. Please keep us informed of information regarding properties with traditional, cultural, and religious significance that may be affiliated to the Zuni Tribe and which may be of consideration in planning this particular project.

On behalf of the Zuni Tribe and the Pueblo of Zuni, we thank you for providing an opportunity to comment on the undertaking. Should you require additional information, please call 505-782-4814.

Sincerely,

Jonathan E. Damp
Director, ZHHPO

Malcolm B. Bowekaty
Governor, Pueblo of Zuni

Operation of
Flaming Gorge Dam
Final Environmental
Impact Statement

Recreation Visitation and Valuation Analysis Technical Appendix

RECREATION VISITATION AND VALUATION ANALYSIS TECHNICAL APPENDIX

Page No.

Recreation Visitation and Valuation Analysis Technical Appendix

1.0 INTRODUCTION

This technical appendix (TA) presents information on the Flaming Gorge EIS recreation analysis. The TA is broken down into two primary sections: affected environment and environmental consequences. The affected environment section describes the geographic impact area where the majority of the recreation effects are anticipated to occur as well as current recreation conditions within the impact area. The environmental consequences section presents a detailed discussion of the various methodologies applied as well as the results of the analysis for each alternative.

2.0 AFFECTED ENVIRONMENT

The affected environment section consists of two subsections: geographic impact area and current conditions. The geographic impact area section provides background on the location and management jurisdiction of the potentially affected lands within the impact area as well as the rationale for defining the impact area. The current conditions section presents information on current conditions in terms of reservoir water levels/river flows, recreation visitation, and recreation economic value.

2.1 Geographic Impact Area

The Bureau of Reclamation (Reclamation) constructed and currently operates Flaming Gorge Dam located on the Green River in northeast Utah. Flaming Gorge Reservoir and the Green River for approximately 12 miles downstream of the dam comprise the Flaming Gorge National Recreation Area (FGNRA) which is managed by the Ashley National Forest, USDA Forest Service (FS). After exiting the FGNRA, the Green River flows across U.S. Bureau of Land Management (BLM) and State of Utah lands for approximately 18 miles before entering the U. S. Fish and Wildlife Service (USFWS) managed Browns Park National Wildlife Refuge along the Utah/Colorado border 30 miles downstream of the dam. Immediately downstream of the refuge, approximately 47 miles downstream of the dam, lies Dinosaur National Monument (NM) managed by the U.S. National Park Service (NPS). The upper portion of Dinosaur NM, upstream of the confluence with the Yampa River, reflects the end of Reach 1 of the study area.

The recreation analysis conducted for the Flaming Gorge EIS addresses impacts to both Flaming Gorge Reservoir and the Green River downstream of Flaming Gorge Dam. Despite the series of Federal and State managed public lands along the river downstream of the dam, the analysis focuses upon recreation effects within Reach 1 and specifically within the FGNRA because that is where the majority of the potentially impacted water based recreation occurs. Relatively little of the river oriented recreation activity within the region (mainly scenic floating via raft/kayak, shoreline and boat based fishing, and camping) initiates within the 35-mile stretch of the river between the FGNRA and Dinosaur NM. In Dinosaur NM, water-based recreation is dominated by rafting activities. Rafting within the monument is managed via a permit system that covers both the Green and Yampa Rivers. If flow conditions deteriorated on the Green River to the point of adversely impacting rafting activity, there exists the possibility of shifting activity to the Yampa River. While NPS constrains the total number of permits for both commercial and private rafting parties across both rivers to 600 a year, and the number of launches from either river to 4 per day, there still exists the potential for rafting substitution between the rivers. In addition, the majority of commercial and private rafting trips are scheduled well ahead of time. Commercial rafting operations are popular and early reservations are often required since space on these trips tends to fill up quickly. Private rafting permits are limited to one per person annually and must be obtained via a lottery system months prior to the actual trip date. Given the degree of planning and financial commitment required for these rafting trips, there exists a fairly strong incentive to take trips even when flow conditions are less than ideal. To substantiate this discussion, attempts were made to model the impact of average monthly flows on rafting visitation within Dinosaur (see Dinosaur NM Rafting Methodology section 3.1.1.1.2). Separate models were estimated for commercial and private rafting activity. These models either resulted in insignificant flow variables (commercial model) or significant flow variables with relatively minor impacts on rafting activity (private model). As a result, the assumption was made that rafting activity within Dinosaur NM would not vary substantially with the fluctuations in Green River flows associated with the EIS alternatives. Finally, changes in water-based recreation activity within Reaches 2 and 3 based on the EIS alternatives were also assumed to be relatively minor either due to low levels of recreation use or the overriding effect of the combined flows from the numerous tributaries (e.g., Yampa, Duchesne, White, etc.) as compared to dam releases. Given all of the above, the decision was made to focus the recreation visitation and value analysis on water-based effects primarily within the Flaming Gorge National Recreation Area.

The Green River portion of the FGNRA is located entirely within Daggett County Utah, found in the northeast corner of the state. The southernmost portions of the reservoir are also found within Daggett County. This part of the reservoir is relatively narrow given the water is impounded via a series of canyons. The reservoir widens as one travels northward out of the canyons and toward the Utah/Wyoming border. The Wyoming portion of the reservoir, located entirely within Sweetwater County, is relatively wide and extends northward for many miles before narrowing at the confluence of the Green and Blacks Fork Rivers.

Potentially affected recreation facilities within the FGNRA along both the Green River and Flaming Gorge Reservoir include the following:

Green River:

1. Boat ramps at the Flaming Gorge Dam spillway and at the Little Hole recreation complex

2. Little Hole National Recreation Trail (from the spillway of Flaming Gorge Dam to the Little Hole recreation complex)

3. Fishing pier at the Little Hole recreation complex

4. 18 riverside campgrounds (7 are on BLM lands outside FGNRA)

Flaming Gorge Reservoir:

1. 11 boat ramps (4 associated with marinas)

2. 3 marinas

3. 3 boat based campgrounds

4. 4 swimming beaches

5. Cut Through - Horseshoe Canyon Bypass (not evaluated within the recreation analysis since it has only minor impacts on recreation use)

While the Green River recreation analysis emphasizes impacts within the upper portion of Reach 1, primarily within Flaming Gorge National Recreation Area, consideration is also given to recreation facilities downstream, all the way to the confluence with the Colorado River. After passing out of Reach 1 within Dinosaur National Monument, the Green River flows across private lands, State of Utah lands, Federal lands (BLM, USFWS including Ouray National Wildlife Refuge), and Ute Indian tribal lands within Reach 2. Very few recreational facilities are found in this reach. Reach 3 of the Green River starts at the confluence with the White River and ends at the Colorado River. This long stretch of river includes Ute Indian tribal lands (including Desolation Canyon), State of Utah lands (including Green River State Park), Federal lands (BLM, NPS including Canyonlands National Park), and private lands. Numerous recreational facilities are located within Reach 3. The following represents a list of recreational facilities found along the Green River downstream of Flaming Gorge National Recreation Area within Reaches 1, 2, and 3.

Green River – Reach 1 (downstream of Flaming Gorge National Recreation Area):

BLM:	1. Three boat ramps (Indian Crossing, Bridge Hollow, and Swallow Canyon – a fourth ramp at the pipeline crossing below Jarvies Ranch, is being phased out).
	2. Twenty campgrounds, of which only one (at Bridge Hollow) may be impacted. Six of these are administered by the FS for BLM.
State of Utah:	3. One boat ramp (Bridge Port Camp)
	4. Five campgrounds (Gorge Creek, Little Davenport, Bridge Port, Elm Grove, and Burned Tree)

USFWS (Browns Park NWR):	5.	Two boat ramps (Swinging Bridge, Crook)
	6.	Two campgrounds (Swinging Bridge, Crook)
	7.	Fishing Pier
NPS (Dinosaur NM):	8.	Three boat ramps (Lodore, Deerlodge, and Split Mountain)
(Note: Facilities located downstream of the Yampa are technically Reach 2 (e.g., Split Mountain))	9.	Five riverside campgrounds (Lodore, Deerlodge, Echo Park, Split Mountain, and Green River)
	10.	One riverside picnic area (Split Mountain)

Green River – Reach 2 (Yampa River to White River):

USFWS (Ouray NWR):	1.	One boat launch site

Green River – Reach 3 (White River to Colorado River):

BLM:	1.	Five boat ramps/launch sites (Sand Wash, Swasey's Beach ramp, Nefertiti, Butler Rapid, and Mineral Bottom)
	2.	One riverside campground (Swasey's Beach)
State of Utah (Green River S.P.):	3.	One boat ramp
	4.	One campground
Private:	5.	One boat launch site (Ruby Ranch)
NPS (Canyonlands N.P.):	6.	Eight campsites

2.2 Current Conditions

This section describes current conditions within the geographic impact area in terms of Green River flows and Flaming Gorge Reservoir water levels, recreation visitation, and economic value. Given the recreation analyses linked hydrologic river flows and reservoir water levels to recreation visitation and economic value to estimate impacts, this current condition information should provide some perspective when considering the impacts presented under the environmental consequences section.

Recreation visitation is measured in terms of the number of recreation trips or visits by recreation activity. A recreation trip or visit reflects a round trip excursion from a recreator's primary residence for the main purpose of recreation. Recreation value reflects the sum of individual recreator benefits aggregated across users of a site. Recreator value is represented by consumer surplus which is measured by estimating recreator willingness-to-pay in excess of per visit costs.

The current condition information and recreation analysis results are presented separately for the Green River and Flaming Gorge Reservoir due to differences in methodology. When referring to current conditions, we describe information which formed the basis or starting point of the two applied analyses: facility availability approach for reservoir visitation and the linear interpolation approach for all other analyses (i.e., river visitation, river valuation, and reservoir valuation). This perspective was selected instead of simply choosing to gather data for the most recent time period because in many cases, recent data does not exist. Furthermore, since current information was used as a data point in the survey based interpolation analysis, it was important to link the current period to the survey period (see section 3.1.1 for more on the recreation survey).

Recreation activities studied were generally water based, implying they require the use of water for participation. Water influenced activities, which do not require water access but typically benefit from the presence of water (such as picnicking, sightseeing), were generally insignificant compared to the water based activities at both these water oriented sites. Activities studied on the Green River include scenic floating, guide boat fishing, private boat fishing, shoreline fishing/trail use, and boat based camping. These activities more or less cover the gamut of activities pursued on the river. Activities studied on Flaming Gorge Reservoir focused on power boating/waterskiing, boat fishing, boat based camping, and swimming/waterplay. These water based activities represent nearly 80 percent of the total visitation at the reservoir. In both cases, the camping activity was considered a water based activity since the studied campsites were accessed from the water.

2.2.1 Current Hydrology

As will be discussed in more detail under the environmental consequences methodology section, the recreation analyses in this appendix relate recreation visitation and value to hydrologic Green River flows (measured in cubic feet per second (cfs)) and Flaming Gorge Reservoir water levels (measured in feet above mean sea level (msl)).

2.2.1.1 Current Green River Flows

To get some perspective on current Green River recreation visitation, it is necessary to have information on current river flows. The difficulty lies in defining what should be considered current. Since the Green River recreation analysis is tied to the results generated from a recreation survey conducted from May to September 2001, and the survey asked recreators about their activity over the past 12 months, it was necessary to gather flow data from June 2000 to September 2001 to estimate current survey oriented monthly flows.

Current monthly flow was calculated from March through October given visitation data, obtained from the FS, was only available for those months. While visitation information was not gathered from November through February, loss of those months was not considered significant.

Calculating current average monthly flows relevant to the survey data was complicated by the fact that depending on when a recreator was contacted during the May through September 2001 survey sampling period, a different annual and monthly perspective could result. For example, when considering June flows, someone contacted about their recreation activity over the past 12 months in May 2001 would visualize June 2000 flows, whereas all others would be visualizing June 2001 flows. To calculate current flows for months with this dual year situation (basically June - September), actual average monthly flows for 2000 and 2001 were weighted by the percent of the sample contacted in each month (May = 11.3%, June = 20.5%, July = 29.2%, August = 15.4%, and September = 23.6%). For the other months (March, April, May, and October), all recreators would be referencing the same months implying no timing conflicts in estimating average monthly flows. Using this weighting procedure, current average monthly

Green River flows were estimated as follows:

	Current Monthly Flows (cfs)
March	1,036
April	1,145
May	2,478
June	1,215
July	1,007
August	1,122
September	1,118
October	1,024

The analysis of economic values was also conducted monthly, but the actual calculation used annual flow information by activity as a reference point. The survey asked recreators for their current value by recreation activity based on activity pursued across the past 12 months. As a result, the current flows associated with the current economic values by activity were based on average annual (technically high season) flows for the months of March to October using data from the June 2000 through September 2001 survey orientation period. The average annual flow for each activity took into consideration both when a recreator was contacted during the sampling period (weighting based on sampling percentage by month as described above) and the percent of visitation by month associated with each activity. The weighted average current annual flows for the five studied Green River recreational activities are as follows:

	Current Annual Flows (cfs)
Scenic Floating	1,097
Guide Boat Fishing	1,359
Private Boat Fishing	1,373
Trail Use/Shoreline Fishing	1,299
Camping	1,115

2.2.1.2 Current Flaming Gorge Reservoir Water Levels

Whereas the Green River recreation analysis used the interpolation approach for both the visitation and value analysis, lack of visitation data for the relevant survey period from June 2000 through September 2001 resulted in the use of a facilities availability approach for estimating reservoir visitation. The interpolation approach was used to estimate economic values by reservoir recreation activity as with the river analysis.

The two different analyses for developing reservoir visitation and value estimates create different perspectives for estimating current reservoir water levels. The visitation analysis is based on information collected during fiscal year 1997 (October 1996–September 1997), whereas the value analysis stems from survey data referring to the June 2000–September 2001 period. Fortunately, regardless of whether one focuses on hydrology from fiscal year 1997 or weighted average water levels during the 2000-2001 survey period, facility availability and associated visitation turns out the same. In both cases, all water based facilities were available, which implies the same visitation estimate using the facility availability approach. Given it doesn't matter which time frame is selected for the visitation analysis and it does for the value analysis, it makes the most sense to simply refer to the current water levels as those represented by the survey period. Table 1 reflects end of month water levels at Flaming Gorge reservoir for both fiscal year 1997 and the survey period.

As with the river economic value analysis, the reservoir value analysis keys into the current weighted average annual water levels by activity as presented in table 1. Note that warm water activities are defined as power boating/waterskiing, boat fishing, swimming and cool water activities are defined as camping.

2.2.2 Current Recreation Visitation

Recreation visits have been counted by FS contractors from March to October on an annual basis since the early 1990's on the Green River portion of the FGNRA. Visitation counts on the reservoir have been more infrequent with the most recent estimates made for fiscal year 1997 (October 1996 to September 1997).

Table 1: Flaming Gorge Reservoir Current Water Level Data (feet above msl)

Month	Fiscal Year 1997	Current Water Levels (Survey Period)
January	6027	6020.3
February	6026	6020.4
March	6024.9	6020.7
April	6023.6	6021.5
May	6023	6021.8
June	6027.7	6021.3
July	6031.5	6021.3
August	6031.3	6020.9
September	6030.5	6020.6
October	6029.6	6020.4
November	6028.5	6020.6
December	6027.4	6020.4
Weighted Average for Warm Water Activities:		6021.2
Weighted Average for Cooler Water Activities:		6021.1

2.2.2.1 Current Green River Visitation

As mentioned above and described in more detail below under the recreation methodology section located under environmental consequences, the Green River analysis was based on interpolation of results obtained from a recreation survey conducted from May to September 2001. Current visitation was one of the data points used in the interpolation analysis. Current visitation was calculated on a monthly basis from March through October based on the FS data. To allow for use in the interpolations, current visitation estimates needed to be consistent with the time period of the recreation data collection.
FS monthly visitation data by recreation activity were weighted, using the monthly sampling percentage approach described above, to come up with the estimates of current monthly visitation by activity.

Summing the current weighted average monthly visitation estimates by activity across the March through October months provided an estimate of current annual visitation. While the FS data was not gathered across the November through February months, the exclusion of these months was not considered significant from the perspective of missing data given these are very low use months. Table 2 presents the current estimates of visitation by activity and month.

Reviewing the data in table 4 indicates that shoreline fishing/trail use (mainly shoreline fishing), scenic floating, and private boat fishing are the top three activities on the Green River portion of FGNRA combining for slightly over 85 percent of the river visitation. The top three high use months are as expected June, July, and August with over 60 percent of the river visitation.

Table 2: Current Green River Visitation Estimates by Activity and Month

Month	Scenic Floating	Guide Boat Fishing	Private Boat Fishing	Shoreline Fishing/ Trail Use	Camping	Total	Percent
March	42	280	1,265	1,774	0	3,361	3.6
April	217	1,560	3,214	5,892	0	10,883	11.8
May	99	2,018	3,549	4,942	0	10,608	11.5
June	5,527	2,099	1,767	5,976	668	16,037	17.3
July	11,063	1,781	1,520	7,708	655	22,727	24.6
August	7,749	1,814	1,457	5,462	600	17,082	18.5
September	62	1,530	4,827	2,935	352	9,707	10.5
October	9	318	932	793	6	2,058	2.2
Total:	24,768	11,400	18,531	35,482	2,281	92,461	100
Percent:	26.8	12.3	20.0	38.4	2.5	100	

2.2.2.2 Current Flaming Gorge Reservoir Visitation

The most recent visitation estimates developed for Flaming Gorge Reservoir were collected by the FS during fiscal year 1997. This data was gathered by recreation activity and reservoir site (i.e., marina, boat ramp, swimming beach, campground). To allow for analysis of monthly facility availability, this annual FS data needed to be converted into monthly estimates. Fortunately, the State of Utah has periodically gathered monthly fishing data for boat fishing, shore fishing, and ice fishing. The boat fishing monthly percentages were used to allocate warm water recreation activities across months, specifically power boating, waterskiing, boat fishing, and swimming/waterplay. The shore fishing monthly percentages were used to allocate cooler month activities across months, specifically camping. While not directly tied to the activities of interest in some cases, the State of Utah percentages were believed to be representative of all warm and cool month activities.

Table 3 presents the current estimates of Flaming Gorge Reservoir visitation by activity, site, and month. The estimates of visitation could be linked to the individual facilities at each site based on the different recreation activities (i.e., power boating/waterskiing/boat fishing were linked to the boat ramps and marinas, boat camping was linked to the boat camp sites, and swimming/waterplay was linked to the swimming beaches).

Reviewing the data in table 3 indicates that the heaviest used reservoir sites from a water based activity perspective are Lucerne Valley (52.8%), Buckboard Crossing (15.8%), and Cedar Springs (15.8%). These three sites combine for nearly 85 percent of the reservoir's water based activity (recall that the water based activities represent nearly 80 percent of the total activity at the reservoir). Of the water based activities, power boating/waterskiing (62.8%) and boat fishing (31.7%) are dominant accounting for nearly 95 percent of the total water based reservoir visitation. Finally, from a monthly perspective, the months of May through August reflect nearly 75 percent of water based visitation, with over 95 percent occurring between April and October.

2.2.3 Current Recreation Valuation

The current total value estimates by activity were developed by simply multiplying the current value estimates per visit by activity, as obtained from the recreation survey, by the estimates of total current visitation by activity, as obtained from manipulating the FS visitation data. All value estimates were developed using a conservative, but frequently applied approach of assuming survey nonrespondents had a value of zero. River camping and reservoir swimming values were most affected by the nonresponse adjustment due to the large number of nonresponses for those activities.

2.2.3.1 Current Green River Valuation

Table 4 presents the estimates of Green River total current value by recreation activity. It is interesting to note the differences when comparing the percent of total visits by activity to the percent of total value by activity. The percent of total value by activity takes into account both the visitation and value per visit. While shore fishing/trail use reflects 38.4 percent of the visitation, it represents only 17.4 percent of the value due to the relatively low value per visit. Conversely, guide boat fishing reflects only 12.3 percent of the visitation, but 43.5 percent of the value due to the high value per visit.

2.2.3.2 Current Flaming Gorge Reservoir Valuation

Table 5 presents the estimates of Flaming Gorge Reservoir total current value by recreation activity. The differences between the reservoir visitation and valuation percentages are less dramatic compared to those of the river. The largest differentials are for power boating/waterskiing and swimming/waterplay. Power boating shows an increasing percentage under value compared to visitation, whereas swimming shows a decreasing percentage.

3.0 ENVIRONMENTAL CONSEQUENCES

This section is broken down into two primary subsections, methodology and results. The methodology section presents detailed information on the various approaches applied to estimate impacts. The results section presents and compares results across alternatives in terms of reservoir water levels/river flows, recreation visitation, recreation economic value, and recreation facility availability.

Table 3: Current Flaming Gorge Reservoir Visitation by Site, Activity, and Month

Site/ Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total	Percent
Antelope Flat:	24	0	117	928	2489	3356	3654	2121	1216	1094	286	185	15469	2.7
Power Boating:	8	0	38	300	805	1085	1181	686	393	353	92	60	5001	
Boat Fishing:	6	0	30	240	643	868	945	548	314	283	74	48	3999	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	10	0	49	388	1041	1403	1528	887	509	458	120	77	6469	
Anvil Draw:	5	0	21	168	450	607	661	384	220	198	52	33	2800	0.5
Power Boating:	2	0	9	72	193	260	283	165	94	85	22	14	1200	
Boat Fishing:	3	0	12	96	257	347	378	219	126	113	30	19	1600	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Buckboard Crossing Marina:	66	0	304	2427	6515	8786	9567	5554	3185	2866	748	482	40500	7.1
Power Boating:	49	0	225	1798	4826	6508	7087	4114	2359	2123	554	357	30000	
Boat Fishing:	17	0	79	629	1689	2278	2480	1440	826	743	194	125	10500	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Buckboard Crossing Boat Ramp:	81	0	371	2967	7963	10738	11693	6788	3892	3503	914	589	49500	8.7
Power Boating:	49	0	225	1798	4826	6508	7087	4114	2359	2123	554	357	30000	
Boat Fishing:	32	0	146	1169	3137	4230	4606	2674	1533	1380	360	232	19500	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cedar Springs Marina:	66	0	304	2427	6515	8786	9567	5554	3185	2866	748	482	40500	7.1
Power Boating:	49	0	225	1798	4826	6508	7087	4114	2359	2123	554	357	30000	
Boat Fishing:	17	0	79	629	1689	2278	2480	1440	826	743	194	125	10500	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cedar Springs Boat Ramp:	81	0	371	2967	7963	10738	11693	6788	3892	3503	914	589	49500	8.7
Power Boating:	49	0	225	1798	4826	6508	7087	4114	2359	2123	554	357	30000	
Boat Fishing:	32	0	146	1169	3137	4230	4606	2674	1533	1380	360	232	19500	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Firehole:	13	0	61	482	1294	1744	1898	1102	632	570	148	96	8037	1.4
Power Boating:	4	0	20	156	420	566	616	358	205	185	48	31	2608	
Boat Fishing:	3	0	15	120	322	434	472	274	157	142	37	24	2000	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	6	0	26	206	552	744	810	470	270	243	63	41	3429	

Gooseneck:	1	0	15	52	75	101	98	64	34	34	15	10	500	0.1
Power Boating:	0	0	1	12	32	43	47	27	16	14	4	2	200	
Boat Fishing:	0	0	1	6	16	22	24	14	8	7	2	1	100	
Boat Camping:	1	0	13	34	27	36	27	23	10	13	9	7	200	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Hideout:	91	0	717	2466	3624	4881	4738	3082	1645	1652	707	497	24100	4.2
Power Boating:	14	0	66	527	1415	1909	2079	1207	692	623	163	105	8800	
Boat Fishing:	8	0	37	300	804	1085	1181	686	393	354	92	60	5000	
Boat Camping:	67	0	607	1579	1244	1670	1242	1052	481	604	434	320	9300	
Swimming:	2	0	7	60	161	217	236	137	79	71	18	12	1000	
Jarvies Canyon:	5	0	39	137	198	268	259	169	90	91	39	28	1325	0.2
Power Boating:	1	0	3	27	72	98	106	62	35	32	8	5	450	
Boat Fishing:	0	0	2	18	48	65	71	41	24	21	6	4	300	
Boat Camping:	4	0	34	89	70	94	70	59	27	34	24	18	525	
Swimming:	0	0	0	3	8	11	12	7	4	4	1	1	50	
Kingfisher Island:	3	0	26	87	122	165	158	104	55	56	25	17	820	0.1
Power Boating:	0	0	2	16	43	59	64	37	21	19	5	3	270	
Boat Fishing:	0	0	1	12	32	43	47	27	16	14	4	2	200	
Boat Camping:	3	0	23	59	47	63	47	40	18	23	16	12	350	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Lucerne Valley Marina:	227	0	1045	8354	22420	30239	32926	19116	10960	9865	2577	1660	139387	24.4
Power Boating:	164	0	756	6041	16214	21868	23811	13824	7926	7134	1863	1200	100800	
Boat Fishing:	54	0	249	1993	5348	7213	7854	4560	2614	2353	615	396	33250	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	9	0	40	320	858	1158	1261	732	420	378	99	64	5337	
Lucerne Valley Boat Ramp:	264	0	1219	9742	26147	35264	38398	22293	12781	11504	3004	1935	162550	28.4
Power Boating:	164	0	756	6041	16214	21868	23811	13824	7926	7134	1863	1200	100800	
Boat Fishing:	100	0	463	3701	9933	13396	14587	8469	4855	4370	1141	735	61750	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Mustang Ridge:	17	0	82	660	1769	2387	2599	1509	865	778	203	131	11000	1.9
Power Boating:	11	0	52	420	1126	1519	1654	960	550	495	129	83	7000	
Boat Fishing:	6	0	30	240	643	868	945	549	315	283	74	48	4000	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Sheep Creek:	34	0	157	1258	3378	4556	4961	2880	1652	1486	388	250	21000	3.7
Power Boating:	19	0	90	719	1930	2603	2835	1646	944	849	222	143	12000	
Boat Fishing:	15	0	67	539	1448	1953	2126	1234	708	637	166	107	9000	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	

Squaw Hollow:	0	0	2	12	32	44	48	28	16	14	4	2	200	0.0
Power Boating:	0	0	1	6	16	22	24	14	8	7	2	1	100	
Boat Fishing:	0	0	1	6	16	22	24	14	8	7	2	1	100	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Sunny Cove Swim Beach:	8	0	37	300	804	1085	1181	686	393	354	92	60	5000	0.9
Power Boating:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Boat Fishing:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	8	0	37	300	804	1085	1181	686	393	354	92	60	5000	
Upper Marsh Creek:	0	0	0	6	16	22	24	14	8	8	2	2	100	0.0
Power Boating:	0	0	0	3	8	11	12	7	4	4	1	1	50	
Boat Fishing:	0	0	0	3	8	11	12	7	4	4	1	1	50	
Boat Camping:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Swimming:	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total:	986	0	4888	35440	91774	123767	134123	78236	44721	40442	10866	7048	572291	100
Percent:	0.2	0	0.9	6.2	16.0	21.6	23.4	13.7	7.8	7.1	1.9	1.2	100	
Power Boating:	583	0	2694	21532	57792	77943	84871	49273	28250	25426	6638	4276	359278	62.8
Boat Fishing:	293	0	1358	10870	29170	39343	42838	24870	14260	12834	3352	2160	181348	31.7
Boat Camping:	75	0	677	1761	1388	1863	1386	1174	536	674	483	357	10374	1.8
Swimming:	35	0	159	1277	3424	4618	5028	2919	1675	1508	393	255	21291	3.7

Table 4: Current Green River Value Estimates by Activity								
Recreation Activity	Original Value per Visit (Survey)	Number of Responses	Full Sample	Revised Current Value per Visit	Current Number of Total Visits	% of Total Visits	Current Total Value	Percent of Total Value
Scenic Floating	80.05	38	65	$ 46.80	24,768	26.8	$ 1,159,154	24.2
Guide Boat Fishing	296.19	21	34	$ 182.94	11,400	12.3	$ 2,085,497	43.5
Private Boat Fishing	85.00	37	84	$ 37.44	18,531	20.0	$ 693,786	14.5
Shoreline Fishing/ Trail Use	33.55	105	150	$ 23.49	35,482	38.4	$ 833,469	17.4
Camping	24.55	8	59	$ 10.78	2,281	2.5	$ 24,588	.5
Total:					92,461	100	$ 4,796,494	100

Table 5: Current Flaming Gorge Reservoir Value Estimates by Activity								
Recreation Activity	Original Value per Visit (Survey)	Number of Responses	Full Sample	Revised Current Value per Visit	Current Number of Total Visits	Percent of Total Visits	Current Total Value	Percent of Total Value
Power Boating/ Waterskiing	$ 50.60	62	122	$ 25.71	359,278	62.8	$9,237,038	66.1
Boat Fishing	$ 57.30	55	125	$ 25.21	181,348	31.7	$4,571,785	32.7
Boat Camping	$ 30.10	46	106	$ 13.06	10,374	1.8	$35,484	1.0
Swimming/ Waterplay	$ 35.00	4	97	$ 1.44	21,291	3.7	$30,659	.2
Total:					572,291	100	$13,974,966	100

3.1 Methodology

This section describes the methodology used to analyze recreation impacts both on Flaming Gorge Reservoir and the Green River. The recreation analyses evaluate effects in terms of visitation, economic value, and facility availability.

3.1.1 Recreation Visitation, Economic Value, and Facility Availability Methodology

The recreation visitation and value analysis compares estimates of visitation and value by recreation activity for the action alternative to those of the no action alternative. The driving force behind the analyses is changes in visitation and value stemming from variations in alternative specific hydrology as measured by reservoir water levels and river instream flows. Recreation visitation is measured in terms of recreation visits which reflect an individual's round-trip recreation excursions typically from their primary residence. Recreation value, measured in terms of per visit willingness-to-pay minus actual per visit costs, reflects the increment in benefits a recreator experiences in excess of what they actually pay. Multiplying and summing hydrology influenced visits and values by recreation activity for each alternative provide estimates of total recreation value by alternative. The gain or loss in recreation visitation and value, compared to the no action alternative, provides one measure of an alternative's effect on recreation.

Initially, attempts were made to gather and apply existing information in the development of the visitation and value analyses. Existing information was sought in terms of recreation visitation and recreation values per visit by activity, as well as how these measures might be affected by changing reservoir water levels and river flows. Some visitation information existed for both the river and reservoir, but very little value information was available. Attempts were made to model statistical relationships between reservoir visitation and water levels and river visitation and instream flows. For various reasons, these modeling efforts proved unsuccessful. Even if they had been successful, the results for the reservoir in particular would still have been insufficient given data was only available for fishing activities. As a result, the FS, one of the EIS's cooperating agencies, contracted with Colorado State University to gather additional recreation information.

The contractor conducted a survey at both Flaming Gorge Reservoir and the Green River within the FGNRA during the summer of 2001. Recreators were contacted on-site from May 2001 through September 2001 and asked a series of questions about their recreation activity over the past year. The survey provided information by recreation activity in terms of visitation and value for both current and preferred reservoir water level and river flow conditions. In many cases, survey responses were adjusted downward using a conservative, but frequently applied approach of assuming nonrespondents equal to zero. As a result, differences exist between certain estimates used in the analysis and those presented in the survey report. In addition, information was also obtained on the water levels and flows where recreators would stop participating due to low or high water level/flow conditions. Detailed information on survey methods and results are presented in Aukerman and Schuster (2002).

3.1.1.1 Green River Visitation and Valuation Analysis Methodology

As noted in the affected environment section, the Green River recreation analysis looked at visitation impacts at both the Flaming Gorge National Recreation Area and Dinosaur NM.

3.1.1.1.1 Flaming Gorge National Recreation Area Analysis Methodology – Using existing data along with information gathered by the contractor, estimates of recreation use and economic value were developed by recreation activity for both current and preferred flow conditions. Combining that information with the high and low flow thresholds by activity where visitation and economic value go to zero, provides four flow oriented data points of visitation and value. These four data points sketch out an inverted U-shaped distribution which was used to estimate Green River visitation and value through a process of linear interpolation.

Typically, the current conditions data point fell between the low end threshold and preferred conditions data points (except for current river flows during May which fell between the preferred flow and high end threshold). To provide a more symmetric distribution and to avoid problems associated rapid drop offs after exceeding the preferred condition, a high end kink data point was estimated. The high end kink (and in May, a low end kink) was developed to be proportional with the location of the current conditions data point. If the current conditions data point fell 75 percent of the way between the low end threshold and the preferred condition, the high end kink was estimated to fall 75 percent of the way between the preferred condition and the high end threshold. Since the location of the high end kink was based on a proportional calculation, the actual distance from the preferred condition of the high end kink and current condition data points would vary in terms of flows, but not percentages. Since the difference between the low and high end thresholds and the preferred condition varies in terms of flow, the same proportional location for the current condition and high end kink would imply different flows. Therefore, the high end kink and the current conditions flows will not be the same distance from the preferred flow condition in terms of flows, but they will be the same distance in terms of percentage.

Combining the high end kink with the other four data points provides five data points for performing the interpolation to estimate recreation visitation and value. The five data points reflect information on river flows, visitation by activity, and values by activity. The linear interpolation starts by evaluating where monthly flows for each alternative and hydrologic condition (i.e., average, wet (90% exceedence), and dry (10% exceedence)) fall within the range of flows of the five data points: low end threshold, current conditions, preferred conditions, high end kink, and high end threshold data points. Once an alternative's monthly flows are located within the range of data points, the calculation progresses to deriving the visitation or value estimate by determining the percentage distance between the two flow data points and applying that percentage to the two relevant visitation or value data points. For example, let's assume that a given monthly flow for the No Action Alternative average condition falls 60 percent of the way between the current conditions and preferred flow data points. The resulting visitation or value estimate would also be estimated at 60 percent of the way between the current conditions and preferred flow visitation or value data points. This linear interpolation procedure was used to develop all the monthly visitation and value estimates by activity for each Green River alternative and hydrologic condition.

Since the five data points in terms of flow, visitation, and value are critical to the entire Green River recreation analysis, it is important to understand how each of these data point was derived. The following presents a discussion of the calculation procedures for each of the data points with respect to flows, visits, and values.

A) Flow Data Points:

1) Low End Threshold Flow: The low end threshold flow for each activity reflects the point were visitation for that recreation activity is assumed to go to zero due to low flows. This flow level was obtained from the survey and represents the average flow where recreators pursuing that activity indicated they would stop participating.

Low end threshold flows by recreation activity were based on recreator rankings in terms of physical descriptions of Green River flows. A range of physical descriptions, from very low to very high flows, were used in each flow oriented survey question. River experts were used to convert the physical description oriented recreator rankings into actual flow estimates (river expert opinions: very low = 800, low = 1,000, medium = 2,000, high = 3,000, very high = 5,000).

	Low End Flow (cfs) Threshold
Scenic Floating:	953
Guide Boat Fishing:	854
Private Boat Fishing:	879
Shoreline Fishing/Trail Use:	825
Camping:	836

2) Current Flow (Monthly or Annually): Current flows, either monthly or annually, needed to be based on the time period associated with the recreation survey. The recreation survey was conducted from May to September 2001, but asked recreators about their activity over the past 12 months, implying it was necessary to gather flow data from June 2000 to September 2001 to estimate current flows.

Current monthly flows were calculated from March through October given visitation data was only available for those months. Calculating current monthly flows relevant to the survey data was complicated by the fact that depending on when a recreator was contacted during the May through September 2001 survey sampling period, a different monthly perspective could result. For example, when considering June flows, someone contacted in May 2001 about their recreation activity over the past 12 months would visualize June 2000 flows, whereas recreators contacted in June, July August, or September 2001 would be visualizing June 2001 flows. To calculate current flows for months with this dual year situation (June–September), actual average monthly flows for 2000 and 2001 were weighted by the percent of the sample contacted in each month (May = 11.3%, June = 20.5%, July = 29.2%, August = 15.4%, and September = 23.6%). For the other months (March, April, May, and October), all recreators would be referencing the same months implying no timing conflicts in estimating average monthly flows. Using this weighting procedure, current average monthly Green River flows relevant for all activities were estimated as follows (measured in cfs):

	Current Flows	Calculation
March	1,036	1,036 (March 2001) across entire sample
April	1,145	1,145 (April 2001) across entire sample
May	2,478	2,478 (May 2001) across entire sample
June	1,215	(2,292*.113 + .887*1,078), 2,292 = 6/2000, 1,078 = 6/2001
July	1,007	(1,408*.318 + .682*820), 1,408 = 7/2000, 820 = 7/2001
August	1,122	(1,311*.61 + .39*827), 1,311 = 8/2000, 827 = 8/2001
September	1,118	(1,203*.764 + .236*843), 1,203 = 9/2000, 843 = 9/2001
October	1,024	1,024 (October 2000) across entire sample

It should be emphasized that the hydrologic data used in the analysis reflects average monthly flows. Regardless of whether the discussion focuses on average, wet, or dry conditions, the underlying hydrologic data is measured in terms of average monthly flows. So even in the extreme hydrologic conditions of wet and dry, the 90% and 10% flow levels still represent average flows (i.e., the highest 90% of average flows and the lowest 10% of average flows for a particular month). This average monthly flow measure was assumed to adequately reflect hydrologic conditions during any given month. This introduces some error into the analysis given the potential variation in flows across the month. In some cases, average monthly flows for a given alternative and hydrologic condition, fall above or below the high and low end flow thresholds for a given recreation activity. As a result, the interpolation analysis predicts zero visitation for that activity and month. Given the average flow may imply that for part of the month, flows may not fall below or exceed the threshold, use of the average flow may somewhat overstate the impact. Perhaps a better approach would be to use a shorter time step, such as a day, but unfortunately the rest of the data for the analysis was not available to such detail. Therefore, the monthly orientation does provide a certain degree of embedded error, but given the analyses were conducted similarly across alternatives, the results are still comparable.

The analysis of economic values was also conducted monthly, but the actual calculation used annual flow information by activity as the current flow reference point. When estimating per trip values, it makes no difference whether the flow reference point is daily, weekly, monthly, or annually. The survey asked recreators for their current value by recreation activity based on activity pursued across the past 12 months (the survey did not ask about values per activity by month since that would be overly complicated). As a result, the current flows associated with the current economic values by activity were based on average annual flows reflected by the high use months from March to October based on data from the June 2000 through September 2001 survey orientation period. The average annual flow for each activity took into consideration both when a recreator was contacted during the sampling period (weighting based on sampling percentage by month) and the percent of visitation by month associated with each activity. Table 6 presents the annual average flow calculation for scenic floating.

Table 6: Scenic Floating Current Average Annual Flows (cfs)

Month	Scenic Floating Current Visits	Percent	Monthly Visits Required Weighting by Sampling %?	Current Flows	Weighted Average Flow
March	42	.2	No	1,036	2.1
April	217	.9	No	1,145	10.3
May	99	.4	No	2,478	9.9
June	5,527	22.3	Yes	1,215	270.9
July	11,063	44.7	Yes	1,007	450.1
August	7,749	31.3	Yes	1,122	351.2
September	62	.3	Yes	1,118	3.3
October	9	0	No	1,024	0
Total:	24,768				1,097

The weighted average current annual flows for the five studied Green River recreational activities are as follows:

	Wtd. Average
Scenic Floating:	1,097
Guide Boat Fishing:	1,359
Private Boat Fishing:	1,373
Trail Use/Shoreline Fishing:	1,299
Camping:	1,115

3) Preferred Flow: The preferred flow for each activity reflects the point were visitation for that recreation activity is assumed to be at the maximum. This flow level was obtained from the survey and represents the average flow where recreators pursuing that activity indicated they would participate the most.

As with the low end threshold flows, preferred flows by recreation activity were based on recreator rankings of physical descriptions of Green River flows combined with expert opinion of what those physical descriptions represent in terms of flow levels.

	Preferred Flow (cfs)
Scenic Floating:	2,170
Guide Boat Fishing:	1,837
Private Boat Fishing:	1,808
Shoreline Fishing/Trail Use:	1,624
Camping:	2,000

4) High End (Low End) Kink Flow: Calculation of the high end kink flow was discussed above. Note that for the river visitation analysis, current monthly flow varies by month, but not by activity. However, since the preferred and low/high threshold flows vary by activity, the monthly high (low) end kink by activity for the visitation analysis varies by month and activity. See table 14 for the various monthly high end kink flows for each activity used in the visitation analysis.

The high end kink of the valuation analysis is based on the current annual flow by activity. The current annual flow varies by activity, but since it is annual, it doesn't vary by month. Therefore, for the valuation analysis, the five data points vary by activity, but not by month. The high end kink flows used in the valuation analysis are as follows:

	"Value Analysis" High End Kink Flow
Scenic Floating:	3,699.9
Guide Boat Fishing:	2,757.9
Private Boat Fishing:	2,672.7
Shoreline Fishing/Trail Use:	2,473.1
Camping:	3,168.7

5) High End Threshold Flow: The high end threshold flow for each activity reflects the point were visitation for that recreation activity is assumed to go to zero due to high flows. This flow level was obtained from the survey and represents the average flow where recreators pursuing that activity indicated they would stop participating.

As with the low end threshold and preferred flows, high end threshold flows by recreation activity were based on recreator rankings of physical descriptions of Green River flows combined with expert opinion of what those physical descriptions represent in terms of flow levels.

	High End Flow Threshold (cfs)
Scenic Floating:	3,905
Guide Boat Fishing:	3,731
Private Boat Fishing:	3,656
Shoreline Fishing/Trail Use:	3,709
Camping:	3,538

B) Visitation Data Points:

1) Low End Visitation: Assumed to be zero by definition.

2) Current Visitation: Current visitation by activity was based on data collected by the FS from June 2000 through September 2001. As discussed throughout this technical appendix, current visitation estimates needed to be tied into the survey period. The recreation survey was conducted from May to September 2001, but asked recreators about their activity over the past 12 months, implying it was necessary to gather visitation data from June 2000 to September 2001 to estimate current visitation. Current monthly visitation was calculated from March through October given visitation data was only available for those months. Calculating current monthly visitation relevant to the survey data was complicated by the fact that depending on when a recreator was contacted during the May through September 2001 sampling period, a different annual and monthly perspective could result. For example, when considering current June visitation, someone contacted in May 2001 about their recreation activity over the past 12 months would be visualize June 2000 visitation, whereas recreators contacted in June, July August, or September 2001 would be visualizing June 2001 visitation. To calculate current visitation for months with this dual year situation (June–September), actual average monthly visitation for 2000 and 2001 were weighted by the percent of the sample contacted in each month (May = 11.3%, June = 20.5%, July = 29.2%, August = 15.4%, and September = 23.6%). For the other months (March, April, May, and October), all recreators would be referencing the same months implying no timing conflicts in estimating average monthly visitation. Using this weighting procedure, current average monthly Green River visitation by activity was estimated as presented in table 2 under Affected Environment current conditions.

3) Preferred Visitation: The survey asked a contingent behavior question to estimate how many more visits by activity recreators would take if flows were at the recreator's preferred level. The survey additional visit responses were averaged by activity and divided by the average current visits by activity (also obtained from the survey) to estimate a percentage change compared to current visitation. The additional visits by activity were revised downward using the conservative, but frequently applied adjustment of assuming nonrespondents equal to zero. Table 7 shows the percentage increase in visits per year under preferred conditions.

Table 7: Preferred (Upper Bound) Green River Visitation Estimates by Activity

Recreation Activity	Additional Visits per Year (Survey)	Number of Responses	Full Sample	Revised Additional Visits per Year	Current Visits per Year	% Increase Visits per Year under Preferred Conditions
Scenic Floating	2.417	18	65	.67	2.765	24.2
Guide Boat Fishing	2.133	15	34	.94	4.875	19.3
Private Boat Fishing	3.563	24	84	1.02	6.137	16.6
Shoreline Fishing/ Trail Use	3.143	70	150	1.47	3.401	43.2
Camping	2.885	13	123	.3	3.074	9.8

The percentage increase by activity (from the survey) was then applied to the current monthly visitation estimates (based on the FS data) to derive the preferred flow monthly visitation estimates.

Given the percentage changes varied by activity, and the current visitation estimates varied by activity and month, the preferred visitation estimates ended up varying by activity and month. Table 8 presents estimates of preferred visitation by activity and month. The estimates of preferred visits reflect an upper bound for potential visitation.

Table 8: Preferred (Upper Bound) Green River Visitation Estimates by Activity and Month

Month	Scenic Floating	Guide Boat Fishing	Private Boat Fishing	Shoreline Fishing/ Trail Use	Camping	Total	Percent
March	52	334	1,475	2,541	0	4,402	3.7
April	270	1,861	3,748	8,439	0	14,318	12.0
May	123	2,407	4,139	7,078	0	13,747	11.5
June	6,867	2,504	2,060	8,559	733	20,723	17.4
July	13,744	2,124	1,773	11,039	719	29,399	24.6
August	9,626	2,163	1,699	7,823	659	21,970	18.4
September	77	1,826	5,629	4,204	386	12,122	10.2
October	11	379	1,087	1,136	7	2,620	2.2
Total:	30,770	13,598	21,610	50,819	2,504	119,301	100
Percent:	25.8	11.4	18.1	42.6	2.1	100	

While the percentage change by activity refers to annual visitation, the decision was made to assume the percentages also held on a monthly basis to allow for monthly analysis. The monthly analysis was seen as a significant improvement over an annual analysis since it allowed for a more thorough evaluation of the month-to-month consequences of each alternative.

4) High End (Low End) Kink Visitation: Since the high end kink data point was analogous to the current conditions data point, visitation for the high end kink was assumed to be the same as current visitation as presented in table 2 under Affected Environment current conditions.

5) High End Visitation: Assumed to be zero by definition.

C) Value per Visit Data Points:

1) Low End Values: Assumed to be zero by definition.

2) Current Values: Current value estimates were obtained by activity from the survey. All value estimates were developed using the conservative, but frequently applied approach of assuming nonrespondents have a value of zero. River camping values were most affected by the nonresponse adjustments due to the large number of nonresponses. Table 4 under Affected Environment current conditions presents the estimates of current value per visit by recreation activity for the Green River.

3) Preferred Values per Visit: As with the preferred visitation estimates, the survey asked a contingent valuation question to estimate how much more value per visit by activity recreators would expect if flows were at the recreator's preferred level. The survey additional value per visit responses were averaged by activity and revised downward using the conservative, but frequently applied adjustment of assuming nonrespondents equal to zero. The revised additional values per

visit by activity were added to the current revised values per visit by activity to estimate preferred values per visit by activity. The preferred values per visit vary by activity, but not by month. Table 9 presents estimates of preferred values per visit by activity. The estimates of preferred values per visit reflect an upper bound.

Table 9: Preferred (Upper Bound) Green River Values per Visit by Activity

Recreation Activity	Additional Value per Visit (Survey)	No. of Responses	Full Sample	Revised Additional Value per Visit	Revised Current Value per Visit	Preferred Value per Visit
Scenic Floating	$ 64.39	48	65	$ 47.55	$ 46.80	$ 94.35
Guide Boat Fishing	$ 71.37	27	34	$ 56.68	$ 182.94	$ 239.62
Private Boat Fishing	$ 55.66	49	84	$ 32.47	$ 37.44	$ 69.91
Shoreline Fishing/Trail Use	$ 13.53	118	150	$ 10.64	$ 23.49	$ 34.13
Camping	$ 9.36	44	123	$ 3.35	$ 10.78	$ 14.13

4) High End (Low End) Kink Value per Visit: Since the high end kink data point was analogous to the current conditions data point, value per visit for the high end kink was assumed to be the same as current value per visit. Table 4 under Affected Environment current conditions presents the estimates of current value per visit by recreation activity for the Green River.

5) High End Value per Visit: Assumed to be zero by definition.

3.1.1.1.2 Dinosaur National Monument Analysis Methodology – Based on conversations with Dinosaur NM staff (personal communications with Christy Wright), there was uncertainty over whether Green River flows would have a significant impact on rafting visitation within Dinosaur. As noted in the affected environment section, given the potential for substitution of rafting activity between the Green and Yampa Rivers and the fact that most rafting trips are scheduled well ahead of time and, thereby, involve both time and financial commitments, the general hypothesis was that changing Green River flows would not have a significant impact on rafting activity.

To test this hypothesis, monthly data on both private and commercial rafting visitation and average Green River flows was gathered over an 11-year period (1993-2003). Annual population data for the States of Colorado, Utah, and Wyoming was also gathered over this period. Using this data, the following models were attempted.

Rafting visits = f (Green River Flows, Green River Flows^2, Population, School)

Dependent Variables:

Private Visits = Number of monthly visitors on private rafting trips
Commercial Visits = Number of monthly visitors on commercial rafting trips

Explanatory Variables:

Green River Flows = Average monthly Green River flows as obtained from the USGS.
Expected sign: +

Green River $Flows^2$ =	Average monthly Green River flows squared. Provides the often assumed quadratic (inverted U-shaped) distribution. Expected sign: -
Population =	Annual population of Colorado, Utah, Wyoming. Reflects trend variable. Expected sign: +
School =	Qualitative variable reflecting 1 when school is out of session (months of June, July, August) and 0 when in session. Expected sign: +

Private Rafting Model Results:

Variables	Constant	Flows	$Flows^2$	Population	School	Adjusted R^2
Constant	-609.469	.3998	-3.855E-05	8.11E-05	856.811	.656
t Statistic	-.941	4.445	-2.973	.919	11.042	

Interestingly, the flow variable in the private model proved to be statistically significant implying that changes in average flows do influence changes in private rafting visitation. However, when plugging the average monthly flows (along with the other variables) associated with both the No Action and Action Alternatives into the model, the estimated visitation differences weren't considered substantial. On average, Action Alternative rafting visits were estimated to increase by less than 8 percent compared to the No Action Alternative. In wet and dry conditions, which each only occur about 10 percent of the time, the change in visitation associated with the Action Alternative was +11% and -5%, respectively.

	Average Conditions	Wet Conditions	Dry Conditions
No Action Alternative Visits	6,750	7,665	4,961
Action Alternative Visits	7,284 (+7.9%)	8,510 (+11.0%)	4,715 (-5.0%)

Commercial Rafting Model Results: In the initial regression, we tested the relationship between commercial rafting visits and average monthly flow only. Given this relationship did not prove significant, we went no further with the commercial rafting analysis.

Bottom line, since the private model indicated fairly minor changes in rafting visitation between the two alternatives and the commercial rafting model showed no statistical relationship between flows and visitation, the assumption was made that rafting in Dinosaur would not be substantially affected by the EIS alternative and, therefore, a detailed analysis of Dinosaur NM rafting would not be included in the EIS.

3.1.1.2 Flaming Gorge Reservoir Visitation and Valuation Analysis Methodology

Whereas the Green River recreation analysis used the interpolation approach for both the visitation and value analyses, lack of visitation data for the relevant survey period from June 2000 through September 2001 precluded use of an interpolation analysis to estimate Flaming Gorge Reservoir visitation. Instead, a facilities availability approach was used to estimate reservoir visitation. However, the interpolation approach was used to estimate economic values by reservoir recreation activity as with the Green River analysis.

3.1.1.2.1 Facility Availability Approach to Flaming Gorge Reservoir Visitation – The facility availability approach to estimating recreation visitation focuses purely on the influence of water access on recreation activity. Water access is determined by the availability of recreation facilities as reservoir water levels fluctuate. The basic concept that recreation visitation varies with availability of facilities is well founded, but it obviously only applies to water based activities. In addition, by focusing purely on access, the approach fails to consider other influential factors such as aesthetics and safety concerns. Nevertheless, facilities availability approaches are often used to estimate changes in visitation.

Step 1: The first step in developing a facility availability analysis is to gather information on the high and low end usability thresholds associated with each potentially affected facility. Usability thresholds, measured in feet above mean sea level (msl), represent the point where each facility would no longer be usable due to either high or low water. For the Flaming Gorge analysis, high end thresholds were of little concern and were not included in the analysis. Table 10 presents a list of sites, facilities, and low end usability thresholds.

Table 10: Flaming Gorge Reservoir Facility List

Site	Facility Type	Low End Threshold (feet above msl)
Antelope Flat	Boat Ramp Swim Beach	6015 6012
Anvil Draw[1]	Boat Ramp	6020
Buckboard Crossing	Marina Boat Ramp	6015 6000
Cedar Springs	Marina Boat Ramp	6018 6018
Firehole	Boat Ramp Swim Beach	6019 6012
Hideout	Boat Camp	6014
Jarvies Canyon	Boat Camp	6012
Kingfisher Island	Boat Camp	6010
Lucerne Valley	Marina Two Boat Ramps Swim Beach	6010 5994 6014
Mustang Ridge	Boat Ramp	6000
Sheep Creek	Boat Ramp	6015
Squaw Hollow	Boat Ramp	6015
Sunny Cove	Swim Beach	6018
Upper Marsh Creek	Boat Ramp	6000

[1] The Anvil Draw boat ramp was extended in 2003 such that the low end threshold changed from 6020 to 6015. This change is not reflected in the analysis because it would not substantially affect the results (impacts only this low use ramp during dry conditions).

Step 2: The next step involves obtaining visitation estimates by activity linked to each of the recreation facilities. The latest, most reliable visitation estimates for the reservoir were gathered by the FS in fiscal year 1997 (October 1996–September 1997). This data was gathered by recreation activity, site, and facility. This annual visitation data needed to be converted into monthly estimates allow for use of the facility availability approach. Fortunately, the State of Utah has periodically gathered monthly data for boat, shore, and ice fishing from which monthly percentages were estimated. The boat fishing monthly percentages were used to allocate warm water recreation activities across months. Warm water activities were defined as power boating, waterskiing, boat fishing, and swimming/waterplay. The shore fishing monthly percentages were used to allocate cooler month activities across months. The only cool water activity of interest was boat camping. While not directly targeted toward each of our activities of interest, the State of Utah percentages were seen as representative of the various warm and cool water activities.

Fishing data from the State of Utah was available for 1993-4, 1988-9, and 1982. Given there was not much variation in these percentages over time, which helped justify their use, it mattered little which set of data was applied. Data from 1988-9, as presented in table 11, was selected as most representative since the reservoir water levels of 1988-9 matched the visitation oriented 1996-7 water levels the closest.

Table 11: Flaming Gorge Reservoir Monthly Percentages by Activity Type

Month	Monthly Percentages for Warm Water Activities	Monthly Percentages for Cool Water Activities
January	.002	.007
February	.000	.000
March	.007	.065
April	.060	.170
May	.161	.134
June	.217	.180
July	.236	.134
August	.137	.113
September	.079	.052
October	.071	.065
November	.018	.047
December	.012	.034

Step 3: The next step in the analysis was to look at the actual availability of the facilities under current conditions and conditions associated with each alternative. As noted in the Affected Environment discussion of current reservoir water levels, use of both a facility availability approach and an interpolation approach to estimate visitation and value respectively within the reservoir recreation analysis complicates the definition of current flows to some extent. Fortunately, regardless of whether one defines current conditions in terms of water levels for fiscal year 1997 (based on visitation data) or water levels from June 2000 through September 2001 (based on survey value data), the current visitation estimate derived from the facility availability approach would be the same. Under both perspectives, all facilities are available in all months. The current visitation estimate is presented in table 3 under Affected Environment current conditions.

The current visitation estimate was used as the starting point for estimating visitation for the No Action and Action Alternatives. End of month reservoir water levels were obtained from the hydrologists for each alternative under a series of conditions ranging from dry (10% exceedence) to wet (90% exceedence). Monthly availability of facilities was evaluated for dry, average, and wet conditions. An implicit assumption is made that end of month water levels are representative of water levels throughout the month. Monthly water level data was used for each alternative since that time step was consistent with the lowest level of detail available for the visitation data as well as the historical water level data.

Step 4: Based on the availability of facilities under each alternative and hydrologic scenario, estimates of visitation were developed. As facilities became unusable, the level of visitation associated with that facility was assumed lost under the initial analysis run. Full loss of visitation as facilities become unusable is a worst case scenario since it fails to address potential substitution of visitation to other facilities along the reservoir. After developing the initial, worst case loss estimates, the results were presented to on-site recreation managers for their opinions as to the potential degree of facility substitution. The final monthly visitation estimates by recreation activity, alternative, and hydrologic condition therefore take into account facility substitution based on the professional judgement of recreation management.

3.1.1.2.2 Interpolation Approach to Flaming Gorge Reservoir Valuation – The linear interpolation approach was also used to estimate monthly recreation values by activity. The approach used was the same as that presented above to estimate Green River values. The following reflects details of the interpolation data points for Flaming Gorge Reservoir water levels and values.

A) Water Level Data Points:

1) Low End Water Level Thresholds: The low end threshold water level for each activity reflects the point were value for that recreation activity is assumed to go to zero due to low flows. This flow level was obtained from the survey and represents the average flow where recreators pursuing that activity indicated they would stop participating.

As with Green River flows, low end threshold water levels by recreation activity were based on recreator rankings in terms of physical descriptions of Flaming Gorge Reservoir water levels. A range of physical descriptions, from very low to very high water levels, were used in each water level oriented survey question. Reservoir experts were used to convert the physical description oriented recreator rankings into actual water level estimates (reservoir expert opinions: very low = 6015, low = 6022, medium = 6028, high = 6030, very high = 6040).

	Low End Water Level Threshold
Power Boating/WaterSkiing:	6016.7
Boat Fishing:	6017.3
Boat Camping:	6017.1
Swimming/Waterplay:	6017.4

2) Current Water Levels: The analysis of economic values was conducted by month and alternative, but the actual calculation used annual water level information by activity as the current flow reference point. When estimating per visit values, it makes no difference whether the water level reference point is daily, weekly, monthly, or annually. The survey asked recreators for their current value by recreation activity based on activities pursued across the past 12 months (the survey did not ask about values per activity by month since that would be overly complicated). As a result, the current water levels associated with the current economic values by activity were based on average annual water levels from the June 2000 through September 2001 survey orientation period. The average annual water level for each activity took into consideration both when a recreator was contacted during the sampling period (weighting based on sampling percentage by month) and the percent of visitation by month associated with each activity.

The weighted average current annual water levels for the four studied Flaming Gorge Reservoir recreational activities hardly varied and are as follows:

	Low End Water Level Threshold
Power Boating/WaterSkiing:	6021.2
Boat Fishing:	6021.2
Boat Camping:	6021.1
Swimming/Waterplay:	6021.2

3) Preferred Water Levels: The preferred water level for each activity reflects the point were visitation for that recreation activity is assumed to be at the maximum. This water level was obtained from the survey and represents the average water level where recreators pursuing that activity indicated they would participate the most.

As with the low end threshold reservoir water levels, preferred water levels by recreation activity were based on recreator rankings of physical descriptions of Flaming Gorge Reservoir water levels combined with expert opinion of what those physical descriptions represent in terms of water levels.

	Preferred Water Levels
Power Boating/WaterSkiing:	6029.0
Boat Fishing:	6029.1
Boat Camping:	6028.9
Swimming/Waterplay:	6028.9

3) High End Kink Water Levels: Calculation of the high end kink water level was discussed above under the Green River section. Note that for the reservoir valuation analysis, current annual water levels (and all data points for that matter) vary by activity, but not by month. As a result, the high end kink water level also varies by activity, but not month. Also note that in all months, this data point reflects a high end kink and never a low end kink.

	High End Kink Water Levels
Power Boating/WaterSkiing:	6021.2
Boat Fishing:	6021.2
Boat Camping:	6021.1
Swimming/Waterplay:	6021.2

4) High End Threshold Water Levels: The high end threshold water level for each activity reflects the point were value for that recreation activity is assumed to go to zero due to high water levels. This water level was obtained from the survey and represents the average water level where recreators pursuing that activity indicated they would stop participating.

As with the low end threshold and preferred reservoir water levels, high end threshold water levels by recreation activity were based on recreator rankings of physical descriptions of Flaming Gorge Reservoir water levels combined with expert opinion of what those physical descriptions represent in terms of water levels.

	High End K Water Level Threshold
Power Boating/WaterSkiing:	6036.8
Boat Fishing:	6037.5
Boat Camping:	6036.7
Swimming/Waterplay:	6036.7

B) Visitation Data Points: Not relevant since the reservoir visitation analysis is based on the facility availability approach as opposed to the interpolation approach.

C) Value per Visit Data Points:

1) Low End Values: Assumed to be zero by definition.

2) Current Values: Current value estimates were obtained by activity from the survey. All value estimates were developed using the conservative, but frequently applied approach of assuming nonrespondents have a value of zero. All activities were significantly affected by this adjustment. Table 5 under Affected Environment current conditions presents the estimates of current value per visit by recreation activity for the reservoir.

3) Preferred Values per Visit: The survey asked a contingent value question to estimate how much more value per visit by activity recreators would expect if water levels were at the recreator's preferred level. The survey additional value per visit responses were averaged by activity and revised downward using the conservative nonrespondent adjustment. The revised additional values per visit by activity were added to the current revised values per visit by activity to estimate preferred values per visit by activity. The preferred values per visit vary by activity, but not by month. Table 12 presents estimates of preferred values per visit by activity. The estimates of preferred values per visit reflect an upper bound.

Table 12: Preferred (Upper Bound) Flaming Gorge Reservoir Values per Visit by Activity

Recreation Activity	Additional Value per Visit (Survey)	Number of Responses	Full Sample	Revised Additional Value per Visit	Revised Current Value per Visit	Preferred Value per Visit
Power Boating/ Waterskiing	$ 41.71	60	122	$ 20.51	$ 25.71	$ 46.22
Boat Fishing	$ 33.79	47	125	$ 12.71	$ 25.21	$ 37.92
Boat Camping	$ 40.52	24	8106	$ 9.17	$ 13.06	$ 22.23
Swimming/ Waterplay	$ 36.25	24	97	$ 8.97	$ 1.44	$ 10.41

4) High End (Low End) Kink Value per Visit: Since the high end kink data point was analogous to the current conditions data point, value per visit for the high end kink was assumed to be the same as current value per visit. See current values per visit in table 12 directly above.

5) High End Value per Visit: Assumed to be zero by definition.

Monthly values by alternative and hydrologic condition were multiplied by monthly visitation estimates by alternative and hydrologic condition to estimate total value by alternative and hydrologic condition.

3.1.1.3 Green River Facility Availability Analysis Methodology

In addition to the visitation and economic value analysis, evaluations were also made as to the availability of recreation facilities for each alternative. As noted above, facility availability provided the basis for estimating visitation effects for the reservoir. Although not used to estimate the visitation effects on the Green River, facility availability was also reviewed on the Green River downstream of the dam, all the way to the confluence with the Colorado River. As with the reservoir visitation analysis, high and low end usability thresholds were obtained for each facility from the various managing entities (i.e., FS, BLM, State of Utah, USFWS, NPS). Average, wet (90^{th} percentile), and dry (10^{th} percentile) flows from the hydrology model for each alternative were compared to the high and low end usability thresholds for each facility to determine availability. In addition, the raw hydrologic output data was searched to determine the percent of time each usability threshold was exceeded for each alternative. This facility availability information is presented for each alternative along with the visitation and valuation information. For consistency with the reservoir analysis, the results of the Green River facility availability analysis are presented within the visitation sections.

The following summarizes information obtained from discussions with the various managing entities. Note that as a result of these discussions, many of the recreation facilities identified in the affected environment section were assumed to be unaffected by river flows given their historical use across a wide range of flow conditions. Table 13 presents the high and low end usability thresholds for each potentially impacted facility on the Green River.

Reach 1: Flaming Gorge Dam to the confluence with the Yampa River

USDA Forest Service: The FS manages two boat ramps (Spillway and Little Hole), a fishing pier, a hiking trail, and 18 riverside campgrounds along the Green River within FGNRA. Use of both boat ramps and the fishing pier become difficult as flows fall below 600 cfs. Significant impacts occur to nine of the eighteen campgrounds as flows exceed 5,000 cfs. The Spillway ramp, the fishing pier, and the hiking trail become unusable or significantly impacted as flows rise above 6,000 cfs. Finally, the Little Hole boat ramp becomes inaccessible as flows exceed 8,000 cfs.

Bureau of Land Management: The BLM manages numerous recreational facilities between FGNRA and Browns Park NWR including three boat ramps and approximately 20 campsites. The boat ramps are found at Indian Crossing, Bridge Hollow, and Swallow Canyon (an additional ramp at Pipeline is being phased out). These ramps have remained usable at very high flows, and therefore no information exists as to high end flow thresholds where the ramps become unusable. However, these ramps do become difficult to use below 800 cfs. The only campsite which may experience flooding is the Bridge Hollow camp. The group campsites at Bridge Hollow have flooded at about 10,000 cfs in the past.

State of Utah: The State manages one boat ramp (Bridge Port Camp) and five campgrounds (Gorge Creek, Little Davenport, Bridge Port, Elm Grove, and Burned Tree) between FGNRA and Browns Park NWR. The boat ramp remains usable at very high flows so no high end flow threshold was assumed, but becomes unusable below 800 cfs. The campgrounds are far enough away from the water that they would be unaffected by high flows.

Table 13. Green River Facility Usability Thresholds				
Site Name	Facility Type	Managing Entity	Low End Usability Threshold (cfs)	High End Usability Threshold (cfs)
Green River – Reach 1 (Dam to Confluence With Yampa River):				
Spillway	Boat Ramp	FS	600	6,000
Little Hole	Boat Ramp	FS	600	8,000
	Fishing Pier	FS	600	6,000
	Trail	FS	n/a	6,000
	9 of 18 Campgrounds	FS	n/a	5,000
Indian Crossing	Boat Ramp	BLM	800	None
Bridge Hollow	Boat Ramp	BLM	800	None
	Campground	BLM	n/a	10,000
Swallow Canyon	Boat Ramp	BLM	800	None
Bridge Port Camp	Boat Ramp	State of Utah – Wildlife Resources	800	None
Green River – Reach 2 (Yampa River to confluence with White River):				
Ouray NWR	Boat Ramp	USFWS	None	25,000
Green River – Reach 3 (White River to confluence with Colorado River):				
Sand Wash	Boat Ramp	BLM	800	50,000
Swasey's Beach	Boat Ramp	BLM	2,000	50,000
Nefertiti	Boat Ramp	BLM	800	[1]27,000
Butler Rapid	Boat Ramp	BLM	800	[1]27,000
Mineral Bottom	Boat Ramp	BLM	800	[1]30,000
Green River State Park	Boat Ramp	State of Utah	800	25,000
	Campground	State of Utah	None	25,000
	Golf Course	State of Utah	None	19,000

[1] Access road to the facility becomes inundated, not the facility itself.

National Park Service (Dinosaur National Monument): Dinosaur NM has three primary boat ramp facilities: Lodore, Deerlodge, and Split Mountain. Generally speaking, these facilities have been usable across all flow levels and hence high and low end usability thresholds are unknown. The likely continued operation of recreation facilities across a wide range of flow levels also holds for the riverside campgrounds (i.e., Lodore, Deerlodge, Echo Park, Split Mountain, and Green River) and picnic areas (i.e., Split Mountain).

Reach 2: Yampa River to the confluence with the White River

U.S. Fish and Wildlife Service (Ouray National Wildlife Refuge): While there is a primitive boat ramp, very little boating activity occurs within the refuge. Site management estimates that use of this ramp becomes difficult at about 25,000 cfs. There are no riverside campgrounds within the refuge.

Reach 3: White River to the confluence with the Colorado River

Bureau of Land Management: The BLM oversees a considerable amount of land within Reach 3 from the confluence with the White River to the northern border of Canyonlands National Park. The agency maintains five boat ramps/launches (Sand Wash, Swasey's Beach, Nefertiti, Butler Rapid, and Mineral Bottom) within this river stretch. Swasey's Beach is the only developed concrete ramp, with the other sites being primitive. Sand Wash is usable at virtually all flow levels, with impacts occurring at the low end below 800 cfs and at the high end above 50,000 cfs. Swasey's Beach ramp becomes unusable below 2,000 cfs due to rocks and at very high flows in excess of 50,000 cfs. The launch sites at Nefertiti and Butler Rapid remain accessible at virtually all flow levels, but the access road to these facilities floods at about 27,000 cfs. At Mineral Bottom, use of the site becomes difficult below 800 cfs. As with Nefertiti and Butler Rapid, the site remains accessible at high flows, but the access road floods at about 30,000 cfs. Finally, three sites at the campground at Swasey's Beach get inundated at about 26,000 cfs, but this is not a significant enough effect to close the campground.

State of Utah (Green River State Park): The park has a developed boat ramp, a 42 unit campground, and a golf course all located along the Green River. At 19,000 cfs the golf course begins to see significant impacts. At 25,000 cfs, impacts begin at both the campground and boat ramp. While these facilities may still be usable at these flow levels, impacts become readily apparent.

Private Lands: A primitive boat launch site exists on private lands at Ruby Ranch upstream of Canyonlands National Park. No information was readily available on high or low end usability thresholds.

National Park Service (Canyonlands National Park): Given there are no boat ramps within the park, Green River boaters within Canyonlands use boat ramps outside the park on BLM, State, or private lands. Boaters use undeveloped, undesignated campsites throughout the park available at all flow levels. Usability thresholds for 8 minimally developed road-accessible campsites along the river are unknown. Above about 30,000 cfs, a portion of the access road from the north becomes inundated, but access is still possible from the south or east.

3.2 Results

This section presents the results of the recreation visitation and value analyses. Results are presented by alternative within each section with the Action Alternative results compared to the No Action Alternative results.

3.2.1 Recreation Visitation and Valuation Results

This section presents the results of the recreation visitation and valuation analysis by alternative starting with the No Action Alternative. Under each alternative, separate sections are presented for hydrology, visitation, and value. Within each hydrology, visitation, and value subsection, a further division is made between the Green River and Flaming Gorge Reservoir analyses, but the visitation and value results are ultimately combined across both sites. Finally, information presented for the Action Alternative will be compared to the No Action Alternative to evaluate the effects of the Action Alternative.

3.2.1.1 No Action Alternative

Within a Federal environmental document, such as this Flaming Gorge EIS, the No Action Alternative reflects the baseline from which to compare all other alternatives.

3.2.1.1.1 Hydrologic Conditions **–**

A) Green River Flows:

Monthly average Green River flows were obtained from the hydrology models for each project alternative. Within the recreation analysis, comparisons were made of recreation effects between alternatives under average, wet, and dry hydrologic conditions. The monthly average flows under average conditions simply reflects the average flows for that particular month across all years within the hydrologic output. As a result, average flows do not necessarily equate to information related to average water year types presented within the context of the Green River flow recommendations. Similarly, the wet and dry flows used in the recreation analysis are not based on information by water year type, but reflect the 90 percent and 10 percent thresholds associated with the output from the hydrologic models. The dry flows represent the lowest 10% flow level whereas the wet flows represent the highest 90% flow level. Table 14 presents the average, wet, and dry flows by month for the No Action Alternative. Also included in the table are the five flow data points used in the interpolations. Comparing the alternative flows to the data points provides an idea as to where the alternative flow falls within the inverted U-shaped flow distribution. For example, the No Action Alternative average condition flow for scenic floating for March of 1,484 falls between the current flow data point (1,036) and the preferred flows data point (2,170). The visitation and value interpolation for the No Action Alternative scenic floating March average condition would therefore also result in estimates falling between the current and preferred visit and value data points.

Note that the Green River recreation analysis evaluated the months of March through October given visitation data was only available for those months. In addition, as described under affected environment, the river recreation analysis focused on the Flaming Gorge NRA which is found in Reach 1. Reach 1 of the Green River is defined within this EIS as the stretch of river from Flaming Gorge Dam to the confluence of the Green and Yampa Rivers.

B) Flaming Gorge Reservoir Water Levels:

End of month Flaming Gorge Reservoir water levels were also obtained from the hydrology models for each alternative. As with the river hydrology, reservoir water levels were obtained by alternative for average, wet, and dry hydrologic conditions. The end of month (EOM) water levels under average conditions simply reflects the average water levels for that particular month across all years within the hydrologic output. As a result, average water levels do not necessarily equate to information related to average water year types presented within the context of the Green River flow recommendations. Similarly, the wet and dry water levels used in the recreation analysis are not based on information by water year type, but reflect the 90 percent and 10 percent thresholds associated with the output from the hydrologic models. The dry water levels represent the lowest 10% water level whereas the wet water levels represent the highest 90% water level. Table 15 presents the average, wet, and dry water levels by month for the No Action Alternative. Note that the Flaming Gorge Reservoir recreation analysis evaluated across all months, and not only March through October as was the river analysis.

Table 14: No Action Alternative, Green River Reach 1 Average Monthly Flows (cfs) by Hydrologic Condition									
		Interpolation Data Points					No Action Alternative		
Month	Recreation Activity	Low End Threshold Flow	Current Flow	Preferred Flow	High End Kink Flow	High End Threshold Flow	Average	Wet	Dry
		Monthly Oriented Flow Data Points for Visitation Analysis Interpolation							
March	Scenic Floating	953	1036.0	2170	3786.7	3905	1484	1898	800
	Guide Boat Fishing	854	“ ”	1837	3380.3	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1808	3343.7	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1624	3158.4	3709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2000	3273.7	3538	“ ”	“ ”	“ ”
April	Scenic Floating	953	1145.0	2170	3631.3	3905	2207	3290	800
	Guide Boat Fishing	854	“ ”	1837	3170.3	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1808	3126.9	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1624	2874.0	3709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2000	3129.7	3538	“ ”	“ ”	“ ”
May	Scenic Floating	953	1954.0	2170	2478.0	3905	3463	5100	1400
	Guide Boat Fishing	854	1504.3	1837	“ ”	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	1471.2	1808	“ ”	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	1296.7	1624	“ ”	3709	“ ”	“ ”	“ ”
	Camping	836	1638.2	2000	“ ”	3538	“ ”	“ ”	“ ”
June	Scenic Floating	953	1215.2	2170	3531.2	3905	2710	5917	800
	Guide Boat Fishing	854	“ ”	1837	3035.1	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1808	2987.3	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1624	2690.8	3709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2000	3037.0	3538	“ ”	“ ”	“ ”
July	Scenic Floating	953	1007.0	2170	3828.0	3905	983	1200	800
	Guide Boat Fishing	854	“ ”	1837	3436.2	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1808	3401.4	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1624	3234.1	3709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2000	3312.1	3538	“ ”	“ ”	“ ”
Aug	Scenic Floating	953	1122.2	2170	3663.7	3905	1251	1531	931
	Guide Boat Fishing	854	“ ”	1837	3214.2	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1808	3172.1	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1624	2933.3	3709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2000	3159.8	3538	“ ”	“ ”	“ ”
Sept	Scenic Floating	953	1118.0	2170	3669.7	3905	1374	1639	1039
	Guide Boat Fishing	854	“ ”	1837	3222.3	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1808	3180.5	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1624	2944.3	3709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2000	3165.3	3538	“ ”	“ ”	“ ”
Oct	Scenic Floating	953	1024.0	2170	3803.8	3905	1654	2075	1039
	Guide Boat Fishing	854	“ ”	1837	3403.5	3731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1808	3367.6	3656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1624	3189.7	3709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2000	3289.6	3538	“ ”	“ ”	“ ”
		Annually Oriented Flow Data Points for Valuation Analysis Interpolation							
		Low End Threshold Flow	Annual Current Flow	Preferred Flow	Annual High End Kink Flow	High End Threshold Flow			
All Months	Scenic Floating	953	1096.9	2170	3699.8	3905	Monthly flows are as above		
	Guide Boat Fishing	854	1359.0	1837	2757.9	3731			
	Private Boat Fishing	879	1373.3	1808	2672.7	3656			
	Shore Fishing/Trail Use	825	1298.6	1624	2473.1	3709			
	Camping	836	1115.5	2000	3168.7	3538			

Table 15: No Action Alternative, Flaming Gorge Reservoir Average End of Month Water Levels (feet above msl) by Hydrologic Condition

Month	Recreation Activity	Annually Oriented Water Level (WL) Data Points for Valuation Analysis Interpolation					No Action Alternative Water Levels		
		Low End Threshold WL	Annual Current WL	Preferred WL	Annual High End Kink WL	High End Threshold WL	Average	Wet	Dry
January	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6024.3	6028.1	6017.4
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
February	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6024.0	6026.8	6017.8
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
March	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6024.0	6027.9	6019.0
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
April	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6024.1	6028.5	6020.1
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
May	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6023.8	6029.4	6017.6
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
June	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6026.6	6031.7	6018.5
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
July	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6029.1	6035.5	6019.3
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
August	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6028.9	6036.0	6018.5
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
September	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6028.3	6035.5	6017.9
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
October	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6027.5	6034.9	6017.3
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
November	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6026.3	6032.9	6017.5
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			
December	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.1	6030.3	6017.3
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5			
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7			
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7			

3.2.1.1.2 Annual Recreation Visitation and Infrastructure Impacts – Based on the methods described above, visitation estimates by recreation activity for both the Green River and Flaming Gorge Reservoir are presented below for the No Action Alternative under average, wet, and dry hydrologic conditions. In addition, impacts to recreation facilities are also presented by alternative and hydrologic condition.

A) Green River Visitation:

Table 16 presents the Green River visitation estimates for the No Action Alternative. The five data points for the interpolation are included in the table as well as the visitation estimates. Note that the data points and visitation estimates vary by recreation activity and month. Visitation estimates were summed across the March through October time period to provide an estimate of annual water based visitation.

No Action Alternative visitation under average conditions was estimated at nearly 83,500 or about 9,000 visits (9.7%) less than current 2000-2001 conditions. The estimated decline in visitation affected all activities due primarily to the high flows in May (3,463 cfs) and low flows in July (983 cfs).

The wet condition was estimated at nearly 69,700 visits. This reflects a drop of about 13,800 visits (16.5%) compared to the No Action Alternative average condition. While certain months were expected to generate more visitation under wet conditions compared to average conditions, the loss of May and June visitation due to flows (5,100 and 5,917 respectively) averaging in excess of the high end thresholds for all activities resulted in the lower visitation estimate. The loss was expected to occur across all activities.

The dry condition was estimated to generate only about 22,300 visits reflecting a 61,200 visit (73.3%) decline compared to average conditions. These declines held for all activities and stemmed mainly from the complete loss of visitation which is expected during the months of March, April, June, and July. Visitation was expected to drop to zero for these months due to the monthly average flows of 800 cfs.

Although unrelated to the interpolation based Green River visitation analysis, an analysis of facility availability was also conducted for Green River recreation facilities. As shown in table 17, within Reach 1, all river facilities were expected to be available based on average monthly flows across all months under No Action Alternative average and dry conditions. However, under No Action Alternative wet conditions, 9 of the 18 riverside campgrounds were expected to be unavailable in May and June due to high flows. Looking across all years, the unavailability percentage, due exclusively to high flows, ranges from 0 to 15.5 percent (or from virtually never to once every 6.5 years). It should be noted that facility unavailability due to low water levels on the reservoir implies little damage to the facilities whereas facility unavailability on the river due to high flows can imply substantial damage. River facility unavailability was based on the point where significant impacts were expected to occur. However, in most cases, erosion damage begins prior to the significant impact flow level (e.g., impacts begin at: 4,200 cfs to Little Hole ramp foundations, 5,000 cfs to trail tread/boardwalk footings and campground banks and vegetation, and 6,000 cfs to Spillway boat ramp protective riprap and foundations).

Within Reach 2, the boat ramp at Ouray National Wildlife Refuge remains available under average, dry, and wet conditions across all months for the No Action Alternative. Looking across all years, unavailability is expected to occur in May and June, but only about 2 percent of the time.

Within Reach 3, all facilities remain available under average conditions for the No Action Alternative. However, under dry conditions, the Swasey's Beach boat ramp would be unavailable during the months of January, February, and July through December. Under wet conditions, the facilities at Green River State Park would be affected during May and June (golf course during both May and June, and the campground and boat ramp during June). Looking across all years, again the Swasey's Beach boat ramp and the Green River State Park facilities show the most dramatic effects. The unavailability percentages displayed in table 17 need to be looked at with some skepticism given the uncertainty associated with the Reach 3 hydrology model.

Table 16: No Action Alternative, Green River Reach 1 Average Monthly Visitation by Hydrologic Condition									
		Interpolation Data Points					No Action Alternative Visits		
Month	Recreation Activity	Low End Threshold Visits	Current Visits	Preferred Visits	High End Kink Visits	High End Threshold Visits	Average	Wet	Dry
March	Scenic Floating	0	42	52	42	0	46	50	0
	Guide Boat Fishing	0	280	334	280	0	310	332	0
	Private Boat Fishing	0	1,265	1,475	1,265	0	1,387	1,463	0
	Shore Fishing/Trail Use	0	1,774	2,541	1,774	0	2,358	2,404	0
	Camping	0	0	0	0	0	0	0	0
	Total:	0	3,361	4,402	3,361	0	4,101	4,249	0
April	Scenic Floating	0	217	270	217	0	269	229	0
	Guide Boat Fishing	0	1,560	1,861	1,560	0	1,777	1,227	0
	Private Boat Fishing	0	3,214	3,748	3,214	0	3,586	2,223	0
	Shore Fishing/Trail Use	0	5,892	8,439	5,892	0	7,251	2,956	0
	Camping	0	0	0	0	0	0	0	0
	Total:	0	10,883	14,318	10,883	0	12,883	6,635	0
May	Scenic Floating	0	99	123	99	0	31	0	44
	Guide Boat Fishing	0	2,018	2,407	2,018	0	432	0	1,694
	Private Boat Fishing	0	3,549	4,139	3,549	0	581	0	3,122
	Shore Fishing/Trail Use	0	4,942	7,078	4,942	0	988	0	5,616
	Camping	0	0	0	0	0	0	0	0
	Total:	0	10,608	13,747	10,608	0	2,032	0	10,476
June	Scenic Floating	0	5,527	6,867	5,527	0	6,336	0	0
	Guide Boat Fishing	0	2,099	2,504	2,099	0	2,209	0	0
	Private Boat Fishing	0	1,767	5,060	1,767	0	1,836	0	0
	Shore Fishing/Trail Use	0	5,976	8,559	5,976	0	5,864	0	0
	Camping	0	668	733	668	0	688	0	0
	Total:	0	16,037	20,723	16,037	0	16,933	0	0
July	Scenic Floating	0	11,063	13,744	11,063	0	6,148	11,508	0
	Guide Boat Fishing	0	1,781	2,124	1,781	0	1,502	1,861	0
	Private Boat Fishing	0	1,520	1,773	1,520	0	1,235	1,581	0
	Shore Fishing/Trail Use	0	7,708	11,039	7,708	0	6,692	8,750	0
	Camping	0	655	719	655	0	563	667	0
	Total:	0	22,727	29,399	22,727	0	16,140	24,367	0
Aug	Scenic Floating	0	7,749	9,626	7,749	0	7,979	8,481	0
	Guide Boat Fishing	0	1,814	2,163	1,814	0	1,877	2,013	521
	Private Boat Fishing	0	1,457	1,699	1,457	0	1,503	1,601	312
	Shore Fishing/Trail Use	0	5,462	7,823	5,462	0	6,068	7,385	1,948
	Camping	0	600	659	600	0	609	628	199
	Total:	0	17,082	21,970	17,082	0	18,036	20,108	2,980
Sept	Scenic Floating	0	62	77	62	0	66	70	32
	Guide Boat Fishing	0	1,530	1,826	1,530	0	1,636	1,745	1,072
	Private Boat Fishing	0	4,827	5,629	4,827	0	5,124	5,432	3,231
	Shore Fishing/Trail Use	0	2,935	4,204	2,935	0	3,577	4,190	2,143
	Camping	0	352	386	352	0	362	372	253
	Total:	0	9,707	12,122	9,707	0	10,765	11,809	6,731
Oct	Scenic Floating	0	9	11	9	0	10	11	9
	Guide Boat Fishing	0	318	379	318	0	365	370	319
	Private Boat Fishing	0	932	1,087	932	0	1,057	1,060	935
	Shore Fishing/Trail Use	0	793	1,136	793	0	1,129	1,037	802
	Camping	0	6	7	6	0	7	7	6
	Total:	0	2,058	2,620	2,058	0	2,568	2,485	2,071
Total	Scenic Floating	0	24,768	30,770	24,768	0	20,885	20,349	85
	Guide Boat Fishing	0	11,400	13,598	11,400	0	10,108	7,548	3,606
	Private Boat Fishing	0	18,531	21,610	18,531	0	16,309	13,360	7,600
	Shore Fishing/Trail Use	0	35,482	50,819	35,482	0	33,927	26,722	10,509
	Camping	0	2,281	2,504	2,281	0	2,229	1,674	458
	Total:	0	9,2461	119,301	92,461	0	83,458	69,653	22,258

Table 17: No Action Alternative, Green River Facility Availability by Site and Hydrologic Condition (Facility Availability: Yes = available, No = unavailable)

Agency	Site	Facility	Low End Thres-hold	High End Thres-hold	Hydrologic Condition	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Reach 1: Flaming Gorge Dam to the Yampa River																	
No Action Alternative, Reach 1, Average Flows:						1,721	1,432	1,484	2,207	3,463	2,710	983	1,251	1,374	1,654	1,969	1,895
USFS	Spillway	Boat Ramp	600	6,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Little Hole	Boat Ramp	600	8,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Fishing Pier	600	6,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Trail	n/a	6,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		9 of 18 Campgrounds	n/a	5,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BLM	Indian Crossing	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Bridge Hollow	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	None	10,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swallow Canyon	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Bridge Port Camp	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No Action Alternative, Reach 1, Dry Flows:						800	800	800	800	1,400	800	800	931	1,039	1,039	800	800
USFS	Spillway	Boat Ramp	600	6,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Little Hole	Boat Ramp	600	8,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Fishing Pier	600	6,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Trail	n/a	6,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		9 of 18 Campgrounds	n/a	5,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BLM	Indian Crossing	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Bridge Hollow	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	None	10,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swallow Canyon	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Bridge Port Camp	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

No Action Alternative, Reach 1, Wet Flows:						3,212	2,895	1,898	3,290	5,100	5,917	1,200	1,531	1,639	2,075	3,389	3,337
USFS	Spillway	Boat Ramp	600	6,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Little Hole	Boat Ramp	600	8,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Fishing Pier	600	6,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Trail	n/a	6,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		9 of 18 Campgrounds	n/a	5,000	Wet	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
BLM	Indian Crossing	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Bridge Hollow	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	None	10,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swallow Canyon	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Bridge Port Camp	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
						Percent of Time, Across All Years, Facilities Are Unavailable											
USFS	Spillway	Boat Ramp	600	6,000	All Years	0	0	0	0	6.3	9.9	0	0	0	0	0	0
	Little Hole	Boat Ramp	600	8,000	All Years	0	0	0	0	2.8	4.0	0	0	0	0	0	0
		Fishing Pier	600	6,000	All Years	0	0	0	0	6.3	9.9	0	0	0	0	0	0
		Trail	n/a	6,000	All Years	0	0	0	0	6.3	9.9	0	0	0	0	0	0
		9 of 18 Campgrounds	n/a	5,000	All Years	0	0	0	0	10.3	15.5	0.1	0	0	0	0	0
BLM	Indian Crossing	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
	Bridge Hollow	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
		Campground	None	10,000	All Years	0	0	0	0	.7	1.1	0	0	0	0	0	0
	Swallow Canyon	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
State of Utah	Bridge Port Camp	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0

Reach 2: Yampa River to the White River																	
No Action Alternative, Reach 2, Average Flows:						2,078	1,884	2,521	5,956	12,429	10,366	2,662	1,702	1,646	2,107	2,409	2,295
FWS	Ouray NWR	Boat Ramp	None	25,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No Action Alternative, Reach 2, Dry Flows:						1,050	1,085	1,501	2,655	5,975	3,349	1,109	1,097	1,132	1,288	1,119	1,080
FWS	Ouray NWR	Boat Ramp	None	25,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No Action Alternative, Reach 2, Extremely Wet Flows:						3,638	3,389	3,584	10,013	19,670	18,113	4,993	2,234	2,081	2,748	3,881	3,821
FWS	Ouray NWR	Boat Ramp	None	25,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
						Percent of Time, Across All Years, Facilities Are Unavailable											
FWS	Ouray NWR	Boat Ramp	None	25,000	All Years	0	0	0	0	2.2	2.4	0	0	0	0	0	0
Reach 3: White River to the Colorado River																	
No Action Alternative, Reach 3, Average Flows:						2,841	3,030	4,163	6,646	14,292	15,189	4,494	2,636	2,487	3,099	3,411	3,076
BLM	Sand Wash	Boat Ramp	800	50,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swasey Beach	Boat Ramp	2000	50,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Nefertiti	Boat Ramp	800	27,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Butler Rapid	Boat Ramp	800	27,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Mineral Bottom	Boat Ramp	800	30,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Green River State Park	Boat Ramp	800	25,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	n/a	25,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Golf Course	n/a	19,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No Action Alternative, Reach 3, Dry Flows:						1,520	1,727	2,266	3,151	6,140	4,819	1,326	1,366	1,520	1,751	1,819	1,441
BLM	Sand Wash	Boat Ramp	800	50,000	Critically Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swasey Beach	Boat Ramp	2000	50,000	Critically Dry	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No
	Nefertiti	Boat Ramp	800	27,000	Critically Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Butler Rapid	Boat Ramp	800	27,000	Critically Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Mineral Bottom	Boat Ramp	800	30,000	Critically Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

State of Utah	Green River State Park	Boat Ramp	800	25,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	n/a	25,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Golf Course	n/a	19,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No Action Alternative, Reach 3, Wet Flows:						4,328	4,770	6,420	11,478	23,500	25,688	9,383	4,450	3,911	4,785	5,076	4,791
BLM	Sand Wash	Boat Ramp	800	50,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swasey Beach	Boat Ramp	2000	50,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Nefertiti	Boat Ramp	800	27,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Butler Rapid	Boat Ramp	800	27,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Mineral Bottom	Boat Ramp	800	30,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Green River State Park	Boat Ramp	800	25,000	Wet	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	n/a	25,000	Wet	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
		Golf Course	n/a	19,000	Wet	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
						Percent of Time, Across All Years, Facilities Are Unavailable											
BLM	Sand Wash	Boat Ramp	800	50,000	All Years	0.3	0.8	0.7	0.1	0	0	1.6	0.8	1.0	0.1	0.2	1.2
	Swasey Beach	Boat Ramp	2000	50,000	All Years	29.4	18.1	4.8	0.7	0	1.2	24.7	34.7	35.9	16.2	15.8	24.5
	Nefertiti	Boat Ramp	800	27,000	All Years	0.3	0.8	0.8	0.1	5.1	7.7	1.8	0.8	1.0	0.1	0.2	1.2
	Butler Rapid	Boat Ramp	800	27,000	All Years	0.3	0.8	0.8	0.1	5.1	7.7	1.8	0.8	1.0	0.1	0.2	1.2
	Mineral Bottom	Boat Ramp	800	30,000	All Years	0.3	0.8	0.8	0.1	2.9	4.6	1.8	0.8	1.0	0.1	0.2	1.2
State of Utah	Green River State Park	Boat Ramp	800	25,000	All Years	0.3	0.8	0.8	0.2	7.6	11.4	1.8	0.8	1.0	0.1	0.2	1.2
		Campground	n/a	25,000	All Years	0	0	0.1	0	7.6	11.4	0.2	0	0	0	0	0
		Golf Course	n/a	19,000	All Years	0	0.2	0.3	0.7	23.6	31.8	1.0	0	0.1	0	0	0

B) Flaming Gorge Visitation:

As noted under methodology, visitation estimates by recreation activity and month at Flaming Gorge Reservoir were developed using a facility availability approach as opposed to the interpolation approach. Table 18 presents facility availability for the No Action Alternative average, wet, and dry conditions by site and facility (while not comparable to the rest of the analysis, table 18 also presents the percent of time each facility is unavailable by month across all years). Comparing end of month water levels by hydrologic condition from table 15 to the low end usability thresholds for each facility provides an estimate of monthly facility availability.

All facilities were expected to be available based on end of month water levels across all months under No Action Alternative average and wet conditions. However, under No Action Alternative dry conditions, several facilities are expected to be unusable. The Anvil Draw boat ramp has a low end usability threshold of 6020 and becomes unusable on average for all months except April during dry conditions. The Cedar Springs marina and boat ramp are expected to experience problems under dry conditions during January, February, May, and September through December. The Firehole boat ramp would only be available under dry conditions during March, April, and July. Finally, the Sunny Cove swim beach follows at pattern similar to Cedar Springs during dry conditions experiencing problems in January, February, May, and September through December.

Table 19, which immediately follows the facility availability table, presents results of a preliminary analysis on visitation for the No Action Alternative dry condition conducted without taking into consideration the potential for recreators moving or substituting to other facilities around the reservoir. The 533,940 visitation estimate reflects a lower bound given it assumes loss of a facility implies a complete loss of visitation from that facility. This information is not the focus of the analysis, but is presented as an indicator of the worst case scenario.

Table 20 presents the results of the with facility substitution analysis for the No Action Alternative dry condition. The No Action Alternative average and wet conditions indicated facility availability in all months such that visitation estimates would be equal to current conditions (572,290 visits). The facility substitution effects were developed based on discussions with Flaming Gorge Reservoir recreation managers (see notes at the end of the table). The table emphasizes changes at the four affected sites: Anvil Draw, Cedar Springs, Firehole, and Sunny Cove. Affected sites are defined as those that suffered some level of facility unavailability under the dry condition. For each recreation activity at each affected site and facility, the table presents visitation estimates by month which continue to occur at the facility, visitation estimates which substitute to other facilities along the reservoir, and the total visitation. The total visitation is simply at the site visitation plus the visitation which moves to other sites, so technically it does not apply only to the site in question. Given the site managers only indicated what percent of visitation lost at a given facility would substitute to all other available facilities, the analysis could not actually estimate total visitation at each site and facility. However, the information provided allowed for the development of visitation estimates by recreation activity across all sites. These estimates were considered to be sufficient for comparison between alternatives.

In addition to the affected site visitation estimates, visitation estimates for the unaffected sites are also included in table 20 to allow for calculation of total visitation across all sites and activities. The term "unaffected sites" is somewhat of a misnomer since several of these sites (i.e., Lucerne Valley, Squaw Hollow, Mustang Ridge, Buckboard Crossing) would probably be affected by the substitution from the "affected sites." The No Action Alternative dry condition visitation estimate is approximately 28,300 below that of current conditions (572,290) or a 4.9-percent decline. Nearly all of the loss (99%) occurred

Table 18: No Action Alternative, Flaming Gorge Reservoir Facility Availability by Site and Hydrologic Condition

Site	Facility	Low End Usability Threshold	Hydrologic Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Antelope Flat	Boat Ramp Swim Beach	6015 6012	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Anvil Draw	Boat Ramp	6020	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Buckboard Crossing	Marina Boat Ramp	6015 6000	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Cedar Springs	Marina Boat Ramp	6018 6018	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Firehole	Boat Ramp Swim Beach	6019 6012	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Hideout	Boat Camp	6014	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jarvies Canyon	Boat Camp	6012	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kingfisher Island	Boat Camp	6010	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	Average	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Mustang Ridge	Boat Ramp	6000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sheep Creek	Boat Ramp	6015	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Squaw Hollow	Boat Ramp	6015	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sunny Cove	Swim Beach	6018	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upper Marsh Creek	Boat Ramp	6000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CUT Through	Boat Channel	6022	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Antelope Flat	Boat Ramp Swim Beach	6015 6012	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Anvil Draw	Boat Ramp	6020	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Buckboard Crossing	Marina Boat Ramp	6015 6000	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Cedar Springs	Marina Boat Ramp	6018 6018	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Firehole	Boat Ramp Swim Beach	6019 6012	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Hideout	Boat Camp	6014	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jarvies Canyon	Boat Camp	6012	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kingfisher Island	Boat Camp	6010	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	Wet	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes

Mustang Ridge	Boat Ramp	6000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sheep Creek	Boat Ramp	6015	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Squaw Hollow	Boat Ramp	6015	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sunny Cove	Swim Beach	6018	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upper Marsh Creek	Boat Ramp	6000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CUT Through	Boat Channel	6022	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Antelope Flat	Boat Ramp Swim Beach	6015 6012	Dry	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Anvil Draw	Boat Ramp	6020	Dry	No	No	No	Yes	No	No	No	No	No	No	No	No
Buckboard Crossing	Marina Boat Ramp	6015 6000	Dry	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Cedar Springs	Marina Boat Ramp	6018 6018	Dry	No No	No No	Yes Yes	Yes Yes	No No	Yes Yes	Yes Yes	Yes Yes	No No	No No	No No	No No
Firehole	Boat Ramp Swim Beach	6019 6012	Dry	No Yes	No Yes	Yes Yes	Yes Yes	No Yes	No Yes	Yes Yes	No Yes	No Yes	No Yes	No Yes	No Yes
Hideout	Boat Camp	6014	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jarvies Canyon	Boat Camp	6012	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kingfisher Island	Boat Camp	6010	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	Dry	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Mustang Ridge	Boat Ramp	6000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sheep Creek	Boat Ramp	6015	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Squaw Hollow	Boat Ramp	6015	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sunny Cove	Swim Beach	6018	Dry	No	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No
Upper Marsh Creek	Boat Ramp	6000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CUT Through	Boat Channel	6022	Dry	No	No	No	No	No	No	No	No	No	No	No	No
				Percent of Time below Low End Threshold											
Antelope Flat	Boat Ramp Swim Beach	6015 6012	All Years	8.9 7.4	7.8 7.4	7.4 5.5	6.0 3.3	4.8 3.3	2.1 1.5	4.7 1.5	7.1 1.6	9.1 3.3	9.1 4.9	9.1 5.4	9.1 6.8
Anvil Draw	Boat Ramp	6020	All Years	12.2	12.2	12.3	9.7	15.9	11.2	12.7	12.6	12.6	12.7	12.5	12.5
Buckboard Crossing	Marina Boat Ramp	6015 6000	All Years	8.9 0.0	7.8 0.1	7.4 0.0	6.0 0.0	4.8 0.1	2.1 0.0	4.7 0.0	7.1 0.0	9.1 0.0	9.1 0.0	9.1 0.0	9.1 0.0
Cedar Springs	Marina Boat Ramp	6018 6018	All Years	10.4 10.4	10.4 10.4	8.1 8.1	7.4 7.4	10.5 10.5	8.2 8.2	9.2 9.2	9.2 9.2	10.5 10.5	10.7 10.7	10.7 10.7	10.7 10.7
Firehole	Boat Ramp Swim Beach	6019 6012	All Years	10.9 7.4	10.8 7.4	10.0 5.5	7.9 3.3	12.0 3.3	10.6 1.5	9.4 1.5	11.1 1.6	11.6 3.3	12.2 4.9	11.4 5.4	11.4 6.8
Hideout	Boat Camp	6014	All Years	7.9	7.6	7.4	5.1	4.4	1.6	2.1	5.0	7.9	9.1	8.5	8.2
Jarvies Canyon	Boat Camp	6012	All Years	7.4	7.4	5.5	3.3	3.3	1.5	1.5	1.6	3.3	4.9	5.4	6.8

Kingfisher Island	Boat Camp	6010	All Years	3.2	3.7	3.2	2.9	2.1	1.5	1.5	1.5	1.6	3.0	3.0	3.2
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	All Years	3.2 0.0 7.9	3.7 0.0 7.6	3.2 0.0 7.4	2.9 0.0 5.1	2.1 0.0 4.4	1.5 0.0 1.6	1.5 0.0 2.1	1.5 0.0 5.0	1.6 0.0 7.9	3.0 0.0 9.1	3.0 0.0 8.5	3.2 0.0 8.2
Mustang Ridge	Boat Ramp	6000	All Years	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sheep Creek	**Boat Ramp**	**6015**	**All Years**	**8.9**	**7.8**	**7.4**	**6.0**	**4.8**	**2.1**	**4.7**	**7.1**	**9.1**	**9.1**	**9.1**	**9.1**
Squaw Hollow	Boat Ramp	6015	All Years	8.9	7.8	7.4	6.0	4.8	2.1	4.7	7.1	9.1	9.1	9.1	9.1
Sunny Cove	Swim Beach	6018	All Years	10.4	10.4	8.1	7.4	10.5	8.2	9.2	9.2	10.5	10.7	10.7	10.7
Upper Marsh Creek	Boat Ramp	6000	All Years	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CUT Through	Boat Channel	6022	All Years	15.8	15.2	15.0	13.4	32.8	23.0	15.9	18.2	18.5	17.8	17.2	17.1

Table 19: No Action Alternative –Dry Condition, Flaming Gorge Reservoir Visitation by Affected Site and Recreation Activity Without Facility Substitution

Without Facility Substitution Analysis:

Site	Facility	Month	Power Boating/ Waterskiing	Boat Fishing	Camping	Swimming and Waterplay	Total
Anvil Draw	Boat Ramp	Jan	0	0		0	0
		Feb	0	0		0	0
		Mar	0	0		0	0
		Apr	72	96		0	168
		May	0	0		0	0
		June	0	0		0	0
		July	0	0		0	0
		Aug	0	0		0	0
		Sept	0	0		0	0
		Oct	0	0		0	0
		Nov	0	0		0	0
		Dec	0	0		0	0
		Total:	72	96		0	168
Cedar Springs	Marina	Jan	0	0			0
		Feb	0	0			0
		Mar	225	79			304
		Apr	1,798	629			2,427
		May	0	0			0
		June	6,508	2,278			8,786
		July	7,087	2,480			9,567
		Aug	4,114	1,440			5,554
		Sept	0	0			0
		Oct	0	0			0
		Nov	0	0			0
		Dec	0	0			0
		Total:	19,732	6,906			26,638
Cedar Springs	Boat Ramp	Jan	0	0			0
		Feb	0	0			0
		Mar	225	146			371
		Apr	1,798	1,169			2,967
		May	0	0			0
		June	6,508	4,230			10,738
		July	7,087	4,606			11,693
		Aug	4,114	2,674			6,788
		Sept	0	0			0
		Oct	0	0			0
		Nov	0	0			0
		Dec	0	0			0
		Total:	19,732	12,825			32,557
Firehole	Boat Ramp	Jan	0	0		6	6
		Feb	0	0		0	0
		Mar	20	15		26	61
		Apr	156	120		206	482
		May	0	0		552	552
		June	0	0		744	744
		July	616	472		810	1,898
		Aug	0	0		470	470
		Sept	0	0		270	270
		Oct	0	0		243	243
		Nov	0	0		63	63
		Dec	0	0		41	41
		Total:	792	607		3,431	4,830

Table 19: No Action Alternative –Dry Condition, Flaming Gorge Reservoir Visitation by Affected Site and Recreation Activity Without Facility Substitution (continued)

Without Facility Substitution Analysis:

Site	Facility	Month	Power Boating/ Waterskiing	Boat Fishing	Camping	Swimming and Waterplay	Total
Sunny Cove	Swim Beach	Jan				0	0
		Feb				0	0
		Mar				37	37
		Apr				300	300
		May				0	0
		June				1,085	1,085
		July				1,181	1,181
		Aug				686	686
		Sept				0	0
		Oct				0	0
		Nov				0	0
		Dec				0	0
		Total:				3,289	3,289
Total for All Affected Sites:		Jan	0	0	0	6	6
		Feb	0	0	0	0	0
		Mar	470	240	0	63	773
		Apr	3,824	2,014	0	506	6,344
		May	0	0	0	552	552
		June	13,016	6,508	0	1,829	21,353
		July	14,790	7,558	0	1,991	24,339
		Aug	8,228	4,114	0	1,156	13,498
		Sept	0	0	0	270	270
		Oct	0	0	0	243	243
		Nov	0	0	0	63	63
		Dec	0	0	0	41	41
		Total:	40,328	20,434	0	6,720	67,482
Total for All Unaffected Sites:		Jan	479	238	75	21	813
		Feb	0	0	0	0	0
		Mar	2,215	1,106	677	96	4,094
		Apr	17,708	8,856	1,761	771	29,096
		May	47,527	23,765	1,388	2,068	74,748
		June	64,101	32,054	1,863	2,789	100,807
		July	69,798	34,902	1,386	3,037	109,123
		Aug	40,522	20,263	1,174	1,763	63,722
		Sept	23,233	11,618	536	1,012	36,399
		Oct	20,910	10,456	674	911	32,951
		Nov	5,460	2,731	483	238	8,912
		Dec	3,517	1,760	357	154	5,788
		Total:	295,470	147,749	10,374	12,860	466,453
Overall Total :		Jan	479	238	75	27	819
		Feb	0	0	0	0	0
		Mar	2,685	1,346	677	159	4,867
		Apr	21,532	10,870	1,761	1,277	35,440
		May	47,527	23,765	1,388	2,620	75,300
		June	77,117	38,562	1,863	4,618	122,160
		July	84,588	42,460	1,386	5,028	133,462
		Aug	48,750	24,377	1,174	2,919	77,220
		Sept	23,233	11,618	536	1,282	36,669
		Oct	20,910	10,456	674	1,154	33,194
		Nov	5,460	2,731	483	301	8,975
		Dec	3,517	1,760	357	195	5,829
		Total:	335,798	168,183	10,374	19,580	533,935

Table 20: No Action Alternative - Dry Condition, Flaming Gorge Reservoir Visitation by Affected Site and Recreation Activity With Facility Substitution

With Facility Substitution Results:

Site	Facility	Month	Power Boating/ Waterskiing			Boat Fishing			Camping			Swimming and Waterplay			Total
			At Site	Substituted to Other Facilities	Total	At Site	Substituted to Other Facilities	Total	At Site	Substituted to Other Facilities	Total	At Site	Substituted to Other Facilities	Total	
Anvil Draw	Boat Ramp	Jan		2	2		3	3	0	0	0	0	0	0	5
		Feb		0	0		0	0	0	0	0	0	0	0	0
		Mar		9	9		12	12	0	0	0	0	0	0	21
		Apr	72		72	96		96	0	0	0	0	0	0	168
		May		193	193		257	257	0	0	0	0	0	0	450
		June		260	260		347	347	0	0	0	0	0	0	607
		July		283	283		378	378	0	0	0	0	0	0	661
		Aug		165	165		219	219	0	0	0	0	0	0	384
		Sept		94	94		126	126	0	0	0	0	0	0	220
		Oct		85	85		113	113	0	0	0	0	0	0	198
		Nov		22	22		30	30	0	0	0	0	0	0	52
		Dec		14	14		19	19	0	0	0	0	0	0	33
		Total:	72	1,128	1,200	96	1,504	1,600	0	0	0	0	0	0	2,800
Cedar Springs	Marina	Jan		5	5		2	2	0	0	0	0	0	0	7
		Feb	0		0	0		0	0	0	0	0	0	0	0
		Mar	225		225	79		79	0	0	0	0	0	0	304
		Apr	1798		1798	629		629	0	0	0	0	0	0	2,427
		May		483	483		169	169	0	0	0	0	0	0	652
		June	6508		6508	2278		2278	0	0	0	0	0	0	8,786
		July	7087		7087	2480		2480	0	0	0	0	0	0	9,567
		Aug	4114		4114	1440		1440	0	0	0	0	0	0	5,554
		Sept		236	236		83	83	0	0	0	0	0	0	319
		Oct		212	212		74	74	0	0	0	0	0	0	286
		Nov		55	55		19	19	0	0	0	0	0	0	74
		Dec		36	36		13	13	0	0	0	0	0	0	49
		Total:	19732	1027	20759	6906	360	7266	0	0	0	0	0	0	28,025
Cedar Springs	Boat Ramp	Jan		5	5		3	3	0	0	0	0	0	0	8
		Feb	0		0	0		0	0	0	0	0	0	0	0
		Mar	225		225	146		146	0	0	0	0	0	0	371
		Apr	1798		1798	1169		1169	0	0	0	0	0	0	2,967
		May		483	483		314	314	0	0	0	0	0	0	797
		June	6508		6508	4230		4230	0	0	0	0	0	0	10,738
		July	7087		7087	4606		4606	0	0	0	0	0	0	11,693
		Aug	4114		4114	2674		2674	0	0	0	0	0	0	6,788
		Sept		236	236		153	153	0	0	0	0	0	0	389
		Oct		212	212		138	138	0	0	0	0	0	0	350
		Nov		55	55		36	36	0	0	0	0	0	0	91
		Dec		36	36		23	23	0	0	0	0	0	0	59
		Total:	19732	1027	20759	12825	667	13492	0	0	0	0	0	0	34,251

Firehole	Boat Ramp	Jan		4	4		3	3	0	0	0	0	0	0	7
		Feb		0	0		0	0	0	0	0	0	0	0	0
		Mar	20		20	15		15	0	0	0	0	0	0	35
		Apr	156		156	120		120	0	0	0	0	0	0	276
		May		378	378		290	290	0	0	0	0	0	0	668
		June		509	509		391	391	0	0	0	0	0	0	900
		July	616		616	472		472	0	0	0	0	0	0	1,088
		Aug		322	322		247	247	0	0	0	0	0	0	569
		Sept		185	185		141	141	0	0	0	0	0	0	326
		Oct		167	167		128	128	0	0	0	0	0	0	295
		Nov		43	43		33	33	0	0	0	0	0	0	76
		Dec		30	30		22	22	0	0	0	0	0	0	50
		Total:	792	1,638	2,430	607	1,255	1,862	0	0	0	0	0	0	4,290
Sunny Cove	Swim Beach	Jan	0	0	0	0	0	0	0	0	0		7	7	7
		Feb	0	0	0	0	0	0	0	0	0		0	0	0
		Mar	0	0	0	0	0	0	0	0	0	37		37	37
		Apr	0	0	0	0	0	0	0	0	0	300		300	300
		May	0	0	0	0	0	0	0	0	0		683	683	683
		June	0	0	0	0	0	0	0	0	0	1,085		1,085	1,085
		July	0	0	0	0	0	0	0	0	0	1,181		1,181	1,181
		Aug	0	0	0	0	0	0	0	0	0	686		686	686
		Sept	0	0	0	0	0	0	0	0	0		334	334	334
		Oct	0	0	0	0	0	0	0	0	0		301	301	301
		Nov	0	0	0	0	0	0	0	0	0		78	78	78
		Dec	0	0	0	0	0	0	0	0	0		51	51	51
		Total:	0	0	0	0	0	0	0	0	0	3,289	1,454	4,743	4,743
Total for All Affected Sites:		Jan			16			11			0			7	34
		Feb			0			0			0			0	0
		Mar			479			252			0			37	768
		Apr			3,824			2,014			0			300	6,138
		May			1,537			1,030			0			683	3,250
		June			13,785			7,246			0			1,085	22,116
		July			15,073			7,936			0			1,181	24,190
		Aug			8,715			4,580			0			686	13,981
		Sept			751			503			0			334	1,588
		Oct			676			453			0			301	1,430
		Nov			175			118			0			78	371
		Dec			114			77			0			51	242
		Total:			45,145			24,220			0			4,743	74,108

Total for All Unaffected Sites:		Jan			479			238			75			27	819
		Feb			0			0			0			0	0
		Mar			2,215			1,106			677			122	4,120
		Apr			17,708			8,856			1,761			977	29,302
		May			47,527			23,765			1,388			2,620	75,300
		June			64,101			32,054			1,863			3,533	101,551
		July			69,798			34,902			1,386			3,847	109,933
		Aug			40,522			20,263			1,174			2,233	64,192
		Sept			23,233			11,618			536			1,282	36,669
		Oct			20,910			10,456			674			1,154	33,194
		Nov			5,460			2,731			483			201	8,975
		Dec			3,517			1,760			357			195	5,829
		Total:			29,5470			147,749			10,374			16,291	469,884
Overall Total:		Jan			495			249			75			34	853
		Feb			0			0			0			0	0
		Mar			2,694			1,358			677			159	4888
		Apr			21,532			10,870			1761			1277	35440
		May			49,064			24,795			1388			3303	78550
		June			77,886			39,300			1863			4618	123667
		July			84,871			42,838			1386			5028	134123
		Aug			49,237			24,843			1174			2919	78173
		Sept			23,984			12,121			536			1616	38257
		Oct			21,586			10,909			674			1455	34624
		Nov			5,635			2,849			483			379	9346
		Dec			3,631			1,837			357			246	6071
		Total:			340,615			171,969			10374			21034	543992

Notes:

1) Anvil Draw Boat Ramp: All visitation losses at Anvil Draw could be completely absorbed by Lucerne Valley and Squaw Hollow boat ramps. Therefore, the loss identified via the without facility substitution analysis would not materialize. True Loss: 0%

2) Cedar Springs Marina and Boat Ramp: Lucerne Valley and Mustang Ridge could absorb only about 10% of the losses at Cedar Springs. Ninety percent of the without facility substitution losses would likely move to another reservoir. True Loss: 90%

3) Firehole Boat Ramp: Antelope Flat, Buckboard Crossing, and Lucerne Valley would likely absorb 90% of the losses at Firehole as identified in the without substitution analysis. True Loss: 10%

4) Sunny Cove Swim Beach: Even when water drops below the edge of the sand at Sunny Cove, most swimmers would cross the mud flats or use other beach such that the swimming loss would not be severe. True Loss: 15%

to power boating (18,660 lost visits) and boat fishing (9,380 lost visits). Comparing the total visitation estimates across activities with facility substitution (approximately 543,990) to those without facility substitution (approximately 533,940) indicates that only about 10,055 visits would substitute to other facilities along the reservoir. The amount of substitution reflects only about 26 percent of the total without facility substitution loss. Nearly all (98%) of the unabsorbed visitation losses stem from the Cedar Springs facilities.

C) Total River and Reservoir Visitation:

Table 21 presents information on water based visitation combined for both the Green River and Flaming Gorge Reservoir for the No Action Alternative under average, wet, and dry conditions. Reservoir visitation accounts for anywhere from 86.1 to 96.1 percent of the total depending on the hydrologic condition. The average condition is slightly less than current visitation (-9000 visits or 1.4%). The percentage loss in total water based visitation compared to average conditions is 2.1% for the wet condition and 13.7% for the dry condition. The Green River losses account for 100% of the difference during wet conditions and 68.4% of the losses during dry conditions. So despite reflecting only a relatively small percent of total water based visitation, Green River losses account for the majority of the impact compared to the average condition.

Table 21: Total Water Based Visitation for Green River and Flaming Gorge Reservoir for No Action Alternative

			Visitation by Hydrologic Condition						
			Average	Wet			Dry		
					Change from Average Condition			Change from Average Condition	
Site	Recreation Activity	Current Visits	Visits	Visits	Visits	%	Visits	Visits	%
Green River	Scenic Floating	24,768	20,885	20,349	-536	-2.6	85	-20,800	-99.6
	Guide Boat Fishing	11,400	10,108	7,548	-2,560	-25.3	3,606	–6,502	-64.3
	Private Boat Fishing	18,531	16,309	13,360	-2,949	-18.1	7,600	-8,709	-53.4
	Shoreline Fishing/Trail Use	35,482	33,927	26,722	-7,205	-21.2	10,509	-23,418	-69.0
	Boat Based Camping	2,281	2,229	1,674	-555	-24.9	458	-1,771	-79.5
	Total:	92,461	83,458	69,653	-13,805	-16.5	22,258	-61,200	-73.3
Flaming Gorge Reservoir	Power Boating/ Waterskiing	359,278	359,278	359,278	0	0	340,615	-18,663	-5.2
	Boat Fishing	181,348	181,348	181,348	0	0	171,969	-9,379	-5.2
	Boat Based Camping	10,374	10,374	10,374	0	0	10,374	0	0
	Swimming/ Waterplay	21,291	21,291	21,291	0	0	21,034	-257	-1.2
	Total:	572,291	572,291	572,291	0	0	543,992	-28,299	-4.9
Both Sites	Combined Total:	664,752	655,749	641,944	-13,805	-2.1	566,250	-89,499	-13.7

3.2.1.1.3 Recreation Value –

A) Green River Valuation:

Table 22 presents value per visit and total value by month and activity for the No Action Alternative under average, wet, and dry conditions. Determining where monthly No Action Alternative flows by hydrologic condition fall within the range of data points allows for interpolation of the per visit value by activity. For example, looking at table 14, compare average condition flows for March to the annual flow oriented data points for the valuation analysis at the bottom of the table. The 1,484 average condition flow falls between the valuation analysis data point current flow and preferred flow levels. As a result, the value per visit for No Action Alternative March average condition in table 22 also falls between current and preferred values per visit. The percentage of the distance the No Action March average flows fall between preferred and current flows is used to calculate the value per visit. Applying the values per visit to the visitation estimates in table 16 results in the total value estimates.

The No Action Alternative average condition total valuation is estimated at nearly $ 4 million ($3,965.7 thousand). This reflects a decline of about $830 million or 17.3 percent compared to current conditions. wet conditions imply a further $206 million or 5.2 percent decline compared to average conditions. Finally, No Action Alternative dry conditions result in a dramatic decline of more than $3.1 million or nearly 80 percent compared to average conditions.

B) Flaming Gorge Valuation:

The Flaming Gorge Reservoir valuation analysis used a similar interpolation approach as the Green River valuation analysis. As a result, the reservoir valuation analysis applies value per visit estimates by activity derived from interpolation to visitation estimates by activity derived from a facility availability approach.

As indicated in table 23, the No Action Alternative average condition value of nearly $21.4 million exceeds current condition values by over $7.4 million or 53 percent. Current water levels for the survey period (table 1) fall in the 6020 to 6021 range, whereas the No Action Alternative flows for the average condition (table 15) fall in the 6024 to 6029 range. The facility availability approach indicates no difference in average condition visitation since all facilities were available in all months in both cases. Herein lies a disadvantage of the facility availability approach, when facilities are available under two varying scenarios, the approach fails to detect potential increases in visitation as water levels rise. The interpolation based valuation analysis is more sensitive to water level changes thereby resulting in the differential.

Compared to the average condition, the No Action Alternative wet and dry conditions both result in declining values. Wet conditions result in nearly a $5.2 million loss (24.1%), whereas dry conditions result in a $16.4 million loss (76.6% decline) compared to average conditions.

C) Total River and Reservoir Valuation:

Table 24 presents information on water based valuation combined for both the Green River and Flaming Gorge Reservoir for the No Action Alternative under average, wet, and dry conditions. Reservoir valuation accounts for anywhere from 81.2 to 86.2 percent of total value depending on the hydrologic condition. The average condition is significantly greater than current valuation (increase of nearly

Table 22: No Action Alternative, Green River Reach 1 Average Monthly Value per Visit by Hydrologic Condition

		Interpolation Data Points					No Action Alternative Values					
							Per Visit			Total ($1,000s)		
Month	Recreation Activity	Low End Threshold Values	Current Values	Preferred Values	High End Kink Values	High End Threshold Values	Average	Wet	Dry	Average	Wet	Dry
March	Scenic Floating	0	46.8	94.35	46.8	0	63.95	82.30	0	2.9	4.1	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	197.76	235.87	0	61.3	78.3	0
	Private Boat Fishing	0	37.44	69.91	37.44	0	45.71	66.53	0	63.4	97.3	0
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	29.55	30.70	0	69.7	73.8	0
	Camping	0	10.78	14.13	10.78	0	12.18	13.74	0	0	0	0
	Total:									197.3	253.6	0
April	Scenic Floating	0	46.8	94.35	46.8	0	93.20	59.54	0	25.1	13.6	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	216.85	82.91	0	385.3	101.7	0
	Private Boat Fishing	0	37.44	69.91	37.44	0	54.93	13.94	0	197.0	31.0	0
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	26.82	7.96	0	194.5	23.5	0
	Camping	0	10.78	14.13	10.78	0	13.54	7.24	0	0	0	0
	Total:									801.9	169.9	0
May	Scenic Floating	0	46.8	94.35	46.8	0	54.16	0	60.23	1.7	0	2.7
	Guide Boat Fishing	0	182.94	239.62	182.94	0	50.38	0	187.80	21.8	0	318.1
	Private Boat Fishing	0	37.44	69.91	37.44	0	7.35	0	39.43	4.3	0	123.1
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	4.68	0	26.81	4.6	0	150.6
	Camping	0	10.78	14.13	10.78	0	2.19	0	11.86	0	0	0
	Total:									32.3	0	594.5
June	Scenic Floating	0	46.8	94.35	46.8	0	77.57	0	0	491.5	0	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	185.89	0	0	410.6	0	0
	Private Boat Fishing	0	37.44	69.91	37.44	0	36.02	0	0	66.1	0	0
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	18.99	0	0	111.4	0	0
	Camping	0	10.78	14.13	10.78	0	12.09	0	0	8.3	0	0
	Total:									1,087.9	0	0
July	Scenic Floating	0	46.8	94.35	46.8	0	9.75	51.37	0	59.9	591.2	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	46.73	125.33	0	70.2	233.2	0
	Private Boat Fishing	0	37.44	69.91	37.44	0	7.88	24.31	0	9.7	38.4	0
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	7.84	18.60	0	52.5	162.8	0
	Camping	0	10.78	14.13	10.78	0	5.67	11.10	0	3.2	7.4	0
	Total:									195.5	1,033.0	0

Aug	Scenic Floating	0	46.8	94.35	46.8	0	53.63	66.03	0	427.9	560.0	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	143.81	203.33	27.89	269.9	409.3	14.5
	Private Boat Fishing	0	37.44	69.91	37.44	0	28.17	49.22	3.94	42.3	78.8	1.2
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	21.13	31.09	5.26	128.2	229.6	10.2
	Camping	0	10.78	14.13	10.78	0	11.29	12.35	3.66	6.9	7.8	.7
	Total:									875.3	1,285.5	26.7
Sept	Scenic Floating	0	46.8	94.35	46.8	0	59.08	70.82	27.96	3.9	5.0	.9
	Guide Boat Fishing	0	182.94	239.62	182.94	0	184.71	216.14	67.01	302.2	377.2	71.8
	Private Boat Fishing	0	37.44	69.91	37.44	0	37.49	57.29	12.12	192.1	311.2	39.2
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	25.96	33.94	10.61	92.9	142.2	22.7
	Camping	0	10.78	14.13	10.78	0	11.76	12.76	7.83	4.3	4.7	2.0
	Total:									595.3	840.3	136.6
Oct	Scenic Floating	0	46.8	94.35	46.8	0	71.49	90.14	27.96	.7	1.0	.3
	Guide Boat Fishing	0	182.94	239.62	182.94	0	217.92	224.97	67.01	79.5	83.2	21.4
	Private Boat Fishing	0	37.44	69.91	37.44	0	58.41	59.88	12.12	61.7	63.5	11.3
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	33.75	28.48	10.61	38.1	29.5	8.5
	Camping	0	10.78	14.13	10.78	0	12.82	13.92	7.83	0	0	0
	Total:									180.2	177.3	41.5
Total	Scenic Floating									1,013.6	1,174.9	3.8
	Guide Boat Fishing									1,600.9	1,283.0	425.9
	Private Boat Fishing									636.7	620.2	174.8
	Shore Fishing/Trail Use									691.8	661.4	192.1
	Camping									22.7	20.0	2.8
	Total:									3,965.7	3,759.5	799.3

Table 23: No Action Alternative, Flaming Gorge Reservoir Monthly Values per Visit by Hydrologic Condition

		Interpolation Data Points					No Action Alternative Values					
							Per Visit			Total ($1,000s)		
Month	Recreation Activity	Low End Threshold Values	Current Values	Preferred Values	High End Kink Values	High End Threshold Values	Average	Wet	Dry	Average	Wet	Dry
Jan	Power Boating/Skiing	0	25.71	46.22	25.71	0	33.89	43.86	4.02	19.8	25.6	2.0
	Boat Fishing	0	25.21	37.92	25.21	0	30.22	36.31	0.65	8.9	10.6	.2
	Boat Camping	0	13.06	22.23	13.06	0	16.79	21.28	0.97	1.3	1.6	.1
	Swimming/Waterplay	0	1.44	10.41	1.44	0	5.06	9.48	0	.2	.3	0
	Total:									30.0	38.1	2.2
Feb	Power Boating/Skiing	0	25.71	46.22	25.71	0	33.10	40.45	6.31	0	0	0
	Boat Fishing	0	25.21	37.92	25.21	0	29.73	34.23	3.25	0	0	0
	Boat Camping	0	13.06	22.23	13.06	0	16.43	19.75	2.26	0	0	0
	Swimming/Waterplay	0	1.44	10.41	1.44	0	4.72	7.97	0.15	0	0	0
	Total:									0	0	0
March	Power Boating/Skiing	0	25.71	46.22	25.71	0	33.10	43.33	13.19	89.2	116.7	35.5
	Boat Fishing	0	25.21	37.92	25.21	0	29.73	35.99	11.04	40.4	48.9	15.0
	Boat Camping	0	13.06	22.23	13.06	0	16.43	21.05	6.13	11.1	14.3	4.2
	Swimming/Waterplay	0	1.44	10.41	1.44	0	4.72	9.25	0.61	.8	1.5	.1
	Total:									141.4	181.3	54.8
April	Power Boating/Skiing	0	25.71	46.22	25.71	0	33.37	44.91	19.50	718.5	967.0	419.9
	Boat Fishing	0	25.21	37.92	25.21	0	29.89	36.96	18.18	324.9	401.8	197.6
	Boat Camping	0	13.06	22.23	13.06	0	16.55	21.76	9.68	29.1	38.3	17.0
	Swimming/Waterplay	0	1.44	10.41	1.44	0	4.83	9.95	1.03	6.2	12.7	1.3
	Total:									1,078.7	1,419.8	635.9
May	Power Boating/Skiing	0	25.71	46.22	25.71	0	32.58	44.90	5.16	1,882.9	2,594.9	253.2
	Boat Fishing	0	25.21	37.92	25.21	0	29.41	37.24	1.95	858.0	1,086.3	48.4
	Boat Camping	0	13.06	22.23	13.06	0	16.20	21.33	1.61	22.5	29.6	2.2
	Swimming/Waterplay	0	1.44	10.41	1.44	0	4.48	9.55	0.08	15.3	32.7	.3
	Total:									2,778.6	3,743.5	304.0
June	Power Boating/Skiing	0	25.71	46.22	25.71	0	39.92	37.29	10.33	3,111.5	2,906.5	804.6
	Boat Fishing	0	25.21	37.92	25.21	0	33.91	32.02	7.79	1,334.1	1,259.8	306.2
	Boat Camping	0	13.06	22.23	13.06	0	19.51	17.2	4.52	36.3	32.0	8.4
	Swimming/Waterplay	0	1.44	10.41	1.44	0	7.74	5.58	0.42	35.7	25.8	1.9
	Total:									4,517.7	4,224.1	1,121.1

July	Power Boating/Skiing	0	25.71	46.22	25.71	0	45.89	23.57	14.92	3894.7	2000.4	1266.3
	Boat Fishing	0	25.21	37.92	25.21	0	37.92	18.01	12.99	1624.4	771.5	556.5
	Boat Camping	0	13.06	22.23	13.06	0	21.87	5.80	7.10	30.3	8.0	9.8
	Swimming/Waterplay	0	1.44	10.41	1.44	0	10.06	0.66	0.72	50.6	3.3	3.6
	Total:									5600.0	2783.3	1836.2
Aug	Power Boating/Skiing	0	25.71	46.22	25.71	0	45.96	20.00	10.33	2264.6	985.5	508.6
	Boat Fishing	0	25.21	37.92	25.21	0	37.60	13.51	7.79	935.1	336.0	193.5
	Boat Camping	0	13.06	22.23	13.06	0	22.23	3.39	4.52	26.1	4.0	5.3
	Swimming/Waterplay	0	1.44	10.41	1.44	0	10.41	0.39	0.42	30.4	1.1	1.2
	Total:									3256.2	1326.6	708.7
Sept	Power Boating/Skiing	0	25.71	46.22	25.71	0	44.38	23.57	6.88	1253.7	665.9	165.0
	Boat Fishing	0	25.21	37.92	25.21	0	36.64	18.01	3.90	522.5	256.8	47.3
	Boat Camping	0	13.06	22.23	13.06	0	21.52	5.80	2.58	11.5	3.1	1.4
	Swimming/Waterplay	0	1.44	10.41	1.44	0	9.71	0.66	0.19	16.3	1.1	.3
	Total:									1804.0	926.9	214.0
Oct	Power Boating/Skiing	0	25.71	46.22	25.71	0	42.28	26.70	3.44	1075.0	678.9	74.3
	Boat Fishing	0	25.21	37.92	25.21	0	35.35	23.41	0	453.7	300.4	0
	Boat Camping	0	13.06	22.23	13.06	0	20.57	8.71	0.65	13.9	5.9	.4
	Swimming/Waterplay	0	1.44	10.41	1.44	0	8.78	1.00	0	13.2	1.5	0
	Total:									1555.8	986.7	74.7
Nov	Power Boating/Skiing	0	25.71	46.22	25.71	0	39.14	33.32	4.59	259.8	221.2	25.9
	Boat Fishing	0	25.21	37.92	25.21	0	33.43	29.3	1.30	112.1	98.2	3.7
	Boat Camping	0	13.06	22.23	13.06	0	19.15	15.04	1.29	9.2	7.3	.6
	Swimming/Waterplay	0	1.44	10.41	1.44	0	7.39	3.51	0.04	2.9	1.4	0
	Total:									384.0	328.0	30.2
Dec	Power Boating/Skiing	0	25.71	46.22	25.71	0	35.99	41.92	3.44	153.9	179.3	12.5
	Boat Fishing	0	25.21	37.92	25.21	0	31.50	35.20	0	68.0	76.0	0
	Boat Camping	0	13.06	22.23	13.06	0	17.74	19.71	0.65	6.3	7.0	.2
	Swimming/Waterplay	0	1.44	10.41	1.44	0	5.99	7.99	0	1.5	2.0	0
	Total:									229.8	264.4	12.7
Total	Power Boating/Skiing									14723.6	11341.7	3567.6
	Boat Fishing									6281.9	4646.3	1368.2
	Boat Camping									197.8	151.1	49.7
	Swimming/Waterplay									173.1	83.5	8.8
	Total:									21376.3	16222.6	4994.4

Table 24: Total Water Based Valuation for Green River and Flaming Gorge Reservoir for No Action Alternative									
			Valuation by Hydrologic Condition						
			Average	Wet			Dry		
					Change from Average Condition			Change from Average Condition	
Site	Recreation Activity	Current Values	Values	Values	Values	%	Values	Values	%
Green River	Scenic Floating	1,159.2	1,013.6	1,174.9	161.3	15.9	3.8	-1,009.8	-99.6
	Guide Boat Fishing	2,085.5	1,600.9	1,283.0	-317.9	-19.9	425.9	-1,175.0	-73.4
	Private Boat Fishing	693.8	636.7	620.2	-16.5	-2.6	174.8	-461.9	-72.6
	Shoreline Fishing/ Trail Use	833.5	691.8	661.4	-30.4	-4.4	192.1	-499.7	-72.2
	Boat Based Camping	24.6	22.7	20.0	-2.7	-11.9	2.8	-19.9	-87.7
	Total:	4,796.5	3,965.7	3,759.5	-206.2	-5.2	799.3	-3,166.4	-79.8
Flaming Gorge Reservoir	Power Boating/ Waterskiing	9,237.0	14,723.6	11,341.7	-3,381.9	-23.0	3,567.6	-11,156.0	-75.8
	Boat Fishing	4,571.8	6,281.9	4,646.3	-1,635.6	-26.0	1,368.2	-4,913.7	-78.2
	Boat Based Camping	135.5	197.8	151.1	-46.7	-23.6	49.7	-148.1	-74.9
	Swimming/ Waterplay	30.7	173.1	83.5	-89.6	-51.8	8.8	-164.3	-94.9
	Total:	13,975.0	21,376.3	16,222.6	-5,153.7	-24.1	4,994.4	-16,381.9	-76.6
Both Sites	Combined Total:	18,771.5	25,342.0	19,982.1	-5,359.9	-21.2	5,793.7	-19,548.3	-77.1

$6.6 million or 25.9%), whereas wet and dry conditions fall below the average condition. The percentage loss in total water based valuation compared to average conditions is 21.2% for the wet condition and 77% for the dry condition. Losses at Flaming Gorge Reservoir account for about 96% and 84% of the differential from average conditions for wet and dry conditions respectively.

3.2.1.2 Action Alternative

The Flaming Gorge EIS has one action alternative based on the flows suggested in the 2000 Flow and Temperature Recommendation Report (Muth et al., 2000).

3.2.1.2.1 Hydrologic Conditions –

A) Green River Flows

Table 25 presents average flows by month for the Action Alternative under average, wet, and dry hydrologic conditions as obtained from the hydrology model. Information is also presented on the difference between the Action and No Action Alternatives in terms of flows (cfs) and percentages. Also included in the table are the five flow data points used in the interpolations.

Table 25: Action Alternative Green River Reach One Flows by Hydrologic Condition and Month

Month	Recreation Activity	Interpolation Data Points					Action Alternative								
							Average Condition			Wet Condition			Dry Condition		
		Low End Threshold Flows	Current Flows	Preferred Flows	High End Kink Flows	High End Threshold Flows	Average Monthly Flows	Change from No Action		Average Monthly Flows	Change from No Action		Average Monthly Flows	Change from No Action	
								Cfs	%		Cfs	%		Cfs	%
		Monthly Oriented Flow Data Points for Visitation Analysis Interpolation													
March	Scenic Floating	953	1036.0	2170	3786.7	3905	1270	-214	-14.4	2030	132	7.0	800	0	0
	Guide Boat Fishing	854	" "	1837	3380.3	3731	" "			" "			" "		
	Private Boat Fishing	879	" "	1808	3343.7	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	" "	1624	3158.4	3709	" "			" "			" "		
	Camping	836	" "	2000	3273.7	3538	" "			" "			" "		
April	Scenic Floating	953	1145.0	2170	3631.3	3905	1904	-303	-13.7	3981	691	21.0	800	0	0
	Guide Boat Fishing	854	" "	1837	3170.3	3731	" "			" "			" "		
	Private Boat Fishing	879	" "	1808	3126.9	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	" "	1624	2874.0	3709	" "			" "			" "		
	Camping	836	" "	2000	3129.7	3538	" "			" "			" "		
May	Scenic Floating	953	1954.0	2170	2478.0	3905	3233	-230	-6.7	5537	437	8.6	800	-600	-42.9
	Guide Boat Fishing	854	1504.3	1837	" "	3731	" "			" "			" "		
	Private Boat Fishing	879	1471.2	1808	" "	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	1296.7	1624	" "	3709	" "			" "			" "		
	Camping	836	1638.2	2000	" "	3538	" "			" "			" "		
June	Scenic Floating	953	1215.2	2170	3531.2	3905	3862	1152	42.5	7038	1121	19.0	893	93	11.6
	Guide Boat Fishing	854	" "	1837	3035.1	3731	" "			" "			" "		
	Private Boat Fishing	879	" "	1808	2987.3	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	" "	1624	2690.8	3709	" "			" "			" "		
	Camping	836	" "	2000	3037.0	3538	" "			" "			" "		
July	Scenic Floating	953	1007.0	2170	3828.0	3905	2185	1202	122.2	4600	3400	283.3	893	93	11.6
	Guide Boat Fishing	854	" "	1837	3436.2	3731	" "			" "			" "		
	Private Boat Fishing	879	" "	1808	3401.4	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	" "	1624	3234.1	3709	" "			" "			" "		
	Camping	836	" "	2000	3312.1	3538	" "			" "			" "		
Aug	Scenic Floating	953	1122.2	2170	3663.7	3905	1626	375	29.9	2131	600	39.2	906	-25	-2.7
	Guide Boat Fishing	854	" "	1837	3214.2	3731	" "			" "			" "		
	Private Boat Fishing	879	" "	1808	3172.1	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	" "	1624	2933.3	3709	" "			" "			" "		
	Camping	836	" "	2000	3159.8	3538	" "			" "			" "		

Sept	Scenic Floating	953	1118.0	2170	3669.7	3905	1639	265	19.3	2239	600	36.6	939	-100	-9.6
	Guide Boat Fishing	854	" "	1837	3222.3	3731	" "			" "			" "		
	Private Boat Fishing	879	" "	1808	3180.5	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	" "	1624	2944.3	3709	" "			" "			" "		
	Camping	836	" "	2000	3165.3	3538	" "			" "			" "		
Oct	Scenic Floating	953	1024.0	2170	3803.8	3905	1487	-167	-10.1	2172	97	4.7	800	-239	-23.0
	Guide Boat Fishing	854	" "	1837	3403.5	3731	" "			" "			" "		
	Private Boat Fishing	879	" "	1808	3367.6	3656	" "			" "			" "		
	Shore Fishing/Trail Use	825	" "	1624	3189.7	3709	" "			" "			" "		
	Camping	836	" "	2000	3289.6	3538	" "			" "			" "		
		Annually Oriented Flow Data Points for Valuation Analysis Interpolation													
		Low End Threshold Flow	Annual Current Flow	Preferred Flow	Annual High End Kink Flow	High End Threshold Flow									
All Months	Scenic Floating	953	1096.9	2170	3699.8	3905	Monthly Flow Information as above.								
	Guide Boat Fishing	854	1359.0	1837	2757.9	3731									
	Private Boat Fishing	879	1373.3	1808	2678.7	3656									
	Shore Fishing/Trail Use	825	1298.6	1624	2473.1	3709									
	Camping	836	1115.5	2000	3168.7	3538									

Comparing the alternative flows to the data points indicates where the alternative flow falls within the inverted U-shaped flow distribution. For example, the Action Alternative average condition flow for March of 1,270 falls between the current flow data point (1,036 or 1,096.9) and the preferred flow data point (2,170) for scenic floating. The scenic floating visitation and value interpolation for the Action Alternative March average condition would therefore also result in estimates falling between the current and preferred visit and value data points. Also note that the Action Alternative March average condition flow is 214 cfs less than the No Action Alternative. This implies that the Action Alternative March average condition visitation and value estimates will be less than those of the No Action Alternative since No Action Alternative March flows are closer to the preferred flow. Generally speaking, the closer an alternative's flow is to the preferred flow, the higher the visitation and value estimate.

Comparing the average condition flows between the Action and No Action Alternatives indicates that from June through September, Action Alternative average flows exceed No Action flows. The largest differences occur in June and July where the Action Alternative flow exceeds the No Action Alternative flow by more than 1,000 cfs.

During wet conditions, Action Alternative flows exceed No Action Alternative flows across the entire March through October period. The largest difference occurs in July where the Action Alternative exceeds the No Action Alternative by 3,400 cfs or 283 percent.

During dry conditions, the difference between the alternatives is less severe in terms of both cfs and percentage. In 4 of the 8 studied months (May, August, September, October), No Action Alternative average monthly flows exceed those of the action alternative. The largest difference (-600 cfs, -42.9%) occurs in May.

B) Flaming Gorge Reservoir Water Levels:

Table 26 presents end of month water levels for the Action Alternative under average, wet, and dry hydrologic conditions as obtained from the hydrology model. Information is also presented on the difference between the Action and No Action Alternatives in terms of water levels.

Comparing average condition end of month water levels between the Action and No Action alternatives indicates very little difference between the two alternatives. The largest difference occurs in May with the Action Alternative only 2 feet higher than the No Action.

Water levels under wet conditions were not evaluated within the recreation visitation analysis since they do not create any problems in terms of recreation access on the reservoir. However, water level differences were evaluated via the interpolation procedure in the reservoir valuation analysis. Action Alternative water levels fell below those of the No Action Alternative in 8 of 12 months, with the most significant differences being in July through November.

Under dry conditions, Action Alternative water levels exceed those of the No Action across all months. The differences between the alternatives range from a low of 2.9 feet to a high of 6.0 feet. These differences are substantially greater than those seen under average conditions and may be more significant given the lower water levels.

Table 26: Action Alternative Flaming Gorge Reservoir Water Levels by Hydrologic Condition and Month

Month	Recreation Activity	Annually Oriented Water Level (WL) Data Points for Valuation Analysis Interpolation					Action Alternative Water Levels					
							Average Condition		Wet Condition		Dry Condition	
		Low End Threshold WL	Annual Current WL	Preferred WL	Annual High End Kink WL	High End Threshold WL	Average Monthly Water Levels	Change from No Action (Feet)	Average Monthly Water Levels	Change from No Action (Feet)	Average Monthly Water Levels	Change from No Action (Feet)
January	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.8	1.5	6028.4	.3	6023.4	6.0
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
February	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.7	1.7	6028.0	1.2	6023.7	5.9
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
March	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.8	1.8	6027.9	0	6023.5	4.5
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
April	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6026.0	1.9	6028.5	0	6023.0	2.9
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
May	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.8	2.0	6029.2	-.2	6022.8	5.2
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
June	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6027.8	1.2	6030.3	-1.4	6024.5	6.0
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
July	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6029.2	.1	6030.7	-4.8	6024.7	5.4
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
August	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6028.4	-.5	6030.5	-5.5	6023.8	5.3
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						

September	Power Boating/Skiing Boat Fishing Boat Camping Swimming/Waterplay	6016.7 6017.3 6017.1 6017.4	6021.2 6021.2 6021.1 6021.2	6029.0 6029.1 6028.9 6028.9	6035.2 6034.7 6034.0 6034.1	6038.8 6037.5 6036.7 6036.7	6027.4	-.9	6030.0	-5.5	6023.2	5.3
October	Power Boating/Skiing Boat Fishing Boat Camping Swimming/Waterplay	6016.7 6017.3 6017.1 6017.4	6021.2 6021.2 6021.1 6021.2	6029.0 6029.1 6028.9 6028.9	6035.2 6034.7 6034.0 6034.1	6038.8 6037.5 6036.7 6036.7	6026.8	-.7	6029.8	-5.1	6023.1	5.8
November	Power Boating/Skiing Boat Fishing Boat Camping Swimming/Waterplay	6016.7 6017.3 6017.1 6017.4	6021.2 6021.2 6021.1 6021.2	6029.0 6029.1 6028.9 6028.9	6035.2 6034.7 6034.0 6034.1	6038.8 6037.5 6036.7 6036.7	6026.5	.2	6029.5	-3.4	6023.3	5.8
December	Power Boating/Skiing Boat Fishing Boat Camping Swimming/Waterplay	6016.7 6017.3 6017.1 6017.4	6021.2 6021.2 6021.1 6021.2	6029.0 6029.1 6028.9 6028.9	6035.2 6034.7 6034.0 6034.1	6038.8 6037.5 6036.7 6036.7	6026.1	1.0	6029.1	-1.2	6023.3	6.0

3.2.1.2.2 Annual Recreation Visitation and Infrastructure Impacts –

A) Green River Visitation:

Table 27 presents the results of the Green River visitation analysis for the Action Alternative. Visitation estimates were developed for the Action Alternative by month and recreation activity. In addition, a comparative analysis is made to the No Action Alternative in terms changes in number of visits and percentage.

For the Action Alternative average condition, the 85.200 plus visitation estimate is slightly above the No Action Alternative average condition estimate by 1.770 visits or 2.1 percent. Looking at the individual activities, the gains in visitation for scenic floating and shoreline fishing/trail use somewhat outweigh the losses in guide boat fishing, private boat fishing, and camping.

Within the interpolation analysis, the closer a flow is to the preferred flow level (in percentage terms), the higher the visitation estimate. Comparing the average condition Action Alternative flows (table 25) and the average condition No Action Alternative flows (table 14, also derivable from table 25) to the visitation analysis oriented data points across the various months, it becomes evident that in some months the Action Alternative average condition is clearly an improvement over the No Action while in other months the reverse is true. For example, the months of May, August, and September have Action Alternative average monthly flows which are clearly closer to the preferred flow for all activities compared to the No Action Alternative. Conversely, the months of March, June, and October are clearly closer to the preferred flow under No Action average conditions. The months of April and July are ambiguous because the flows fall on either side of the preferred level (e.g., the April No Action flow of 2,207 falls above the preferred flow of 2,170 whereas the Action Alternative April flow of 1,904 falls below the preferred flow). The formula calculates visitation based on the percentage of the distance between data points, in April it turns out that the No Action Alternative average condition flow of 2,207 is closer on a percentage basis than the Action Alternative flow of 1,904. While one could guess that the 2,207 was closer to the preferred flow based simply on the numeric difference (2,207-2,170 = 37 versus 2,170-1,904 = 266), the assumption that the closer the numeric difference implies a higher the visitation estimate does not always hold since we are working with percentages. Hypothetically, let’s say that the difference between the preferred flow and the high end kink was only 100 cfs, but the difference between the preferred flow and the current flow was 1,000 cfs. Note that widely divergent locations for the high end kink and current conditions did result in some cases from the survey data. In such a case, the Action Alternative flow would be closer to the preferred flow on a percentage basis (37/100 = 37% versus 226/1,000 = 22.6%). The fact that 5 months resulted in gains and three months resulted losses lead to slightly positive difference for the Action Alternative average condition over the No Action Alternative. The months of May, July, and August were relatively large gainers and the month of June a large loser for the Action Alternative compared to the No Action. When considering changes in visitation between the alternatives, obviously the flow differentials play a significant role, but so does the baseline visitation estimates for each month. Looking at the preferred visitation estimates, note that the heaviest use months are June, July, and August with visitation tailing off as one approaches the edges of the high recreation season in March and October. Therefore, a smaller flow differential during the highest use months could result in a larger impact compared to a larger flow differential during the lower use months.

Under Action Alternative wet conditions, Green River visitation drops significantly compared to the No Action Alternative. Total visitation drops to under 39,000 visits, a decline of over 31,000 visits and

Table 27: Action Alternative, Green River Reach One Average Monthly Visitation by Hydrologic Condition

Month	Recreation Activity	Interpolation Data Points					Action Alternative								
							Average Condition			Wet Condition			Dry Condition		
		Low End Threshold Visits	Current Visits	Preferred Visits	High End Kink Visits	High End Threshold Visits	Average Monthly Visits	Change from No Action		Average Monthly Visits	Change from No Action		Average Monthly Visits	Change from No Action	
								Visits	%		Visits	%		Visits	%
March	Scenic Floating	0	42	52	42	0	44	-2	-4.3	51	1	2.0	0	0	0
	Guide Boat Fishing	0	280	334	280	0	296	-14	-4.5	327	-5	-1.5	0	0	0
	Private Boat Fishing	0	1,265	1,475	1,265	0	1,329	-58	-4.2	1,445	-18	-1.2	0	0	0
	Shore Fishing/Trail Use	0	1,774	2,541	1,774	0	2,079	-279	-11.8	2,338	-66	-2.7	0	0	0
	Camping	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total:	0	3,361	4,402	3,361	0	3,748	-353	-8.6	4,161	-88	-2.1	0	0	0
April	Scenic Floating	0	217	270	217	0	256	-13	-4.8	0	-229	-100	0	0	0
	Guide Boat Fishing	0	1,560	1,861	1,560	0	1,846	69	3.9	0	-1,227	-100	0	0	0
	Private Boat Fishing	0	3,214	3,748	3,214	0	3,709	123	3.4	0	-2,223	-100	0	0	0
	Shore Fishing/Trail Use	0	5,892	8,439	5,892	0	7,868	617	8.5	0	-2,956	-100	0	0	0
	Camping	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total:	0	10,883	14,318	10,883	0	13,679	796	6.2	0	-6,635	-100	0	0	0
May	Scenic Floating	0	99	123	99	0	47	16	51.6	0	0	0	0	-44	-100
	Guide Boat Fishing	0	2,018	2,407	2,018	0	802	370	85.6	0	0	0	0	-1,694	-100
	Private Boat Fishing	0	3,549	4,139	3,549	0	1,274	693	119.3	0	0	0	0	-3,122	-100
	Shore Fishing/Trail Use	0	4,942	7,078	4,942	0	1,911	923	93.4	0	0	0	0	-5,616	-100
	Camping	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total:	0	10,608	13,747	10,608	0	4,034	2,002	98.5	0	0	0	0	-10,476	-100
June	Scenic Floating	0	5,527	6,867	5,527	0	636	-5,700	-90	0	0	0	0	0	n/a
	Guide Boat Fishing	0	2,099	2,504	2,099	0	0	-2,209	-100	0	0	0	227	227	n/a
	Private Boat Fishing	0	1,767	2,060	1,767	0	0	-1,836	-100	0	0	0	74	74	n/a
	Shore Fishing/Trail Use	0	5,976	8,559	5,976	0	0	-5,864	-100	0	0	0	1,042	1,042	n/a
	Camping	0	668	733	668	0	0	-688	-100	0	0	0	100	100	n/a
	Total:	0	16,037	20,723	16,037	0	636	-16,297	-96.2	0	0	0	1,443	1,443	n/a
July	Scenic Floating	0	11,063	13,744	11,063	0	13,720	7,572	123.2	0	-11,508	-100	0	0	n/a
	Guide Boat Fishing	0	1,781	2,124	1,781	0	2,049	547	36.4	0	-1,861	-100	454	454	n/a
	Private Boat Fishing	0	1,520	1,773	1,520	0	1,713	478	38.7	0	-1,581	-100	166	166	n/a
	Shore Fishing/Trail Use	0	7,708	11,039	7,708	0	9,878	3,186	47.6	0	-8,750	-100	2,880	2,880	n/a
	Camping	0	655	719	655	0	710	147	26.1	0	-667	-100	218	218	n/a
	Total:	0	22,727	29,399	22,727	0	28,070	11,930	73.9	0	-24,367	-100	3,718	3,718	n/a

Aug	Scenic Floating	0	7,749	9,626	7,749	0	8,651	672	8.4	9,556	1,075	12.7	0	0	0
	Guide Boat Fishing	0	1,814	2,163	1,814	0	2,060	183	9.7	2,088	75	3.7	352	-169	-32.4
	Private Boat Fishing	0	1,457	1,699	1,457	0	1,635	132	8.8	1,642	41	2.6	162	-150	-48.1
	Shore Fishing/Trail Use	0	5,462	7,823	5,462	0	7,819	1,751	28.9	6,909	-476	-6.4	1,488	-460	-23.6
	Camping	0	600	659	600	0	634	25	4.1	652	24	3.8	147	-52	-26.1
	Total:	0	17,082	21,970	17,082	0	20,799	2,763	15.3	20,847	739	3.7	2149	-831	-27.9
Sept	Scenic Floating	0	62	77	62	0	70	4	6.1	76	6	8.6	0	-32	-100
	Guide Boat Fishing	0	1,530	1,826	1,530	0	1,745	109	6.7	1,740	-5	-0.3	493	-579	-54.0
	Private Boat Fishing	0	4,827	5,629	4,827	0	5,432	308	6.0	5,377	-55	-1.0	1,212	-2,019	-62.5
	Shore Fishing/Trail Use	0	2,935	4,204	2,935	0	4,190	613	17.1	3,613	-577	-13.8	1,142	-1,001	-46.7
	Camping	0	352	386	352	0	372	10	2.8	379	7	-1.9	129	-124	-49.0
	Total:	0	9,707	12,122	9,707	0	11,809	1,044	9.7	11,185	-624	-5.3	2,976	-3,755	-55.8
Oct	Scenic Floating	0	9	11	9	0	10	0	0	11	0	0	0	-9	-100
	Guide Boat Fishing	0	318	379	318	0	353	-12	-3.3	366	-4	-1.1	0	-319	-100
	Private Boat Fishing	0	932	1,087	932	0	1,024	-33	-3.1	1,051	-9	-0.8	0	-935	-100
	Shore Fishing/Trail Use	0	793	1,136	793	0	1,058	-71	-6.3	1,016	-21	-2.0	0	-802	-100
	Camping	0	6	7	6	0	6	-1	-14.3	7	0	0	0	-6	-100
	Total:	0	2,058	2,620	2,058	0	2,451	-117	-4.6	2,451	-34	-1.4	0	-2,071	-100
Total:	Scenic Floating	0	24,768	30,770	24,768	0	23,434	2,549	12.2	9,694	-10,655	-52.4	0	-85	-100
	Guide Boat Fishing	0	11,400	13,598	11,400	0	9,151	-957	-9.5	4,521	-3,027	-40.1	1,526	-2,080	-57.7
	Private Boat Fishing	0	18,531	21,610	18,531	0	16,116	-193	-1.2	9,515	-3,845	-28.8	1,614	-5,986	-78.8
	Shore Fishing/Trail Use	0	35,482	50,819	35,482	0	34,803	876	2.6	13,876	-12,846	-48.1	6,552	-3,957	-37.7
	Camping	0	2,281	2,504	2,281	0	1,722	-507	-22.7	1,038	-636	-38.0	594	136	29.7
	Total:	0	92,461	119,301	92,461	0	85,226	1,768	2.1	38,644	-31,009	-44.5	10,286	-11,972	-53.8

44 percent. All activities experienced significant losses. Every month with changes in visitation (note May and June resulted in no change), except for August, resulted in lost visitation for the Action Alternative wet condition compared to the No Action. The months with the largest losses were April and July, where July accounts for nearly 80% of the total loss. In April, Action Alternative flows of 3,981 exceed the high end threshold flow for all activities resulting in an estimate of zero visits. Conversely, the No Action flow of 3,290 generally falls just beyond the high end kink flow, well below the high end threshold. In July the same situation occurs, but the impact is more severe since the No Action flow of 1,200 cfs actually falls between current and preferred flows (i.e., it is even closer to preferred flows than in April) and the base level of visitation is higher.

Under Action Alternative dry conditions, visitation drops to slightly under 10,300 visits, a decline of nearly 12,000 visits or almost 54 percent compared to the No Action Alternative. The decline is experienced for all activities except camping. The Action Alternative dry condition resulted in four months of losses and two months of gains (and 2 months of zero impact) compared to the No Action Alternative. The months with gains were relatively insignificant resulting in the 12,000 visit loss. The months of May, September, and October were the largest losers with May accounting for about 88% of the overall loss. The dry May flow of 800 cfs for the Action Alternative falls below the low end threshold for all activities resulting in a zero visitation estimate. Conversely, the 1,400 cfs May flow for the No Action Alternative falls above the low end threshold and in the case of shoreline fishing/trail use, the 1,440 cfs flow falls above the low end kink. As a result, a nearly 10,500 visit loss is predicted for the month of April for the Action Alternative dry condition compared to the No Action Alternative.

Although unrelated to the visitation and value analysis, as noted previously, an analysis of facility availability was also conducted for Green River recreation facilities. As shown in table 28, within Reach 1, all river facilities were expected to be available based on average monthly flows across all months under Action Alternative average and dry conditions. However, under wet conditions, the following Forest Service facilities are expected to be unavailable in June due to high flows: the spillway boat ramps, fishing pier, hiking trail, and 9 of 18 riverside campgrounds. In addition, 9 of the 18 riverside campgrounds are also expected to be unavailable in May under wet conditions. The June unavailability of the Spillway ramp, the Little Hole fishing pier, and the recreation trail reflect additional facility unavailability compared to the No Action Alternative. Looking across all years, the unavailability percentage, due exclusively to high flows, ranges from 0 to 27.2 percent (or from virtually never to once every 3.7 years). Across all years, the percentage difference between Action and No Action Alternatives is generally minor, with the largest differences occurring during June (Forest Service campgrounds, +11.7%) and July (spillway ramp, pier, and trail; +7%). Erosion of river facilities is similar to that discussed under the No Action Alternative, but occurs to a greater degree due to higher flows.

Within Reach 2, the boat ramp at Ouray National Wildlife Refuge remains available under average, dry, and wet conditions across all months for the Action Alternative. This implies no change in facility availability within Reach 2 between the alternatives during those hydrologic conditions. Looking across all years, unavailability is expected to occur in May and June, but only about 1.5 to 2 percent of the time. This implies virtually no change in reach two facility availability between the alternatives.

Within Reach 3, all facilities remain available under average conditions for the Action Alternative. However, under dry conditions, the Swasey's Beach boat ramp would be unavailable during the months of January, February, and July through December. Under wet conditions, the facilities at Green River State Park would be affected during May and June (golf course during both May and June, and the campground and boat ramp during June). The facility unavailability for the Action Alternative within Reach 3 mirrors that of the No Action Alternative, implying no change in facility availability between the alternatives within Reach 3 under these conditions. Looking across all years, again the Swasey's Beach

Table 28: Action Alternative, Green River Facility Availability by Site and Hydrologic Condition (Facility Availability: Yes = available, No = unavailable)

Agency	Site	Facility	Low End Thres-hold	High End Threshold	Hydrologic Condition	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Reach 1: Flaming Gorge Dam to the Yampa River																	
Action Alternative, Reach 1, Average Flows:						1,243	1,118	1,270	1,904	3,233	3,862	2,185	1,626	1,639	1,487	1,402	1,331
USFS	Spillway	Boat Ramp	600	6,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Little Hole	Boat Ramp	600	8,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Fishing Pier	600	6,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Trail	n/a	6,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		9 of 18 Campgrounds	n/a	5,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BLM	Indian Crossing	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Bridge Hollow	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	None	10,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swallow Canyon	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Bridge Port Camp	Boat Ramp	800	None	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Action Alternative, Reach 1, Dry Flows:						800	800	800	800	800	893	893	906	939	800	800	800
USFS	Spillway	Boat Ramp	600	6,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Little Hole	Boat Ramp	600	8,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Fishing Pier	600	6,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Trail	n/a	6,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		9 of 18 Campgrounds	n/a	5,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BLM	Indian Crossing	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Bridge Hollow	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	None	10,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swallow Canyon	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Bridge Port Camp	Boat Ramp	800	None	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Action Alternative, Reach 1, Wet Flows:						2,086	1,968	2,030	3,981	5,537	7,038	4,600	2,131	2,239	2,172	2,243	2,214
USFS	Spillway	Boat Ramp	600	6,000	Wet	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
	Little Hole	Boat Ramp	600	8,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Fishing Pier	600	6,000	Wet	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
		Trail	n/a	6,000	Wet	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
		9 of 18 Campgrounds	n/a	5,000	Wet	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
BLM	Indian Crossing	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Bridge Hollow	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	None	10,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swallow Canyon	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Bridge Port Camp	Boat Ramp	800	None	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
						Percent of Time, Across All Years, Facilities Are Unavailable											
USFS	Spillway	Boat Ramp	600	6,000	All Years	0	0	0	0	7.5	14.6	7.0	0	0	0	0	0
	Little Hole	Boat Ramp	600	8,000	All Years	0	0	0	0	4.2	8.5	1.2	0	0	0	0	0
		Fishing Pier	600	6,000	All Years	0	0	0	0	7.5	14.6	7.0	0	0	0	0	0
		Trail	n/a	6,000	All Years	0	0	0	0	7.5	14.6	7.0	0	0	0	0	0
		9 of 18 Campgrounds	n/a	5,000	All Years	0	0	0	0	13.0	27.2	2.8	0	0	0	0	0
BLM	Indian Crossing	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
	Bridge Hollow	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
		Campground	None	10,000	All Years	0	0	0	0	1.9	4.1	0	0	0	0	0	0
	Swallow Canyon	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
State of Utah	Bridge Port Camp	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0

						Change in Percent of Time, Across All Years, Facilities Are Unavailable (Action minus No Action)											
USFS	Spillway	Boat Ramp	600	6,000	All Years	0	0	0	0	1.2	4.7	7.0	0	0	0	0	0
	Little Hole	Boat Ramp	600	8,000	All Years	0	0	0	0	1.4	4.5	1.2	0	0	0	0	0
		Fishing Pier	600	6,000	All Years	0	0	0	0	1.2	4.7	7.0	0	0	0	0	0
		Trail	n/a	6,000	All Years	0	0	0	0	1.2	4.7	7.0	0	0	0	0	0
		9 of 18 Campgrounds	n/a	5,000	All Years	0	0	0	0	2.7	11.7	2.8	0	0	0	0	0
BLM	Indian Crossing	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
	Bridge Hollow	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
		Campground	None	10,000	All Years	0	0	0	0	1.1	2.9	0	0	0	0	0	0
	Swallow Canyon	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
State of Utah	Bridge Port Camp	Boat Ramp	800	None	All Years	0	0	0	0	0	0	0	0	0	0	0	0
Reach 2: Yampa River to the White River																	
Action Alternative, Reach 2, Average Flows:						1,606	1,567	2,300	5,600	12,111	11,548	3,955	2,085	1,941	1,939	1,862	1,729
FWS	Ouray NWR	Boat Ramp	None	25,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Action Alternative, Reach 2, Dry Flows:						1,040	1,080	1,350	2,205	5,320	3,943	1,206	1,170	1,036	1,100	1,115	1,060
FWS	Ouray NWR	Boat Ramp	None	25,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Action Alternative, Reach 2, Wet Flows:						2,665	2,642	3,650	9,625	20,310	20,160	7,949	2,884	2,818	2,837	2,747	2,776
FWS	Ouray NWR	Boat Ramp	None	25,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
						Percent of Time, Across All Years, Facilities Are Unavailable											
FWS	Ouray NWR	Boat Ramp	None	25,000	All Years	0	0	0	0	1.95	1.64	0	0	0	0	0	0
						Change in Percent of Time, Across All Years, Facilities Are Unavailable (Action minus No Action)											
FWS	Ouray NWR	Boat Ramp	None	25,000	All Years	0	0	0	0	-0.24	-0.73	0	0	0	0	0	0

Reach 3: White River to the Colorado River																	
Action Alternative, Reach 3, Average Flows:						2,347	2,681	3,934	6,390	13,882	16,201	5,825	3,028	2,799	2,990	2,877	2,476
BLM	Sand Wash	Boat Ramp	800	50,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swasey Beach	Boat Ramp	2,000	50,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Nefertiti	Boat Ramp	800	27,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Butler Rapid	Boat Ramp	800	27,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Mineral Bottom	Boat Ramp	800	30,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Green River State Park	Boat Ramp	800	25,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	n/a	25,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Golf Course	n/a	19,000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Action Alternative, Reach 3, Dry Flows:						1,470	1,610	2,120	2,783	5,243	5,499	1,494	1,475	1,460	1,591	1,770	1,327
BLM	Sand Wash	Boat Ramp	800	50,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swasey Beach	Boat Ramp	2,000	50,000	Dry	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No
	Nefertiti	Boat Ramp	800	27,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Butler Rapid	Boat Ramp	800	27,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Mineral Bottom	Boat Ramp	800	30,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Utah	Green River State Park	Boat Ramp	800	25,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	n/a	25,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Golf Course	n/a	19,000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Action Alternative, Reach 3, Wet Flows:						3,438	3,995	6,256	11,507	23,690	26,730	11,880	4,967	4,333	4,692	4,149	3,769
BLM	Sand Wash	Boat Ramp	800	50,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Swasey Beach	Boat Ramp	2,000	50,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Nefertiti	Boat Ramp	800	27,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Butler Rapid	Boat Ramp	800	27,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Mineral Bottom	Boat Ramp	800	30,000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

State of Utah	Green River State Park	Boat Ramp	800	25,000	Extremely Wet	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
		Campground	n/a	25,000	Extremely Wet	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
		Golf Course	n/a	19,000	Extremely Wet	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
						Percent of Time, Across All Years, Facilities Are Unavailable											
BLM	Sand Wash	Boat Ramp	800	50,000	All Years	0.9	1.1	0.9	0.2	0	0	0.6	0.4	0.6	0.1	0.3	2.0
	Swasey Beach	Boat Ramp	2,000	50,000	All Years	37.4	24.8	7.4	1.8	0.1	1.4	18.5	23.5	26.5	21.7	18.9	33.9
	Nefertiti	Boat Ramp	800	27,000	All Years	0.9	1.1	0.9	0.2	5.6	9.6	1	0.4	0.6	0.1	0.3	2.0
	Butler Rapid	Boat Ramp	800	27,000	All Years	0.9	1.1	0.9	0.2	5.6	9.6	1	0.4	0.6	0.1	0.3	2.0
	Mineral Bottom	Boat Ramp	800	30,000	All Years	0.9	1.1	0.9	0.2	3.5	5.3	0.8	0.4	0.6	0.1	0.3	2.0
State of Utah	Green River State Park	Boat Ramp	800	25,000	All Years	0.9	1.1	0.9	0.2	8.1	15.2	1.4	0.4	0.6	0.1	0.3	2.0
		Campground	n/a	25,000	All Years	0	0	0	0	8.1	15.2	0.7	0	0	0	0	0
		Golf Course	n/a	19,000	All Years	0	0.2	0.4	0.9	22.8	37.1	2.2	0	0	0	0	0
						Change in Percent of Time, Across All Years, Facilities Are Unavailable (Action minus No Action)											
BLM	Sand Wash	Boat Ramp	800	50,000	All Years	0.6	0.3	0.1	0.1	0	0	-1.0	0	-0.3	0	0.1	0.8
	Swasey Beach	Boat Ramp	2,000	50,000	All Years	8.1	6.7	2.6	1.1	0	0.1	-6.2	-11.2	-9.4	5.5	3.2	9.4
	Nefertiti	Boat Ramp	800	27,000	All Years	0.6	0.3	0.1	0.1	0.6	1.9	-0.8	0	-0.3	0	0.1	0.8
	Butler Rapid	Boat Ramp	800	27,000	All Years	0.6	0.3	0.1	0.1	0.6	1.9	-0.8	0	-0.3	0	0.1	0.8
	Mineral Bottom	Boat Ramp	800	30,000	All Years	0.6	0.3	0.1	0.1	0.6	0.8	-1.0	0	-0.3	0	0.1	0.8
State of Utah	Green River State Park	Boat Ramp	800	25,000	All Years	0.6	0.3	0.1	0.1	0.5	3.8	-0.5	0	-0.3	0	0.1	0.8
		Campground	n/a	25,000	All Years	0	0	-0.1	0	0.5	3.8	0.5	0	0	0	0	0
		Golf Course	n/a	19,000	All Years	0	0	0.1	0.3	-0.8	5.3	1.2	0	0	0	0	0

boat ramp and the Green River State Park facilities show the most dramatic effects. The unavailability percentages displayed in table 28 need to be looked at with some skepticism given the uncertainty associated with the reach three hydrology model. As a result, it makes sense to focus more on the differences in the unavailability percentages between the alternatives as compared to the percentages themselves. For the most part, the differences in the percentages between the alternatives are fairly minor. The largest differences (both + and -) occur with the Swasey's Beach boat ramp. The difference exceeds 5% for 7 of the months, although 3 of those months show a reduction in unavailability for the Action Alternative. In only one other month (June), did a facility (Green River State Park golf course) experience a 5% difference between alternatives?

B) Flaming Gorge Visitation:

Table 29 presents the Flaming Gorge Reservoir facility availability for the Action Alternative under average, wet, and dry conditions (while not comparable to the rest of the analysis, table 18 also presents the percent of time each facility is unavailable by month across all years). Under all three hydrologic conditions, all the facilities are available based on end of month water levels provided by the hydrologic models (table 26). The highest low end usability threshold is for the Anvil Draw boat ramp at 6020. Even under dry conditions, end of month water levels were not expected to decline below that level. As a result, reservoir visitation estimates for the Action Alternative under average, wet, and dry conditions are all estimated at the nearly 572,300 level. Visitation was also estimated at this level for the No Action Alternative average and wet conditions, therefore the only situation where a visitation difference results between alternatives is for the dry condition.

Under the No Action Alternative dry condition, losses in facility availability imply the Action Alternative dry condition results in a gain in visitation compared to the No Action Alternative. Table 30 presents information on visitation for the Action Alternative under dry conditions by activity, month, and affected site. Bottomline, the majority of the gain in visitation during dry conditions compared to No Action occurs due to the availability of the Cedar Springs marina and boat ramp. Virtually all of the gain accrues to power boating and boat fishing activities. The 28,300 visit gain reflects a 5.2 percent increase compared to No Action Alternative. Nearly 47 percent of the gain occurs in May, with 90 percent occurring across May, September, and October.

C) Total River and Reservoir Visitation:

Table 31 presents information on water based visitation combined for both the Green River and Flaming Gorge Reservoir for the Action Alternative under average, wet, and dry conditions. Reservoir visitation accounts for anywhere from 87.0 to 98.2 percent of the total depending on the hydrologic condition. For information on what these changes in recreation visitation mean in terms of expenditures, jobs, and other measures of regional economic activity, see the socioeconomic section.

For the Action Alternative average condition, the combined visitation barely changes from the No Action Alternative average condition. The Action Alternative's approximately 1,770 additional visits represent less than a 1 percent change compared to No Action. This change in visitation from the No Action Alternative was not considered significant. Since the facility availability approach indicated no visitation changes on the reservoir, the gains in visitation are completely attributable to the river. Gains in scenic floating and shoreline fishing/trail use in July and August slightly outweigh losses to guide boat fishing, private boat fishing, and boat based camping which occur primarily in June.

Table 29: Action Alternative, Flaming Gorge Reservoir Facility Availability by Site and Hydrologic Condition

Site	Facility	Low End Usability Threshold	Hydrologic Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Antelope Flat	Boat Ramp Swim Beach	6015 6012	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Anvil Draw	Boat Ramp	6015	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Buckboard Crossing	Marina Boat Ramp	6015 6000	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Cedar Springs	Marina Boat Ramp	6018 6018	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Firehole	Boat Ramp Swim Beach	6019 6012	Average	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Hideout	Boat Camp	6014	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jarvies Canyon	Boat Camp	6012	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kingfisher Island	Boat Camp	6010	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	Average	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Mustang Ridge	Boat Ramp	6000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sheep Creek	Boat Ramp	6015	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Squaw Hollow	Boat Ramp	6015	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sunny Cove	Swim Beach	6018	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upper Marsh Creek	Boat Ramp	6000	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CUT Through	Boat Channel	6022	Average	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Antelope Flat	Boat Ramp Swim Beach	6015 6012	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Anvil Draw	Boat Ramp	6020	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Buckboard Crossing	Marina Boat Ramp	6015 6000	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Cedar Springs	Marina Boat Ramp	6018 6018	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes

Firehole	Boat Ramp Swim Beach	6019 6012	Wet	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Hideout	Boat Camp	6014	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jarvies Canyon	Boat Camp	6012	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kingfisher Island	Boat Camp	6010	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	Wet	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Mustang Ridge	Boat Ramp	6000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sheep Creek	Boat Ramp	6015	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Squaw Hollow	Boat Ramp	6015	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sunny Cove	Swim Beach	6018	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upper Marsh Creek	Boat Ramp	6000	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CUT Through	Boat Channel	6022	Wet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Antelope Flat	Boat Ramp Swim Beach	6015 6012	Dry	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Anvil Draw	Boat Ramp	6020	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Buckboard Crossing	Marina Boat Ramp	6015 6000	Dry	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Cedar Springs	Marina Boat Ramp	6018 6018	Dry	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Firehole	Boat Ramp Swim Beach	6019 6012	Dry	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Hideout	Boat Camp	6014	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jarvies Canyon	Boat Camp	6012	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kingfisher Island	Boat Camp	6010	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	Dry	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Mustang Ridge	Boat Ramp	6000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sheep Creek	Boat Ramp	6015	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Squaw Hollow	Boat Ramp	6015	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Sunny Cove	Swim Beach	6018	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upper Marsh Creek	Boat Ramp	6000	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CUT Through	Boat Channel	6022	Dry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
				Percent of Time Unavailable by Month											
Antelope Flat	Boat Ramp Swim Beach	6015 6012	All Years	1.1 0.1	1.7 0.2	2.1 0.3	1.5 0.2	1.5 0.6	0.4 0.0	0.2 0.0	0.2 0.0	0.4 0.0	0.5 0.0	0.7 0.0	1.0 0.1
Anvil Draw	Boat Ramp	6020	All Years	6.6	6.7	5.0	2.9	3.2	3.0	1.9	2.3	3.8	5.4	6.2	6.6
Buckboard Crossing	Marina Boat Ramp	6015 6000	All Years	1.2 0.0	1.7 0.0	2.1 0.0	1.5 0.0	1.5 0.0	.4 0.0	.2 0.0	.2 0.0	.4 0.0	.5 0.0	.7 0.0	1.0 0.0
Cedar Springs	Marina Boat Ramp	6018 6018	All Years	3.9 3.9	4.5 4.5	3.0 3.0	2.0 2.0	2.5 2.5	1.9 1.9	1.2 1.2	1.5 1.5	1.8 1.8	2.1 2.1	3.0 3.0	3.1 3.1
Firehole	Boat Ramp Swim Beach	6019 6012	All Years	5.0 0.1	5.1 0.2	4.3 0.3	2.4 0.2	3.0 0.6	1.9 0.0	1.5 0.0	1.7 0.0	2.4 0.0	3.2 0.0	3.4 0.0	4.9 0.1
Hideout	Boat Camp	6014	All Years	0.6	0.9	1.0	1.1	1.5	0.2	0.0	0.1	0.2	0.3	0.3	0.6
Jarvies Canyon	Boat Camp	6012	All Years	0.1	0.2	0.3	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Kingfisher Island	Boat Camp	6010	All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucerne Valley	Marina Boat Ramps Swim Beach	6010 5994 6014	All Years	0.0 0.0 0.6	0.0 0.0 0.9	0.0 0.0 1.0	0.0 0.0 1.1	0.0 0.0 1.5	0.0 0.0 0.2	0.0 0.0 0.0	0.0 0.0 0.1	0.0 0.0 0.2	0.0 0.0 0.3	0.0 0.0 0.3	0.0 0.0 0.6
Mustang Ridge	Boat Ramp	6000	All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sheep Creek	Boat Ramp	6015	All Years	1.1	1.7	2.1	1.5	1.5	0.4	0.2	0.2	0.4	0.5	0.7	1.0
Squaw Hollow	Boat Ramp	6015	All Years	1.1	1.7	2.1	1.5	1.5	0.4	0.2	0.2	0.4	0.5	0.7	1.0
Sunny Cove	Swim Beach	6018	All Years	3.9	4.5	3.0	2.0	2.5	1.9	1.2	1.5	1.8	2.1	3.0	3.1
Upper Marsh Creek	Boat Ramp	6000	All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CUT Through	Boat Channel	6022	All Years	7.8	7.8	7.8	6.6	7.3	3.4	3.6	6.6	8.0	7.9	7.3	8.1

Table 30: Action Alternative - Dry Condition, Flaming Gorge Reservoir Visitation by Affected Site, Activity and Month (Accounts for Facility Substitution)

			Action Alternative Visitation					Change from No Action Alternative									
								Power Boating/ Waterskiing		Boat Fishing		Camping		Swimming and Waterplay		Total	
Site	Facility	Month	Power Boating/ Water-skiing	Boat Fishing	Camping	Swimming & Waterplay	Total	Visits	%	Visits	%	Visits	%	Visits	%	Visits	%
Anvil Draw	Boat Ramp	Jan	2	3	0	0	5	0		0		0		0		0	
		Feb	0	0	0	0	0	0		0		0		0		0	
(affected,		Mar	9	12	0	0	21	0		0		0		0		0	
but losses		Apr	72	96	0	0	168	0		0		0		0		0	
completely		May	193	257	0	0	450	0		0		0		0		0	
absorbed		June	260	347	0	0	607	0		0		0		0		0	
by other		July	283	378	0	0	661	0		0		0		0		0	
sites)		Aug	165	219	0	0	384	0		0		0		0		0	
		Sept	94	126	0	0	220	0		0		0		0		0	
		Oct	85	113	0	0	198	0		0		0		0		0	
		Nov	22	30	0	0	52	0		0		0		0		0	
		Dec	14	19	0	0	33	0		0		0		0		0	
		Total:	1,200	1,600	0	0	2,800	0	0	0	0	0	0	0	0	0	0
Cedar Springs	Marina	Jan	49	17	0	0	66	44		15		0		0		59	
		Feb	0	0	0	0	0	0		0		0		0		0	
		Mar	225	79	0	0	304	0		0		0		0		0	
		Apr	1,798	629	0	0	2,427	0		0		0		0		0	
		May	4,826	1,689	0	0	6,515	4,343		1,520		0		0		5,863	
		June	6,508	2,278	0	0	8,786	0		0		0		0		0	
		July	7,087	2,480	0	0	9,567	0		0		0		0		0	
		Aug	4,114	1,440	0	0	5,554	0		0		0		0		0	
		Sept	2,359	826	0	0	3,185	2,123		743		0		0		2,866	
		Oct	2,123	743	0	0	2,866	1,911		669		0		0		2,580	
		Nov	554	194	0	0	748	499		175		0		0		674	
		Dec	357	125	0	0	482	321		113		0		0		434	
		Total:	30,000	10,500	0	0	40,500	9,241	44.5	3,234	44.5	0	0	0	0	12,475	44.5

Cedar Springs	Boat Ramp	Jan	49	32	0	0	81	44		29		0		0		73	
		Feb	0	0	0	0	0	0		0		0		0		0	
		Mar	225	146	0	0	371	0		0		0		0		0	
		Apr	1,798	1,169	0	0	2,967	0		0		0		0		0	
		May	4,826	3,137	0	0	7,963	4,343		2,823		0		0		7,166	
		June	6,508	4,230	0	0	10,738	0		0		0		0		0	
		July	7,087	4,606	0	0	11,693	0		0		0		0		0	
		Aug	4,114	2,674	0	0	6,788	0		0		0		0		0	
		Sept	2,359	1,533	0	0	3,892	2,123		1,380		0		0		3,503	
		Oct	2,123	1,380	0	0	3,503	1,911		1,242		0		0		3,153	
		Nov	554	360	0	0	914	499		324		0		0		823	
		Dec	357	232	0	0	589	321		209		0		0		530	
		Total:	30,000	19,500	0	0	49,500	9,241	44.5	6,008	44.5	0	0	0	0	15,249	44.5
Firehole	Boat Ramp	Jan	4	3	0	0	7	0		0		0		0		0	
		Feb	0	0	0	0	0	0		0		0		0		0	
		Mar	20	15	0	0	35	0		0		0		0		0	
		Apr	156	120	0	0	276	0		0		0		0		0	
		May	420	322	0	0	742	42		32		0		0		74	
		June	566	434	0	0	1,000	57		43		0		0		100	
		July	616	472	0	0	1,088	0		0		0		0		0	
		Aug	358	274	0	0	632	36		27		0		0		63	
		Sept	205	157	0	0	362	21		16		0		0		37	
		Oct	185	142	0	0	327	19		14		0		0		33	
		Nov	48	37	0	0	85	5		4		0		0		9	
		Dec	31	24	0	0	55	3		2		0		0		5	
		Total:	2,608	2,000	0	0	4,608	178	7.3	138	7.4	0	0	0	0	316	7.4
Sunny Cove	Swim Beach	Jan	0	0	0	8	8	0		0		0		1		1	
		Feb	0	0	0	0	0	0		0		0		0		0	
		Mar	0	0	0	37	37	0		0		0		0		0	
		Apr	0	0	0	300	300	0		0		0		0		0	
		May	0	0	0	804	804	0		0		0		121		121	
		June	0	0	0	1,085	1,085	0		0		0		0		0	
		July	0	0	0	1,181	1,181	0		0		0		0		0	
		Aug	0	0	0	686	686	0		0		0		0		0	
		Sept	0	0	0	393	393	0		0		0		59		59	
		Oct	0	0	0	354	354	0		0		0		53		53	
		Nov	0	0	0	92	92	0		0		0		14		14	
		Dec	0	0	0	60	60	0		0		0		9		9	
		Total:	0	0	0	5,000	5,000	0	0	0	0	0	0	257	5.4	257	5.4

Total for Affected Sites:		Jan	98	49	0	8	155	88		44		0		1		133	
		Feb	0	0	0	0	0	0		0		0		0		0	
		Mar	450	225	0	37	712	0		0		0		0		0	
		Apr	3,596	1,798	0	300	5,694	0		0		0		0		0	
		May	9,652	4,826	0	804	15,282	8,728		4,375		0		121		13,224	
		June	13,016	6,508	0	1,085	20,609	57		43		0		0		100	
		July	14,174	7,087	0	1,181	22,442	0		0		0		0		0	
		Aug	8,228	4,114	0	686	13,028	36		27		0		0		63	
		Sept	4,718	2,359	0	393	7,470	4,267		2,139		0		59		6,465	
		Oct	4,246	2,123	0	354	6,723	3,841		1,925		0		53		5,819	
		Nov	1,108	554	0	92	1,754	1,003		503		0		14		1,520	
		Dec	714	357	0	60	1,131	645		324		0		9		978	
		Total:	60,000	30,000	0	5,000	95,000	18,660	41.3	9,380	38.7	0	0	257	5.4	28,297	38.2
Total for Unaffected Sites:		Jan	485	244	75	27	831	0		0		0		0		0	
		Feb	0	0	0	0	0	0		0		0		0		0	
		Mar	2,244	1,133	677	122	4,176	0		0		0		0		0	
		Apr	17,936	9,072	1,761	977	29,746	0		0		0		0		0	
		May	48,140	24,344	1,388	2,620	76,492	0		0		0		0		0	
		June	64,927	32,835	1,863	3,533	103,158	0		0		0		0		0	
		July	70,697	35,751	1,386	3,847	11,681	0		0		0		0		0	
		Aug	41,045	20,756	1,174	2,233	65,208	0		0		0		0		0	
		Sept	23,532	11,901	536	1,282	37,251	0		0		0		0		0	
		Oct	21,180	10,711	674	1,154	33,719	0		0		0		0		0	
		Nov	5,530	2,798	483	301	9,112	0		0		0		0		0	
		Dec	3,562	1,803	357	195	5,917	0		0		0		0		0	
		Total:	299,278	151,348	10,374	16,291	477,291	0	0	0	0	0	0	0	0	0	0
Overall Total:		Jan	583	293	75	35	986	88		44		0		1		133	
		Feb	0	0	0	0	0	0		0		0		0		0	
		Mar	2,694	1,358	677	159	4,888	0		0		0		0		0	
		Apr	21,532	10,870	1,761	1,277	35,440	0		0		0		0		0	
		May	57,792	29,170	1,388	3,424	91,774	8,728		4,375		0		121		13,224	
		June	77,943	39,343	1,863	4,618	123,767	57		43		0		0		100	
		July	84,871	42,838	1,386	5,028	134,123	0		0		0		0		0	
		Aug	49,273	24,870	1,174	2,919	78,236	36		27		0		0		63	
		Sept	28,250	14,260	536	1,675	44,721	4,267		2,139		0		59		6,465	
		Oct	25,426	12,834	674	1,508	40,442	3,841		1,925		0		53		5,819	
		Nov	6,638	3,352	483	393	10,866	1,003		503		0		14		1,520	
		Dec	4,276	2,160	357	255	7,048	645		324		0		9		978	
		Total:	359,278	181,348	10,374	21,291	572,291	18,660	5.5	9,380	5.5	0	0	257	1.2	28,297	5.2

Table 31: Total Water Based Visitation for Green River and Flaming Gorge Reservoir for Action Alternative										
		Action Alternative Visitation by Hydrologic Condition								
		Average			Wet			Dry		
			Change from No Action Average Condition			Change from No Action Wet Condition			Change from No Action Dry Condition	
Site	Recreation Activity	Visits	Visits	%	Visits	Visits	%	Visits	Visits	%
Green River	Scenic Floating	23,434	2,549	12.2	9,694	-10,655	-52.4	0	-85	-100
	Guide Boat Fishing	9,151	-957	-9.5	4,521	-3,027	-40.1	1,526	-2,080	-57.7
	Private Boat Fishing	16,116	-193	-1.2	9,515	-3,845	-28.8	1,614	-5,986	-78.8
	Shoreline Fishing/ Trail Use	34,803	876	2.6	1,3876	-12,846	-48.1	6,552	-3,957	-37.7
	Boat Based Camping	1,772	-507	-22.7	1,038	-636	-38.0	5,94	136	29.7
	Total:	85,226	1,768	2.1	38,644	-31,009	-44.5	10,286	-11,972	-53.8
Flaming Gorge Reservoir	Power Boating/ Waterskiing	35,9278	0	0	359,278	0	0	359,278	18,663	5.5
	Boat Fishing	18,1348	0	0	181,348	0	0	181,348	9,379	5.5
	Boat Based Camping	10,374	0	0	10,374	0	0	10,374	0	0
	Swimming/ Waterplay	21,291	0	0	21,291	0	0	21,291	257	1.2
	Total:	572,291	0	0	572,291	0	0	57,291	28,299	5.2
Both Sites	Combined Total:	657,517	1,768	.3	610,935	-31,009	-4.8	582,577	16,327	2.9

For the Action Alternative wet condition, combined visitation declines about 31,000 or nearly 5 percent compared to the No Action Alternative wet condition. This change in visitation from the No Action Alternative was not considered significant especially given that wet conditions occur only 10 percent of the time. Since the facility availability approach indicated no visitation changes on the reservoir, all of this decline stems from losses experienced on the river. All river activities were estimated to experience losses compared to No Action with the majority of the losses (over 75%) accruing to scenic floating and shoreline fishing/trail use during April and July.

For the Action Alternative dry condition, combined visitation is estimated to increase by over 16,300 visits or just under 3 percent compared to the No Action Alternative dry condition. This change in visitation from the No Action Alternative was not considered significant especially given that conditions occur only 10 percent of the time. Visitation on the reservoir is estimated to increase by about 28,300 visits whereas visitation on the river is estimated to decline by nearly 12,000 visits. The largest gains are expected for reservoir power boating and boat fishing during the months of May, September, and October, and the largest losses are expected for river private boat fishing and shoreline fishing/trail use during the month of May.

3.2.1.2.3 Recreation Value **–** This section presents the results of the valuation analysis for the Action Alternative for both the Green River and Flaming Gorge Reservoir.

A) Green River Valuation:

Table 32 presents the results of the Green River value per visit interpolations for the Action Alternative under average, wet, and dry conditions. The five value data points used in the interpolation are presented should one be interested in comparing the values per visit to the flows and flow data points from table 25 (note that the flow data points used in the valuation analysis are those at the bottom of table 25). Zero values are the result of flows either below the low end threshold or above the high end threshold.

Table 32 also includes a comparison of values per visit by activity, month, and hydrologic condition between the Action and No Action Alternatives. Generally speaking, since the value interpolations are based on the same average monthly flows as the visitation analysis, months which provided visitation gains (losses) compared to the No Action Alternative would also provide valuation gains (losses). The magnitude or percentage change for the same month within the visitation and valuation analysis would vary because differential flow oriented interpolation data points were used in the visitation (monthly oriented data) and valuation (annually oriented data) analyses. In comparing the impacts for both the visitation and valuation analyses, the results are consistent. See the flow related discussion under the visitation section for more elaboration as to gains and losses by month.

As with the visitation analysis, Action Alternative average conditions results in gains compared to No Action Alternative average conditions in 5 of the 8 months. The largest gains in value per visit appear to occur in July and August with the largest loss in June.

Under Action Alternative wet conditions, all months with changed values (note that May and June showed no change) except August, generated predominately lower values compared to the No Action Alternative. The largest losses appear to occur in April and July.

Finally, under the Action Alternative dry condition, four months indicated losses, two months indicated gains, and two months showed no change. The months with the most significant losses appear to be May, September and October.

Table 33 presents the results of applying the values per visit from table 32 to the visitation estimates from table 27. Values are measured in thousands of dollars for the Action Alternative under average, wet, and dry conditions. Changes from the No Action Alternative for the same hydrologic condition are presented in dollar and percentage terms. The impacts by month generally align between the visitation and valuation analyses; however the magnitude of the change within the two analyses varies due to the different flow data points used in the interpolations.

For the Action Alternative average condition, total river recreation value is estimated at $5.7 million. This reflects nearly a $1.75 million or 44 percent increase over No Action Alternative average conditions. All activities, except camping, show gains in value with over 50 percent of the gain stemming from scenic floating. Five of the eights months indicate gains in value with the largest gains seen in July through September.

For the Action Alternative wet condition, total river recreation value is estimated at $2.8 million. This reflects over a $940 thousand or 25 percent loss in value compared to No Action Alternative wet conditions. All activities are estimated to result in losses compared to No Action with the largest losses due to guide boat fishing, shoreline fishing/trail use, and scenic floating. The vast majority of the loss in value occurs in July.

Table 32: Action Alternative, Green River Reach One Average Monthly Value per Visit by Hydrologic Condition

Month	Recreation Activity	Interpolation Data Points: Low End Threshold Values	Current Values	Preferred Values	High End Kink Values	High End Threshold Values	Action Alternative Values: Average Values	Change from No Action Average: $	%	Wet Values	Change from No Action Wet: $	%	Dry Values	Change from No Action Dry: $	%
March	Scenic Floating	0	46.8	94.35	46.8	0	54.47	-9.48	-14.8	88.15	5.85	7.1	0	0	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	150.69	-47.07	-23.8	227.74	-8.13	-3.4	0	0	0
	Private Boat Fishing	0	37.44	69.91	37.44	0	29.61	-16.10	-35.2	61.57	-4.96	-7.5	0	0	0
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	22.07	-7.48	-25.3	29.04	-1.66	-5.4	0	0	0
	Camping	0	10.78	14.13	10.78	0	11.37	-0.81	-6.7	14.04	0.30	2.2	0	0	0
April	Scenic Floating	0	46.8	94.35	46.8	0	82.56	-10.64	-11.4	0	-59.54	-100	0	0	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	235.50	18.65	8.6	0	-82.91	-100	0	0	0
	Private Boat Fishing	0	37.44	69.91	37.44	0	66.30	11.37	20.7	0	-13.94	-100	0	0	0
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	30.62	3.80	14.2	0	-7.96	-100	0	0	0
	Camping	0	10.78	14.13	10.78	0	13.77	0.23	1.7	0	-7.24	-100	0	0	0
May	Scenic Floating	0	46.8	94.35	46.8	0	61.31	7.15	13.2	0	0	0	0	-60.23	-100
	Guide Boat Fishing	0	182.94	239.62	182.94	0	93.62	43.24	85.8	0	0	0	0	-187.80	-100
	Private Boat Fishing	0	37.44	69.91	37.44	0	16.11	8.76	119.2	0	0	0	0	-39.43	-100
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	9.05	4.37	93.4	0	0	0	0	-26.81	-100
	Camping	0	10.78	14.13	10.78	0	8.90	6.71	306.4	0	0	0	0	-11.86	-100
June	Scenic Floating	0	46.8	94.35	46.8	0	9.81	-67.76	-87.4	0	0	0	0	0	n/a
	Guide Boat Fishing	0	182.94	239.62	182.94	0	0	-185.89	-100	0	0	0	14.13	14.13	n/a
	Private Boat Fishing	0	37.44	69.91	37.44	0	0	-36.02	-100	0	0	0	1.06	1.06	n/a
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	0	-18.99	-100	0	0	0	3.37	3.37	n/a
	Camping	0	10.78	14.13	10.78	0	0	-12.09	-100	0	0	0	2.20	2.20	n/a
July	Scenic Floating	0	46.8	94.35	46.8	0	93.88	84.13	862.9	0	-51.37	-100	0	0	n/a
	Guide Boat Fishing	0	182.94	239.62	182.94	0	218.20	171.47	366.9	0	-125.33	-100	14.13	14.13	n/a
	Private Boat Fishing	0	37.44	69.91	37.44	0	55.75	47.87	607.5	0	-24.31	-100	1.06	1.06	n/a
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	27.10	19.26	245.7	0	-18.60	-100	3.37	3.37	n/a
	Camping	0	10.78	14.13	10.78	0	13.60	7.93	139.9	0	-11.10	-100	2.20	2.20	n/a
Aug	Scenic Floating	0	46.8	94.35	46.8	0	70.24	16.61	31.0	92.62	26.59	40.3	0	0	0
	Guide Boat Fishing	0	182.94	239.62	182.94	0	214.60	70.79	49.2	221.53	18.20	9.0	18.84	-9.05	-32.4
	Private Boat Fishing	0	37.44	69.91	37.44	0	56.31	28.14	99.9	57.78	8.56	17.4	2.04	-1.90	-48.2
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	34.10	12.97	61.4	27.78	-3.31	-10.6	4.02	-1.24	-23.6
	Camping	0	10.78	14.13	10.78	0	12.71	1.42	12.6	13.75	1.40	11.3	2.70	-0.96	-26.2
Sept	Scenic Floating	0	46.8	94.35	46.8	0	70.82	11.74	19.9	92.21	21.39	30.2	0	-27.96	-100
	Guide Boat Fishing	0	182.94	239.62	182.94	0	216.14	34.43	17.0	214.88	-1.26	-0.6	30.79	-36.22	-54.1
	Private Boat Fishing	0	37.44	69.91	37.44	0	57.29	19.80	52.8	53.73	-3.56	-6.2	4.54	-7.58	-62.5
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	33.94	7.98	30.7	26.42	-7.52	-22.2	5.65	-4.96	-46.7
	Camping	0	10.78	14.13	10.78	0	12.76	1.00	8.5	13.44	0.68	5.3	3.97	-3.86	-49.3
Oct	Scenic Floating	0	46.8	94.35	46.8	0	64.08	-7.41	-10.4	94.29	4.15	4.6	0	-27.96	-100
	Guide Boat Fishing	0	182.94	239.62	182.94	0	198.11	-19.81	-9.1	219.00	-5.97	-2.7	0	-67.01	-100
	Private Boat Fishing	0	37.44	69.91	37.44	0	45.93	-12.48	-21.4	56.24	-3.64	-6.1	0	-12.12	-100
	Shore Fishing/Trail Use	0	23.49	34.13	23.49	0	29.65	-4.10	-12.1	27.26	-1.22	-4.3	0	-10.61	-100
	Camping	0	10.78	14.13	10.78	0	12.19	-0.63	-4.9	13.64	-0.28	-2.0	0	-7.83	-100

Table 33: Action Alternative, Green River Reach 1 Average Monthly Total Values by Hydrologic Condition ($1,000s)										
		Action Alternative Total Values			Change from No Action					
					Average		Wet		Dry	
Month	Recreation Activity	Average	Wet	Dry	$	%	$	%	$	%
March	Scenic Floating	2.3	4.5	0	-.5	-18.5	.4	9.3	0	0
	Guide Boat Fishing	44.6	74.5	0	-16.7	-27.2	-3.8	-4.9	0	0
	Private Boat Fishing	39.4	89.0	0	-24.1	-37.9	-8.4	-8.6	0	0
	Shore Fishing/Trail Use	45.9	68.0	0	-23.8	-34.2	-5.9	-8.0	0	0
	Camping	0	0	0	0	0	0	0	0	0
	Total:	132.2	235.8	0	-65.1	-33.0	-17.7	-7.0	0	0
April	Scenic Floating	21.1	0	0	-3.9	-15.7	-13.6	-100	0	0
	Guide Boat Fishing	434.7	0	0	49.4	12.8	-101.7	-100	0	0
	Private Boat Fishing	245.9	0	0	48.9	24.8	-31.0	-100	0	0
	Shore Fishing/Trail Use	240.9	0	0	46.4	23.9	-23.5	-100	0	0
	Camping	0	0	0	0	0	0	0	0	0
	Total:	942.7	0	0	140.8	17.6	-169.9	-100	0	0
May	Scenic Floating	2.9	0	0	1.2	71.6	0	0	-2.7	-100
	Guide Boat Fishing	75.1	0	0	53.3	245.0	0	0	-318.1	-100
	Private Boat Fishing	20.5	0	0	16.3	380.6	0	0	-123.1	-100
	Shore Fishing/Trail Use	17.3	0	0	12.7	274.0	0	0	-150.6	-100
	Camping	0	0	0	0	0	0	0	0	0
	Total:	115.8	0	0	83.4	258.0	0	0	-594.5	-100
June	Scenic Floating	6.2	0	0	-485.2	-98.7	0	0	0	0
	Guide Boat Fishing	0	0	3.2	-410.6	-100	0	0	3.2	n/a
	Private Boat Fishing	0	0	0	-66.1	-100	0	0	0	0
	Shore Fishing/Trail Use	0	0	3.5	-111.4	-100	0	0	3.5	n/a
	Camping	0	0	.2	-8.3	-100	0	0	.2	n/a
	Total:	6.2	0	7.0	-1,081.7	-99.4	0	0	7.0	n/a
July	Scenic Floating	1,288.0	0	0	1,228.1	2,048.8	-591.2	-100	0	0
	Guide Boat Fishing	447.1	0	6.4	376.9	537.0	-233.2	-100	6.4	n/a
	Private Boat Fishing	95.5	0	.2	85.8	881.3	-38.4	-100	.2	n/a
	Shore Fishing/Trail Use	267.7	0	9.7	215.2	410.2	-162.8	-100	9.7	n/a
	Camping	9.7	0	.5	6.5	202.5	-7.4	-100	.5	n/a
	Total:	2,108.0	0	16.8	1,912.5	978.1	-1,033.0	-100	16.8	n/a
Aug	Scenic Floating	607.6	885.1	0	179.7	42.0	325.1	58.0	0	0
	Guide Boat Fishing	442.1	462.6	6.6	172.1	63.8	53.3	13.0	-7.9	-54.4
	Private Boat Fishing	92.1	94.9	.3	49.7	117.4	16.1	20.4	-.9	-73.1
	Shore Fishing/Trail Use	266.6	191.9	6.0	138.4	108.0	-37.7	-16.4	-4.3	-41.6
	Camping	8.1	9.0	.4	1.2	17.2	1.2	15.6	-.3	-45.5
	Total:	1,416.5	1,643.4	13.3	541.2	61.8	357.9	27.8	-13.4	-50.1
Sept	Scenic Floating	5.0	7.0	0	1.1	27.1	2.1	41.4	-.9	-100
	Guide Boat Fishing	377.2	373.9	15.2	75.0	24.8	-3.3	-.9	-56.7	-78.9
	Private Boat Fishing	311.2	288.9	5.5	119.1	62.0	-22.3	-7.2	-33.7	-85.9
	Shore Fishing/Trail Use	142.2	95.4	6.4	49.4	53.1	-46.8	-32.9	-16.3	-71.6
	Camping	4.7	5.1	.5	.5	11.5	.3	7.3	-1.5	-74.1
	Total:	840.3	770.4	27.6	245.0	41.2	-69.9	-8.3	-109.0	-79.8
Oct	Scenic Floating	.6	1.0	0	-.1	-10.4	0	4.6	-.3	-100
	Guide Boat Fishing	69.9	80.2	0	-9.6	-12.1	-3.1	-3.7	-21.4	-100
	Private Boat Fishing	47.0	59.1	0	-14.7	-23.8	-4.4	-6.9	-11.3	-100
	Shore Fishing/Trail Use	31.4	27.7	0	-6.7	-17.7	-1.8	-6.2	-8.5	-100
	Camping	.1	.1	0	0	-18.5	0	-2.0	0	-100
	Total:	149.1	168.1	0	-31.1	-17.3	-9.2	-5.2	-41.5	-100
Total	Scenic Floating	1,933.9	897.6	0	920.3	90.8	-277.2	-23.6	-3.8	-100
	Guide Boat Fishing	1,890.9	991.1	31.4	289.8	18.1	-291.9	-22.8	-394.4	-92.6
	Private Boat Fishing	851.6	531.9	6.1	214.9	33.8	-88.4	-14.2	-168.7	-96.5
	Shore Fishing/Trail Use	1,012.0	383.0	25.7	320.2	46.3	-278.4	-42.1	-166.4	-86.6
	Camping	22.5	14.2	1.6	-.2	-.9	-5.8	-29.2	-1.1	-41.6
	Total:	5,710.7	2,817.7	64.8	1745.0	44.0	-941.8	-25.1	-734.5	-91.9

For the Action Alternative dry condition, total river recreation valuation was estimated at only $65 thousand. This reflects a loss of nearly $735 thousand or 92 percent compared to No Action Alternative dry conditions. All activities are estimated to experience losses with the largest associated with guide boat fishing, private boat fishing, and shoreline fishing/trail use. The majority of the losses occur during May and September with over 80 percent of the loss occurring in May.

B) Flaming Gorge Valuation:

Table 34 presents the results of the Flaming Gorge Reservoir value per visit interpolations for the Action Alternative under average, wet, and dry conditions. The five value data points used in the interpolation are presented should one be interested in comparing the values per visit to the water levels and data points from table 26. The table also includes a comparison of Action Alternative values by hydrologic condition to those of the No Action Alternative in terms of both dollars and percent.

For the Action Alternative average condition, water levels were closer to preferred conditions during 8 of the 12 months. The months with the largest gains appear to be February through May where the largest differentials in water levels between the alternatives also occur. Given these months are associated with relatively low visitation, the gain in value is not particularly large.

For the Action Alternative wet condition, 10 of the 12 months indicated gains in values per visit compared to No Action Alternative wet conditions. The other 2 months (March and April) showed no change. The largest increases in value per visit appear to occur in July through November where the largest differentials in water levels between the two alternatives also occur.

For the Action Alternative dry condition, all months resulted in sizable gains in values per visit compared to the No Action Alternative. The increase in water level associated with the Action Alternative dry condition over that of the No Action Alternative ranged from a low of 2.9 feet to a high of 6 feet (averaging 5.3 feet).

Table 35 presents the results of applying the values per visit from table 34 to the visitation estimates from table 30. Values are measured in thousands of dollars for the Action Alternative under average, wet, and dry conditions. Changes from the No Action Alternative for the same hydrologic condition are presented in dollar and percentage terms.

For the Action Alternative average condition, total reservoir recreation value is estimated at over $22 million. This reflects about a $650 thousand or 3.0 percent increase over No Action Alternative average conditions. All activities show gains in value with nearly 97 percent of the gain stemming from power boating/waterskiing and boat fishing. Gains in value were estimated for 7 of the 12 months with the largest gains seen in April through June. All of the gain in value is attributable to the gain in values per visit obtained from the interpolation analysis since visitation was estimated via the facility availability approach to be the same under both Action and No Action Alternative average conditions at the reservoir. Recall that the facility availability approach is less sensitive to changes in water levels compared to the interpolation approach. Gains in value per trip were estimated via the interpolation approach and applied to current visitation (given the facility availability approach estimated no change in visitation) to obtain the overall gain in valuation. It is interesting to note that the months with the largest estimated gains in values per visit were not the months with the largest total value gains. This was because several of the months with large gains in values per visit were low visitation months.

For the Action Alternative wet condition, total reservoir recreation value is estimated at $22.2 million. This reflects over a $5.9 million or 36.6 percent increase in value compared to No Action Alternative wet

Table 34: Action Alternative, Flaming Gorge Reservoir Monthly Value per Visit by Hydrologic Condition

Month	Recreation Activity	Interpolation Data Points					Action Alternative Values								
		Low End Threshold Values	Current Values	Preferred Values	High End Kink Values	High End Threshold Values	Average Values	Change from No Action Average		Wet Values	Change from No Action Wet		Dry Values	Change from No Action Dry	
								$	%		$	%		$	%
Jan	Power Boating/Skiing	0	25.71	46.22	25.71	0	37.83	3.94	11.6	44.65	.79	1.8	31.53	27.51	684.3
	Boat Fishing	0	25.21	37.92	25.21	0	32.62	2.40	7.9	36.80	.49	1.3	28.77	28.12	4,326.2
	Boat Camping	0	13.06	22.23	13.06	0	18.56	1.77	10.5	21.64	.36	1.7	15.72	14.75	1,520.6
	Swimming/Waterplay	0	1.44	10.41	1.44	0	6.81	1.75	34.6	9.83	.35	3.7	4.02	4.02	N/A
Feb	Power Boating/Skiing	0	25.71	46.22	25.71	0	37.56	4.46	13.5	43.60	3.15	7.8	32.32	26.01	412.2
	Boat Fishing	0	25.21	37.92	25.21	0	32.46	2.73	9.2	36.15	1.92	5.6	29.25	26.00	800.0
	Boat Camping	0	13.06	22.23	13.06	0	18.45	2.02	12.3	21.17	1.42	7.2	16.08	13.82	611.5
	Swimming/Waterplay	0	1.44	10.41	1.44	0	6.69	1.97	41.7	9.36	1.39	17.4	4.37	4.22	2,813.3
March	Power Boating/Skiing	0	25.71	46.22	25.71	0	37.83	4.73	14.3	43.33	0	0	31.79	18.6	141.0
	Boat Fishing	0	25.21	37.92	25.21	0	32.62	2.89	9.7	35.99	0	0	28.93	17.89	162.0
	Boat Camping	0	13.06	22.23	13.06	0	18.56	2.13	13.0	21.05	0	0	15.84	9.71	158.4
	Swimming/Waterplay	0	1.44	10.41	1.44	0	6.81	2.09	44.3	9.25	0	0	4.13	3.52	577.0
April	Power Boating/Skiing	0	25.71	46.22	25.71	0	38.35	4.98	14.9	44.91	0	0	30.48	10.98	56.3
	Boat Fishing	0	25.21	37.92	25.21	0	32.94	3.05	10.2	36.96	0	0	28.13	9.95	54.7
	Boat Camping	0	13.06	22.23	13.06	0	18.80	2.25	13.6	21.76	0	0	15.25	5.57	57.5
	Swimming/Waterplay	0	1.44	10.41	1.44	0	7.04	2.21	45.8	9.95	0	0	3.55	2.52	244.7
May	Power Boating/Skiing	0	25.71	46.22	25.71	0	37.83	5.25	16.1	45.56	0.66	1.5	29.96	24.8	480.6
	Boat Fishing	0	25.21	37.92	25.21	0	32.62	3.21	10.9	37.69	0.45	1.2	27.81	25.86	1,326.2
	Boat Camping	0	13.06	22.23	13.06	0	18.56	2.36	14.6	21.69	0.36	1.7	15.02	13.41	832.9
	Swimming/Waterplay	0	1.44	10.41	1.44	0	6.81	2.33	52.0	9.89	0.34	3.6	3.32	3.24	4,050.0
June	Power Boating/Skiing	0	25.71	46.22	25.71	0	43.07	3.15	7.9	41.92	4.63	12.4	34.41	24.08	233.1
	Boat Fishing	0	25.21	37.92	25.21	0	35.83	1.92	5.7	35.20	3.18	9.9	30.54	22.75	292.0
	Boat Camping	0	13.06	22.23	13.06	0	20.93	1.42	7.3	19.71	2.51	14.6	17.03	12.51	276.8
	Swimming/Waterplay	0	1.44	10.41	1.44	0	9.13	1.39	18.0	7.99	2.41	43.2	5.30	4.88	1,161.9
July	Power Boating/Skiing	0	25.71	46.22	25.71	0	45.56	-0.33	-0.7	40.60	17.03	72.3	34.94	20.02	134.2
	Boat Fishing	0	25.21	37.92	25.21	0	37.69	-0.23	-0.6	34.29	16.28	90.4	30.86	17.87	137.6
	Boat Camping	0	13.06	22.23	13.06	0	21.69	-0.18	-0.8	18.99	13.19	227.4	17.26	10.16	143.1
	Swimming/Waterplay	0	1.44	10.41	1.44	0	9.89	-0.17	-1.7	7.31	6.65	1,000.6	5.53	4.81	668.1
Aug	Power Boating/Skiing	0	25.71	46.22	25.71	0	44.65	-1.31	-2.9	41.26	21.26	106.3	32.58	22.25	215.4
	Boat Fishing	0	25.21	37.92	25.21	0	36.80	-0.80	-2.1	34.74	21.23	157.1	29.41	21.62	277.5
	Boat Camping	0	13.06	22.23	13.06	0	21.64	-0.59	-2.7	19.35	15.96	470.8	16.20	11.68	258.4
	Swimming/Waterplay	0	1.44	10.41	1.44	0	9.83	-0.58	-5.6	7.65	7.26	1,861.5	4.48	4.06	966.7
Sept	Power Boating/Skiing	0	25.71	46.22	25.71	0	42.02	-2.36	-5.3	42.91	19.34	82.1	31.00	24.12	350.6
	Boat Fishing	0	25.21	37.92	25.21	0	35.19	-1.45	-4.0	35.88	17.87	99.2	28.45	24.55	629.5
	Boat Camping	0	13.06	22.23	13.06	0	20.46	-1.06	-4.9	20.25	14.45	249.1	15.49	12.91	500.4
	Swimming/Waterplay	0	1.44	10.41	1.44	0	8.67	-1.04	-10.7	8.51	7.85	1,189.4	3.79	3.60	1,894.7
Oct	Power Boating/Skiing	0	25.71	46.22	25.71	0	40.45	-1.83	-4.3	43.57	16.87	63.2	30.74	27.3	793.6
	Boat Fishing	0	25.21	37.92	25.21	0	34.23	-1.12	-3.2	36.33	12.92	55.2	28.29	28.29	N/A
	Boat Camping	0	13.06	22.23	13.06	0	19.75	-0.82	-4.0	20.61	11.90	136.6	15.37	14.72	2,264.6
	Swimming/Waterplay	0	1.44	10.41	1.44	0	7.97	-0.81	-9.2	8.86	7.86	786.0	3.67	3.67	N/A
Nov	Power Boating/Skiing	0	25.71	46.22	25.71	0	39.66	0.52	1.3	44.57	11.25	33.8	31.27	26.68	581.3
	Boat Fishing	0	25.21	37.92	25.21	0	33.75	0.32	1.0	37.01	7.71	26.3	28.61	27.31	2,100.8
	Boat Camping	0	13.06	22.23	13.06	0	19.39	0.24	1.3	21.15	6.11	40.6	15.61	14.32	1110.1
	Swimming/Waterplay	0	1.44	10.41	1.44	0	7.62	0.23	3.1	9.37	5.86	167.0	3.90	3.86	9,650.0
Dec	Power Boating/Skiing	0	25.71	46.22	25.71	0	38.61	2.62	7.3	45.89	3.97	9.5	31.27	27.83	809.0
	Boat Fishing	0	25.21	37.92	25.21	0	33.10	1.60	5.1	37.92	2.72	7.7	28.61	28.61	N/A
	Boat Camping	0	13.06	22.23	13.06	0	18.92	1.18	6.7	21.87	2.16	11.0	15.61	14.96	2,301.5
	Swimming/Waterplay	0	1.44	10.41	1.44	0	7.16	1.17	19.5	10.06	2.07	25.9	3.90	3.9	N/A

Table 35: Action Alternative, Flaming Gorge Reservoir Monthly Total Values by Hydrologic Condition ($1,000s)										
			Change from No Action Average Condition			Change from No Action Wet Condition			Change from No Action Dry Condition	
Month	Recreation Activity	Average Values	$	%	Wet Values	$	%	Dry Values	$	%
Jan	Power Boating/Skiing	22.1	2.3		26.0	.5		18.4	16.4	
	Boat Fishing	9.6	.7		10.8	.1		8.4	8.3	
	Boat Camping	1.4	.1		1.6	0		1.2	1.1	
	Swimming/Waterplay	.2	.1		.3	0		.1	.1	
	Total:	33.2	3.2	10.6	38.8	.6	1.7	28.1	25.9	1,164.4
Feb	Power Boating/Skiing	0	0		0	0		0	0	
	Boat Fishing	0	0		0	0		0	0	
	Boat Camping	0	0		0	0		0	0	
	Swimming/Waterplay	0	0		0	0		0	0	
	Total:	0	0	0	0	0	0	0	0	0
March	Power Boating/Skiing	101.9	12.7		116.7	0		85.6	50.1	
	Boat Fishing	44.3	3.9		48.9	0		39.3	24.3	
	Boat Camping	12.6	1.4		14.3	0		10.7	6.6	
	Swimming/Waterplay	1.1	.3		1.5	0		.7	.6	
	Total:	159.9	18.4	13.0	181.3	0	0	136.3	81.5	148.9
April	Power Boating/Skiing	825.8	107.3		967.0	0		656.3	236.4	
	Boat Fishing	358.1	33.2		401.8	0		305.8	108.2	
	Boat Camping	33.1	4.0		38.3	0		26.9	9.8	
	Swimming/Waterplay	9.0	2.8		12.7	0		4.5	3.2	
	Total:	1,225.9	147.2	13.6	1,419.8	0	0	993.5	357.6	56.2
May	Power Boating/Skiing	2,186.3	303.4		2,633.0	38.1		1,731.5	1,478.3	
	Boat Fishing	951.5	93.6		1,099.4	13.1		811.2	762.9	
	Boat Camping	25.8	3.3		30.1	.5		20.8	18.6	
	Swimming/Waterplay	23.3	8.0		33.9	1.1		11.4	11.1	
	Total:	3,186.9	408.3	17.9	3,796.4	52.9	1.4	2,574.9	2,270.9	747.0
June	Power Boating/Skiing	3,357.0	245.5		3,267.4	360.9		2,682.0	1,877.5	
	Boat Fishing	1,409.7	75.5		1,384.9	125.1		1,201.5	895.4	
	Boat Camping	39.0	2.6		36.7	4.7		31.7	23.3	
	Swimming/Waterplay	42.2	6.4		36.9	11.1		24.5	22.5	
	Total:	4,847.8	330.1	7.3	4,725.9	501.8	11.9	3,939.8	2,818.7	251.4
July	Power Boating/Skiing	3,866.7	-28.0		3,445.8	1,445.4		2,965.4	1,699.1	
	Boat Fishing	1,614.6	-9.9		1,468.9	697.4		1,322.0	765.5	
	Boat Camping	30.1	-0.3		26.3	18.3		23.9	14.1	
	Swimming/Waterplay	49.7	-0.9		36.8	33.4		27.8	24.2	
	Total:	5,561.1	-39.0	-0.7	4,977.8	2,194.5	78.8	4,339.1	2,502.9	136.3
Aug	Power Boating/Skiing	2,200.0	-64.5		2,033.0	1,047.5		1,605.3	1,096.7	
	Boat Fishing	915.2	-19.9		864.0	528.0		731.4	537.9	
	Boat Camping	25.4	-.7		22.7	18.7		19.0	13.7	
	Swimming/Waterplay	28.7	-1.7		22.3	21.2		13.1	11.9	
	Total:	3,169.4	-86.8	-2.7	2,942.0	1,615.5	121.8	2,368.8	1,660.2	234.3
Sept	Power Boating/Skiing	1,187.1	-66.7		1,212.2	546.4		875.8	710.7	
	Boat Fishing	501.8	-20.7		511.6	254.8		405.7	358.4	
	Boat Camping	11.0	-.6		10.9	7.7		8.3	6.9	
	Swimming/Waterplay	14.5	-1.7		14.3	13.1		6.3	6.0	
	Total:	1,714.4	-89.7	-5.0	1,749.0	822.1	88.7	1,296.1	1,082.1	505.8
Oct	Power Boating/Skiing	1,028.5	-46.5		1,107.8	428.9		781.6	707.3	
	Boat Fishing	439.3	-14.4		466.3	165.8		363.1	363.1	
	Boat Camping	13.3	-.6		13.9	8.0		10.4	9.9	
	Swimming/Waterplay	12.0	-1.2		13.4	11.9		5.5	5.5	
	Total:	1,493.1	-62.7	-4.0	1,601.3	614.6	62.3	1,160.6	1,085.9	1,453.8
Nov	Power Boating/Skiing	263.3	3.5		295.9	74.7		207.6	181.7	
	Boat Fishing	113.1	1.1		124.1	25.8		95.9	92.2	
	Boat Camping	9.4	.1		10.2	3.0		7.5	6.9	
	Swimming/Waterplay	3.0	.1		3.7	2.3		1.5	1.5	
	Total:	388.8	4.7	1.2	433.8	105.8	32.3	312.5	282.3	934.7
Dec	Power Boating/Skiing	165.1	11.2		196.2	17.0		133.7	121.2	
	Boat Fishing	71.5	3.5		81.9	5.9		61.8	61.8	
	Boat Camping	6.8	.4		7.8	.8		5.6	5.3	
	Swimming/Waterplay	1.8	.3		2.6	.5		1.0	1.0	
	Total:	245.2	15.4	6.7	288.5	24.2	9.1	202.1	189.4	1,488.3
Total	Power Boating/Skiing	15,203.7	480.1	3.3	15,301.0	3,959.3	34.9	11,743.1	8,175.5	229.2
	Boat Fishing	6,428.6	146.7	2.3	6,462.5	1,816.1	39.1	5,346.1	3,977.9	290.7
	Boat Camping	207.7	9.9	5.0	212.8	61.7	40.8	166.0	116.3	233.8
	Swimming/Waterplay	185.6	12.5	7.2	178.2	94.8	113.6	96.5	87.7	998.2
	Total:	22,025.5	649.2	3.0	22,154.5	5,931.9	36.6	17,351.8	12,357.4	247.4

conditions. All activities are estimated to result in gains compared to No Action with the largest gain due to power boating/waterskiing and boat fishing. Nearly 97 percent of the gain occurs in the months of June through October. As with the average condition, all gains in total value under wet conditions stem from gains in value per visit since visitation was estimated to be the same under both the Action and No Action Alternatives.

For the Action Alternative dry condition, total reservoir recreation valuation was estimated at nearly $17.4 million. This reflects a substantial gain of nearly $12.4 million or 247 percent compared to No Action Alternative dry conditions. All activities are estimated to experience gains with the largest associated with power boating/waterskiing and boat fishing. Gains are expected in virtually all months with the largest accruing from May through October. The Action Alternative dry condition gains are driven by gains in both visitation and value per visit compared to No Action.

C) Total Valuation:

Table 36 presents the sum of the Green River and Flaming Gorge Reservoir recreation values for the Action Alternative under average, wet, and dry conditions. The table displays the Green River values, the Flaming Gorge Reservoir values, and the combined total across both sites. In addition to the total values

Table 36: Total Water Based Activity Valuation for Green River and Flaming Gorge Reservoir for Action Alternative

		Action Alternative Valuation by Hydrologic Condition								
		Average			Wet			Dry		
			Change from No Action Average Condition			Change from No Action Wet Condition			Change from No Action Dry Condition	
Site	Recreation Activity	Total Value	Value	%	Total Values	Value	%	Total Value	Value	%
Green River	Scenic Floating	1,933.9	920.3	90.8	897.6	-277.2	-23.6	0	-3.8	-100
	Guide Boat Fishing	1,890.9	289.8	18.1	991.1	-291.9	-22.8	31.4	-394.4	-92.6
	Private Boat Fishing	851.6	214.9	33.8	531.9	-88.4	-14.2	6.1	-168.7	-96.5
	Shoreline Fishing/ Trail Use	1,012.0	320.2	46.3	383.0	-278.4	-42.1	25.7	-166.4	-86.6
	Boat Based Camping	22.5	-.2	-.9	14.2	-5.8	-29.2	1.6	-1.1	-41.6
	Total:	5,710.7	1,745.0	44.0	2,817.7	-941.8	-25.1	64.8	-734.5	-91.9
Flaming Gorge Reservoir	Power Boating/ Waterskiing	15,203.7	480.1	3.3	15,301.0	3,959.3	34.9	11,743.1	8,175.5	229.2
	Boat Fishing	6,428.6	146.7	2.3	6462.5	1816.1	39.1	5,346.1	3,977.9	290.7
	Boat Based Camping	207.7	9.9	5.0	212.8	61.7	40.8	166.0	116.3	233.8
	Swimming/ Waterplay	185.6	12.5	7.2	178.2	94.8	113.6	96.5	87.7	998.2
	Total:	22,025.5	649.2	3.0	22,154.5	5,931.9	36.6	17,351.8	12,357.4	247.4
Both Sites	Combined Total:	27,736.2	2,394.2	9.5	24,972.2	4,990.1	25.0	17,416.6	11,622.9	200.6

by hydrologic condition, the table also presents the change from the No Action Alternative both in terms of values and percentage. Reservoir valuation accounts for anywhere from 79.4 to 99.6 percent of the total depending on the hydrologic condition.

For the Action Alternative average condition, the combined valuation was estimated at $27.7 million. This reflects nearly a $2.4 million or 10 percent increase from the No Action Alternative average condition. Gains in value occur on both the river and reservoir with the largest gains accruing to scenic floating on the river and power boating/waterskiing on the reservoir. Given the insignificant increase in visitation for the Action Alternative average condition, virtually all of the increase in value stems from increases in value per visit. The majority of the gains on the river occur from July through September and on the reservoir from April through June.

Note that total values for the Action Alternative average condition increased compared to the No Action Alternative for both guide boat and private boat fishing on the river despite the losses in visitation displayed in table 31. This result stemmed from the fact that the annual loss in visitation included certain months with gains (mainly July, August, and September) as well as the months with losses (mainly June). As it turns out, the losses in visitation were associated with months of relatively low value per visit and the gains with months of high value per visit. Recall that values per visit increase the closer flows come to the preferred flow level for each activity. When combined, the influence of the higher values per visit outweighed the influence of the lost visitation.

For the Action Alternative wet condition, combined valuation was estimated at nearly $25 million. This reflects an increase of almost $5 million or 25 percent compared to the No Action Alternative wet condition. The $5.9 million of increased value for the reservoir outweighs the $940 thousand of lost value on the river. Power boating/waterskiing and boat fishing on the reservoir account for the majority of the increase in value. The largest gains on the reservoir occur in the months of June through October, and the largest losses on the river occur in July. Keep in mind that wet conditions are expected only about 10 percent of the time.

For the Action Alternative dry condition, combined valuation is estimated at $17.4 million. This reflects an increase of over $11.6 million or 200 percent compared to the No Action Alternative dry condition. The nearly $12.4 million of increased value for the reservoir outweighs the $735 thousand of lost value on the river. Power boating/waterskiing and boat fishing on the reservoir account for the majority of the increase in value. The largest gains in value occur on the reservoir in the months of May through October. Losses on the river are seen across all activities with the majority occurring in the month of May. Keep in mind that dry conditions are expected only about 10 percent of the time.

4.0 REFERENCES

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Socioeconomics Technical Appendix

SOCIOECONOMICS TECHNICAL APPENDIX

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Socioeconomics Technical Appendix

1.0 INTRODUCTION

This technical appendix reviews the current economic environment that could be affected by implementation of either the No Action or Action Alternatives, discusses regional economic methods, and provides detailed results of the regional analysis. Under affected environment, a brief discussion of the geographic impact area is followed by a description of current conditions. Under environmental consequences, a methodology discussion is followed by regional economic impact results for each alternative, along with comparisons of the Action Alternative to the No Action Alternative.

This EIS presents two types of economic analyses, one measuring economic benefits and the other regional economic impacts. Regional economic impacts for this study have been developed based on recreation effects and are presented in the EIS under socioeconomics. Economic benefits have been estimated separately for agriculture, hydropower, and recreation and are presented within each relevant EIS section.

Regional economic impacts attempt to measure changes in total economic activity within a specified geographic region stemming from changes in within region expenditures. Regional economic impacts are typically described using such general indicators as output, income, and employment. Conversely, economic benefits attempt to measure changes in societal or national welfare based on a net value concept.[1] Theoretically, nationally oriented economic benefit analyses attempt to provide a broader geographic focus compared to regional economic impact analyses. Unfortunately, in practice, the geographic difference between the analyses may be less pronounced given the difficulty in evaluating national implications of an action. If an action is relatively small from a national perspective, repercussions outside the directly impacted area may be insignificant. If the opposite is true, nationwide displacement or substitution effects may need to be taken into consideration. The difficultly lies in trying to estimate these substitution effects. For this analysis, the changes in economic benefits within the directly affected areas were assumed to be small enough so as not to create significant changes in national benefits. As a result, evaluation of nationwide substitution effects was deemed unnecessary.

One way to visualize the difference between regional economic impacts and economic benefits is to consider how each reacts to increases in regional expenditures. Regional economic impacts typically increase as in-region expenditures increase, whereas consumer surplus/profitability benefits tend to decrease as costs or expenditures alone increase. It should be noted that regional economic impacts and benefits often move in unison since they both typically rise or fall with levels of production (including recreation visitation). On the benefit side, as production changes, so do both production costs/expenditures and revenues/total consumer benefits, the net effect is that benefits generally move in the same direction as production changes. Nevertheless, there are many situations where changes in benefits and economic impacts diverge. This potential for divergence, along with the fact that different user groups are often interested in different economic measures, creates a need for both analyses.

Given the above discussion, the basic objective of the regional economic analysis is to measure changes in total economic activity within the affected region for the Action Alternative as compared to the No Action Alternative. The proposed Action Alternative potentially affects regional economic activity mainly through changes in: 1) costs of agricultural production due to flooding effects on irrigated acreage, 2) recreational expenditures due to the effects of changes in reservoir water levels and river flows on recreation visitation, and 3) costs of electricity as the timing and production of hydropower varies with the fluctuation in releases from Flaming Gorge Dam. Flooding effects upon agricultural lands along the Green River proved to be relatively minor and were consequently dropped from the regional analysis. Regional impacts due to losses in hydropower generation were also deemed to be relatively insignificant locally given any increased costs of power generation would be distributed across thousands of power users throughout the Western United States. Also, given this EIS is primarily a reservoir re-operation study, the lack of structural adjustments to the dam implies that construction costs would be minimal. Other typically encountered project purposes, such as municipal and industrial uses, were either not applicable or not significantly affected. Bottomline, the only factor used to evaluate changes in regional economic activity were the changes in recreation expenditures.

Regional economic impacts were measured using input-output (I-O) analysis. I-O estimates regional economic impacts based on a region's inter-industry trade linkages. The analyses present changes in total economic impact as measured by the sum of direct effects (impacts to

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[1] For consumers, economic welfare reflects the value of goods and services consumed above what is actually paid for them. Such consumer welfare estimates are measured in terms of willingness-to-pay (WTP) in excess of cost, otherwise referred to as consumer surplus. This is the approach used in the recreation and hydropower analyses. While the hydropower analysis does not go through the process of estimating WTP, by focusing on differences in the replacement cost of power which are passed along to consumers, the resulting benefit measure is essentially the same. For producers or businesses, economic welfare is generally reflected in terms of gross revenues minus operating costs, otherwise referred to as profitability. This later approach is used in the agriculture analysis.

initially affected industries), indirect effects (impacts to industries providing inputs to directly impacted industries, i.e., backward linkages), and induced effects (impacts from employees spending wages within the region) all caused by the initial change in demand. For example, if $1,000 in agricultural product is lost from irrigated acreage idled by flooding (direct effect), and the farmer buys $500 less in seed and fertilizer from the local store (indirect effect), and the farm workers spend $100 less for household goods and services within the region (induced effect), then the total loss in output from regional agriculture is $1,000, but the total regional output loss is $1,600.

Three measures of regional economic activity provide the basis of the evaluation: total industry output, total labor income, and employment.

- Total Industry Output: Dollar value of production (sales revenues and gross receipts) from all industries in the region. Total industry output includes the value of inter-industry trade of intermediate goods prior to final manufacture and sale.
- Total Labor Income: Employment income derived at the workplace including wages and benefits (employee compensation) plus self-employed income (proprietary income).
- Employment: Total of hourly wage, salary, and self-employed jobs (part-time and full-time), measured in terms of number of jobs, not full-time equivalents.

The majority of the regional analysis discussion is based on the results of a regional modeling effort. In addition, information is presented at the end of the Action Alternative section on the results of surveys conducted with commercial guide operators on both the Green River and Flaming Gorge Reservoir. It was anticipated that commercial guide operators, particularly those on the Green River, may be adversely affected by the Action Alternative. Given the regional analysis focused on a three-county area, impacts to commercial guide operators would not be directly discernible. As a result, surveys of commercial guide operators were conducted to try and identify impacts. Other tourist oriented sectors, such as lodging and restaurants, were not anticipated to be as adversely affected since they cater to both river and reservoir recreators.

2.0 AFFECTED ENVIRONMENT

This section includes a brief discussion of the geographic impact area followed by descriptions of current conditions.

2.1 Geographic Impact Area (Region)

As described under the recreation section, the recreation analysis focuses on effects at Flaming Gorge Reservoir and along the Green River primarily within the Flaming Gorge NRA. Flaming Gorge Reservoir is located within Sweetwater County, Wyoming and Daggett County, Utah. The relevant portions of the Green River are located within Daggett County, Utah. Access to the northern portions of the reservoir would likely involve economic activity in the Wyoming towns of Green River and Rock Springs. Conversely, access to the southern reaches of the reservoir and the Green River may involve economic activity in more southern communities. Since Daggett County has little by way of significantly sized communities, the decision was made to include

Uintah County, Utah, within the impact region due to the influence of the town of Vernal. As a result, the geographic impact area for both the reservoir and river recreation analyses includes all three counties.

2.2 Current Conditions

The latest available data for the IMPLAN regional input-output model used in the analysis reflects regional economic activity for calendar year 1999 (for information on the IMPLAN model, see section 3.1 on Regional Economic Impact Analysis Methodology). Table 1 presents "current" base year 1999 conditions from the IMPLAN three-county model for total industry output, employment, and labor income. The table is broken down by major aggregated industry as well as the eight most directly impacted recreation oriented economic sectors identified in the analysis. The eight directly impacted sectors are shown separately, but under their associated major industry (e.g., "air transportation" is presented separately, but under transportation). Adding the separately presented directly impacted sectors with their associated major industry provides an estimate of the total for that industry (e.g., adding "air transportation" with "other transportation estimates total transportation).

Reviewing the percentages in table 1, the most important industries vary depending on the measure. From an output perspective, the top five industries include mining (33.8 percent [%]), transportation (12.0%), services (9.7%), construction (8.4%), and manufacturing (8.1%). Conversely, from an employment perspective, the top five industries include services (20.9%), retail trade (17.6%), government (17.3%), mining (10.8%), and manufacturing (8.3%). Comparing services and mining under these two perspectives indicates that the service industry is relatively more labor intensive that the mining industry. Similarly, the government sector appears to involve a fairly significant work force, but a relatively low level of marketable output. Finally, the top five industries from the perspective of labor income includes mining (22.1%), government (16.1%), transportation (14.8%), services (13.1%), and construction (8.7%). Comparing these percentages to the employment percentages provides an indication as to the relatively high and low paying industries. Mining and transportation appear to be high paying industries given they reflect only 10.8 and 7.6% of employment, but 22.1 and 14.8% of labor income respectively. The opposite appears to be true for the retail trade and service industries.

The eight directly impacted sectors, from a recreation expenditure perspective, combined to provide 5.4% of total industry output, 16.6% of employment, and 7.3% of labor income. These directly impacted sectors are fairly significant contributors to regional employment, but are relatively insignificant in terms of output and income. Food stores, automobile dealers and service stations, eating and drinking establishments, miscellaneous retail stores, and hotels and lodging places in particular combine for 16.1% of total regional employment.

3.0 ENVIRONMENTAL CONSEQUENCES

This section describes the regional economic impact methodology as well as the results of the analyses.

Table 1: Current Conditions Data Year: 1999		(Impact Area Counties: Daggett and Uintah, Utah, Sweetwater, Wyoming)					
		Total Industry Output		Employment		Labor Income	
Primary Industries/Sectors	IMPLAN Industry Number	Millions of Dollars ($M)	% of Total	No. of Jobs	% of Total	Millions of Dollars ($M)	% of Total
Agriculture, Forestry, Fishing	1-27	50.8	1.3	1,340	3.5	15.9	1.2
Mining	28-47, 57	1,349.7	33.8	4,146	10.8	283.9	22.1
Construction	48-56	335.5	8.4	3,210	8.3	111.3	8.7
Manufacturing	58-432	322.1	8.1	1,728	4.5	85.4	6.7
Other Transportation	433-436, 438-440	471.8	11.8	2,899	7.5	187.4	14.6
- Air Transportation:	437	6.4	0.2	74	0.1	2.7	0.2
Communications	441-442	45.7	1.1	194	0.5	11.1	0.9
Utilities	443-446	285.2	7.1	625	1.6	45.4	3.5
Wholesale Trade	447	89.3	2.2	1,074	2.8	36.9	2.9
Other Retail Trade	448-449, 452-453	52.9	1.3	1,579	4.1	25.8	2.0
- Food Stores:	450	32.2	0.8	882	2.3	18.9	1.5
- Automotive Dealers & Service Stations:	451	55.4	1.4	1,076	2.8	25.3	2.0
- Eating & Drinking:	454	66.5	1.7	2,292	6.0	22.6	1.8
- Miscellaneous Retail:	455	17.1	0.4	921	2.4	8.4	0.7
Finance, Insurance, & Real Estate (FIRE)	456-462	206.2	5.2	1,769	4.6	27.2	2.1
Other Services	464-476, 478-487, 489-509	345.7	8.7	6,891	17.9	152.1	11.9
- Hotels and Lodging Places:	463	36.1	0.9	1,004	2.6	14.4	1.1
- Automobile Rental and Leasing:	477	.4	0.0	13	0.0	0.1	0.0
- Amusement and Recreation Services:	488	3.2	0.1	149	0.4	1.4	0.1
Federal, State, and Local Government	510-515, 519-523	261.7	6.6	6,659	17.3	207.1	16.1
TOTAL:		3,993.7	100	38,523	100	1,283.3	100
MOST AFFECTED SECTORS:		217.3	5.4	6,410	16.6	93.8	7.3

3.1 Regional Economic Impact Analysis Methodology

The majority of the regional analysis discussion is based on the results of a regional modeling effort. In addition to the regional modeling results, a brief discussion is presented at the end of the Action Alternative section on the results of surveys conducted with commercial operators on both the Green River and Flaming Gorge Reservoir.

3.1.1 Regional Modeling Methodology

The regional economic impact analysis involves running alternative specific estimates of recreation expenditures through the IMPLAN input output model of the three-county regional economies. The IMPLAN (IMpact analysis for PLANning) model was originally developed by the U.S. Department of Agriculture Forest Service to assist in land and resource planning. This personal computer based software is widely used for the development of regional economic analyses.

Input-output analysis is a procedure for examining relationships both between businesses and between businesses and consumers. The analysis captures all the monetary market transactions within a specified region for a given period of time via the inter-industry transaction table. The resulting mathematical formulas allow for examination of the effects of a change in one or more economic activities upon the overall regional economy (Minnesota IMPLAN Group, Inc., 2000).

Regional economic effects stemming from river and reservoir recreational activities within the three-county Utah/Wyoming area are driven by levels of within region recreation expenditures. The recreation analysis developed visitation results by month and activity for each alternative and hydrologic condition (i.e., average, dry, and wet water conditions). This information, combined with estimates of recreational expenditures per visit by month and activity for each alternative and hydrologic condition allowed for calculation of total within region recreational expenditures by alternative and hydrologic condition. Changes in recreational expenditures for the Action Alternative compared to the No Action Alternative for each hydrologic condition were entered into the IMPLAN model. The resulting differences in regional economic activity between the Action Alternative and No Action Alternative for each hydrologic condition provide a measure of the regional economic impacts associated with the Action Alternative.

As described under the affected environment current conditions section, the latest available IMPLAN data reflects regional economic activity during 1999. While the total recreation expenditure information reflects visitation and expenditures per visit during 2000-2001, the difference in years was considered insignificant enough to assume the 1999 version of the regional economy was reflective of the No Action Alternative. Given that 1999 was a wet year for both the river and reservoir, the underlying picture of the economy was considered analogous to the No Action Alternative wet condition. To estimate regional economic conditions for the No Action Alternative under average and dry conditions, differences in recreation expenditures for the No Action average and dry conditions were estimated as compared to No Action wet conditions. The expenditure differences were entered into IMPLAN to calculate regional economic activity under No Action average and dry conditions. The differences in Action Alternative expenditures compared to No Action expenditures under average, wet, and dry conditions were also run through IMPLAN to estimate impacts for the Action Alternative.

Typically, a recreation oriented regional analysis focuses on the expenditures made by nonlocal recreators, defined as recreators who do not reside in the region of interest. The logic is that increases or decreases in within region recreational expenditures by local residents would likely represent a wash to the regional economy since those expenditures would displace other within region expenditures. For example, if we anticipate that a local recreator will take more rafting trips and spend more money recreating on the Green River as a result of an alternative, the standard logic assumes that individual would reduce within region expenditures for other items, not necessarily recreational items, by an equal amount. The resulting implication is this transfer of within region spending would have very little effect upon regional economic activity. While this assumption sounds reasonable, it is often faulty for several reasons. First, it is possible that additional within region recreational expenditures may displace recreational spending outside the region, implying substitution of recreation visits between sites. In this case, the additional spending would reflect a true gain for the region. Secondly, even if the additional within region recreational expenditures did displace other within region expenditures, differences in the types or size of expenditures could affect the level of regional economic activity. If within region recreation expenditures for gas, food, etc. associated with the additional recreation visitation displaced within region expenditures for going to the movies or some other within region activity, the fact that the expenditures are incurred within different economic sectors would imply different regional effects. As a result, the decision was made to evaluate regional economic impacts based on all recreation expenditures, not just those expenditures generated by nonlocal residents. No attempt was made to estimate the level of offset in recreational expenditures for local residents given the inherently speculative nature of such an analysis. As a result, the regional impacts for recreation may be somewhat overstated.

Average per visit current total recreation expenditures by activity within the region were obtained from the recreation survey described within the recreation section. Information was also gathered from the survey as to the breakdown of expenditures by expenditure category. Expenditure categories include camping fees, lodging, restaurants, groceries and liquor, gasoline, recreation supplies, guide services, car rental, other rentals, public transportation, and other. Expenditure categories varied somewhat by activity. For example, guide boat fishing was the only activity which included guide services.

In addition to the current recreation expenditure information, the survey also asked if the recreator's length of visit might increase under preferred river flow and reservoir water level conditions. The results of this preferred conditions length of trip question were adjusted downward using the conservative, but often applied approach of assuming nonrespondent responses would be equal to zero. The preferred conditions length of visit was divided by the current average length of visit to estimate a percentage increase in length of visit under preferred conditions for each recreation activity. These activity specific percentage increases were applied to current per visit expenditures to estimate per visit expenditures by activity under preferred conditions.

As with the recreation analysis, current and preferred conditions were used to develop recreation expenditures per visit by activity for each alternative using an interpolation approach. Assuming length of stay per visit, and consequently expenditures per visit, peak under preferred conditions, an inverted U-shaped distribution was assumed to hold for recreation expenditures as it did for recreation visitation and value. A high end kink expenditure estimate was developed as in the recreation analysis. The high end kink was assumed to fall at proportionally the same position as the current condition expenditure location. Low end and high end thresholds, points where river flows or reservoir water levels were so low or high as to prevent use, were also obtained from the survey. The high end kink was assumed to fall the same percentage distance from the preferred flow/WL as the current conditions data point. If current conditions falls 75% of the way between preferred conditions and the low end threshold, then the high end kink was also assumed to fall 75% of the way between preferred conditions and the high end threshold. Including the high end kink, five data points now exist for conducting a linear interpolation of per visit recreation expenditures (i.e., low end threshold, current conditions, preferred conditions, high end kink, and high end threshold).

Instead of doing an interpolation using all five data points as was done in the recreation analyses, a modified interpolation was done using only the current conditions, preferred conditions, and high end kink data points. The logic for this was that for conditions below current conditions or above high end kink conditions, the full scale interpolation would predict recreation expenditures per visit to fall below current expenditures. While this may sound reasonable, at the extremes where conditions approach the low or high end thresholds, per visit expenditures would be estimated to approach zero. While values per trip may indeed approach zero for the last few visits taken, the expenditures for those visits will obviously not decline to zero. As a result, the decision was made to only interpolate between current conditions and the high end kink. This results in expenditures per visit falling within the range of current conditions to preferred conditions (note that the expenditures for the high end kink would be equivalent to current conditions). For cases where river flows or reservoir water levels fall below current conditions or above high end kink conditions, the expenditures per visit were assumed to hold at current/high end kink levels. To the extent that actual visit length declines below current visit length, the assumption that expenditures wouldn't't drop below current expenditures per visit may somewhat overstate total expenditures. The following presents the information on the three data points used in the interpolations.

1) Current Expenditures

Current and high end kink expenditures per visit were developed separately for Green River and Flaming Gorge Reservoir recreation activities based on information obtained from the recreation survey. Given that the high end kink is analogous to current conditions from an expenditure per visit perspective, the expenditures per visit for current and high end kink conditions were assume to be the same.

A) Green River Current/High End Kink Expenditures per Visit

To calculate current expenditures per visit by recreation activity, information was gathered from two primary questions from the recreation survey. The first question asked how much the recreator spends per visit on average for each of the expenditure categories. The second question asked how much the recreator spent on average by recreation activity. Combining the two questions allows for estimation of the expenditures per visit by recreation activity and expenditure category. Instead of trying to ask complex questions about costs by expenditure category for each recreation activity, this approach gets to essentially the same information.

As with many of the recreation calculations, the conservative but often applied approach of assuming zero values for nonrespondents was again applied to calculate expenditures. Question responses from the survey were reported by Aukerman et al., 2002 in terms of the average values for those who responded to each question. For example, average public transportation costs for those that used it were calculated at $255.71 per visit. But, only 7 of 195 respondents on the river indicated that they used public transit. Instead of calculating expenditures per visit based on the averages of the respondents, we assumed nonrespondents incurred zero costs for expenditure categories they didn't respond to. The result of this adjustment was to reduce total average expenditures across all activities from $1,463.81 to $316.22 per visit.

A couple of distinctions were made between presumed camping and non-camping trips and between guide boat fishing and other activities. For recreators who identified their primary activity as camping, an assumption was made that certain expenditure categories would not be relevant (e.g., lodging, restaurants, car rental, and public transportation). With the low overall expenditures per visit for Green River camping ($80.59), this assumption leads to more reasonable expenditure estimates for the relevant expenditure categories. Similarly, guide boat fishing was separated from all other activities so that the expenditure for guide services could be included within the overall expenditure estimate.

Once these adjustments had been made, percentages were calculated for each expenditure category. Percentages by expenditure category for guide boat fishing, camping, and all other activities were applied to the current total expenditure estimates obtained from the survey for each recreation activity (scenic floating, guide boat fishing, private boat fishing, shoreline fishing/trail use, and camping) to estimate current expenditures by activity as shown in table 2.

B) Flaming Gorge Reservoir Current/High End Kink Expenditures per Visit

The approach used to estimate current/high end kink expenditures per visit for the reservoir followed closely the procedure described directly above for the river. However, a couple of differences need to be mentioned. First, given guide boat fishing is not a significant activity on

Table 2: Current and High End Kink Green River Expenditures per Visit					
Expenditure Categories	Scenic Floating	Guide Boat Fishing	Private Boat Fishing	Shoreline Fishing/ Trail Use	Camping
Camping Fees	$ 25.14	$ 20.49	$ 17.95	$ 10.53	$ 10.32
Lodging	64.00	52.14	45.68	26.80	0
Restaurants	50.00	40.73	35.69	20.94	0
Groceries and Liquor	55.75	45.42	39.80	23.35	22.89
Gasoline	54.58	44.47	38.96	22.86	22.41
Recreation Supplies	32.51	26.49	23.21	13.62	13.35
Guide Services	0	444.10	0	0	0
Car Rental	22.95	18.70	16.38	9.61	0
Other Rentals	19.33	15.75	13.80	8.10	7.94
Public Transit	9.96	8.12	7.11	4.17	0
Other	8.95	7.29	6.39	3.75	3.68
Total:	$ 343.17	$ 723.70	$ 244.97	$ 143.73	$ 80.59

the reservoir, it was dropped from the analysis. As a result, no distinction needed to be made between activities based on the incorporation of a guide services expenditure category. Second, as with the river analysis, expenditure category differences were assumed between camping and non-camping activities (e.g., lodging, restaurants, car rental, and public transportation costs were assumed irrelevant on a camping visit). For the reservoir analysis, the camping based percentages of costs by expenditure category were applied to both camping and swimming/waterplay. The swimming/waterplay total expenditure per visit estimate was so low (only $55.24) as to make it questionable to divide the cost among all expenditure categories. Survey results indicated that average length of visit for swimming visits did exceed one day suggesting that we could not assume swimming visits were day trips. Given the low expenditures per visit, the assumption was made that swimmers typically camped. The resulting current/high end kink expenditures per visit by activity are presented in table 3.

2) Preferred Expenditures:

A) Green River Preferred Expenditures per Visit:

Similar to the river visitation calculation described under the recreation section, a survey question asked if recreators by activity would extend the length of their visits under preferred flow conditions. Average increased length of visit by activity was again adjusted downward assuming nonrespondents would not extend their visits. The adjusted increase in length of stay was divided by the average current length of stay to estimate a percentage increase in length of stay by recreation activity. The percentage increase in length of stay was applied to the current expenditures per visit by activity to estimate the expenditures per visit by activity under preferred flow conditions as presented in table 4.

Table 3: Current and High End Kink Flaming Gorge Reservoir Expenditures per Visit				
Expenditure Categories	Power Boating/ Waterskiing	Boat Fishing	Boat Camping	Swimming/ Waterplay
Camping Fees	$ 15.74	$ 10.28	$ 17.42	6.99
Lodging	14.15	9.25	0	0
Restaurants	19.85	12.97	0	0
Groceries and Liquor	32.24	21.06	35.68	14.31
Gasoline	48.42	31.64	53.59	21.50
Recreation Supplies	10.17	6.64	11.25	4.51
Other Rentals	5.22	4.41	5.78	2.32
Other	12.64	8.26	13.99	5.61
Total:	$ 158.43	$ 103.51	$ 137.71	$ 55.24

Table 4: Preferred Conditions Green River Expenditures per Visit					
Expenditure Categories	Scenic Floating	Guide Boat Fishing	Private Boat Fishing	Shoreline Fishing/ Trail Use	Camping
Camping Fees	$ 32.49	$ 29.73	$ 26.43	$ 15.67	$ 11.78
Lodging	82.72	75.65	67.25	39.92	0
Restaurants	64.63	59.10	52.55	31.19	0
Groceries and Liquor	72.06	65.90	58.60	34.78	26.14
Gasoline	70.55	64.52	57.36	34.05	25.59
Recreation Supplies	42.02	38.43	34.17	20.29	15.24
Guide Services	0	644.35	0	0	0
Car Rental	29.66	27.13	24.12	14.31	0
Other Rentals	24.98	22.85	20.32	12.06	9.07
Public Transit	12.87	11.78	10.47	6.21	0
Other	11.57	10.58	9.41	5.59	4.20
Total:	$ 443.55	$ 1,050.02	$ 360.68	$ 214.08	$ 92.02

B) Flaming Gorge Reservoir Preferred Expenditures per Visit:

The procedure described directly above for the river was also applied to estimate the preferred Flaming Gorge Reservoir expenditures per visit as presented in table 5.

Table 5: Preferred Conditions Flaming Gorge Reservoir Expenditures per Visit				
Expenditure Categories	Power Boating/ Waterskiing	Boat Fishing	Boat Camping	Swimming/ Waterplay
Camping Fees	$ 27.98	$ 14.94	$ 20.78	$ 8.21
Lodging	25.16	13.44	0	0
Restaurants	35.29	18.85	0	0
Groceries and Liquor	57.32	30.61	42.57	16.81
Gasoline	86.08	45.99	63.94	25.26
Recreation Supplies	18.08	9.65	13.42	5.30
Other Rentals	9.28	4.96	6.90	2.73
Other	22.47	12.01	16.69	6.59
Total:	$ 281.66	$ 150.45	$ 164.30	$ 64.90

These three recreation expenditure data points (current expenditures, preferred expenditures, and high end kink expenditures), for both the river and reservoir, provided the basis for the per visit expenditure interpolations. As with the recreation visitation and valuation analyses, expenditures per visit were estimated by activity, month, alternative and hydrologic condition based on the associated river flows and reservoir water levels. The expenditures per visit by activity, month, alternative and hydrologic condition were applied to similar estimates of recreation visitation to calculate total expenditures by alternative and hydrologic condition. The changes in total expenditures by expenditure category for the Action Alternative compared to the No Action Alternative, were entered into the IMPLAN model to generate impact estimates associated with the Action Alternative.

3.1.2 Commercial Operator Survey Methodology

Given the regional analysis focused on a three-county area, and lack of county specific expenditure data precluded the development of county level regional economic impact models, anticipated adverse impacts to commercial guide operators concentrated within Daggett County would not be directly discernible. As a result, surveys of commercial guide operators were conducted to try and identify impacts.

The results of the surveys of both Green River and Flaming Gorge Reservoir recreational commercial operators is presented at the end of the Action Alternative subsection in terms of: 1) average visitation and revenue, 2) high end, low end, and preferred flows/water levels, and 3) preferred flow/water level visitation and revenue. Unfortunately, the survey data did not provide enough information to estimate impacts by alternative. However, the high end, low end, and preferred flows/water levels obtained from the survey were compared to flows and water levels from March to October for each alternative under average, wet, and dry conditions. Attempts were made to evaluate which alternative would be preferred for each commercially supported recreation activity.

3.2 Regional Economic Impact Results

This section presents the results of the recreation expenditure based regional economic analysis. The results are presented by alternative, starting with the No Action Alternative.

3.2.1 No Action Alternative

Given the large volume of recreation expenditure estimates (estimates calculated for each of the eleven expenditure categories, for each recreation activity, for each month, for each alternative and hydrologic condition), the individual monthly estimates are not presented. Instead, information on No Action Alternative total recreation expenditures by expenditure category, hydrologic condition, site (river versus reservoir), and recreation activity are presented in table 6. These estimates portray the product of recreation visits from the recreation analysis times the expenditures per visit from the expenditure interpolations.

As mentioned above under methodology, given the IMPLAN 1999 base data is considered reflective of No Action Alternative wet conditions, table 6 also includes estimates of the differences in No Action average and dry expenditures as compared to No Action wet conditions. The gain in No Action Alternative average condition expenditures compared to No Action Alternative wet condition expenditures of $23.6 million reflects almost a 20% increase. The decline in No Action dry expenditures compared to No Action wet expenditures of $39.1 million reflects a 32.6%drop in recreation expenditures.

These expenditure differences were run through the IMPLAN model to estimate regional economic conditions under No Action average and dry hydrologic conditions. As presented in table 7, differences in the overall three-county regional economy were insignificant between No Action Alternative average, wet, and dry conditions. Looking at employment, the most volatile regional economic measure on a percentage basis, indicates that the 330 and 908 job declines compared to average conditions under wet and dry conditions respectively, reflect only a 0.9 and 2.3% reduction in overall employment.

Focusing in on the overall economy is important, but can gloss over industry by industry changes. To address this issue, reviews were also made of the eight most affected economic sectors, those sectors directly impacted by changing recreational expenditures. Table 8 describes the linkage from each recreation expenditure category to Standard Industrial Classification (SIC) industry codes to IMPLAN industry codes. Based on this table, the most directly affected IMPLAN industries are as follows: air transportation (#437), food stores (#450), automotive dealers and service stations (#451), eating and drinking (#454), miscellaneous retail (#455), hotels and lodging places (#463), automobile rental and leasing (#477), and amusement and recreation services (#488).

Comparing employment for the No Action Alternative under average and wet conditions shows a minor decline of 294 jobs (-4.4%) between these eight most affected sectors. The 805 job loss from average to dry conditions for these sectors was more noticeable reflecting a 12.0% drop. The nearly 44% decline in recreation expenditures under dry conditions compared to average conditions generated a much less severe decline in regional economic activity, even for the eight most affected sectors, implying that a significant share of recreation

Table 6: No Action Alternative Recreation Expenditures ($1,000s) 2000-2001 $ (Impact Area Counties: Daggett and Uintah, Utah, Sweetwater, Wyoming)

Hydrologic Condition	Site	Recreation Activity	Expenditures Categories: Camping Fees	Lodging	Restaurants	Groceries	Gas	Supplies	Guides	Car Rental	Other Rentals	Public Transit	Other	Total
Average	Green River	Scenic Floating	565.9	1,440.6	1,125.5	1,254.9	1,228.5	731.8	0	516.5	435.1	224.2	201.5	7,724.4
		Guide Boat Fishing	221.3	563.1	439.9	490.6	480.3	286.1	4,796.5	202.0	170.1	87.7	78.7	7,816.2
		Private Boat Fishing	318.0	809.2	632.2	705.0	690.1	411.1	0	290.2	244.5	126.0	113.2	4,339.5
		Shoreline Fishing/Trail Use	385.7	981.8	767.1	855.4	837.5	499.0	0	352.0	296.7	152.8	137.4	5,265.6
		Boat Based Camping	23.7	0	0	52.6	51.5	30.7	0	0	18.2	0	8.4	185.0
		Total:	1,514.6	3,794.7	2,964.8	3,358.4	3,287.9	1,958.7	4,796.5	1,360.7	1,164.6	590.6	539.3	25,330.7
	Flaming Gorge Reservoir	Power Boating/Waterskiing	8,928.7	8,029.1	11,261.9	18,292.6	27,470.6	5,769.5	0	0	2,961.1	0	7,170.2	89,883.7
		Boat Fishing	2,491.3	2,241.3	3,143.0	5,104.1	7,668.6	1,609.2	0	0	826.8	0	2,002.7	25,087.0
		Boat Camping	203.5	0	0	416.9	626.2	131.4	0	0	67.6	0	163.5	1,609.2
		Swimming/Waterplay	168.2	0	0	344.4	517.5	108.6	0	0	55.9	0	135.0	1,329.6
		Total:	11,791.7	10,270.4	14,404.9	24,158.1	36,282.9	7,618.7	0	0	3,911.4	0	9,471.4	117,909.4
		FGNRA Total:	13,306.3	14,065.1	17,369.7	27,516.5	39,570.8	9,577.4	4,796.5	1,360.7	5,076.0	590.6	10,010.7	143,240.1
		Change from No Action Extremely Wet:	+2200.6	+2185.4	+2846.9	+4534.4	+6643.2	+1514.7	+977.7	+125.8	+792.4	+54.6	+1703.1	+23,578.3
Wet	Green River	Scenic Floating	546.0	1,389.9	1,086.0	1,210.8	1,185.3	706.0	0	498.3	419.8	216.3	194.4	7,453.0
		Guide Boat Fishing	176.2	448.3	350.2	390.6	382.4	227.8	3,818.8	160.8	135.4	69.8	62.7	6,223.1
		Private Boat Fishing	290.2	738.5	577.0	643.5	629.9	375.3	0	264.8	223.2	114.9	103.4	3,960.6
		Shoreline Fishing/Trail Use	340.7	867.1	677.5	755.4	739.6	440.7	0	310.9	262.0	134.9	121.4	4,650.1
		Boat Based Camping	18.1	0	0	40.2	39.4	23.5	0	0	14.0	0	6.5	141.6
		Total:	1,371.2	3,443.9	2,690.7	3,040.5	2,976.6	1,773.2	3,818.8	1,234.9	1,054.4	536.0	488.2	22,428.4
	Flaming Gorge Reservoir	Power Boating/Waterskiing	7,223.2	6,494.8	9,110.0	14,796.4	22,221.2	4,667.5	0	0	2,395.7	0	5,801.1	72,709.9
		Boat Fishing	2,157.6	1,941.0	2,722.1	4,420.2	6,640.7	1,393.5	0	0	716.0	0	1,734.0	21,725.1
		Boat Camping	196.8	0	0	403.1	605.5	127.1	0	0	65.3	0	158.1	1,555.8
		Swimming/Waterplay	157.2	0	0	321.9	483.7	101.4	0	0	52.2	0	126.2	1,242.6
		Total:	9,734.8	8,435.8	11,832.1	19,941.6	29,951.0	6,289.5	0	0	3,229.2	0	7,819.4	97,233.4
		FGNRA Total:	11,106.0	11,879.7	14,522.8	22,982.1	32,927.6	8,062.7	3,818.8	1,234.9	4,283.6	536.0	8,307.6	119,661.8
Dry	Green River	Scenic Floating	2.2	5.7	4.4	4.9	4.8	2.9	0	2.0	1.7	.9	.8	30.4
		Guide Boat Fishing	75.2	191.4	149.5	166.8	163.3	97.3	1,630.5	68.7	57.8	29.8	26.8	2,657.0
		Private Boat Fishing	138.0	351.3	274.5	306.1	299.6	178.5	0	126.0	106.1	54.7	49.2	1,883.9
		Shoreline Fishing/Trail Use	119.6	304.6	238.0	265.4	259.8	154.8	0	109.2	92.0	47.4	42.6	1,633.5
		Boat Based Camping	4.7	0	0	10.5	10.2	6.1	0	0	3.6	0	1.7	36.9
		Total:	339.9	853.0	666.4	753.6	737.8	439.5	1,630.5	305.8	261.3	132.8	121.0	6,241.7
	Flaming Gorge Reservoir	Power Boating/Waterskiing	5,361.2	4,819.7	6,761.2	10,981.4	16,492.5	3,464.0	0	0	1,778.0	0	4,305.3	53,963.3
		Boat Fishing	1,767.8	1,590.7	2,230.4	3,621.6	5,441.1	1,141.9	0	0	586.4	0	1,420.5	17,800.4
		Boat Camping	180.7	0	0	370.1	555.9	116.7	0	0	60.0	0	145.1	1,428.6
		Swimming/Waterplay	147.0	0	0	301.0	452.2	94.9	0	0	48.8	0	118.0	1,161.9
		Total:	7,456.8	6,410.4	8,991.6	15,274.1	22,941.7	4,817.5	0	0	2,473.2	0	5,988.9	74,354.3
		FGNRA Total:	7,796.7	7,263.4	9,658.0	16,027.7	23,679.5	5,257.0	1,630.5	305.8	2,734.5	132.8	6,109.9	80,596.0
		Change from No Action Extremely Wet:	-3,309.3	-4,616.3	-4,864.8	-6,954.4	-9,248.1	-2,805.7	-2,188.3	-929.1	-1,549.1	-403.2	-2,197.7	-39,065.8

Table 7: No Action Alternative — Data Year: 1999 — (Impact Area Counties: Daggett and Uintah, Utah, Sweetwater, Wyoming)

Primary Industries/Sectors	IMPLAN Industry Number	Average Condition			Wet Condition			Dry Condition		
		Total Industry Output ($M)	Employment (Jobs)	Labor Income ($M)	Total Industry Output ($M)	Employment (Jobs)	Labor Income ($M)	Total Industry Output ($M)	Employment (Jobs)	Labor Income ($M)
Agriculture, Forestry, Fishing	1-27	50.8	1,340	15.9	50.8	1,340	15.9	50.8	1,338	15.9
Mining	28-47, 57	1349.8	4,146	283.9	1,349.7	4,146	283.9	1,349.6	4,145	283.9
Construction	48-56	335.6	3,212	111.3	335.5	3,210	111.3	335.2	3,205	111.1
Manufacturing	58-432	322.2	1,729	85.4	322.1	728	85.4	322.0	1,727	85.4
Other Transportation	433-436, 438-440	472.0	2,901	187.5	471.8	2,899	187.4	471.5	2,892	187.3
- Air Transportation:	437	6.4	74	2.7	6.4	74	2.7	6.3	72	2.7
Communications	441-442	45.9	195	11.1	45.7	194	11.1	45.4	192	11.0
Utilities	443-446	285.4	626	45.4	285.2	625	45.4	284.8	623	45.3
Wholesale Trade	447	89.4	1,076	36.9	89.3	1,074	36.9	89.0	1,069	36.7
Other Retail Trade	448-449, 452-453	53.0	1,582	25.9	52.9	1,579	25.8	52.7	1,572	25.7
- Food Stores:	450	33.4	914	19.6	32.2	882	18.9	30.4	814	17.5
- Automotive Dealers & Service Stations:	451	56.8	1,103	25.9	55.4	1,076	25.3	53.5	1,021	24.0
- Eating & Drinking:	454	69.0	2,382	23.5	66.5	2,292	22.6	62.0	2,085	20.6
- Miscellaneous Retail:	455	17.5	945	8.7	17.1	921	8.4	16.4	867	8.0
Finance, Insurance, & Real Estate (FIRE)	456-462	206.8	1,776	27.3	206.2	1,769	27.2	205.0	1,750	27.0
Other Services	464-476, 478-487, 489-509	346.4	6,907	152.4	345.7	6,891	152.1	344.6	6,854	151.3
- Hotels and Lodging Places:	463	39.4	1,096	15.7	36.1	1,004	14.4	30.2	784	11.2
- Automobile Rental and Leasing:	477	0.5	14	0.1	.435	13	0.1	0.2	5	0.0
- Amusement and Recreation Services:	488	3.8	177	1.6	3.2	149	1.4	1.9	84	0.8
Federal, State, and Local Government	510-515, 519-523	261.8	6,660	207.2	261.7	6,659	207.1	21.5	6,656	207.0
TOTAL:		4008.8	38,853	1,288.2	3,993.7	38,523	1,283.3	3,966.4	37,757	1,272.3
Change from Average Condition ($M, Jobs):					-15.1	-330	-4.9	-42.4	-1096	-15.9
(Percent):					-0.4	-0.9	-0.4	-1.1	-2.8	-1.2
MOST AFFECTED SECTORS:		226.9	6,704	97.8	217.3	6,410	93.8	200.8	5,733	84.7
Change from Average Condition ($M, Jobs):					-9.6	-294	-4.0	-26.1	-971	-13.1
(Percent):					-4.2	-4.4	-4.1	-11.5	-14.5	-13.4

Table 8: Conversion of SIC Code Industries to IMPLAN Industries

Recreation Expenditure Category	SIC Industry Code Number	SIC Industry Name	Industry Description	IMPLAN Industry Number	IMPLAN Industry Name
Camping Fees	7033	Recreational Vehicle Parks and Campsites		463	Hotels and Lodging Places
Lodging	7011	Hotels and Motels		463	Hotels and Lodging Places
Restaurants	5812	Eating Places		454	Eating and Drinking
Groceries	5411	Grocery Stores		450 (retail)	Food Stores
Gasoline	5541	Gasoline Service Stations	Includes gasoline service stations, boat dealers, and recreation vehicle dealers	451 (retail)	Automotive Dealers and Service Stations
Recreation Supplies (fishing)	5941	Sporting Goods Stores and Bike Stops	Includes bait and tackle, fishing equipment.	455 (retail)	Miscellaneous Retail
Guide Services	7999	Amusement and Recreation Services, not elsewhere classified	Includes hunting and tourist guides	488	Amusement & Recreation Services, NEC
Car Rental	7514	Passenger Car Rental		477	Automobile Rental and Leasing
Other Rentals (boats)	7999	Amusement and Recreation Services, not elsewhere classified	Includes boat and canoe rental	488	Amusement and Recreation Services, NEC
Public Transit (airlines)	4512	Air Transportation, scheduled		437	Air Transportation
Other	5946 5947	Camera and Photographic Supply stores Gift, Novelty, and Souvenir Shops	Includes drug stores, liquor stores, sporting goods, camera and photographic supply stores, gift and souvenir shops	455 (retail)	Miscellaneous Retail

expenditures must pass through the economy without creating much impact. This is not surprising since the three-county economy has a relatively small manufacturing base suggesting much of the inputs to the most affected sectors likely come from outside the region.

3.2.2 Action Alternative

This section describes changes in regional economic activity associated with implementing the Action Alternative under average, wet, and dry conditions. For each hydrologic condition, changes in recreation expenditures compared to the No Action Alternative for the same hydrologic condition were run through the IMPLAN model. As a result, impacts are measured for the Action Alternative compared to the No Action Alternative within the context of the same hydrologic condition. In no instances are impacts measured across hydrologic conditions.

Table 9 presents recreation expenditures by category, recreation activity, site, and hydrologic condition for the Action Alternative. The table presents total expenditures as well as changes compared to the No Action Alternative in both dollar and percentage terms. Under all three hydrologic conditions, total Action Alternative expenditures are higher than those of the No Action Alternative. The gain in expenditures is about 5.6% under average conditions, 13.7% under wet conditions, and 22.7% under dry conditions.

While the overall change in expenditures is positive, this doesn't imply consistent expenditure gains on both the river and reservoir. The change in Action Alternative expenditures for the Green River follow the direction of the change in visitation—positive for the average condition and negative for the wet and dry conditions. Losses in river recreation expenditures were estimated at 38% and 60% compared to the No Action Alternative under wet and dry conditions, respectively. Conversely, changes in Action Alternative expenditures for Flaming Gorge Reservoir were positive under each hydrologic condition despite the lack of visitation change under average and wet conditions.

The facility availability approach, used to measure changes in reservoir visitation, is less sensitive than the interpolation approach for measuring gains in visitation as water levels rise. As a result, no changes in visitation were estimated for the reservoir under average and wet conditions. However, recreation expenditures are estimated based on both visitation and expenditures per trip. Since expenditures per trip are based on an interpolation, increases in expenditures per trip, due to increased length of stay associated with higher water levels, when applied to existing visitation levels, results in gains in recreation expenditures at the reservoir under both average and wet conditions. Under wet conditions, these gains in reservoir expenditures exceeded the losses in river expenditures leading to the odd situation of an estimated overall loss in visitation coupled with an overall gain in expenditures. Under dry conditions, gains in reservoir visitation and expenditures out weigh losses on the river.

While the overall level of expenditures shows gains compared to the No Action Alternative, the individual expenditure categories include both gains and losses. This is because expenditure categories vary by recreation activity and the visitation by activity varies by month, alternative, and hydrologic condition. Some activities may post gains while others show losses. The potential for both gains and losses in recreation visitation and recreation expenditures per trip across activities and months creates the possibility of both positive and negative expenditures. For example, losses in recreation expenditures for river guides under wet and dry conditions are not offset because they are applicable only to the guide boat fishing activity.

Table 9: Action Alternative Recreation Expenditures ($1,000s)			2000-2001 $								(Impact Area Counties: Daggett and Uintah, Utah, Sweetwater, Wyoming)			
			Expenditures Categories											
Hydrologic Conditions	Site	Recreation Activity	Camping Fees	Lodging	Restaurants	Groceries	Gas	Supplies	Guides	Car Rental	Other Rentals	Public Transit	Other	Total
Average	Green River	Scenic Floating	722.2	1,838.7	1,436.6	1,601.7	1,568.1	934.1	0	659.2	555.2	286.0	257.1	9,858.9
		Guide Boat Fishing	236.0	600.6	469.2	523.2	512.3	305.1	5,116.0	215.4	181.4	93.5	84.0	8,337.0
		Private Boat Fishing	363.9	926.0	723.6	806.9	789.9	470.5	0	332.1	279.8	144.2	129.6	4,966.4
		Shoreline Fishing/Trail Use	475.5	1,210.2	945.7	1,054.4	1,032.3	615.0	0	433.9	365.6	188.3	169.4	6,490.3
		Boat Based Camping	19.5	0	0	43.3	42.4	25.2	0	0	15.0	0	7.0	152.3
		Total:	1,817.1	4,575.7	3,575.0	4,029.5	3,944.9	2,350.0	5,116.0	1,640.6	1,397.1	712.0	647.0	29,805.0
	Flaming Gorge Reservoir	Power Boating/Waterskiing	9,216.0	8,286.3	11,623.3	18,878.6	28,351.9	5,954.2	0	0	3,057.0	0	7,400.8	92,768.1
		Boat Fishing	2,545.3	2,289.7	3,211.3	5,214.7	7,834.2	1,644.3	0	0	844.8	0	2,045.6	25,629.9
		Boat Camping	207.2	0	0	424.4	637.4	133.8	0	0	68.8	0	166.4	1,637.9
		Swimming/Waterplay	169.9	0	0	347.9	522.7	109.7	0	0	56.5	0	136.4	1,343.0
		Total:	12,138.4	10,575.9	14,834.6	24,865.6	37,346.2	7,841.9	0	0	4,027.0	0	9,749.2	121,378.9
		FGNRA Total:	13,955.5	15,151.6	18,409.6	28,895.1	41,291.1	10,191.9	5,116.0	1,640.6	5,424.1	712.0	10,396.2	151,183.9
	Change from No Action Alternative:	$:	649.2	1,086.5	1,039.9	1,378.6	1,720.3	614.5	319.5	279.9	348.1	121.4	385.5	7,943.8
		%:	4.9	7.7	6.0	5.0	4.4	6.4	6.7	20.6	6.9	20.6	3.9	5.6
Wet	Green River	Scenic Floating	312.3	795.2	621.3	692.7	678.2	403.9	0	285.2	240.1	123.7	111.2	4,263.8
		Guide Boat Fishing	119.4	303.7	237.3	264.6	259.1	154.3	2,587.1	108.9	91.7	47.3	42.5	4,216.0
		Private Boat Fishing	216.6	551.3	430.8	480.4	470.2	280.1	0	197.7	166.6	85.8	77.1	2,956.7
		Shoreline Fishing/Trail Use	173.7	442.2	345.5	385.3	377.2	224.8	0	158.5	133.6	68.8	61.9	2,371.6
		Boat Based Camping	12.0	0	0	26.7	26.1	15.5	0	0	9.2	0	4.3	93.8
		Total:	834.0	2,092.5	1,634.9	1,849.6	1,810.8	1,078.7	2,587.1	750.3	641.3	325.6	296.9	13,901.8
	Flaming Gorge Reservoir	Power Boating/Waterskiing	9,273.5	8,338.4	11,696.1	18,997.0	28,529.7	5,991.8	0	0	3,076.5	0	7,446.6	93,349.6
		Boat Fishing	2,557.7	2,300.7	3,227.0	5,239.7	7,872.4	1,652.2	0	0	849.1	0	2,055.9	25,754.5
		Boat Camping	209.1	0	0	428.2	643.3	135.0	0	0	69.4	0	167.9	1,652.9
		Swimming/Waterplay	169.0	0	0	345.8	519.6	109.0	0	0	56.1	0	135.6	1,335.1
		Total:	12,209.2	10,639.1	14,923.0	25,010.7	37,565.0	7,888.1	0	0	4,051.0	0	9,806.0	122,092.1
		FGNRA Total:	13,043.2	12,731.6	16,557.9	26,860.3	39,375.8	8,966.8	2,587.1	750.3	4,692.3	325.6	10,102.9	135,993.9
	Change from No Action Alternative:	$:	1,937.2	851.9	2,035.1	3,878.2	6,448.2	904.1	-1,231.7	-484.6	408.7	-210.4	1,795.3	16,332.1
		%:	17.4	7.2	14.0	16.9	19.6	11.2	-32.3	-39.2	9.5	-39.3	21.6	13.7
Dry	Green River	Scenic Floating	0	0	0	0	0	0	0	0	0	0	0	0
		Guide Boat Fishing	31.3	79.6	62.2	69.3	67.9	40.4	677.7	28.5	24.0	12.4	11.1	1,104.4
		Private Boat Fishing	29.0	73.7	57.6	64.2	62.9	37.5	0	26.4	22.3	11.5	10.3	295.4
		Shoreline Fishing/Trail Use	69.0	175.6	137.2	153.0	149.8	89.2	0	63.0	53.1	27.3	24.6	941.7
		Boat Based Camping	6.1	0	0	13.6	13.3	7.9	0	0	4.7	0	2.2	47.9
		Total:	135.4	328.9	257.0	300.1	293.8	175.1	677.7	117.9	104.1	51.2	48.2	2,489.3
	Flaming Gorge Reservoir	Power Boating/Waterskiing	7,150.4	6,428.6	9,018.6	14,647.6	21,998.2	4,620.8	0	0	2,371.6	0	5,741.7	71,977.5
		Boat Fishing	2,147.9	1,933.0	2,709.7	4,400.4	6,611.7	1,387.8	0	0	713.0	0	1,726.6	21,630.2
		Boat Camping	191.9	0	0	393.1	590.4	123.9	0	0	63.7	0	154.1	1,517.2
		Swimming/Waterplay	157.8	0	0	323.0	485.3	101.9	0	0	52.5	0	126.7	1,247.1
		Total:	9,647.9	8,361.6	11,728.3	19,764.1	29,685.7	6,234.4	0	0	3,200.8	0	7,749.1	96,371.9
		FGNRA Total:	9,783.3	8,690.5	11,985.3	20,064.2	29,979.5	6,409.5	677.7	117.9	3,304.9	51.2	7,797.3	98,861.2
	Change from No Action Alternative:	$:	1,986.6	1,427.1	2,327.3	4,036.5	6,300.0	1,152.5	-952.8	-187.9	570.4	-81.6	1,687.4	18,265.2
		%:	25.5	19.7	24.1	25.2	26.6	21.9	-58.4	-61.5	20.9	-61.5	27.6	22.7

The impacts of the Action Alternative under average, wet, and dry conditions are described in three separate tables to allow for presentation of both totals by industry and the changes compared to the No Action Alternative in terms of both dollars/jobs and percentage for all three regional economic impact measures.

Table 10 reports the effects of the Action Alternative under average conditions. The "total" columns for total industry output, employment, and labor income portray overall estimates of economic activity for each industry and for the economy as a whole. The "change from No Action" columns depict changes in both dollars/jobs and percent.

The overall change in Action Alternative total output, employment, and income compared to No Action average conditions was positive but quite small, reflecting less than a 1% change. Looking at the sum of the eight most directly affected sectors, the gains are somewhat higher in percentage terms indicating about a 1.5% change. The largest percentage change (gain) occurred in the automotive rental and leasing and the amusement and recreation services sectors, both small sectors in the three-county economy. These gains in economic activity associated with the Action Alternative under average conditions were considered insignificant from both the overall and most affected sector perspectives.

Table 11 reports the effects of the Action Alternative under wet conditions. The overall change in Action Alternative total output, employment, and income compared to No Action wet conditions was also positive but very small, again reflecting less than a 1% change. Looking at the sum of the eight most directly affected sectors, the gains were slightly higher in percentage terms indicating nearly a 3% change. The largest percentage change (loss) occurred in the automotive rental and leasing and the amusement and recreation services sectors, both small sectors in the three-county economy. These gains in economic activity associated with the Action Alternative under wet conditions were considered insignificant from both the overall and most affected sector perspectives.

Table 12 reports the effects of the Action Alternative under dry conditions. The overall change in Action Alternative total output, employment, and income compared to No Action wet conditions was again positive but very small, reflecting less than a 1% change. Looking at the sum of the eight most directly affected sectors, the gains were slightly higher in percentage terms indicating about a 3.5% change. The largest percentage change occurred in the automotive rental and leasing, hotel and lodging places, and the amusement and recreation services sectors. The hotel and lodging places sector is relatively large compared to the other two sectors. These gains in economic activity associated with the Action Alternative under dry conditions were considered insignificant from both the overall and most affected sector perspectives.

While the lack of expenditure data by county precluded county specific analyses, it is possible that certain impacts could be centered within certain counties. For example, negative impacts estimated for the amusement and recreation services sector under the Action Alternative during wet and dry conditions, stem from losses in guide boat fishing services expenditures which appear to be centered in and around the town of Dutch John in Daggett County. This loss of jobs during wet and dry conditions, while not overly apparent from a three-county perspective, could be more detrimental from the perspective of Daggett County alone and Dutch John in particular.

Table10: Action Alternative Average Condition — Data Year: 1999 — (Impact Area Counties: Daggett and Uintah, Utah, Sweetwater, Wyoming)

Primary Industries/Sectors	IMPLAN Industry Number	Total Industry Output: Total ($M)	Total Industry Output: Change from No Action		Employment: Total (Jobs)	Employment: Change from No Action		Labor Income: Total ($M)	Labor Income: Change from No Action	
			$M	Percent		Jobs	Percent		$M	Percent
Agriculture, Forestry, Fishing	1-27	50.8	.0058	0.0	1340	0	0	15.9	.0021	0.0
Mining	28-47, 57	1349.8	.0185	0.0	4146	0	0	284.0	.0039	0.0
Construction	48-56	335.7	.0538	0.0	3213	1	0.0	111.4	.0257	0.0
Manufacturing	58-432	322.2	.0273	0.0	1729	0	0	85.5	.0052	0.0
Other Transportation	433-436, 438-440	472.1	.0744	0.0	2902	1	0.0	187.5	.0266	0.0
- Air Transportation:	437	6.4	.0353	0.6	74	0	0	2.8	.0151	0.6
Communications	441-442	46.0	.0623	0.1	195	0	0	11.2	.0151	0.1
Utilities	443-446	285.5	.0848	0.0	626	0	0	45.5	.0158	0.0
Wholesale Trade	447	89.5	.0570	0.1	1076	1	0.1	37.0	.0235	0.1
Other Retail Trade	448-449, 452-453	53.0	.0343	0.1	1583	1	0.1	25.9	.0165	0.1
- Food Stores:	450	33.7	.3547	1.1	923	10	1.1	19.8	.2085	1.1
- Automotive Dealers & Service Stations:	451	57.2	.3713	0.7	1111	7	0.7	26.1	.1692	0.7
- Eating & Drinking:	454	70.0	.9469	1.4	2414	33	1.4	23.8	.3219	1.4
- Miscellaneous Retail:	455	17.7	.1414	0.8	952	8	0.8	8.7	.0700	0.8
Finance, Insurance, & Real Estate (FIRE)	456-462	207.1	.240	0.1	1779	3	0.2	27.3	.0320	0.1
Other Services	464-476, 478-487, 489-509	346.7	.2458	0.1	6913	6	0.1	152.5	.1155	0.1
- Hotels and Lodging Places:	463	40.7	1.303	3.3	11132	36	3.3	16.2	.5181	3.3
- Automobile Rental and Leasing:	477	.55	.0792	16.8	16	2	16.8	.2	.0229	16.8
- Amusement and Recreation Services:	488	4.0	.2212	5.9	187	10	5.9	1.7	.0945	5.9
Federal, State, and Local Government	510-515, 519-523	261.9	.0428	0.0	6660	0	0.0	207.2	.0146	0.0
TOTAL:		4014.6	5.72	0.1	38853	120	0.3	1289.9	1.7173	0.1
MOST AFFECTED SECTORS:		230.3	3.45	1.5	6810	107	1.6	99.3	1.4	1.5

Table 11: Action Alternative Wet Condition — Data Year: 1999 — (Impact Area Counties: Daggett and Uintah, Utah, Sweetwater, Wyoming)

Primary Industries/Sectors	IMPLAN Industry Number	Total Industry Output: Total ($M)	Total Industry Output: Change from No Action $M	Total Industry Output: Change from No Action Percent	Employment: Total (Jobs)	Employment: Change from No Action Jobs	Employment: Change from No Action Percent	Labor Income: Total ($M)	Labor Income: Change from No Action $M	Labor Income: Change from No Action Percent
Agriculture, Forestry, Fishing	1-27	50.8	.0098	0.0	1340	0	0	15.9	.0035	0.0
Mining	28-47, 57	1349.7	.0299	0.0	4146	0	0	283.9	.0064	0.0
Construction	48-56	335.6	.0933	0.0	3211	1	0.0	111.3	.0441	0.0
Manufacturing	58-432	322.1	.0466	0.0	1729	0	0	85.5	.0087	0.0
Other Transportation	433-436, 438-440	471.9	.1217	0.0	2900	2	0.1	187.5	.0426	0.0
- Air Transportation:	437	6.3	-.0465	-0.7	73	-1	-0.7	2.7	-.0199	-0.7
Communications	441-442	45.8	.1086	0.2	194	1	0.3	11.1	.0263	0.2
Utilities	443-446	285.4	.1505	0.1	625	0	0	45.4	.0279	0.1
Wholesale Trade	447	89.4	.1008	0.1	1075	1	0.1	36.9	.0416	0.1
Other Retail Trade	448-449, 452-453	53.0	.0624	0.1	1581	2	0.1	25.8	.0301	0.1
- Food Stores:	450	33.2	.9785	3.0	909	27	3.0	19.5	.5752	3.0
- Automotive Dealers & Service Stations:	451	56.8	1.337	2.4	1102	26	2.4	25.9	.6092	2.4
- Eating & Drinking:	454	68.3	1.846	2.8	2356	64	2.8	23.2	.6275	2.8
- Miscellaneous Retail:	455	17.5	.3703	2.2	941	20	2.2	8.6	.1832	2.2
Finance, Insurance, & Real Estate (FIRE)	456-462	206.6	.4156	0.2	1773	5	0.3	27.2	.0541	0.2
Other Services	464-476, 478-487, 489-509	346.2	.4243	0.1	6901	10	0.1	152.2	.1980	0.1
- Hotels and Lodging Places:	463	38.2	2.097	5.8	1062	58	5.8	15.2	.8336	5.8
- Automobile Rental and Leasing:	477	.3	-.1360	-31.3	9	-4	-31.3	.1	-.0393	-31.3
- Amusement and Recreation Services:	488	2.9	-.2642	-8.3	137	-12	-8.3	1.2	-.1129	-8.3
Federal, State, and Local Government	510-515, 519-523	261.8	.0797	0.0	6659	1	0	207.2	.0266	0.0
TOTAL:		4001.8	8.15	0.2	38724	201	0.5	1286.5	3.1678	0.2
MOST AFFECTED SECTORS:		223.5	6.2	2.8	6588	178	2.8	96.5	2.7	2.8

Table 12: Action Alternative Dry Condition		Data Year: 1999			(Impact Area Counties: Daggett and Uintah, Utah, Sweetwater, Wyoming)					
Primary Industries/Sectors	IMPLAN Industry Number	Total Industry Output			Employment			Labor Income		
		Total ($M)	Change from No Action		Total (Jobs)	Change from No Action		Total ($M)	Change from No Action	
			$M	Percent		Jobs	Percent		$M	Percent
Agriculture, Forestry, Fishing	1-27	50.8	.0117	0.0	1,339	0	0	15.9	.0042	0.0
Mining	28-47, 57	1,349.6	.0362	0.0	4,146	0	0	283.9	.0077	0.0
Construction	48-56	335.3	.1102	0.0	3,208	2	0.1	111.2	.0523	0.1
Manufacturing	58-432	322.0	.0551	0.0	1,728	1	0.0	85.4	.0104	0.0
Other Transportation	433-436, 438-440	471.6	.1471	0.0	2,896	2	0.1	187.4	.0519	0.0
- Air Transportation:	437	6.3	-.0122	-0.2	72	0	0	2.7	-.0052	-0.2
Communications	441-442	45.5	.1277	0.1	193	1	0.3	11.1	.0309	0.3
Utilities	443-446	285.0	.1765	0.1	624	1	0.1	45.4	.0328	0.1
Wholesale Trade	447	89.1	.1184	0.1	1,072	1	0.1	36.8	.0489	0.1
Other Retail Trade	448-449, 452-453	52.8	.0725	0.1	1,576	2	0.1	25.8	.0349	0.1
- Food Stores: - Automotive Dealers & Service Stations: - Eating & Drinking: - Miscellaneous Retail:	450 451 454 455	31.5 54.8 64.1 16.8	1.0228 1.3160 2.1127 .3922	3.4 2.5 3.4 2.4	861 1,063 2,212 904	28 26 73 21	3.4 2.5 3.4 2.4	18.5 25.0 21.8 8.3	.6012 .5995 .7182 .1940	3.4 2.5 3.4 2.4
Finance, Insurance, & Real Estate (FIRE)	456-462	205.5	.4913	0.2	1,760	6	0.3	27.1	.0646	0.2
Other Services	464-476, 478-487, 489-509	345.1	.5011	0.1	6,875	12	0.2	151.7	.2343	0.2
- Hotels and Lodging Places: - Automobile Rental and Leasing: - Amusement and Recreation Services:	463 477 488	32.7 .1 1.8	2.5646 -.0523 -.1192	8.5 -30.5 -6.2	909 3 85	71 -2 -6	8.5 -30.5 -6.2	13.0 0 .8	1.0197 -.0151 -.0510	8.5 -30.5 -6.2
Federal, State, and Local Government	510-515, 519-523	261.6	.0921	0.0	6,658	1	0.0	207.1	.0309	0.0
TOTAL:		3,976.6	10.2278	0.3	38,185	240	0.6	1278.8	3.6666	0.3
MOST AFFECTED SECTORS:		208.1	7.2	3.6	6,111	212	3.6	90.0	3.06	3.5

3.3 Commercial Operator Surveys

In addition to the recreator surveys described previously under the recreation section, surveys of both Green River and Flaming Gorge Reservoir commercial operators were also conducted during the summer of 2001 to try and identify anticipated adverse impacts not discernable from the three-county oriented regional analysis. Commercial operations on the Green River include rafting/scenic floating and boat fishing guides. Commercial operations on Flaming Gorge Reservoir include fishing guides and marinas.

The survey response rate was fairly good overall, especially for the Green River operators. Of the 12 river commercial operators, 10 returned surveys. The two that didn't respond were small operators. As a result, the responses provided for the river are assumed to represent a census. On the reservoir, five of the nine boat guides and two of the three marinas provided responses. While not indicative of a census, the reservoir response rate was considered sufficiently representative to present the survey results.

Despite the reasonable response rates, the survey data did not provide enough information to estimate impacts by alternative since not all the respondents answered all the questions. While it would have been useful to separately identify impacts to commercial operations on both the river and reservoir, it should be noted that the regional modeling analysis incorporates (but does not strictly identify) most of the impacts to the commercial operators by addressing changes in visitation and recreation expenditures (including guide fees and marina rentals). As a result, if estimation of direct impacts to commercial operators had been possible from the survey, it would have been inappropriate to add them to the impacts already estimated via the regional model since that would have implied double counting. The difficultly with the regional modeling results are that they are aggregated by economic sector and industry and do not provide detailed impacts for specific businesses.

For both the river and reservoir, the surveys did provide some useful commercial operator information by recreation activity in terms of: 1) average visitation and revenue, 2) high end, low end, and preferred flows/water levels, and 3) preferred flow/water level visitation and revenue. The site and activity specific high end, low end, and preferred flow/water level information was compared to average flow/end of month water level information for each alternative under average, wet, and dry conditions for the months from March to October to try and evaluate alternative preferences (see tables 13 and 14).

In addition, assuming historical averages for visitation and revenue reflect No Action average conditions, the additional visitation and revenue under preferred conditions may provide an indicator of possible impacts under average conditions. In the typical case where Action Alternative flows/water levels are closer to preferred flows/water levels than No Action flows/water levels, the difference between average historical/No Action conditions and preferred conditions presented below could be used to as an upper bound on possible Action Alternative visitation and revenue impacts. The further away Action Alternative flows/water levels fall from preferred flows, the lower the impact. In cases where No Action Alternative flows/water levels are closer to preferred flows/water levels, the visitation and revenue impacts presented below would not reflect an upper bound.

In table 13, for Green River scenic floating operations, the survey indicated that preferred flows for reach 1 from the dam to the confluence of the Yampa River averaged 4,040 cubic feet per second (cfs) with a range from 2,000 to 10,000 cfs. High end and low end thresholds, depicting the points where flows are either too high or too low for rafting, averaged 15,200 and 715 cfs, respectively.

Table 13: Green River Commercial Operator Hydrology Comparisons

Recreation Activity	Flow Levels	Month	Average Conditions: No Action Flow	Average Conditions: Beyond Usable Range?	Average Conditions: Action Flow	Average Conditions: Beyond Usable Range?	Average Conditions: Closest to Preferred Flow	Wet Conditions: No Action Flow	Wet Conditions: Beyond Usable Range?	Wet Conditions: Action Flow	Wet Conditions: Beyond Usable Range?	Wet Conditions: Closest to Preferred Flow	Dry Conditions: No Action Flow	Dry Conditions: Beyond Usable Range?	Dry Conditions: Action Flow	Dry Conditions: Beyond Usable Range?	Dry Conditions: Closest to Preferred Flow
Scenic Floating	Preferred: 4,040	Mar	1,484	No	1,270	No	No Action	1,898	No	2,030	No	Action	800	No	800	No	Same
	High End: 15,000	Apr	2,207	No	1,904	No	No Action	3,290	No	3,981	No	Action	800	No	800	No	Same
	Low End: 715	May	3,463	No	3,233	No	No Action	5,100	No	5,537	No	No Action	1,400	No	800	No	No Action
		June	2,710	No	3,962	No	Action	5,917	No	7,038	No	No Action	800	No	893	No	Action
		July	983	No	2,185	No	Action	1,200	No	4,600	No	Action	800	No	893	No	Action
		Aug	1,251	No	1,626	No	Action	1,531	No	2,131	No	Action	931	No	906	No	No Action
		Sept	1,374	No	1,639	No	Action	1,639	No	2,239	No	Action	1,039	No	939	No	No Action
		Oct	1,654	No	1,487	No	No Action	2,075	No	2,172	No	Action	1,039	No	800	No	No Action
						Overall:	Action				Overall:	Action				Overall:	No Action
Boat Fishing	Preferred: 2,338	Mar	1,484	No	1,270	No	No Action	1,898	No	2,030	No	Action	800	No	800	No	Same
	High End: 7,530	Apr	2,207	No	1,904	No	No Action	3,290	No	3,981	No	No Action	800	No	800	No	Same
	Low End: 800	May	3,463	No	3,233	No	Action	5,100	No	5,537	No	No Action	1,400	No	800	No	No Action
		June	2,710	No	3,962	No	No Action	5,917	No	7,038	No	No Action	800	No	893	No	Action
		July	983	No	2,185	No	Action	1,200	No	4,600	No	No Action	800	No	893	No	Action
		Aug	1,251	No	1,626	No	Action	1,531	No	2,131	No	Action	931	No	906	No	No Action
		Sept	1,374	No	1,639	No	Action	1,639	No	2,239	No	Action	1,039	No	939	No	No Action
		Oct	1,654	No	1,487	No	No Action	2,075	No	2,172	No	Action	1,039	No	800	No	No Action
						Overall:	Action				Overall:	No Action				Overall:	No Action

Table 14: Flaming Gorge Reservoir Commercial Operator Hydrology Comparisons

Recreation Activity	Flow Levels	Month	Average Conditions					Wet Conditions					Dry Conditions				
			No Action Flow	Beyond Usable Range?	Action Flow	Beyond Usable Range?	Closest to Preferred Flow	No Action Flow	Beyond Usable Range?	Action Flow	Beyond Usable Range?	Closest to Preferred Flow	No Action Flow	Beyond Usable Range?	Action Flow	Beyond Usable Range?	Closest to Preferred Flow
Boat Fishing	Preferred: 6,029	Mar	,6024.0	No	6,025.8	No	Action	6,027.9	No	6,027.9	No	Same	6,019.0	No	6,023.5	No	Action
	High End: 6,040	Apr	6,024.1	No	6,026.0	No	Action	6,028.5	No	6,028.5	No	Same	6,020.1	No	6,023.0	No	Action
	Low End: 6,006	May	6,023.8	No	6,025.8	No	Action	6,029.4	No	6,029.2	No	Action	6,017.6	No	6,022.8	No	Action
		June	6,026.6	No	6,027.8	No	Action	6,031.7	No	6,030.3	No	Action	6,018.5	No	6,024.5	No	Action
		July	6,029.1	No	6,029.2	No	No Action	6,035.5	No	6,030.7	No	Action	6,019.3	No	6,024.7	No	Action
		Aug	6,028.9	No	6,028.4	No	No Action	6,036.0	No	6,030.5	No	Action	6,018.5	No	6,023.8	No	Action
		Sept	6,028.3	No	6,027.4	No	No Action	6,035.5	No	6,030.0	No	Action	6,017.9	No	6,023.2	No	Action
		Oct	6,027.5	No	6,026.8	No	No Action	6,034.9	No	6,029.8	No	Action	6,017.3	No	6,023.1	No	Action
						Overall:	Action				Overall:	Action				Overall:	Action
Marinas	Preferred: 6,031	Mar	6,024.0	No	6,025.8	No	Action	6,027.9	No	6,027.9	No	Same	6,019.0	Yes	6,023.5	No	Action
	High End: 6,035	Apr	6,024.1	No	6,026.0	No	Action	,6028.5	No	6,028.5	No	Same	6,020.1	Yes	6,023.0	No	Action
	Low End: 6,023	May	6,023.8	No	6,025.8	No	Action	6,029.4	No	6,029.2	No	No Action	6,017.6	Yes	6,022.8	Yes	Range
		June	6,026.6	No	6,027.8	No	Action	6,031.7	No	6,030.3	No	Same	6,018.5	Yes	6,024.5	No	Action
		July	6,029.1	No	6,029.2	No	Action	6,035.5	Yes	6,030.7	No	Action	6,019.3	Yes	6,024.7	No	Action
		Aug	6,028.9	No	6,028.4	No	No Action	6,036.0	Yes	6,030.5	No	Action	6,018.5	Yes	6,023.8	No	Action
		Sept	6,028.3	No	6,027.4	No	No Action	6,035.5	Yes	,6030.0	No	Action	6,017.9	Yes	6,023.2	No	Action
		Oct	6,027.5	No	6,026.8	No	No Action	6,034.9	No	6,029.8	No	Action	6,017.3	Yes	6,023.1	No	Action
						Overall:	Action				Overall:	Action				Overall:	Action

Comparing the high end/low end flow thresholds to average condition flows for both the No Action and Action Alternatives indicates that average flows for both alternatives for the March thru October months fall within the usable range. For each month, an evaluation was also made as to which alternative's flows were closer to the preferred flow (monthly comparison). Of the 8 months studied, 4 months resulted in the Action Alternative being preferred and 4 months resulted in the No Action being preferred. Finally, differences between the preferred flow level and both No Action and Action Alternative flows were calculated for each month. The absolute value of these differences was summed, and the alternative with the lowest total difference was considered preferred (seasonal comparison). The Action Alternative was judged to be preferred by commercial rafters based on this seasonal comparison.

The Action Alternative was deemed to be preferred by commercial rafting operators under wet conditions. Both alternatives fell within the usable flow ranges for all months. The results suggest the Action Alternative would be preferred under wet conditions based on both the overall seasonal flow difference as well as 6 of the 8 months studied.

Conversely, the No Action Alternative would appear to be preferred by commercial rafting operators under dry conditions. Both alternatives fell within the usable flow ranges for all months. It appears the No Action Alternative would be preferred based both on the overall seasonal flow difference as well as 4 of the 6 months studied (note that the difference from the preferred flow was the same for 2 months for both alternatives).

Rafting operators indicated an average of 40 boat trips a year with a range from 10 to 90. Note that boat trips would include multiple rafters and perhaps multiple days. Average annual revenues were estimated at about $235,000 with a range from $35,000 to $476,000. Average additional annual trips under preferred flows were estimated at about 17 trips with a range from zero to 54. Some operators noted that visitation is controlled within Dinosaur National Monument such that number of trips could not increase under preferred flows, but number of clients per trip could increase. Average additional annual revenues under preferred flows were estimated at about $39,000 (+16.6%) with a range from $0 to $90,000.

For Green River boat fishing operations, in table 13, the surveys suggest that preferred flows for the portion Reach 1 associated with boat fishing (from the dam to the Utah/Colorado State line) averaged 2,338 cfs with a range from 1,400 to 2,800 cfs. High and low end thresholds for boat fishing averaged 7,530 and 1,030 cfs, respectively. Based on comments from the Green River Outfitter and Guides Association, the low end threshold was further reduced to 800 cfs.

The Action Alternative was deemed to be preferred by commercial boat fishing operators on the Green River under average conditions based on comparisons to preferred flows since both alternatives fell within the usable range across all months. The comparisons to preferred flows resulted in the Action Alternative being preferred based on the overall seasonal flow difference. Individual monthly comparisons resulted in no obvious preference since 4 of the 8 months went to each alternative, although the lower use months of March and October showed a preference for the No Action implying the higher use months of April through September preferred the Action Alternative.

The No Action Alternative was deemed to be preferred by commercial boat fishing operators under wet conditions. Both alternatives fell within the usable flow ranges for all months. The preferred flow comparisons resulted in the No Action Alternative being preferred based on the overall seasonal flow difference, but both alternatives appear to be equally attractive based on the monthly comparisons. Looking at the higher use months of April through September, the No Action Alternative would be preferred.

Similarly, the No Action Alternative would appear to be preferred by commercial boat fishing operators under dry conditions. While both alternatives fall within the usable range in all months, the No Action would be preferred based on comparisons to preferred flow. The No Action Alternative would be preferred in 4 of the 6 months with preferred flow based differences.

Two of the four boat fishing operators who responded to the survey question indicated an average of 210 boat trips a year. Average annual revenues across all four operators were estimated at about $245,600 with a range from $32,000 to $500,000. Average additional annual trips under preferred flows was estimated at about 54 trips with a range from 23 to 108. Average additional annual revenues under preferred flows was estimated at about $17,000 (+6.9%) with a range from $7,200 to $35,000.

In table 14, for Flaming Gorge Reservoir boat fishing operations, preferred water levels averaged 6029 feet above mean sea level. High and low end thresholds averaged 6040 and 6006, respectively.

The Action Alternative was deemed to be preferred by commercial boat fishing operators on Flaming Gorge Reservoir under average conditions. Both alternatives fell within the usable water level ranges for all months. The comparisons to preferred water levels resulted in the Action Alternative being preferred based on the overall seasonal water level difference and in 4 of 8 monthly comparisons.

The Action Alternative was deemed to be preferred by commercial boat fishing operators under wet conditions. Both alternatives fell within the usable water level ranges for all months. The comparisons resulted in the Action Alternative being preferred based on the overall seasonal water level difference and in 6 of 6 months (note that 2 months resulted in the same water level differential for both alternatives).

The Action Alternative would appear to be preferred by commercial boat fishing operators under dry conditions. Both alternatives fell within the usable water level ranges for all months. The Action Alternative would be preferred based on both the overall seasonal water level difference and the monthly comparisons for all months studied.

Reservoir boat fishing operators indicated an average of 107 clients a year with a range from 20 to 220. Average annual revenues were estimated at about $12,800 with a range from $4,000 to $38,000. Average additional annual trips under preferred water levels was estimated at 5 trips with a range from zero to 18. Average additional annual revenues under preferred water levels were estimated at only $650 (5.1%) with a range from $0 to $2,250.

For Flaming Gorge Reservoir marina operations, table 14 indicates preferred water levels across all boat based activities averaged 6031 feet with a range from 6030 to 6035 depending on activity. High and low end thresholds averaged 6035 and 6023, respectively.

The Action Alternative was deemed to be preferred by commercial boat fishing operators on Flaming Gorge Reservoir under average conditions. Both alternatives fell within the usable water level ranges for all months. The comparisons to preferred water levels resulted in the Action Alternative being preferred based on the overall seasonal water level difference and in 5 of 8 monthly comparisons.

The Action Alternative was deemed to be preferred by commercial boat fishing operators under wet conditions. No Action water levels for July through September were the only months to fall outside the usable range. The comparisons resulted in the Action Alternative being preferred based on the overall seasonal water level difference and in 4 of 5 months (note that 3 months resulted in the same water level differential for both alternatives).

The Action Alternative would appear to be preferred by commercial boat fishing operators under dry conditions. This is primarily because the No Action Alternative falls outside the usable water level range in all months compared to only 1 month (May) for the Action Alternative.

Marina operators responded with an average of 97,200 clients a year. Average annual revenues were estimated at about $915,800. Average additional annual trips under preferred water levels was estimated at 10,600 trips. Average additional annual revenues under preferred water levels were estimated at $225,400 (+24.6%). These additional revenues include cost savings associated with reduced operation and maintenance (O&M) related to moving and shoring up docks, moorings, etc. under preferred water levels. In general, the cost of operating and maintaining marinas, boat ramps, and boat camps increases as water levels drop below preferred water levels. The annual O&M costs savings under preferred conditions at the two marinas averaged $46,000.

Comparing the high and low end thresholds provided by the commercial operators to those from the recreator surveys for the same recreation activity indicates that generally speaking the commercial operators were willing to pursue visits over a wider range of flows/water levels. In other words, the high end thresholds were higher and the low end thresholds were lower for the commercial operators. The preferred flows/water levels for the commercial operators were higher than those from the recreator surveys.

4.0 BIBLIOGRAPHY

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Operation of
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Final Environmental
Impact Statement

Visual Analysis
Special Report
Technical Appendix

VISUAL ANALYSIS SPECIAL REPORT
TECHNICAL APPENDIX

Page No.

Visual Analysis Specialist Report Technical Appendix

Prepared by Brent Hanchett
Landscape Architect
Ashley National Forest
July 19, 2002

INTRODUCTION

This report addresses the scenic resources surrounding Flaming Gorge Reservoir and the Green River Corridor. The focus is on potential visual impacts to changes in shoreline exposure resulting from fluctuating ongoing water levels and downstream water flows. Discussion will include scenic resources on the Flaming Gorge National Recreation Area (NRA) and the Green River Corridor.

The U.S. Department of Agriculture Forest Service (USDA Forest Service) and Bureau of Land Management (BLM) have developed systems for the administration of scenic qualities on Federal lands (Scenery Management System, USDA Forest Service, 1995, 1974; Visual Resource System, BLM, 1991). Both agency systems are addressed where applicable.

The Bureau of Reclamation has requested the report and is providing funding.

AFFECTED ENVIRONMENT

Flaming Gorge Reservoir is situated on the eastern slope of the scenic Uinta Mountains in Northeastern Utah. The concrete arch dam was constructed during the early 1960s. The heart of the Flaming Gorge National Recreation Area is a

91-mile long reservoir, created by Flaming Gorge Dam. There are over 300 miles of shoreline. An estimated 3,000 acres of shoreline are involved.

The Green River flows out of the dam, down through the lower reaches of Red Canyon, and into Brown's Park. The stretch of river covers approximately 20 miles. An estimated 100 acres of riverbank are involved.

Landscape Character

The landscape consists of a high plateau, about 8,000 feet in elevation, covered by Ponderosa pine, and pinyon-juniper; and is dissected by Red Canyon. The Green River flows through the deep Red Canyon beginning at Flaming Gorge, near Sheep Creek Flats and exits at Brown's Park, a broad open valley near the Utah-Colorado State line. Rock formations are prominent and soils are reddish in color. The Uinta Mountains form a high scenic backdrop to the west.

The Wyoming portion consists of a different land type, prominent grayish ledges and bluffs, where the Green River Corridor is not as deeply defined. Vegetative patterns are of a sage nature. Soils consist of a shale or clay type material. Open spaces are prominent.

Scenic Integrity

Visual qualities are perceived by those who normally recreate or spend time in a particular area who, in this case would be the Casual Forest Visitor. Much of their recreational experience relates to their concern for scenic quality and the condition of the view shed.

Scenic values and qualities within the Flaming Gorge NRA and along the Green River Corridor are high. With a background of the Uinta Mountains and distant vistas, this is the premier scenic showcase for northeastern Utah and southwestern Wyoming.

The normal goal for the USDA Forest Service and BLM would be to manage the NRA and Green River Corridor for a "Naturally Appearing" landscape character. To go back in time about 50 years, there was a river, flowing through a series of canyons, including the Firehole regions of Wyoming, Flaming Gorge, Red Canyon and Brown's Park in Utah and on into Colorado. Human intrusions were minimal, with a few occasional dirt roads and homesteads. The area was truly scenic, unaltered and natural in appearance.

During the mid-1960s, a dam was constructed in Red Canyon and backed up water for 91 miles. Along with the reservoir, a large influx of people desiring a recreational experience was anticipated. Highways were constructed. Bridges, boat ramps, campgrounds, visitor centers, restaurants, lodges, and service stations followed. A town site was constructed. Along with the dam, came power generators and transmission lines to serve distant communities. Utilities and lines, such as water, gas, sewer and electrical distribution, were needed to support the local facilities.

As anticipated, the public does visit the NRA and uses the facilities as listed above. They enjoy the "natural" scenery, camping, fishing, floating the river and hiking the trails. They truly enjoy the area. Scenic Byways extend along both sides of the NRA and Flaming Gorge Reservoir from Wyoming into Utah.

The scene has changed in the last 40 years. We now manage a "Cultural" landscape, at least on the Utah side, which has a high influence of recreational aspects. There are enough developed and dispersed overnight facilities within the NRA to accommodate over ten thousand people in any one night. The scenic values for the area still persist, as people are able to sort out and look beyond the negative scenic features.

The Recreation Opportunity Spectrum would call for this area to be managed for a Roaded-Natural or Roaded-Modified setting. The Recreation Opportunity Spectrum for the area around Flaming Gorge Dam is close to an "Urban" setting.

The Scenic Integrity Level for the southern end of the NRA, including Cedar Springs, the dam, Dutch John, Antelope Flats, and Little Hole is considered Moderate to Low, because of related service developments as mentioned above. Scenic Integrity Levels for the Wyoming portion and Green River Corridor, below Little Hole would be considered as High to Moderate. The desired condition for the entire NRA and Green River Corridor would be "Natural Appearing" and "Cultural".

Bureau of Land Management Lands along the Green River Corridor, below Little Hole have a Class II Objective, "Change is visible, but does not attract attention."

Constituent Information

Visitors to the NRA come from Utah, Wyoming, Colorado, and all over the United States. Most foreign Visitors are from England, Germany, France and Japan. They expect to view outstanding scenery, visit the dam, and catch trophy fish. The majority of recreation use occurs during the summer months, between Labor Day and Memorial Day, or approximately 100 days.

Recreational opportunities include driving for pleasure, viewing scenery, fishing, boating, floating, waterskiing, swimming, scuba diving, hunting, mountain biking and hiking. Winter activities include cross-country skiing, snowmobiling and ice fishing on the reservoir and stream fishing on the river. Facilities include visitor centers, boat ramps, campgrounds, trails, commercial lodges, service stations, and marinas.

The Green River, below the dam is classified as a Recreational River, within the Wild and Scenic Rivers Classification system. The trail from Spillway to Little Hole is classified as a National Recreation Trail. The Green River is a Blue ribbon trout fishery and is heavily fished throughout the year. Rafting is popular on the Green River from May through September. A popular Scenic Backway extends from the Utah Colorado State Line through Brown's Park and into Vernal. Attractions along the Backway include John Jarvies Historical Ranch, campgrounds and picnic facilities.

The Flaming Gorge-Uintas National Scenic Byway, US Highway 191, begins in Vernal, Utah, and extends past Dutch John and to the Wyoming state line. Included is Highway 44, from Greendale Junction with US 191 to Manila, Utah. Intrinsic qualities include Scenic, Recreational, Natural, Historical, and Cultural. The Byway Theme is "Wildlife Through the Ages."

The Flaming Gorge-Green River Basin Scenic Byway picks up at the Wyoming State line and carries northward on Highway 530 to Green River, and US Highway 191 to Rock Springs. Designated by Wyoming in 2002, this byway has Recreational and Natural intrinsic qualities. The Byway Theme carries over from the Utah neighbor, "Wildlife Through the Ages."

Landscape Visibility

Most areas within the NRA are seen by the public from one point or another. People in boats scrutinize all parts of the reservoir and shoreline from the water level. Other Forest visitors and fishermen view the reservoir from above and points around the NRA, such as Red Canyon Visitor Center, Flaming Gorge Dam and Visitor Center, campgrounds, marinas and dispersed areas.

People floating the Green River and hiking the trail have the perspective of Red Canyon at the water level. Only a few vista points along the river are available from roadways. These include views from Flaming Gorge Dam, Spillway Boat Ramp, Little Hole area, and at Brown's Park.

APPLICATION

Flaming Gorge Reservoir

The visual management inventory for the Flaming Gorge NRA (Baird, 1985) calls for the area within the Flaming Gorge NRA as "Retention" of visual quality. This visual quality objective would provide for management activities that are not visually evident.

The Scenery Management System (SMS), adopted by the USDA Forest Service in December, 1995, supercedes the Visual Management System and

USDA Forest Service directives called for future visual analyses to adopt the new Scenery Management System. Subsequent discussion for this visual analysis will use SMS.

As mentioned above, the desired visual resource management goal on the NRA would be for a "Naturally Appearing" landscape. We are in a "Cultural" setting where concentrations of people and developments exist, such as the Cedar Springs area, at Flaming Gorge Dam and the Dutch John Townsite. Several factors need to be considered here.

Although a reservoir with draw down, some local entities have renamed it "Lake Flaming Gorge." The perception is for many people to view the reservoir as a lake. The draw down levels of 20 or 30 feet below high water line is minor to the entire scale of the reservoir, especially as viewed from any one viewpoint.

Several natural conditions exist, some as a result of man's activities of dam construction. Man has built the dam and has caused water to back up in Red Canyon. As a result of this action, natural processes are taking place, such as a buildup of calcium bicarbonate in the water, which tends to coat rocks and other features with a white film in which it comes in contact.

Another natural process is the weather patterns for Utah and Wyoming, and more specifically, the Green River Corridor. Provided that we experience normal or wet weather patterns every year, it could be feasible to manage at the high water level within the reservoir through time. Because of dry cyclic conditions, such as we are currently experiencing, there is a natural draw down of the reservoir surface. The surface elevation will either rise or drop, according to available natural water supply.

A third natural condition, or possible act of man, is to simulate historic natural spring flooding downstream in order to maintain habitat for endangered and sensitive species. These seasonal flows seem to tax a lot of storage reserve, which adds to changing water levels during the summer recreational season.

Many of the access points to Flaming Gorge Reservoir were visited and photographed by this writer. (See photographs in this report.) The visual effect of the draw down and white mineral coating is most apparent in the lower regions of the reservoir, specifically from Red Canyon Visitor Center and the Dam Visitor Center. The view from Red Canyon Visitor Center and overlook is from a distance and height that a few miles of shore line is visible. The view from the Dam Visitor Center is at water level. The white line does not stand out as much from many other locations around the reservoir.

This author visited visitor centers and information outlets around Flaming Gorge NRA and at Brown's Park. Facilities visited include:

1. Dam Visitor Center,
2. Red Canyon Visitor Center,
3. Flaming Gorge NRA Headquarters in Manila,
4. Dutch John USDA Forest Service Office,
5. Rock Springs Chamber of Commerce,
6. Green River Chamber of Commerce and Forest Service Office,
7. Lucerne Valley Marina,
8. Red Canyon Lodge, and
9. John Jarvie's Historical Ranch in Brown's Park (BLM).

At least 10 people at these information outlets were interviewed (see attachment), and most comments concerning the low water level indicated public concern about the dry climate conditions of the area and low water levels as a result. The public registers and comment forms - for the past several months were reviewed at Red Canyon Visitor Center and Dam Visitor Center. All comments entered were of a positive nature expressing the awesome scenery of the area. (See attached comment forms for the Dam Visitor Center.) Only one verbal comment concerning visual concerns was received by Bill Shane, Information Specialist at Red Canyon Visitor Center. Bill indicated that a lady asked, "Who painted the white line?"

At State Line Cove, near Manila, Utah, and at various other places in Wyoming around the reservoir, people choose to camp within the high water line of the reservoir. The lower the water level, the better it is for more places to camp and more space between units.

Many of the photographs of Flaming Gorge National Recreation Area, which have been taken by professional photographers, show the reservoir and white line. These are award winning photographs, transferred to post cards and on sale at the commercial outlets around the area. They are popular sale items and Forest visitors don't seem to hesitate to purchase them.

People do notice the draw down level of the reservoir, along with white line, but it does not detract from their overall recreational experience in the area. The low water marks and white line effects are only noticeable along some segments of the entire 300 miles of shoreline. During winter months any impacts are naturally mitigated with a covering of snow.

Visual effects are negligible as compared with the inherent scenery of the area.

The Green River

The USDA Forest Service visual management goal for the Green River Corridor would be for a "Natural Appearing Landscape Character."

The BLM has completed a Visual Resource Analysis along the Green River, downstream from the Forest Boundary to Brown's Park, which calls for Class II management. Some altering of the landscape can occur within Class II areas, but management activities and structures should not attract a viewer's attention.

In viewing the low-water stream flows along the Green River, there are few to no visual effects on the stream banks, from the perspective of the casual visitor. Some mud banks and exposed rocks stick out of the water, however they appear as a natural occurrence under low water conditions. Very few indications of white buildup are apparent on the cobble rocks or along the stream banks.

To summarize, the visual effects of low water flows along the Green River are negligible. Any effects are well within management prescriptions for the area.

ATTACHMENTS

Compilation of Visitor's Comments by Information Specialist, Brent Hanchett, 2002.

Visitor Comments at Flaming Gorge Dam. Hard Copy, 2002.

Photographs of Flaming Gorge and Green River, 2002.

ATTACHMENT 1
COMPILATION OF VISITOR'S COMMENTS, 2002

by Information Specialist
Brent Hanchett
June/July 2002

JUNE 10, 2002

Lori, Dinosaur Nature Association Tour Guide Flaming Gorge Dam and Visitor Center

Lori indicates there have been no questions or comments about the ring or white line around the reservoir. They bring up the fact that the reservoir presently has a 25-foot drawdown and is from drought and dry conditions. The publics concern then focuses on the drought conditions.

When asked, Lori said that people do ask about the pipeline clearing that goes over Dutch John Gap, and about fire scars in the area.

Nanette Gamble USDA Forest Service and two other interpreters Flaming Gorge Dam and Visitor Center

The reservoir drawdown is an indicator of drought and weather conditions and is used by the interpreters as a discussion item.

Nanette will send comment forms from the Dam Visitor Center.

Individual from Cheyenne, Wyoming at Dam Point Picnic Area

The water level being low is of concern, but the drawdown ring is not a problem. He has been floating the Green River and can tell a difference in low water conditions.

Bill Shane Information Specialist Red Canyon Visitor Center

Bill indicates that people do ask about the white line around the reservoir and why. After explanation, they are ok. One lady asked, "Who painted the white line?"

Mark Wilson Owner/Operator Red Canyon Lodge

Mark indicates no concern from the public that would impede recreational use of the area.

Jerry Taylor Owner/Operator Lucerne Valley Marina

Yes, people are concerned about the drawdown, especially Stateline Cove. Use is way down. Because of the low water, there is a large sandbar that extends out into the water that makes access difficult to the water.

Jerry also commented that people wanting to visit Flaming Gorge Reservoir have the conception of not enough water to boat on.

Bill, Information Specialist Green River Visitor Information Center

Bill indicates that weather and dry conditions are of concern to people, but not the visual aspects of the drawdown ring.

JUNE 27, 2002

Farah Humphrey
Frontline Receptionist
Flaming Gorge National Recreation Headquarters
Manila, Utah.

There is no visual concern, but there is concern about the water level and weather.

JULY 10, 2002

Volunteer Interpreter
John Jarvies Historic Ranch
Brown's Park, Utah

People floating the Green River have not expressed concern about visual problems related to low water flows.

ATTACHMENT 2
COMPILATION OF VISITOR'S COMMENTS
HARD COPY, 2002

PLEASE REGISTER
FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: Flaming Gorge Dam Visitor Center

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
1/24/02	[illegible]	Miami, Fla 331[illegible]7	4	Beautiful [illegible] cold
1/27/02	James, Lynette, Rick & Wyatt	#40 C.R. 7138, Aztec NM 87410	3	
1/31/02	[illegible]	Billings, MT 5910[illegible]	2	could be [illegible]!
1/31/02	HARRY DAVIS	PLEASANT GROVE, UT	1	
[illegible]	[illegible]	[illegible]	2	[illegible]
2/2/02	[illegible]	Cheyenne, Wy	3	
2/4/02	Judy [illegible]	Brownsville TX 7852[illegible]		
2/8/02	[illegible]	Roosevelt, ut 8406[illegible]	2	Great
2-8-02	Ronny & [illegible]	Crangeville, Ut	2	
2/8/02	Leroy Family	Huntington, Utah	3	
2-9-02	Janette & Ron Decker	Cody, Wy 82414	2	Nice
2-10-02	[illegible]	Rock Springs, WY 82901	3	where is the [illegible]!
2-10-02	Carlos A. Garza	LAREDO TX 78043	7	NICE
2-10-02	Raul Madrigal	LAREDO TX 78046	7	Real NICE
2-10-02	Angelina Rodriguez	Laredo TX 78041	7	" "
2-11-02	Bob & BARB FOE	[illegible]AUKEE WI 53072	2	GOOD JOB BY ALL
2-11-02	Kathi Jackson	Green River WY 82935	3	Cool!
2-11-02	SEAN NIX	SPRINGFIELD MO	3	Sweet!
2-12-02	[illegible] Ebert	Gaylord MN	2	Great!!!
2-12-02	Ruben Ebert	" " 55334		
2-12-02	[illegible]	[illegible]	2	
2-15-02	Kim & Mary Kroening / [illegible] & Maxine Hall	St Charles MN / [illegible] MN	4	
2-16-02	[illegible] & Vicky Morford	Chadron, NE	2	Beautiful
2-16-02	Andrea [illegible]	Pueblo West CO	2	Beautiful
2-16-02	[illegible]	[illegible]	2	[illegible]
2-16-02	[illegible]	Chester, IL	2	Beautiful!
2-19-02	Devona Malion	Rock Island, IL	2	Gorgeous!
2-19-02	John M & Bowman	Eugene Or	2	
2-19-02	Kristen Baumgarten	Vernal, Ut.	3	
2-22-02	[illegible] & Claudia Reed	[illegible], MS	4	Great
2-22-02	[illegible]	Roosevelt Ut.	2	
2-22-02	Raquel [illegible]	SONORA Mex	1	

PLEASE REGISTER
FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ______

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
2-4-02	Ronald Stoltz	Dane Wis 53529		
2-4-02	Ken Meier	Dane, Wis 53529		
2-24-02	[illegible]	Radcliffe Co	2	
2-27-02	LARRY PORCO	P.O. BOX 1019 BX NY 10462	1	
3/5/02	Louis D Bernier	Westminster, MD 21157	1	
3/5/02	Mathew D. Goulsby	17194 E. [illegible] D.	1	
3/6/02	Bob & Dianne Hagard	111 Riverview Watertown WI	2	
3/ /02	[illegible]	[illegible] 83401	2	
3-7-02	RUTH ARTERBURN	St. PAUL, NE 68873	1	
3-10-02	Sharon Price	Coeur d'Alene Idaho	2	
3-11-02	[illegible]	[illegible]	4	
3/16/02	Hutcheon Jack	South Jordan UT	3	
3/16/02	Hutcheon Jesse	Salt Lake City, UT	2	
3/16/02	Hutcheon, Ashly	SLC UT	1	
3/17/02	D. A McIntyre	Birch Hills Saskatchewan	2	
3/17/02	John/Bonnie Landwehr	Bozeman, MT	2	
3/19/02	Lisa Hettich	Muenster Tx 76252	4	WOW –
3/20/02	Jerry & Nina Hanson	Robertson Wyo.	2	
3/20/02	Father Bruce Philip	Memphis, TN 38126		
3/20/02	Fr. [illegible]	[illegible] UT 84078		great
3/21/02	[illegible]	Bethel OH 45106	2	beautiful
3/21/02	Carol Kopeka	GWS Colorado		
3/21/02	Stewart	Topeka, KS 66609	4	
3/21/02	Wm. R. Snow	N.S.C. UT	2	ENJOYED IT
3/23/02	[illegible] Allen	Corinna, Maine	4	Awesome
3/23/02	Darell Hunt	New Whiteland, Indiana	2	Better catch some fish
3/23/02	Rachel Ousley	LAKE CHARLES LA	1	
3-23/02	Bryan Cindy, Bernadine, Lindsey	Panhandle Tx 79068	3	
3-23/02	[illegible] Chen	Taipei / Taiwan	5	
3/24/02	Williams [illegible]	[illegible] Calif	9	Great View
3/25/02	Leo & Joan Bell	Killdeer ND	2	Great View
3/26/02	[illegible]	Thermopolis Wy	2	Great Place
3/26/02	PASSEY	LAS VEGAS NV	2	Wonderful
"	Rockefeller	Gloucester MA	1	
3/27/02	Christy	Athens Ohio	2	
3/27/02	Lauren Roberts	Omaha, Nebraska	4	Awesome
3/27/02	Scott, Teri, Tommy, [illegible], Kaiya	GRAND JUNCTION	5	BEAUTIFUL

PLEASE REGISTER

FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ___________

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
3/28/02	The Barry Amberg Family	Riverton, UT 84065	7	Awesome !
3/29/02	[illegible]	Lyndon, Co	2	Great
3/30/02	Bill & Ilka Cooley	Hattiesburg, MS.	2	Beautiful !!!
3/30/02	The Johnsons	FILLMORE UT. 84631	4	BREATH TAKING
3/30/02	POKORNEY FAMILY	NORTHFIELD MN 55057	5	
3/30/02	Bascom family	Orem UT 84058	2	Thank-you
3-30-02	Maumber family	Orem UT 84058	3	Thank you
3/30/02	Mills	LAYTON UT 84040	2	
3/30/02	MARK WALLIS	VERNAL UT 84078	3	
3/31/02	[illegible]	Cheyenne, WY	2	
"	Vern & Lola Chast	PLEASANT VIEW UT	9	
3/31/02	[illegible]	Vernal UT	3	Beautiful
3/31/02	Hewitt's	SLC UT	4	
3/31/02	James & Barb Trefethen	Corpus Christi Texas	2	Wow
3/31/02	Stephen Jones	Greenville, SC	4	Beautiful
3/31/02	Curi Shoemaker/Weber	Rock Springs WY	2	Breath taking
4/1/02	Trotter	Sommerville AR 35146	2	Beautiful
4-1-02	Jim + Gail Dawson	Mpls. MN.	2	informative
4-2-02	Dane + Suzanne Luecke	SLC, UT 84106	2	Awesome
4-3-02	Traci, Tammy, Riley Dav. & Nolan	Cincinnati, Oh	3	lovely
4-2-2002	John + Tedi MacDonald	Bellingham WA	2	— Superb! —
4-3-2002	Mike Eggett	Clfd. UT 84015	3	Totally awesome.
4-3-02	TERRY + PAT CALLAHAN	CLARKSVILLE, TN.	2	AWESOME
4-3-02	Timko family	Vicksburg, MI 49097	4	
4-4-02	Hunsaker Niewoehner	Lakeside Ca. 92021	2	BUENO
4-4-02	[illegible] Silva	Huron Co 80?59	7	
4-4-02	D&C RAHM	STEAMBOAT CO	7	
4-4-02	Lee + Ellen Walker	Brigham city, Utah	2	Beautiful, breath taking
4-4-02	Ruth Reed [illegible]	Pinedale, WY	4	
4-8-02	J&M. Kondersink	Cochrane AB Canada	2	Most Interesting Thank you
4-5-02	James Garrett	Huntsville AL	2	Great
4-9	Ray Kemp	Sandy, UT	2	
4-9	Elden Dayley's	Rigby Id.	2	

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FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ___________

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
3-27	Rhonda	Happy Valley / Provo	1	
3-29	Mike Hunt	V town	5	Say Name out loud
3-29	Chad	V town	20	
3-29	Melinda Mims	Sioux City / Ia / 51104	4	
3-29	Porter + Sherrie Martin	Shabbona, IL / 60550	2	
3-27	Melissa + Jake Fausse	Rock Springs Wy 82901	2	
3-29	Marni Hansen	Roy, Ut, 84067	5	Great Sites of Gorge
3-29	Chelsey Hansen	Roy, Ut 84067	6	Wonderful
3-29	Jim Alberts	Waterford, Mi	1	
4/5	Normelllyn Brown	Stone Mtn, GA	2	
4/5	Byland	Oh.	2	
4/5	Dan + Ashley, OHO	Omaha NE 68154	2	Great
4-6	Candy & Shelley Shelf	Derby Ks	2	
4/6	Greg Bushing	SLC- Ut	1	
04-06-02	Rick: Rose Cherry	Saskatoon, SK Canada	2	
[illegible]	Les Bailey	[illegible]	2	Beautiful as [illegible]
4-6/02	D+I. Williams	Oakland Pa.	2	
4-6-02	Russ+Renee Roberts	Grand Haven MI	2	
4-7-02	Kees Schot	mpls, MN	1	
4/7/02	Randy, Gran, Amber Cafe	[illegible] WY	3	
4/7/02				
4/7/02	Larry Hulsbey	RS WY	2	
4/7/02	Michael & Nancy Wimington	RS / Wy	2	
4/7/02	IAN D. CORBETT	BLUFF UT 84512	1	
4/7/02	Tim Schmidt/Family	Rock Springs, WY		
4/7/02	David Terny	SLC, UT	1	Beautiful
4-7-02	Olsen's	Soda Springs ID	3	Awesome!
4-7-02	[illegible]	[illegible]	4	[illegible]
4-7-02	Pasley	Cody, Wy, 82414	2	Rice Butt
4-9-02	Bob + Gail [illegible]	R.S. Wy 82901	2	
4-10-02	Blom [illegible]	R.S. Wy 82901	1	
4-10	M. Kuecher	[illegible], CO	2	
4-10	Roger [illegible]	Hackensack, Illin	2	
4-12	R. Sell [illegible]	Gotch, B.C	2	
4-12	Donna + Andy Leigh	Houston Tx.	2	

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DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
4/13	Vikki & Dave Yates	Ponte Vedra Bch, FL	3	Let's catch some
	Kevin Miller	Richland, MI	↓	fish!
4/13/2002	Rob & Kelly Beck	Commerce City Co	5	Beautiful!
	Ayiana & Hannah Vaughan			
	[illegible]	[illegible] CA	2	Lovely
4-14-02	[illegible]	[illegible] WY 83[illegible]	4	
4-14-02	[illegible]	Kansas City MO [illegible]	2	Very Nice
4-14-02	Lucus, Cerina, Liesa, & Annie	Cedar City, UT 84720	4	Beautiful
4-14-02	Michael Johnson	Albany Oregon	2	
4-15-02	Gary W Roland	Cheyenne Wy 82001	1	Good
4-15-02	[illegible]	[illegible] ID 83[illegible]	2	Sign Included
4-15-02	Mary Larson	Cass Lake MN 56633	2	"
4/16/02	Paul & Bobbie Wilson	Honolulu Hi 96825	2	"
4/16/02	[illegible]	[illegible]	2	"
4/16/02	Linda [illegible]	Darby MT	1	"
4/17/02	Jean Silang	Rizal City	3	awesome
	Jeffrey Silang	Philippines		"
4/17/02	Jody McClung	Grand Junction Co 81503	2	
4/18/02	[illegible]	[illegible] IL 60[illegible]	2	GREAT / BEAUTIFUL SCENE
18 Apr 02	Al Stevens	Denver Co 80220	1	
4-18-02	The Cogliati's	Jackson & Maple Creek, Ca	3	I'm hungry for fresh fish
4/18/02	The [illegible]	Longmont Co 80501	2	Very very nice
4-18-02	Keith Christensen	Orem UT 84097	6	pretty
4-19-02	Harwards	Orem, UT 84097	7	view
4-20-02	T. Lawson Gullette	Sterling, VA 20165	5	
4-20-02	Andrea Bristol	Galesburg IL	1	went to school at U of Idaho [illegible]
4-20-02	John & Jackie Kush	Rocklin CA	2	Nice TIME to VISIT
4-20-02	Joe & Tracy	Craig CO	2	Snowing
4-20-02	Burton Family	PG. UT	4	Impressive
4-20-02	Mason Howell	Highlands Ranch CO	1	Beautiful
4-20-02	C & N Miller	Craig	2	
4/22/02	Mary Dayes	Window Rock AZ		Great [illegible]
4/24/02	Donna Skinner	[illegible] Wy	2	
4/23/02	Jim & Ruth Schutter	Big Timber mt	2	
4/24/02	Wayne Petry	Buffalo, TX	1	Beautiful

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DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
4-23	Cliff + Dris Parks	Lake Isabella CA	2	Beautiful Area
4-23	Cari Park		1	Fishermen make my [illegible]
4-24	D [illegible]	[illegible] 32220	2	
4-24	John Sawick	Shelby, IA	2	OUTSTANDING
4-24	Otto & Helen Brown	Oregon	2	
4/24	Mitchell Jan Kelly	Tremont UT		Beautiful Area
4/25	Chelsea Pa Hoic	Colorado Springs, CO	3	Breathtaking
4/25	Travis [illegible]			
	Lisa [illegible]	S.L., CO	3	Beautiful Scenery
4-26-02	Howard & Eileen Bink	New Cumberland PA	2	
4-26	[illegible] Dick [illegible]	[illegible], OR 97370	2	
	Lynn Earlene & Luke [illegible]	Bern ID	3	Beautiful
4-26	Rob Streetman	Granby CO	1	
4-26	Bob + Lee Mueller	Westminster, CA.	5	
4.27.02	John, Ben Benedict	Colo Springs, CO	2	Cool.
4.27.02	F Winkler	Germany	3	
4/27/02	Julie Kirton	Mustelluye Lake		
	Sean Regan	Theresa, NY	2	Awesome!
4-27-02	Sid [illegible]	R.S. Wyo	3	
4/27/02	Jim Mercer[illegible]	Bloomington MN	3	Fantastic
4/26/02	Richard Harris	Smithfield UT	6	
4/28/02	John Smith	Franklin NC	2	Great
4/28/02	Marie [illegible]	Huntington[illegible]	2	Great
4/28/02	Angela Richardson	Vernal UT	5	Great
04/28/02	Alex Johnson Kuipers	The Netherlands	2	Prachtig!
04/28/02	Sonia A.	Green River WY		Nice & Scenery
04/28/02	Erin A	Green River WY		
04/28/02	Tim A.	Green River WY		
4/30/02	Rod & Barbara [illegible]	Riverton UT	2	Beautiful
4/28/02	Curt & Connie Salisbury	Roy, UT.	2	Wonderful!
5/1/02	Dick Fraap	Auburn, N.H.	2	"
4/29/02	Paul & Carolyn Savoy	Jamestown CA 95327	3	Peaceful!
4/29/02	Mike & Amy [illegible]	Elk River MN 55330	4	
4/30/02	Keith Morris	Denver CO 80231	2	Beautiful
4/30/02	Renate Arg Medical	Knoxville TN 37917	3	
4/30/02	Mary Helen Firth	Spearfish, S.D.	2	Nice

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DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
4-30-02	[illegible]	Cheyenne WY 82009		
[illegible] 02	Bus Mary Barton	Fresno CA 93725	2	Very nice
5-1-02	[illegible] Sheila Hansen	[illegible], CA 95465	2	Fantastic
5-1-02	Paul & Glynda Byerley	716 N. 2nd Olsburg KS 66520	2	Great
5-1-02	John & Betty Jo McCarney	[illegible], WA	2	[illegible]
5-1-02	Michael & Michele Horgan	[illegible] UT	2	Great
5/2/02	Jim/Sue Reilly	McKinleyville 95519	2	
5/2/02	[illegible] & Barbara [illegible]	Horseshoe Lake [illegible]	3	Great
5/2/02	[illegible] Barron	Caulfield Mo.		
5/2/2	Debbie & David Upton	Roy, UT 84067	2	Wonderful!
5/2/2002	Peter Casey	Co. Cavan Ireland	2	So many [illegible]
5/3-02	John & Margaret Johnston	[illegible] Oregon	2	Beautiful
5-3/02	Br. Roy & Janice Southern	Arcadia, LA	2	Wonderful
5/3/02	John Linn	Richmond, VT, 05477	1	[redacted]
5/3/02	Walter Helen Skow [illegible]	Santa Monica Ca	2	
5/3/02	Lever's - Jon & Sandy	Green River, Wy	2	
5/3/02	Lever's - Bob & Jennie	Fargo, ND	2	
5/3/02	[illegible]	[illegible]	2	[illegible]
5/4/02	Norm & Donna Stuhlgheisz	Anoka, MN	2	"
5/4/02	Chuck & Alice Meyer	Ashland, Virginia	2	Spectacular!
5/4/02	[illegible]	[illegible]	2	
5/5/02	Ray & Audrey Gales	Ft Dodge, IA 50501-5614	2	Excellent!
5/6/02	[illegible]	[illegible] WY	1	
5-6-02	Russ & Sue Jones	South Fork, Pennsylvania	2	Nice facilities / folks
	[illegible] Doran	Bothell WA	3	Small
5.6.02	Mike Williams	Logan, Ut	4	Swell
5 6 02	Ben & Bea Lou	Columbus Ohio	2	
5-7-02	[illegible]	[illegible] City Cal	2	
5-7-02	[illegible]	Duluth, MN	1	
5-7-02	Allen Lesson	Rock, NY	3	
5/7/2002	Mike & Diane Cooker	Concord CA	2	very nice
"	Don Schroeder	Bellevue WA	2	"
5-8-02	Bob & Mary Baine	Huntington Bch. CA	2	
5-8-02	Sadie Harvey	Basalt CO	21	windy
5-8-02	Kelsey [illegible]	Glenwood Springs CO.	#8	cold
5/8/02	Elsa Larson	Aspen CO		to Cold and windy But cool and fun!

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DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
5/8/02	Caitlin Doyle	Aspen CO	—	Windy & Cold but pretty
5/8/02	ANIA Brooks	Carbondale CO	2	windy-cold
5/8/02	Sadie Hanway	Basalt CO		pretty
5/8/02	Gina Fields	Glenwood Spgs CO		nice view
5/8/02	Margaret Downing	Woody Creek CO		Nice view
5/8/02	[illegible]	Collbran, Colo	3	great - fascinating
5/8/02	Michael & Carmen [illegible]	Germany	2	nice view
5/8/02	Wayne & Betty [illegible]	Tampa, Idaho	3	
5-8-02	Evelyn [illegible]	Rock Springs	1	
5-8-02	Larry Sandy [illegible]	ARIZONA	3	beautiful
5-8-02	[illegible]	UK	1	Great place
5-9-02	[illegible]	R. Springs Walmart	4	Great place
5-9-02	Deanne	Georgetown TX	2	gorgeous
5/9/02	Butch & Rachael Scott	Sevierville TN 37862	4	beautiful
5/9/02	JAMES + SUSAN Phillip	Sevierville, TN 37876	15	
5/9/02	Richard & Shirley Deboer	Clemmons NC	2	
[illegible]	Robinson	Atchison KS	2	
5-10-02	W. Krawza	Lakeville Mn	2	very impressive
5-10-02	Rich Riddle	Springfield, CO	1	nice
5-10-02	Sandy & Jim Houston	Buena Vista, CO	2	Fantastic
5/10/02	Dave Hafner	Rock Springs Wyo	7	keep coming back
5-10-02	Keith & Connie Stone	Granger In. (South Bend)	2	
5-11-02	Julie Hazlett & Beers	SLC, UT	4	
5-11-02	George Ciel	[illegible] FC	2	
5-11-02	[illegible]	Ft. HALL IDAHO	1	splendid
5-11-02	Art & Shirley [illegible]	St. Louis MO 63128	2	breath-taking
5-11-02	GEL WICKS	DORSET, ENGLAND	2	IMPRESSIVE.
5-11-02	Harald Stockwieser	Uttendorf, Germany	1	nice
5-11-02	Hans-Jörg [illegible]	" "	1	very nice
5-12-02	Dave & Lucy Woodwell	Los Cruces N.M.	2	Nice views
5/12/02	Stephen Scott	Parker, AZ. 85344		Nice Place.
5/12/02	D.+J. [illegible]	[illegible] Germany		
5/12/02	L. Smith	Laramie, WY 82070	4	WHEEEE!!
5/12/02	[illegible] Williams	15275 S. Sunset [illegible]	2	Mother's Day Delight
5/12/02	Jim & Fran CATRON	Kingsport TN. 37663	2	
5/12/02	BILL & JAN [illegible]	BOULDER CO	2	

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5/13/2002	Don/Jackie Bailey	Durango Colo 81301	2	Great
5/13/02	Logan + Pat Miller	" "	2	
5-13-02	Bob & Gail Downs	Durango, Co	2	Nice Day, Nice View
5-13-02	Glen & Cindy Hendrickson	Int'l. Falls, MN	3	Beautiful
5-13-02	Mike Steele	Sandy Ut 84070	4	Nice
5-13-02	Pat Dahlin	Fargo ND	Bus Tour (45)	Beautiful
5/13/02	Betty [illegible]	[illegible] Mt.	Bus Tour	very beautiful
	[illegible]	Polson Mt	"	
5/14/02	Aubrey & Jean Johnson	Avinger Tx 75630		
5-14-02	John & Mary Divigginas	Chicago/Palm Springs	2	Love the dam!
5-14-02	Mary + Kathy Ankele	Newberg / Or.	2	
5-14-02	Kenneth & Carol Buckner	Ellijay GA 30540	2	Beautiful
5-14-02	G.W. Warick	Sequim WA 98382	2	"
4-5-02	Syd Crompton	Liverpool. England	2	Amazing & Beautiful
5-14-02	Wm M. Nussong	Palmdale Ca	2	Fantastic
5-14-02	Mariël Gerts/Hans Kuiskes	Hoofddorp/Netherlands	2	beautiful!
5/14/02	Tom + Margaret Porter	Running Springs, CA	2	
5-14-02	Kendy Storie	Pendleton OR	1	
5-14-02	Thelma Lee	Silver City N.M.	1	great
5-14-02	David/Lucy [illegible]	Ocean Park, WA	2	fantastic
5-14-02	J. Masaki	Tokyo, Japan	2	Beautiful
5-14-02	Valerie Bye	Ephrata, Wa	5	Really Pretty
5-14-02	Keri Swift	Quincy Wa	5	Really Beautiful
5-15-02	R+S. Filer	Redmond, WA 98052	2	
5-15-02	Dorothy + Rick Olson	Fargo ND	2	Fantastic
5-15-02	Conrad Larson	Aspen Colo	2	Nice!
5-15-02	Gene & Bracha Hague	Morgan Hill Calif.	2	Tax Dollars well spent
5-15-02	Bob + Janice [illegible]	Sonoita, Az	2	
5-15-02	Jay & Michael [illegible]	Australia	2	
[illegible]	[illegible]	[illegible]	2	
[illegible]	[illegible]	[illegible]	2	[illegible] place !!
5-16-02	Lou Fraser [illegible]	[illegible] Junction Co	2	Awesome
[illegible]	[illegible]	[illegible]	1	
5/16/02	[illegible]	[illegible]	1	

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DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
5-16-02	Ed + Judy Sonny	Glendale CA	2	SPECTACULAR!
[illegible]	[illegible]	[illegible]	3	[illegible]
[illegible]-02	Dan + Judy Alchison	Gilbert AZ 85234	2	[illegible]
5-16-02	[illegible] Sarah Ketter	Corvallis OR 97330	3	[illegible]
5-16-02	Bill + Martha McGhee	Albuquerque NM	4	GREAT !!!
5-17-02	Cliff + Bev Rohlf	Arvada Co	2	wonderful
5-17-02	[illegible]	[illegible]		[illegible]
5-18-02	Alane + John Scott	Denver CO	4	
5-18-02	Mike + Amy Cook	Denver CO	4	
5-18-02	[illegible]	[illegible], NE	3	I love [illegible]
5-18-02	[illegible]	New York		GREAT!
5-18-02	[illegible]	Pueblo West 81007	4	
5-18-02	[illegible]	Pueblo Co. 81004	4	
5-19-02	[illegible]	Sun City, Az	2	Beautiful!
5-19-02	[illegible]	Salt Lake City, UT	3	[illegible]
5-19-02	[illegible] Anderson	Rapid City SD	2	Beautiful
5-19-02	The Wilkinson	Chicago, IL	2	Wow!
5-19-02	The Saxtons	Geneva, ID	4	Neat!
5-19-02	Charles Maloney	Cullman, AL.	1	Great
5-19-02	Karen Martinez	Clinton Utah 84052	5	Great
5-19-02	Loretta Dauphin	Houston Tx 77429	1	
5-19-02	Paul & Genevieve Breilbar	Wake Forest NC 27587	2	Advice not to pull a camper
5-19-02	Everett Kerr [illegible] family	Rock Springs WY 82901	4	Cool - Liked Alot
5-19-02	Angie Anthony	Tickfaw La 70466	2	
5-19-02	Cerina Hela	Hammond La 70461	6	
5-19-02	Dan & Donna Sewren	Central Point OR 97502	2	
5/19/02	Debi Colbert	Ellsworth, ME	1	
5-19-02	[illegible] Beaker	[illegible] NM	2	
5-20-02	[illegible]	[illegible] NY	2	
5-20-02	Jay Booth	Colfax Ca.	1	Awesome!
5-20-02	[illegible] Lillian [illegible]	Orlando Florida	2	GREAT
5-20-02	[illegible]	FLORIDA	2	"
5/20/02	[illegible]	Grand Junction, CO	2	Spectacular!
5/20/02	[illegible]	[illegible]	[illegible]	
5/20/02	[illegible]	[illegible]	2	

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5-20-02	[illegible]	[illegible] 95540		
5-20-02	[illegible]	[illegible], FL 34241	2	Very Helpful [illegible]
5-20-02	[illegible] Mike Peterson	Port Angeles, WA	2	
5-20-02	Jim & [illegible] Roberts	Seneca, SC	2	Beautiful
5-20-02	Doug Snyder	Sedalia CO	6	Awesome
5-20-02	[illegible]	[illegible] TX	2	
5-21-02	[illegible]	Billings MT	1	
5-21-02	[illegible]	[illegible] 44549	2	[illegible]
5-21-02	THE [illegible]	BUFFALO GROVE, IL	2	GREAT!!
5-21-02	Karl and Carol Brush	Indpls. Ind / Green Valley Az.	2	Beautiful area
5-21-02	[illegible]	[illegible] PA 18444	2	Very nice Area & ppl.
5-22-02	[illegible]	[illegible] TX	2	[illegible]
5-22-02	[illegible]	[illegible]	2	[illegible]!
5-22-02	[illegible] Zimmerman	SLC UT	4	[illegible]
5/23/02	Ryuko Yanagidaira	Sudo, Niigata, Japan	2	Beautiful!!
5-23-02	Jerry + Lori Priebe	[illegible] Prairie OH 44611	5	Awesome Country
5-24-02	[illegible]	Flagstaff Az	1	
5-24-02	CLINT & JOYCE	ROSEVILLE CA	2	ENJOYING
5/24/02	[illegible]	Twin Falls, ID	2	God's country
5/24/02	[illegible]	[illegible], CA	2	[illegible]
	DON MEEK	Topeka, KS	3	great!!
5/24/02	Velma Castor	Fruita, CO	1	nice!
" "	Donna Meek	Fruita, CO		
5-24-02	Glenn + Jane Larson	Fountain Hills AZ	2	very interesting
5-24-02	[illegible]	Livingston TX	2	Great!
5-24-02	[illegible]	Salt Lake City	3	Very helpful
5-24-02	[illegible]	WVC, UT	5	Nice!
5-24-02	Cathy Smith	Roy Ut. [illegible]	2	Great place
5-24-02	PEASE, TOBY	NORFOLK, VA	2	I WANTED TO WALK ON THE DAM
5-24-02	CARSON, Zoanne L.	Grand Jct Co	1	family reunion
5-24-02	LEO & GENNE KWICOT	Platteville Wisc.	2	at buckboard marina
5-24-02	Nate + Nikki Robinson	Midvale, Ut. 84047	2	
5-24-02	CAI [illegible]	SYRACUSE, UT 84075	5	
5/24/02	Frank & Mary Gerlach	New Haven, Ct.	2	Its our anniversary!!
5/25/02	T & B LEY	LIVINGSTON, TX	2	VACI
5/25/02	Don & Jean Kaye	Aurora, CO	2	

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5-29-02	M.A. FARACHER	Kenn West 129N Perry 99336		
5-25-02	Darrin Mathews	Wellsville Utah 84339	4	
" "	GARY SASLO	ABERDEEN, SCOTLAND	1	
5-25-	Andrew Hoggatt	Houston TX	6	
5-25-02	Joe + Tami Burkholder	Green River, WY	2	
5-25-02	Daniel & Tara Southwick	West Jordan Utah	4	
5-25-02	SHANE & SHANNON BROWN	Roy, UT	3	
5-25-02	Josh + Jacinda Holland	Midland, OK	4	
5-25-02	Bob, Sylvia Buechler	Saskatoon SK, Canada	4	Very Impressive
5-25-02	Joe & Pat Simac	Fairview, IL	2	
5-25-02	Wise family	Clearfield utah	4	WOW
5-25-02	Lindsay Westin & Tayler	Vernal, UT	3	We - Baby!
5-25-02	Tyler & Lisa Westerman	Logan UT	3	
5-26-02	[illegible]	SLC UT	3	[illegible]
5-26-02	McClure Family	SLC UT	5	
5-26-02	Waybourn Family	NSL UT	2	
5-26-02	Rodger + Donna Nipper	Longmont, CO	2	
5-26-02	Brett & Cyndi Morgan	Cheyenne, WY	2	Awesome Views
5-26-02	Terry Tom Logan	Orem	5	great
5-26-02	Marshall King	Park City UT 84060	1	
5-26-02	The Johnson Clan	Salt Lake City Ut. 84084	11	great.
5/26/02	The Watsons	North Ogden, UT	6	Good
5/26/02	[illegible]lund + Eliason	Salt Lake City UT 84118	5	Great + perfect
5/26/02	Shockeys	Denver Colorado	12	Nice.
5/26/02	The Hoths	Highlands Ranch Colorado	4	Awesome
5/26/02	Underdown Compton	Park city UT 84098	2	
5-26-02	The Crocketts	Rock Springs WY 82901	3	
5-26-02	M. Hadsen	Orem UT 84058	1	
5-25-02	F. CROMACK	Scotland UK	4	Fantastic
5/25/02	S. Wright	SLC, UT	2	Tite
5/26/02	E. Jackson	WVC, UT	2	Unmitigated
5-26-02	C. McKenzie	Green River, WY	2	
5-26-02	R. LEE	HEBER, UTAH	1	
5-26-02	Veronica Britygun	UTAH SLC.	9	wow
5-26-02	McClure Family	Pleasant Grove UT	6	
5-26-02	J. Rith	Jackson, WY	2	

PLEASE REGISTER

FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ____________

DATE 5/29/02	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
5/29/02	Anderson	Livingston TX	2	Enjoyed limited tour
5/29/02	Gaylord	Princeton, WI	2	Interesting
5/29/02	REGD	Imperial Beach	2	
5/29/02	M.L. MERRETT	BENBROOK, TX	1	GORGEOUS
5/29/02	MARTINI	ORLANDO FL	5	Thanks for the frisbee!
5-29-02	Smith	Springfield Missouri	2	You Made !
5-30-02	STATLER	Columbus, OHIO	4	
5-30-02	NIELSEN DICK JULIE	Glendive, MT	2	Very nice
5-30-02	Doran	Trinidad, CO	4	Awesome.
5-30-02	andrew, Reed	Seymour IN.	4	Neat
5/31/02	[illegible]	Salida, CO	2	Wonderful
5/31/02	Tonja Skiiko	Vernal UT	2	Wonderful
5/31/02	BRIAN JENSEN	ANCHORAGE		NICE,
5/31/02	AMANDA JENSEN	ALASKA		WOW.
	[illegible]	Livingston TX	2	thanks !
5/31/02	[illegible]	Netherlands	2	Nice
5/31/02	[illegible] Hammond	HIRAM, ME	4	Beautiful
5/31/02	[illegible]	Calistoga CA	1	My first time here
6-1-02	[illegible]	[illegible] BANK, MT	4	BEAUTIFUL
6-2-02	Lerry Howell	Lucedale, MS	4	Real Nice
6-2-02	Jennings	farmington, nm.	4	Beautiful [illegible]
6/2/02	[illegible] Kay Hill	[illegible]	2	Love It!
6/2/02	Mel + Middy Smith	Billings, MT	2	Very Nice
6/2/02	JOHN + [illegible] MABLNEA	SLC, UT	5	AWESOME
6/2/02	HARRY & [illegible]	IRVING IL 62051	2	
6/2/02	R + T Fortier	AL	4	
6/2/02	Judy [illegible]	Glendale, AZ, 85301	4	Interesting.....
6/2/02	Dallas Horn	Glendale, AZ, 85303	4	Cool + wet
6/2/02	[illegible]	[illegible] 51453	5	"Beautiful & Cool."
6/2/02	[illegible]	[illegible] 30256	2	
6-2-02	Jackie + [illegible]	[illegible], TX	2	
6-2-02	DAVE KELLOGG	SAN JOSE CA 95129	4	GREAT !
6-2-02	[illegible]	Los Gatos CA 95033	1	Nice
6-2-02	SAM "DANGER" MULLINS	GREEN RIVER WY	1	SPIFFY !
6-3-02	Betty Gearhart	W. Covina CA	1	
6-3-02	Chuck + Geri Corliss	Pleasant Lake, Michigan	2	

PLEASE REGISTER

FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ____________

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
5/26/02	K+J Bry	Ketchum, Id.	2	
[illegible]	Bernice & Wanford [illegible]	Klamath Falls, Or	2	
5 27 02	Uni Geology Field Camp	Laramie, WY	30	
5/27/02	Norm + Dee Bettencourt	Sonora, Ca	2	
5/27/02	Joe & TERRIE Rondo	Rifle, Co	2	
5/27/02	Mae & Chandra	Farmington, NM	5	wonderful place
5-27-02	Nelson Family	Eden, UT	5	Cool!
5-27-02	Bowles family	Rock Springs, Wyo	2	
5/27/02	Amy Shaw	Winfield, KS	4	beautiful
5/27/02	Emily Middleton	Tyler TX	4	beautiful!!
5-27-02	Marly, David, Shaw	Lewiston, NC	6	
5/28/02	Brumfiend family	Casper, WY	6	Beautiful as always!
5/27/02	Mathe son Family	Tooele UT	5	
5/Mon/02	RON JOHNSON	Douglas, WY	2	
5/27/02	ELDON-JEAN SWANSON	SUN LAKES AZ 85248	2	
5/27/02	Buzz & Vicky Knight	Siletz Oregon	4	beautiful
5/27/02	ROSE & MIKE [illegible]	Woodinville, WA	2 5:15	beautiful -
5/27/02	Valda Judd	Long Beach, CA 90803	2	Beautiful.
5-27-02	Sean Meissner	Jackson, WY 83002	1	Always a wonderful drive!
5-28-02	Bob & Donna Adams	Lemon Grove 91945	2	
5-28-02	J. Smerud	Eveleth MN	3	beautiful
5/28/02	Trista + Pat Burdick	Thornton, CO 80241	2	nice, friendly, informative rangers!
5/28/02	Tom + Carla	BRISTOL, ENGLAND	4	Great
5/28/02	Ian Williams	UNIV WISCONSIN - RIVER FALLS	22	+ visiting geology group - v. nice!
"	[illegible]	Port Orchard, WA. 98366	2	Very Nice
	Phyllis & Forrest Wood	Tucson AZ 85749	2	
5/28	[illegible]	Pittsburg 94565 [illegible]	2	Very nice
5/28	[illegible] Clark	[illegible] 80501	2	beautiful
5/28	Frost family	Breckenridge + Grand [illegible] CO	6	beautiful.
5/28	MR + MRS FRANK [illegible]	OCEAN SPRINGS MS.	2	great
5/29	Mr & Mrs Dan [illegible]	Versailles, Mo.	2	Beautiful
5/29	Mr + Mrs. R Reed	Christoval TX	2	spectacular!!!
5/29	M/M BOB GOLDING	CARMEL CA	2	Thank You
5/29	Ric Mirazon	Sheridan WY	1	
5/29	Rich + Nora, Elsa, Hanna W Wendy	Julesburg CO 80737	4	We saw a moose!
5 29	PETER FASSEARD	ZEVENAAR, Netherlands	1	

PLEASE REGISTER
FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ____________

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
6/3/02	GREGG FOLKES	LAKE OSWEGO, OR	1	PRETTY GOOD
6/3/02	[illegible]	[illegible] 39641	2	Neat
6/3/02	[illegible]	[illegible] 48229	2	Special
6/3/02	[illegible]	[illegible]	2	
6/3/02	[illegible]	Eagle Grove Iowa	2	excellent
6/3/02	Lindeen family	Lakewood CO 80227	5	awesome!
6/3/02	Turner Family	Arlington TX 76012	2	Beautiful
6-3-02	Wells Carlos	USA	2	Great!
6-3-02	[illegible]	Greeley CO	2	Good
6-3-02	Charles Bruning	Ft Collins CO	1	Nice
" "	[illegible]	[illegible] 11-711	2	[illegible]
6-3-02	[illegible]	Arizona		Cool
6/3/02	JANEL STURGEON	FRUITA, CO / 81521	1	God is AWESOME!
6/3/02	DAVE BOEHR	SUTTER CK, CA 95685	2	
6/3/02	[illegible]	Oskaloosa IA	5	
6/4/02	[illegible]	Helper Utah	1	
6/4/02	John & Judy Jett	HORNBECK, LA	2	Awesome!!
6/4/02	RONALD ICE PIOTRASCHKE	FT COLLINS, CO 80525	2	
6/4/02	Karen + Ernie	PORTLAND, OR	2	Spectacular Spectacular
6/4/02	Ray + Mary Johnson	Hemet, CA / Barron, WI	2	Very Beautiful
6/4/02	Jack + Pat [illegible]	Houston TX	2	" "
6-4-02	[illegible]	Arvada CO	2	Same - great
6-4-02	Anne + Leroy [illegible]	Austin TX	2	
6/4/02	[illegible]	[illegible]	2	
6-4-02	[illegible]	Vernal UT	4	
6-4-02	[illegible]	[illegible]	[illegible]	
6-4-02	[illegible]	[illegible]		
6-4-02	[illegible]	Vernal UT		
6-4-02	NATE ABNEY JR	HATFIELD PA	2	
6-4-02	WILLIAM KERR	OLEY PA	2	GREAT
6-4-02	Doug + Vicki Thompson	Othe Iowa	3	
6-4-02	H. + R. Bauer	CHL 4/5 [illegible]	2	
6-4-02	Bill [illegible]	Rockport, TX	2	Out Standing
6-5-02	Lindsey [illegible]	Fort Collins Co 8[illegible]	2	
6-5-02	Kevin + Jana [illegible]	Ft Collins, Co 80521	1	Wonderful
6-5-02	Zack [illegible]	Ft Collins CO	5	Neat

PLEASE REGISTER
FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ____________

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
4 [illegible]	Jessica Kelley	Ft. Collins CO 80521	9	Great!!
4-5-02	Kacey Kelley	Ft. Collins CO 80521	9	Great (Almost)
4-5-02	Megan Kelley	Ft. Collins CO [illegible]	9	Very good
6-5-02	Dave, Joanne & M. Walker	Union, KY 41091	2	Great [illegible]
6-5-02	[illegible]	[illegible]	4	[illegible]
6-6-02	C+K Herman	Washington [illegible] 61571	—	Beautiful
6-6	Donahue's	Phoenix, AZ	2	Great
6-5-02	McGie's	Albany [illegible]	2	Impressive
6-5-02	Ilka / Gertzo	Mainz	2	Germany
6-5-02	Kate & Scott Gible	Santa Rosa CA	2	Great!
6-6-02	Duncan	Woodland Park, CO	4	Interesting
6/6/02	Charles & Carolyn Kuhn	Evansville, IN	2	
6/6/02	Stan & Ruth Johnson	Longwood, Fla.	3	Great
6/6/02	Blinda Lyon	St Joseph MO 64503	3	
6-6-02	Ron & LaVonne	UPLAND CA 91784	2	GREAT
"	CARRIER	St. Louis, MO 63128	3	Thank you
"	STACEY	HUDSON FL 34667	2	Great
	Parker, John	BOYNTON BEACH FL 33467	2	
06-06-02	Margaret Twomey	Green River, WY	3	
6-6-02	Duane J Allen Family	Magna, UT	7	Awesome We'll be back
6-6-02	Max Bateman Family	Vernal, UT	5	Awesome!
6-6/02	Lisa Moore	Steamboat Spgs CO 80477	1	Wonderful!
6-6-02	Bob & Kitty Johnson	Royal Palm Bch, FL 33412	2	beautiful
6-6-02	Sue & Marilyn Stahl	Cape Coral, FL	2	beautiful
6-6-02	Richard & [illegible] Whit[illegible]	Okmulgee, OK	6	GREAT
6-6-02	[illegible]	[illegible] OK	1	
6-6-02	[illegible]	Houston TX	3	
6-7-02	[illegible]	Corsicana [illegible]	2	
6-7-02	McClury	Hudson WY	2	
6-7-02	McCrackman John	Lubbock, TX	2	
6-7-02	Paul E Mattingly Family	Denver Colorado	4	
6-7-02	[illegible] Campbell	Tyrone, PA	2	
6-7-02	[illegible] Family	[illegible], C 80203	4	Very Beautiful
6-7-02	[illegible]	[illegible], UT	2	
6-7-02	[illegible]	Puerto Rico	1	No words to describe it
6-7-02	Müller H+R	Germany	2	Very Beautiful

PLEASE REGISTER

FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ____________

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
6-7-02	R + R. Buchmann	Germany	2	
6-7-02	[illegible] Family	[illegible] UT [illegible]	4	
7/6/02	The Gotlands	New Zealand	6.	
6/7/02	[illegible]	[illegible] TX	2	
6/7/02	VECMIKA	Roy UT	7	
6/7/02	Cordova	Clif UT	5	
6/7/02	Bybee	Roy Ut.	7	
6/7/02	Sabine Krüger	Germany	3	
6/7/02	HAIT	Houston TX	2	
	Susan [illegible]	San Francisco	2	[illegible] !
6/7/02	[illegible] Hamel	Longmont, Co	6	
6-7-02	Kym Wilson	Bellevue Ky	2	
7/6/02	PHIL KRETSCHMER	AUSTRALIA (ADELAIDE)	2	WOW!
7/6/02	SUE ENGLAND	AUSTRALIA (ADELAIDE)		SURREAL!
6/7/02	John Chee	Houston, TX	4	amazing
"	Michael Chee	"	"	"
06/06/02	W. & Heide Verbeek	Gouda, Netherlands	2	Beautiful
6-8/2002	[illegible] & Elroy [illegible]	Sweden, [illegible]	2	
6/6/02	K. S[illegible]	TONBRIDGE ENGLAND	2	
6/8/02	J.C. O'NEILL	DEPTFORD London ENGLAND	2	
6/8/02	James & Kim Mosley	Borger TX 79007	2	
6-8-02	Tim Davis	Chiefland FL 32626	3	
6-8-02	Tide Langure	Utah	3	I wish we could go inside!
6-8-02	Carol Orchard	Baggs, WY	4	
6-8-02	Larry & Pat Brown	North Fairfield Ohio	2	☺
6-8-02	B&D [illegible]	Montrose, Co	2	WOW!
6-8-02	Arthur Flo[illegible]	Tucson, AZ	3	
	AEK			
	Anne[illegible]	IAT		
6-8-02	[illegible]	Salt Lake UT	3	
6-8-02	[illegible] Hicks	WAKEFIELD W. YORKS ENGLAND	4	Beautiful
6-8-02	Laura Robinson	WAKEFIELD ENGLAND	4	[illegible]
6-8-02	[illegible]	[illegible] City TX.		
6-8-02	Keith [illegible]	[illegible] AZ	6	?
6-8-02	Jessica [illegible]	[illegible]	6	?
6-8-02	Mark, Tina, [illegible] Curtis	[illegible], Co	4	

PLEASE REGISTER

FLAMING GORGE NATIONAL RECREATION AREA

LOCATION: ____________

DATE	NAME	CITY/ST/ZIP	# IN GROUP	COMMENTS
				For the cost/night
6/7/02	[illegible]	SLC UT	12	[illegible]
6-8-02	D+K CATALANO	MEDFORD, OR 97504	2	Awesome …
6-8-02	Bendy + Mi[illegible]	SLC, UT	4	Cool - neat to see
6-8-02	Rob + Kathi Family	Cody, Wy	2	Beautiful
6/8/02	[illegible]	B[illegible] UT	9	[illegible]
6-8-02	[illegible]	[illegible]	4	Great
6-8-02	[illegible]	[illegible]	5	[illegible] Great
6-9-02	TROY & MIRANDA	Groshen UT	2	Neat
"	Ed TRAUTWEIN	Billings MT	1	
6-9-02	Willie HANN	Bluebell, UT	1	Great
6-9-02	Fowlets	Ocala, FL	3	
6-9-02	Richards	Ogden, UT	4	
6-9-02	[illegible]	[illegible] ID	2	
6/9/02	[illegible]	[illegible] KS	2	
6/9/02	IRV & Betty KENNEDY	Denver, Co	2	
	[illegible]	Toronto, Canada	2	[illegible]
6-9-02	Harold Lewis	Westminster, CO	2	
6-9-02	Andy+Mary Tisler	Roswell, NM	7	
6-9-02	[illegible]	[illegible] OK	4	
6-9-02	Ken Smith family	Wheatland, WY	4	
6-9-02	[illegible] + Molly Dietrich	Rock Springs WY	4	
6-9-02	[illegible]	[illegible] ID	1	
6-9-02	[illegible]	[illegible]	1	
6-9-02	Pullan family	Salt Lake City UT	4	
6-9-02	[illegible]	Punta Gorda FL	7	
6-9-02	[illegible]	[illegible] Ca	2	
6-9-02	[illegible]	[illegible], Iowa	2	
6/9/02	Jim + [illegible]	Woodhull IL	5	
6-9-02	Todd [illegible]	[illegible]	4	[illegible]
6-9-02	[illegible]	Ft Collins CO	3	
6-9-02	[illegible]	PA.	4	good. [illegible]
6/9/02	John & Connie DALY	California	4	
6/9/02	[illegible]	[illegible]	3	
6/9/02	J. Collier	Salt Lake City Utah	5	[illegible]

ATTACHMENT 3
PHOTOGRAPHS OF FLAMING GORGE AND GREEN RIVER, 2002

Flaming Gorge Dam

The Flaming Gorge Reservoir as viewed from the Flaming Gorge Dam.

View of Island from picnic area, next to Flaming Gorge Dam.

Red Canyon from Red Canyon Visitors Center Overlook.

Flaming Gorge from Sheep Creek Overlook.

Lucerne Valley Marina, Utah.

State Line Cove, Wyoming.

Looking West of Buckboard Marina, Wyoming.

View of Flaming Gorge Reservoir at Blacks Fork on Highway 530, Wyoming.

Looking North from Firehole Boating Site.

View of Flaming Gorge Reservoir from above Dam.

Green River

View of Flaming Gorge Dam from Spillway Launch Ramp.

View of Green River from Dam Spillway Launch Ramp.

Green River at Little Hole Boating Site.

Green River at Little Hole with John Wesley Powell historic site in middle ground.

Green River from lower Little Hole Boat Ramp.
Note recent fire activity in background.

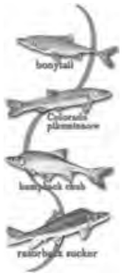
Green River at Brown's Park from John Jarvies Historical Ranch.

Looking North at Brown's Park Bridge.

Upstream from Swinging Bridge in Brown's Park.

Operation of
Flaming Gorge Dam
Final Environmental
Impact Statement

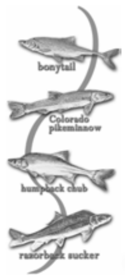
Final Biological Opinion Technical Appendix



FINAL BIOLOGICAL OPINION TECHNICAL APPENDIX

Page No.

Final Biological Opinion Technical Appendix



United States Department of the Interior
FISH AND WILDLIFE SERVICE
UTAH FIELD OFFICE
2369 WEST ORTON CIRCLE, SUITE 50
WEST VALLEY CITY, UTAH 84119

6-UT-05-F-006
05-1380

September 6, 2005

Mr. Rick Gold, Regional Director
Upper Colorado Region
U.S. Bureau of Reclamation
125 South State Street, Room 6107
Salt Lake City, Utah 84138

Mr. Bruce Barrett, Provo Area Office Manager
U.S. Bureau of Reclamation
302 East 1860 South
Provo, Utah 84606

Mr. Brad Warren, Area Manager
Western Area Power Administration
P.O. Box 11606
Salt Lake City, Utah 84147

RE: Final Biological Opinion on the Operation of Flaming Gorge Dam (Consultation # 6-UT-05-F-006)

Dear Sirs,

This letter transmits the enclosed Final Biological Opinion on the Preferred Alternative of the Flaming Gorge Dam Environmental Impact Statement. Reclamation proposes to modify the operations of Flaming Gorge Dam, to the extent possible, to achieve U.S. Fish and Wildlife Service flow and temperature recommendations identified in the Upper Colorado River Endangered Fish Recovery Program report "Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam" (Muth et al. 2000).

I would like to take this opportunity to commend you on your significant contributions, past and present, to the recovery of the endangered fishes of the Colorado River system. Implementation of the revised flow recommendations for Flaming Gorge Dam is the culmination of 13 years of effort by Reclamation, Western, U.S. Fish and Wildlife Service and the Recovery Program and represents a significant achievement as we seek ways to recover the endangered fishes and provide for future water development. I would also like to express my appreciation to you and your staffs for your cooperation and considerable efforts in successfully completing this consultation. If you have any questions please feel free to contact Mr. Larry Crist or myself at 801-975-3330 ext. 126 or ext. 124, respectively.

Sincerely,

Henry R. Maddux
Utah Field Supervisor

Memorandum

To: Regional Director, Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah

Area Manager, Bureau of Reclamation, Provo Area Office, Provo, Utah

Area Manager, Western Area Power Administration, Salt Lake City, Utah

From: Field Supervisor, Utah Field Office Fish and Wildlife Service
Salt Lake City, Utah

Subject: Final Biological Opinion on the Operation of Flaming Gorge Dam

In accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), and the Interagency Cooperation Regulations (50 CFR 402), this transmits the Fish and Wildlife Service's (Service) final biological opinion for impacts to federally listed endangered species for Reclamation's proposed action to operate Flaming Gorge Dam to protect and assist in recovery of populations and designated critical habitat of the four endangered fishes found in the Green and Colorado River Basins. Reference is made to your February 1, 2005, correspondence (received in our Utah Field office on February 1, 2005) requesting initiation of formal consultation for the subject project. Based on the information presented in the biological assessment and the Operation of Flaming Gorge Environmental Impact Statement that you provided, I concur that the proposed action may adversely effect the threatened Ute ladies'-tresses (*Spiranthes diluvialis)* and the endangered Colorado pikeminnow *(Ptychocheilus lucius*), humpback chub (*Gila cypha*), bonytail (*Gila elegans*), and razorback sucker (*Xyrauchen texanus*) and critical habitat.

Based on the information provided in the biological assessment, I also concur that the proposed operation of Flaming Gorge Dam may affect, but is not likely to adversely affect, the bald eagle (*Haliaeetus leucocephalus*) and southwestern willow flycatcher (*Empidonax traillii extimus*). In addition, I concur with the determination of no effect for the California condor (*Gymnogyps californiannus)*, black-footed ferret (*Mustela* nigripes) and Canada lynx (*Lynx* canadensis). The bald eagle's preferred prey are fish and waterfowl, and the proposed action involves implementation of flow recommendations that should support its prey and benefit the riparian forest that eagles use for roosting. The southwestern willow flycatcher nests in riparian corridors, islands and sandbars vegetated with willow, tamarisk and other shrubs. The species may occur in low numbers during the summer along the Green River downstream of Ouray, Utah, though subspecific identity has not been confirmed. Riparian habitats utilized by the southwestern willow flycatcher are expected to benefit from implementation of a flow recommendations for the endangered fishes that would result in a more natural flow regime. The California condor is not a resident in the Green River subbasin and would not be affected. The proposed action would also have no effect on black-footed ferret's and lynx since their upland habitats and their prey base are not affected by Flaming Gorge Dam operations.

Consultation History

Construction of Flaming Gorge Dam predates the Endangered Species Act of 1973 and as a result consultation on its construction has never been required. Consultation on operations at Flaming Gorge Dam and other Reclamation projects in the Green River subbasin first started in the late 1970s and early 1980s. The earliest link between operations at Flaming Gorge Dam and other Reclamation consultations was in November 1979 when the Service issued a jeopardy biological opinion for the Upalco Unit of the Central Utah Project and stipulated in the Reasonable and Prudent Alternative (RPA) that Flaming Gorge would compensate for depletions of the project.

On February 27, 1980, the Service requested consultation under Section 7 of the ESA for projects currently under construction in the Upper Colorado River Basin and for the continued operation of all existing Reclamation projects in the basin, including the Colorado River Storage Project (CRSP). Reclamation agreed with the request and formal consultation on the operation of Flaming Gorge Dam was initiated on March 27, 1980. Issuance of a final biological opinion by the Service for the operation of Flaming Gorge Dam was delayed until data collection and studies related to habitat requirements for the endangered fishes could be completed and used to recommend specific flows in the Green River downstream from the dam. Between 1980 and 1991 there were a series of agreements between Reclamation and the Service delaying the issuance of a biological opinion until sufficient information was collected. Existing dam operations were initially evaluated for potential effects on endangered fishes from 1979 to 1984. In 1984 the Service and Reclamation reached an interim flow agreement that constrained summer flows to benefit the endangered fishes and between 1985 and 1991 effects of the constrained summer flows were studied. Reclamation served as the lead agency for this consultation, with Western Area Power Administration (Western) becoming a party to the consultation in 1991.

During this same period, the Service issued a final biological opinion (USFWS 1980) for the Strawberry Aqueduct and Collection System (SACS), a major feature of the Central Utah Project. The SACS biological opinion determined that flow depletions from the Duchesne and Green Rivers would likely jeopardize the continued existence of the endangered Colorado pikeminnow and humpback chub. The SACS biological opinion also included a RPA that stated "Jeopardy from the Bonneville Unit, considered with the other CUP units, could be avoided by operating Flaming Gorge Dam in a more environmentally sensitive manner. Since modification of the Flaming Gorge penstock in 1978, this reservoir could be operated with much less impact on endangered fishes. Modified operations would not only compensate for effects of CUP, but also could help restore the Green River to a healthy condition for the listed fishes."

Using information collected from 1979 to 1991, the Biological Opinion on the Operation of Flaming Gorge Dam (1992 FGBO) was issued on November 25, 1992 (USFWS 1992a). The opinion stated that the then-current operation of Flaming Gorge Dam was likely to jeopardize the continued existence of the endangered fishes in the Green River. Flow recommendations in the 1992 FGBO for spring, summer, autumn, and winter were based on the best available information and professional judgment of researchers who had collected and analyzed much of the data. The recommended flows were intended to restore a more natural hydrograph and to provide a flow regime that would allow for enhancement and recovery of endangered and other native fishes in the Green River. Because of data limitations and the desire to protect areas believed to be crucial for protection of the endangered fishes, the 1992 FGBO only recommended target flows for the Green River at the U.S. Geological Survey (USGS) gage near Jensen, Utah (located 157 km, or 98 mi, downstream from the dam). The 1992 FGBO also called for refining operations so that temperature regimes, especially downstream of the confluence of the Green and Yampa Rivers, would more closely resemble historic conditions and to examine the feasibility and effects of releasing warmer water during the late spring/summer period.

The 1992 FGBO described elements of a Reasonable and Prudent Alternative (RPA) that would offset jeopardy to the endangered fishes (USFWS 1992a). The RPA included the following elements:

- Refine the operation of Flaming Gorge Dam so that flow and temperature regimes of the Green River more closely resemble historic conditions.
- Conduct a 5-year research program that includes winter and spring research flows, to allow for potential refinement of flows for these seasons.
- Determine the feasibility and effects of releasing warmer water during the late spring/summer period and investigate the feasibility of retrofitting the river bypass tubes to include power generation, thereby facilitating higher spring releases.
- Legally protect Green River flows from Flaming Gorge Dam to Lake Powell.
- Initiate discussions with the Service after conclusion of the 5-year research program to examine further refinement of flows for the endangered Colorado River fish. Under this element, results of the research program will be used to reevaluate and, if necessary, refine recommendations presented in the biological opinion.

The five-year research program concluded in 1996. At that time, the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program) developed a report that summarized research and developed flow recommendations that were based on all the available information. That report (Muth et al. 2000) provided the basis for Reclamation's proposed action evaluated in their EIS and this biological opinion.

During the time that consultation for the 1992 FGBO was ongoing, other ESA related activities were occurring in the basin. In 1984, the Department of the Interior, Colorado, Wyoming, Utah, water users, and environmental groups formed a coordinating committee to discuss a process to recover the endangered fishes while new and existing water development proceeded in the Upper Colorado River Basin in compliance with Federal and State law and interstate compacts.

After 4 years of negotiations, the Secretary of the Interior; Governors of Wyoming, Colorado, and Utah; and the Administrator of the Western Area Power Administration (Western) cosigned a Cooperative Agreement on January 21-22, 1988, to implement the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program). Current participants in the Recovery Program include: the Service, Reclamation, National Park Service, Western, Colorado, Utah, Wyoming, Western Resource Advocates, The Nature Conservancy, Colorado Water Congress, Utah Water Users Association, Wyoming Water Development Association, and the Colorado River Energy Distributors Association. The goal of the Recovery Program is to recover the listed species while providing for new and existing water development in the Upper Colorado River Basin. All participants agreed to cooperatively work toward the successful implementation of a recovery program that will provide for recovery of the endangered fish species, consistent with Federal law and all applicable State laws and systems for water resource development and use. Each signatory assumed certain responsibilities in implementing the Recovery Program. In particular, the refined operation of Federal reservoirs by Reclamation to reduce or eliminate impacts to endangered fish and contribute to their recovery was identified as critical to the Recovery Program. To further define and clarify processes outlined in sections 4.1.5, 4.1.6, and 5.3.4 of the Recovery Program (USFWS 1987), the *Section 7 Consultation, Sufficient Progress, and Historic Projects Agreement* (Section 7 Agreement) and *Recovery Implementation Program Recovery Action Plan* (RIPRAP) were developed in 1993 and updated yearly (USFWS 2003). The Section 7 Agreement established a framework for conducting section 7 consultations on depletion impacts related to new projects and impacts associated with existing projects in the upper basin. Procedures outlined in the Section 7 Agreement are used to determine if sufficient progress is being accomplished in the recovery of endangered fishes to enable the Recovery Program to serve as a reasonable and prudent alternative to avoid the likelihood of jeopardy and/or adverse modification of critical habitat.

Since the inception of the Recovery Program, the Service has consulted on over 700 projects depleting water from the Upper Colorado River Basin. The Recovery Program, through its implementation of the RIPRAP, has avoided the likelihood of jeopardy and/or adverse modification of critical habitat on behalf of these projects.

The RIPRAP outlines specific recovery actions, including such measures as acquiring and managing aquatic habitat and water, re-operating existing reservoirs to provide instream flows for fishes, constructing fish passage facilities, controlling nonnative fishes, and propagating and stocking listed fish species. It also stipulates which entity is responsible for taking action, when these actions would be undertaken, and how they would be funded. The RIPRAP was finalized on October 15, 1993, and has been reviewed and updated annually.

One high priority RIPRAP element under the FY 2004 Green River Action Plan: Green River above Duchesne River I.A.3.d., is to operate Flaming Gorge Dam to provide winter and spring flows and revised summer/fall flows, pursuant to the new Flaming Gorge biological opinion. Implementation of this priority RIPRAP item by Reclamation through adoption of Flow Recommendations is intended to offset in part the adverse effects of water depletions by other projects and fulfill a commitment by Reclamation to refine operations at its facilities, including

Flaming Gorge to assist in meeting instream flow requirements for endangered fishes (USFWS 1987).

Other consultations that rely on Flaming Gorge Dam as a RPA to offset their depletions include; the 1998 programmatic biological opinion for the Duchesne River Basin (447,000 af) and the 2000 Narrows Project (5,717 af). Projects covered under the programmatic biological opinion for the Duchesne River include; Strawberry Valley Project, Provo River Project, Moon Lake Project, Midview Exchange, Ute Indian Irrigation Project, and the Central Utah Project which includes the Bonneville, Uintah and Upalco Units. Consultations that received non-jeopardy biological opinions but also depend operation of Flaming Gorge Dam to meet flow recommendation as part of continued sufficient progress of the Recovery Program to offset water depletions include the Price-San Rafael Unit of the Salinity Control Program (1992) and the Programmatic Biological Opinion on the Management Plan for Endangered Fishes in the Yampa River Basin.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

Scope of Biological Opinion

Emergencies

This biological opinion does not cover emergency operations at Flaming Gorge Dam. Where emergency circumstances mandate the need to consult in an expedited manner, consultation may be conducted informally through alternative procedures that are consistent with the requirements of section 7 (a)-(d) of the Act. This provision applies to situations involving acts of God, disasters, casualties, national defense or security emergencies, etc. (50 CFR 402.05). The timing and nature of emergencies are typically not predictable but at Flaming Gorge Dam they may be associated with dam safety, personal safety of individuals or groups associated with recreation or other activities on the river or power system conditions. Emergencies associated with dam safety could include unforeseen releases or operations to protect dam infrastructure. Emergencies associated with the safety of individuals or groups may be associated with river rescue or recovery operations. Types of emergency powerplant operations are discussed in Section 1.6 of the Operation of Flaming Gorge Dam Environmental Impact Statement (FGEIS) and include insufficient generation capacity, transmission (overload and voltage control), load shedding and system restoration. Emergency operations are typically of short duration as a result of emergencies occurring at the dam or within the transmission network. In the event of an emergency, Reclamation and/or Western will contact the Service in a timely manner for advice on measures to minimize the effects of the response on species and critical habitat, and formal consultation, if needed, will be conducted after the fact. This should not be interpreted to mean that an emergency response should be delayed if it is not possible to contact the Service. Spills associated with normal dam operations or to meet the proposed action are not considered emergencies and are covered in this biological opinion.

Action Area

Under the proposed action, Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended in Muth et al. (2000), while maintaining all authorized purposes of the Flaming Gorge Unit of the CRSP, particularly those related to the development of water resources in accordance with the Colorado River Compact. The flow and temperature recommendations describe the peak flows, durations, water temperatures, and base flow criteria believed by the Service to be necessary for the survival and recovery of endangered fishes. This biological opinion addresses the effects of the proposed action and associated flow regime on the endangered Colorado pikeminnow, humpback chub, bonytail and razorback sucker and the threatened Ute ladies'-tresses in the Green River downstream of Flaming Gorge Dam

The flow and temperature recommendations include specified peak and base flows (Table 1) to be achieved in the three portions of the Green River defined as follows:

- **Reach 1:** Flaming Gorge Dam to the Yampa River confluence (river kilometer [RK] 555 to 660, or river mile [RM] 345 to 410). Flow in this reach, which is measured at the USGS gage near Greendale, Utah, is almost entirely regulated by releases from Flaming Gorge Dam.

- **Reach 2:** Yampa River confluence to White River confluence (RK 396 to 555, or RM 246 to 345). Flow in this reach is measured at the USGS gage near Jensen, Utah. In this reach, tributary flows from the Yampa River combine with releases from Flaming Gorge Dam to provide a less regulated flow regime than in Reach 1.

- **Reach 3:** White River confluence to Colorado River (RK 0 to 396 or RM 0 to 246). Flow in this reach is measured at the USGS gage near Green River, Utah. In this reach, the Green River is further influenced by tributary flows from the White, Duchesne, Price, and San Rafael Rivers.

These three reaches (Figure 1) of the Green River and the adjacent 100 year floodplain constitute the action area considered in this biological opinion.

Flow and Temperature Recommendations

The proposed action would provide increased interannual variability in peak and base flows. Such variability is thought to support in-channel and floodplain geomorphic processes that would maintain the ecosystem dynamics to which the endangered fishes are adapted. Not all objectives for each species can or need to be met within each year. Different species occupy different ecological niches, and distinct life stages benefit from different specific hydrologic conditions. For all species, short-term adverse effects of high or low flows would be offset by longer-term benefits. The flow patterns of the proposed action approximate unregulated flow conditions more closely than the flow conditions required under the 1992 FGBO. The magnitude, duration, and timing of releases from Flaming Gorge Dam would be tied to the anticipated hydrologic condition in a given year. This approach would tend to mimic the natural hydrology of the Green River subbasin and provide within-year and between-year variability.

Forecasted runoff volume would be used to determine the magnitude, duration, and timing of releases from Flaming Gorge Dam to enhance downstream habitat conditions. When above-average runoff conditions are forecasted, bypass tubes or the spillway at Flaming Gorge Dam would be used to increase peak spring flows in downstream reaches. During average or drier years, spring releases would be at maximum power plant levels or greater to achieve specific target peak flows in downstream reaches. Peak releases from Flaming Gorge Dam would be timed to coincide with peak and immediate post-peak flows of the Yampa River to maximize the magnitude and duration of the peak, restore in-channel processes, inundate floodplain habitats, and extend the duration of peak flows in Reaches 2 and 3. Similar to peak flows, base flows during summer–winter would be tied to annual hydrologic conditions and would be higher in wetter years than in drier years.
Under the proposed action, hydrologic conditions in any given year would be placed in one of the following categories:

- **Wet (0–10% exceedance[1]).** Annual forecasted runoff volume is larger than almost all of the historic runoff volumes (10% probability of occurrence).
- **Moderately wet (10–30% exceedance).** Annual forecasted runoff volume is larger than most of the historic runoff volumes (20% probability of occurrence).
- **Average (30–70% exceedance).** Annual forecasted runoff volume is larger than about half of the historic runoff volumes (40% probability of occurrence).
- **Moderately dry (70–90% exceedance).** Annual forecasted runoff volume is less than most of the historic runoff volumes (20% probability of occurrence).
- **Dry (90–100% exceedance).** Annual forecasted runoff volume is less than almost all of the historic runoff volumes (10% probability of occurrence).

These exceedance intervals were chosen to provide guidance for setting peak- and base-flow targets under different hydrologic conditions so as to achieve the desired hydrologic variability. In reality, annual runoff volume is a continuous variable, and any categorization scheme is somewhat arbitrary. Release patterns in any given year would reflect where within the wet to dry continuum the hydrologic condition in that year falls.

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[1] Exceedance values refer to the percentage of recorded flows that have been higher than that value. An exceedance value is equivalent to 1 minus the percentile.

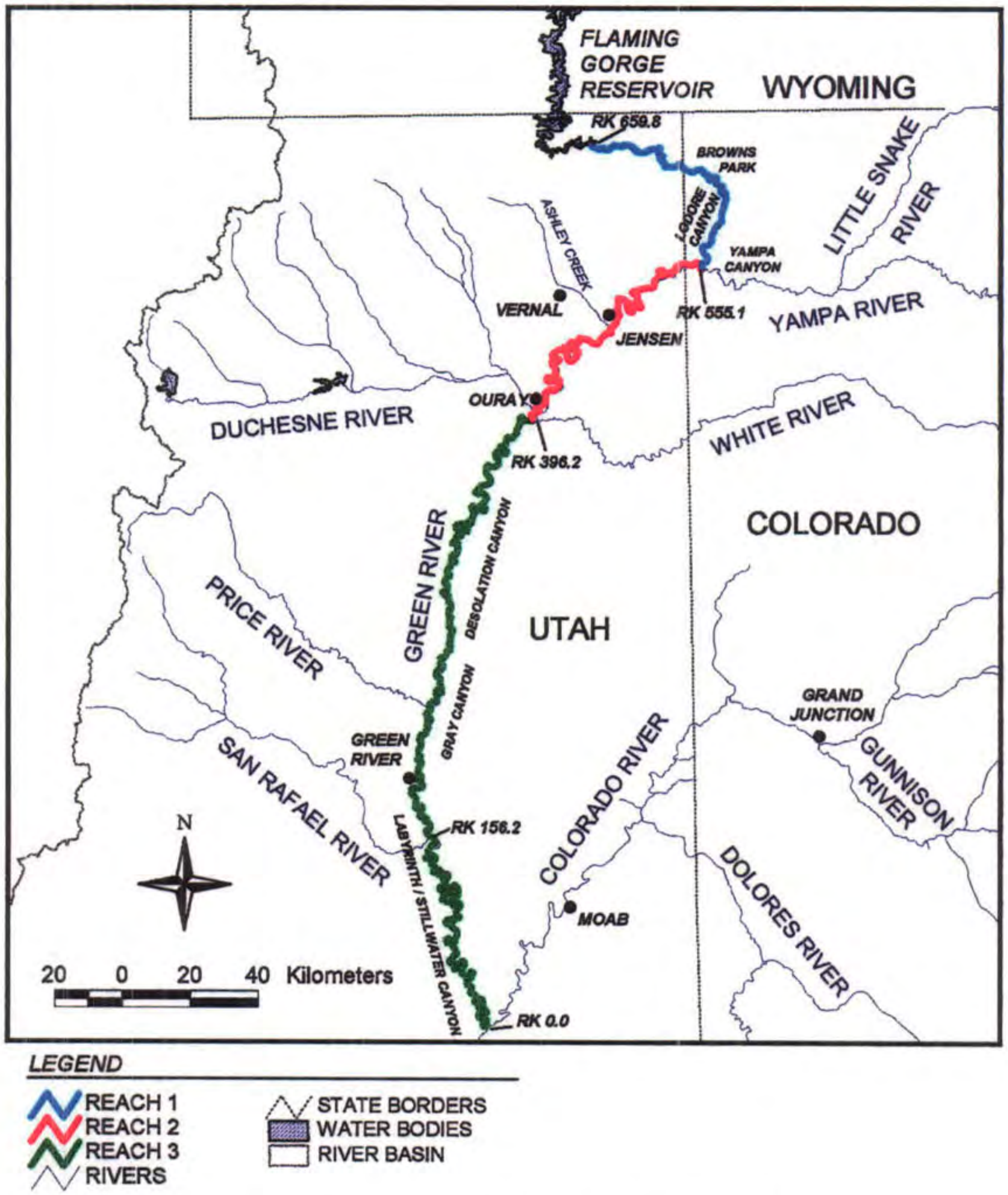

FIGURE 1 Map of the Green River Downstream of Flaming Gorge Dam (Source: Muth et al. 2000)

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Due to the fact that it was not feasible to cover every contingency in the flow recommendations, the authors of the flow recommendations recommended that real-time data and other available year-specific information would be factored into annual implementation of the proposed action. Yearly patterns of releases from Flaming Gorge Dam to meet the recommended flows and temperatures for each hydrologic condition could then be adjusted on the basis of information about hydrology, the status of endangered fish life stages and populations, and habitat conditions. Muth et al. (2000) recommended that Reclamation, Western, and the Service establish a technical working group of biologists and hydrologists to help refine release plans for each year and provide advice on modifying releases during changing hydrologic conditions.

Table 1 summarizes the recommended peak and base flows from Muth et al. (2000) for all three reaches of the Green River. Under the proposed action, Flaming Gorge Dam would be operated with the goal of achieving these recommended flows as often as possible while maintaining the other authorized purposes of Flaming Gorge Dam and Reservoir.

Operations under the Proposed Action

This section describes the process that Reclamation would use to implement the proposed action while maintaining other authorized purposes and assuring safe operations of Flaming Gorge Dam under normal operational conditions. Operational plans, however, may be altered temporarily to respond to emergencies. Safe operation of Flaming Gorge Dam is of paramount importance, and is applicable to all dam operations under the proposed action. In order to safely and efficiently operate Flaming Gorge Dam, forecasted future inflows must be incorporated into the decision making process. These forecasted future inflows are provided by the National Weather Service through the River Forecast Center and are issued as monthly or seasonal (April through July) volumes of unregulated inflow that are anticipated to occur during the forecast period. A forecast error is the volume difference between the forecasted and actual inflow volume for the period. Forecast errors mostly are attributable to hydrologic variability and to a much lesser degree the forecasting procedure. Consequently, forecast errors will always be a factor associated with the operation of Flaming Gorge Dam.

Analysis of the historic forecast errors at Flaming Gorge Dam was performed by the Colorado River Forecasting Service Technical Committee (CRFSTC) in April 1987. They determined the magnitude of 5% exceedance forecast errors associated with the various forecast products issued by the Colorado River Basin Forecast Center (CBRFC). These errors occur in one out of every 20 years on average and errors of greater magnitude occur less frequently. From the information provided by the CRFSTC, forecast errors at the 1% exceedance level (1 out of every 100 years) were computed.

Safe operation of Flaming Gorge Dam limits the risk of uncontrolled spills to 1% when the greatest foreseeable forecast error occurs. In other words, safe operation must assure that 99% of the foreseeable forecast errors can be successfully routed through Flaming Gorge Reservoir without uncontrolled spills occurring. To limit this risk, Reclamation maintains vacant storage

TABLE 1 Recommended Magnitudes and Duration of Maximum Spring Peak and Summer-to-Winter Base Flows and Temperatures for Endangered Fishes in the Green River Downstream From Flaming Gorge Dam as Identified in the 2000 Flow and Temperature Recommendations

Location	Flow and Temperature Characteristics	Hydrologic Conditions and 2000 Flow and Temperature Recommendations[a]				
		Wet (0–10% Exceedance)	Moderately Wet (10–30% Exceedance)	Average (30–70% Exceedance)	Moderately Dry (70–90% Exceedance)	Dry (90–100% Exceedance)
Reach 1 Flaming Gorge Dam to Yampa River	Maximum Spring Peak Flow	≥8,600 cfs (244 cubic meters per second [m3/s])	≥4,600 cfs (130 m3/s)	≥4,600 cfs (130 m3/s)	≥4,600 cfs (130 m3/s)	≥4,600 cfs (130 m3/s)
	Peak flow duration is dependent upon the amount of unregulated inflows into the Green River and the flows needed to achieve the recommended flows in Reaches 2 and 3.					
	Summer-to-Winter Base Flow	1,800–2,700 cfs (50–60 m^3/s)	1,500–2,600 cfs (42–72 m^3/s)	800–2,200 cfs (23–62 m^3/s)	800–1,300 cfs (23–37 m^3/s)	800–1,000 cfs (23–28 m^3/s)
Above Yampa River Confluence	Water Temperature Target	≥ 64 °F (18 °C) for 3-5 weeks from mid-August to March1	≥ 64 °F (18 °C) for 3-5 weeks from mid-August to March 1	≥ 64 °F (18 °C) for 3-5 weeks from mid-July to March 1	≥ 64 °F (18 °C) for 3-5 weeks from June to March 1	≥ 64 °F (18 °C) for 3-5 weeks from mid-June to March 1
Reach 2 Yampa River to White River	Maximum Spring Peak Flow	≥26,400 cfs (748 m^3/s)	≥20,300 cfs (575 m^3/s)	≥18,600 cfs[b] (527 m^3/s) ≥8,300 cfs[c] (235 m3/s)	≥8,300 cfs (235 m^3/s)	≥8,300 cfs (235 m^3/s)
	Peak Flow Duration	Flows greater than 22,700 cfs (643 m^3/s) should be maintained for 2 weeks or more, and flows 18,600 cfs (527 m^3/s) for 4 weeks or more.	Flows greater than 18,600 cfs (527 m^3/s) should be maintained for 2 weeks or more.	Flows greater than 18,600 cfs (527 m^3/s) should be maintained for at 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m^3/s) should be main-tained for 2 days or more except in extremely dry years (98% exceedance).
	Summer-to-Winter Base Flow	2,800–3,000 cfs (79–85 m^3/s)	2,400–2,800 cfs (69–79 m^3/s)	1,500–2,400 cfs (43–67 m^3/s)	1,100–1,500 cfs (31–43 m^3/s)	900–1,100 cfs (26–31 m^3/s)

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TABLE 1 (Cont.)

Location	Flow and Temperature Characteristics	Hydrologic Conditions and 2000 Flow and Temperature Recommendations[a] **Wet** (0–10% Exceedance)	**Moderately Wet** (10–30% Exceedance)	**Average** (30–70% Exceedance)	**Moderately Dry** (70–90% Exceedance)	**Dry** (90–100% Exceedance)
Below Yampa River Confluence	Water Temperature Target	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.
Reach 3 White River to Colorado River	Maximum Spring Peak Flow	≥39,000 cfs (1,104 m^3/s)	≥24,000 cfs (680 m^3/s)	≥22,000 cfs[d] (623 m^3/s)	≥8,300 cfs (235 m^3/s)	≥8,300 cfs (235 m^3/s)
	Peak Flow Duration	Flows greater than 24,000 cfs (680 m^3/s) should be maintained for 2 weeks or more, and flows 22,000 cfs (623 m^3/s) for 4 weeks or more.	Flows greater than 22,000 cfs (623 m^3/s) should be maintained for 2 weeks or more.	Flows greater than 22,000 cfs (623 m^3/s) should be maintained for 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for 2 days or more except in extremely dry years (98% exceedance).
	Summer-to-Winter Base Flow	3,200–4,700 cfs (92–133 m^3/s)	2,700–4,700 cfs (76–133 m^3/s)	1,800–4,200 cfs (52–119 m^3/s)	1,500–3,400 cfs (42–95 m^3/s)	1,300-2,600 cfs (32–72 m^3/s)

[a] Recommended flows as measured at the USGS gage located near Greendale, Utah, for Reach 1; Jensen, Utah, for Reach 2; and Green River, Utah, for Reach 3.
[b] Recommended flows ≥18,600 cfs (527 m^3/s) in 1 of 2 average years.
[c] Recommended flows ≥8,300 cfs (235 m^3/s) in other average years.
[d] Recommended flows ≥22,000 cfs (623 m^3/s) in 1 of 2 average years.

space in the reservoir at various times of the year to absorb the additional inflow volume if a forecast error occurs. Reservoir elevation is intentionally drawn down by Reclamation during the fall and winter months to accommodate additional inflow.

The upper limit draw-down levels for safe operation were determined through routing studies of forecast error scenarios. These scenarios were based on the 1% exceedance forecast errors. The scenario that had the largest risk of an uncontrolled spill was routed through the reservoir beginning in May with various reservoir elevations and various inflow volumes that were based on historic records. The highest elevations, where the largest risk scenario successfully routed the inflow volume through the reservoir without an uncontrolled spill, was established as the upper limit draw-down levels for that forecast volume.

Inter-agency coordination would be used to implement the flow and temperature recommendations of Muth et al. (2000). A technical working group representing Reclamation, Service, and Western, as well as other qualified individuals who choose to participate on a voluntary basis, would convene at various times throughout the year to discuss future operational plans and to refine these plans to best meet the needs of the endangered fish. Release patterns for all seasons would be discussed by this technical working group and recommendations would incorporate real time and year specific information identified in Table 5.3 of Muth et al. (2000). These meetings would also provide an opportunity to discuss historic operations in terms of the accomplishments and short comings of meeting the flow and temperature recommendations. Reclamation would maintain an administrative record of these meetings to document the planning process.

Operations in May through July (Spring Period)

Under the proposed action, Reclamation would establish the hydrologic classification for the spring period (May through July) based on the forecasted unregulated inflow to Flaming Gorge Reservoir for the April through July period. This forecast is issued by the River Forecast Center beginning in early January and is updated twice per month until the end of July. Reclamation would classify the hydrology of the Green River system into one of the five hydrologic classifications described above (wet, moderately wet, average, moderately dry, and dry).

The hydrologic classification would be used to establish the range of flow magnitudes and durations that could be targeted for the approaching spring release period. These targets would be incorporated into a spring operations plan. This plan would be prepared each year by Reclamation in coordination with the technical working group prior to the spring Flaming Gorge Working Group meeting. Various year-specific factors listed in Table 5.3 of Muth et al. (2000) along with the established hydrologic classification would be considered in the development of the operations plan.

It is expected that in most years, the flow magnitudes and durations achieved in Reach 2 each spring would be consistent with the flow magnitudes and durations described in Muth et al. (2000) for the hydrologic classification established in May of each year. However, because factors listed in Muth et al. (2000) are also considered, particularly runoff conditions in the Yampa River, there would be some years where the peak flows that occur in Reach 2 achieve the targets for either one or two classifications higher (wetter) or one classification lower (drier) than the actual classification established for the Green River. It is anticipated that in some years, when the hydrologic classification for the Green River is average, that conditions would be such that it would be possible to achieve the targets established for either the moderately wet or wet classifications. Conversely, there would be some years classified as moderately wet when the conditions would be such that targets established for the average classification would be met. There could also be years classified as wet where moderately wet targets would be achieved because of year-specific conditions. It would be Reclamation's responsibility in coordination with the technical working group to assure that over the long term, Flaming Gorge Dam operations are consistent with the Muth et al. (2000) flow and temperature recommendations.

The operations plan would describe the current hydrologic classification of the Green River subbasin and the hydrologic conditions in the Yampa River Basin, including the most probable runoff patterns for the two basins. The operations plan would also identify the most likely Reach 2 flow magnitudes and durations that would be targeted for the upcoming spring release. Because hydrologic conditions often change during the April through July runoff period, the operations plan would contain a range of operating strategies that could be implemented under varying hydrologic conditions. Flow and duration targets for these alternate operating strategies would be limited to those described for one classification lower or two classifications higher than the classification for the current year.

In years classified as wet, bypass releases would usually be required for both safe operation of the dam and to meet the flow recommendations. In some years classified as wet, spillway releases would be necessary for safe operation of the dam. Releases above powerplant capacity in these wet years would be expected to be made for a period of about 4 to 9 weeks. The exact magnitude of the release and duration of the release would depend upon the year-specific conditions of factors listed in Table 5.3 of Muth et al. (2000) as well as the carryover storage from the previous year. Wet year high releases would be expected to occur from mid-May to early July (and in very wet years through July). The bypass and spillway releases, required for safe operation of the dam in wet years, would be timed with the objective to meet Reach 2 wet or moderately wet year targets depending upon the hydrologic conditions in the Yampa River. The initiation of bypass and spillway releases would take place in mid to late May coincident with the Yampa River peak. In extremely wet years, releases above powerplant capacity could be initiated in April or early-May before the Yampa River peak.

In years classified as moderately wet, bypass releases would usually (but not always) be required for safe operation of the dam. Occasionally, some use of the spillway might also be required in moderately wet years for safe operation of the dam. Bypass volume in moderately wet years would be less than in wet years and would generally occur for a period of about 1 to 7 weeks. The timing of these releases would be from mid May to June and could sometimes extend into July. Releases from Flaming Gorge Reservoir in moderately wet years would be timed with the objective of meeting Reach 2 wet, moderately wet, or average year targets depending upon the hydrologic conditions in the Yampa River basin and other factors.

In years classified as average, bypass releases would not likely be required for safe operation of the dam, but would periodically be needed to meet the objectives of the flow and temperature recommendations of Muth et al. (2000). In most average years, spring peak releases would be limited to power-plant capacity (about 130 m^3/s [4,600 cfs]) with peak releases taking place for about one to eight weeks usually in mid-May to late-June (but occasionally extending into July). In about one out of three average years, bypass releases from Flaming Gorge Dam might be required to achieve the Reach 2 flow recommendation peak and duration targets. In these years, the objective would be to achieve targeted flows in Reach 2 of 527 m^3/s (18,600 cfs) for two weeks. To conserve water, bypass releases in these average years would be made only to the extent necessary to achieve this target. It can be expected that bypass releases, when required to meet flow recommendations in average years would be implemented for a period of less than two weeks. In some years classified as average, the targets that would be achieved during the spring would be moderately wet or wet targets as a result of Yampa River flows.

The objective in dry and moderately dry years would be to conserve reservoir storage while meeting the recommended peak flow targets in Reach 2. The bypass tubes and the spillway would not be used to meet flow targets in moderately dry and dry years but on rare occasion might be needed to supplement flows that cannot be released through the power plant because of maintenance requirements. In dry years, a peak release (power-plant capacity or less) of one day to one week would occur during the spring and this release would be timed with the peak of the Yampa River. In moderately dry years, a one to two week power-plant capacity release would occur during the spring and would be timed with the peak and post peak of the Yampa River.

After the spring flow objectives have been achieved, Reclamation would establish a release regime within powerplant capacity that gradually decreases the release rate limited to the down ramp rates described in Muth et al. (2000) until the beginning of the base flow period which begins some time between mid-June and mid-August, depending on the hydrologic classification set during the spring.

The bypass tubes and the spillway at Flaming Gorge Dam have been utilized historically, as needed, for safe operation of the dam. In years with high inflow, bypass releases, and sometimes spillway releases, may be required under the proposed action to meet the flow and temperature recommendations. Bypass and spillway releases, required for safe operation of the dam and to meet the flow and temperature recommendations, would be scheduled coincident with Yampa River peak and post peak flow (the mid-May to mid-June time period) with the objective of meeting flow recommendation targets in Reach 2. There would be some years (moderately wet years and average years) where use of the bypass would not be required for safe operation but would be needed to meet the flow recommendations. As part of the annual planning process discussed above, Reclamation would consult with the Service and Western and coordinate with the technical working group and make a determination whether bypasses should be attempted to achieve the targeted Reach 2 magnitudes and durations.

Cavitation resulting from use of the spillway has been shown to cause excessive erosion in concrete spillway structures at other Reclamation dams. In 1984, the spillway at Flaming Gorge Dam was retrofitted with air slots that have been tested and deemed successful in reducing cavitation. However, should damage to the spillway become excessive as a result of increased use repairs would be made and use of the spillway could be limited to levels that do not cause damage or to only times when hydrologically necessary.

Operations in August through February (Base-Flow Period)

Under the proposed action, Reclamation would classify the hydrology of the Green River during the base-flow period into one of the five hydrologic classifications (wet, moderately wet, average, moderately dry, and dry). For the month of August, the hydrologic classification would be based on the percentage exceedance of the volume of unregulated inflow into Flaming Gorge Reservoir during the spring period. For the months of September through February, the percentage exceedance would be based on the previous month's volume of unregulated inflow into Flaming Gorge Reservoir. If the unregulated inflow during the previous month is such that the percentage exceedance falls into a different classification than the classification assigned for the previous month, then the hydrologic classification for the current month could be shifted by one classification to reflect the change in hydrology. This shift would only be made when the reservoir condition indicates that the shift would be necessary to achieve the March 1 drawdown level of 1,837 m (6,027 ft) above sea level. Otherwise the hydrologic classification for the current month would remain the same as for the previous month.

The range of acceptable base flows for Reach 2 would be selected from the flow and temperature recommendations for the hydrologic classification set for the current month. Reclamation would make releases to achieve flows in Reach 2 that are within the acceptable range that also assure that the reservoir elevation on March 1 would be no higher than 1,837 m (6,027 ft) above sea level.

The flow and temperature recommendations for the base-flow period allow for some operational flexibility, and the proposed action accommodates this flexibility. Under the proposed action, the flows that would occur in Reach 2 during the base-flow period would be allowed to vary from the targeted flow by $\pm$ 40% from August through November and by $\pm$ 25% from December through February as long as the day to day change is limited to 3% of the average daily flow and the variation is consistent with all other applicable flow and temperature recommendations. Reclamation would utilize the allowed flexibility to the extent possible, to efficiently manage the authorized resources of Flaming Gorge Dam. Flaming Gorge Dam would be operated through the base-flow period so that the water surface elevation would not be greater than 1,837 m (6,027 ft) above sea level on March 1.

During the base-flow period, hourly release patterns from Flaming Gorge Dam would be patterned so that they produce no more than a 0.1-m (0.3-ft) stage change each day at the Jensen gage.

Operations in March and April (Transition Period)

Muth et al. (2000) make no specific flow recommendations for the period from March 1 through the initiation of the spring peak release (typically this occurs in mid to late May). For the proposed action, releases during this transition period would be made to manage the reservoir elevation to an appropriate drawdown level based on the forecasted unregulated inflow into Flaming Gorge Reservoir for the April through July period. Appropriate drawdown levels under normal operations during the transition period are those that would allow for safe operation of the dam through the spring.

Implied in the drawdown levels is the assumption that upstream regulation above Flaming Gorge Reservoir remains relatively consistent with historic regulation. In the event that less storage space would be available above Flaming Gorge Reservoir during the spring, these drawdown levels may have to be lower than those specified for safe operation of Flaming Gorge Dam. In extremely wet years, the drawdown level for May 1 could be lower than what is specified to maintain safe operation of the dam.

Reclamation would determine the appropriate reservoir drawdown based on the percentage exceedance of the forecasted volume of unregulated inflow into Flaming Gorge Reservoir between April and July. The forecast is issued two times each month during March and April. Under normal operations during the transition period, releases would be between 23 m^3/s (800 cfs) and power-plant capacity (130 m^3/s [4,600 cfs]).

Releases during the transition period would be patterned to be consistent with the release patterns of the preceding base-flow period. Muth et al. (2000) do not make recommendations for hourly fluctuation patterns during the transition period. However, Reclamation would maintain the fluctuation pattern limitations of the base flow period to provide operational consistency as has been done historically.

Use of Adaptive Management in Implementing the Proposed Action

This biological opinion and the Operation of Flaming Gorge Draft EIS present a number of uncertainties regarding the endangered fish associated with implementing the proposed action. These uncertainties would be addressed by integrating an adaptive management process into the current framework of dam operations, while maintaining the authorized purposes of the Flaming Gorge Unit of the CRSP. This would involve using research and monitoring to test the outcomes of implementing the proposed action and employing the knowledge gained to further refine operations as required. It is expected that any refinements in operation of Flaming Gorge Dam would be within the scope of the current proposed action and that implementation of refinements would occur with appropriate Section 7 consultation (formal or informal). Research and monitoring studies would be conducted within the framework of the ongoing Recovery Program with regard to native fish, undesirable nonnative fish, and related habitat issues. These studies may involve research or test flow releases from Flaming Gorge Dam. As participants in the Recovery Program, Reclamation, Western and the Service would be involved in the identification, discussion, implementation and approval of new tasks within the Recovery Program to address refinement of flows below Flaming Gorge Dam.

Uncertainties about riparian vegetation and geomorphic surfaces, particularly as they may affect Ute ladies'-tresses will be addressed through a monitoring plan developed by Reclamation, Western, Service, NPS, and other knowledgeable scientists. Recommendations for actions to assist riparian vegetation health and Ute ladies'-tresses conservation developed as a result of the monitoring efforts will be will be coordinated by the Service and forwarded to Reclamation or other entities as appropriate. Any requests for flows to benefit Utes'-ladies tresses would be reconciled by the Service with flow needs for other endangered species.

Conservation Measures

Conservation measures are actions that the action agency agrees to implement to further the recovery of the species under review. Section 4.21 of the draft EIS for Operation of Flaming Gorge Dam specifies ten environmental commitments related to implementation of the proposed action. Several of those commitments are reiterated here in order to clarify operations under the proposed action:

- The Flaming Gorge Working Group, an informal stakeholder group, which meets two times per year, would continue to function as a means of providing information to and gathering input from stakeholders and interested parties on dam operations, as described in Section 1.5 of the draft EIS.

- The adaptive management process will rely on the Recovery Program for monitoring and research studies to test the outcomes of implementing the proposed action and proposing refinements to dam operations.

- Reclamation agrees to develop a process for operating the selective withdrawal structure consistent with the objectives of improving temperature conditions for the endangered native fish. Such a process would include identification of lines of communication for planning and making changes to selective withdrawal release levels, coordination with other agencies, recognition of equipment limitations that may affect the ability to release warmer water, and the costs and equipment impacts associated with operating at higher temperatures.

- Reclamation, in coordination with the Service, National Park Service, and other knowledgeable scientists, agrees to develop and implement a monitoring plan for Ute ladies'-tresses populations for determination of possible effects from the proposed action. Possible effects to be monitored include response to any habitat changes (such as geomorphic, hydrologic, and vegetation) associated with the proposed action.

- Reclamation will establish the Technical Working Group, as detailed in Section 2.5.3 of the draft EIS, consisting of biologists and hydrologists involved with endangered fish recovery issues. The Technical Working Group would meet at various times throughout the year to comment and provide input on endangered fish needs and implementation of the flow recommendations.

- Implementation of the proposed action will include development of an administrative record and annual report to document annual operations and the information used to develop those operations. Over time, it is expected that these data will be of benefit in correlating and analyzing conditions for the endangered fish species and their habitat downstream from Flaming Gorge Dam.

Monitoring and research to evaluate the effects of modified flows and temperatures will be conducted through the Recovery Program, and include (1) investigations to determine the effects of increased spillway releases and the concomitant release of fishes from the reservoir on the downstream fish community; (2) an evaluation of the effects of increased release temperatures on the downstream fish community, and (3) an evaluation of increased floodplain inundation in Reach 2 on the fish community. Reclamation, Western and the Service will use any new information collected in these studies and other studies to determine the need for management actions or modification of operations as determined appropriate.

STATUS OF THE SPECIES AND CRITICAL HABITAT

Colorado Pikeminnow

Species/Critical Habitat Description

The Colorado pikeminnow is the largest cyprinid fish (minnow family) native to North America and evolved as the main predator in the Colorado River system. It is an elongated pike-like fish that during predevelopment times may have grown as large as 6 feet in length and weighed nearly 100 pounds (Behnke and Benson 1983). Today, Colorado pikeminnow rarely exceed 3 feet in length or weigh more than 18 pounds; such fish are estimated to be 45-55 years old (Osmundson et al. 1997). The mouth of this species is large and nearly horizontal with long slender pharyngeal teeth (located in the throat), adapted for grasping and holding prey. The diet of Colorado pikeminnow longer than 3 or 4 inches consists almost entirely of other fishes (Vanicek and Kramer 1969). Males become sexually mature earlier and at a smaller size than do females, though all are mature by about age 7 and 500 mm (20 inches) in length (Vanicek and Kramer 1969, Seethaler 1978, Hamman 1981). Adults are strongly countershaded with a dark, olive back, and a white belly. Young are silvery and usually have a dark, wedge-shaped spot at the base of the caudal fin.

Critical habitat was designated for Colorado pikeminnow on March 21, 1994 (59 FR 13374). Designated critical habitat makes up about 29% of the species' original range and occurs exclusively in the Upper Colorado River Basin. River reaches (including the 100-year floodplain) that mak up critical habitat for Colorado pikeminnow in the Green River system include the Yampa River from Craig, Colorado, downstream to the Green River; Green River downstream of the Yampa River to the confluence with the Colorado River; and White River from Rio Blanco Reservoir downstream to the Green River.

Colorado: Moffat County. The Yampa River and its 100-year floodplain from the State Highway 394 bridge in T. 6 N., R. 91 W., section 1 (6^{th} Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).

Utah: Uintah, Carbon, Grand, Emery, Wayne and San Juan Counties; and Colorado: Moffat County. The Green River and its 100 year floodplain from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6^{th} Principal Meridian) to the confluence with the Colorado River in T. 30 S., R. 19 E., section 7 (Salt Lake Meridian).

Colorado: Rio Blanco County and Utah: Uintah County. The White River and its 100-year floodplain from Rio Blanco Lake Dam in T.1N., R96W., section 6 (6th Principal Meridian) to the confluence with the Green River in T.9S., R20E., section 4 (Salt Lake Meridian).

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of critical habitat (59 FR 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment.

Status and Distribution

Based on early fish collection records, archaeological finds, and other observations, the Colorado pikeminnow was once found throughout warmwater reaches of the entire Colorado River Basin down to the Gulf of California, and including reaches of the upper Colorado River and its major tributaries, the Green River and its major tributaries, and the Gila River system in Arizona (Seethaler 1978). Colorado pikeminnow apparently were never found in colder, headwater areas. The species was abundant in suitable habitat throughout the entire Colorado River Basin prior to the 1850s (Seethaler 1978). By the 1970s they were extirpated from the entire lower basin (downstream of Glen Canyon Dam) and portions of the upper basin as a result of major alterations to the riverine environment. Having lost some 75 to 80 percent of its former range due to habitat loss, the Colorado pikeminnow was federally listed as an endangered species in 1967 (Miller 1961, Moyle 1976, Tyus 1991, Osmundson and Burnham 1998). Full protection under the Act of 1973 occurred on January 4, 1974.

Colorado pikeminnow are presently restricted to the Upper Colorado River Basin and inhabit warmwater reaches of the Colorado, Green, and San Juan rivers and associated tributaries. The Colorado pikeminnow recovery goals (USFWS 2002a) identify occupied habitat of wild Colorado pikeminnow as follows: the Green River from Lodore Canyon to the confluence of the Colorado River; the Yampa River downstream of Craig, Colorado; the Little Snake River from its confluence with the Yampa River upstream into Wyoming; the White River downstream of Taylor Draw Dam; the lower 89 miles of the Price River; the lower Duchesne River; the upper Colorado River from Palisade, Colorado, to Lake Powell; the lower 34 miles of the Gunnison River; the lower mile of the Dolores River; and 150 miles of the San Juan River downstream from Shiprock, New Mexico, to Lake Powell.

Recovery goals for the Colorado pikeminnow (USFWS 2002a) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- a genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult (age 7+; > 450 mm total length) point estimates for the middle Green River and the lower Green River do not decline significantly, and (b) mean estimated recruitment of age-6 (400–449 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds 2,600 adults (2,600 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- a self-sustaining population of at least 700 adults (number based on inferences about carrying capacity) is maintained in the upper Colorado River subbasin such that (a) the trend in adult point estimates does not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality; and

- a target number of 1,000 age-5+ fish (> 300 mm total length; number based on estimated survival of stocked fish and inferences about carrying capacity) is established through augmentation and/or natural reproduction in the San Juan River subbasin; and

- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 7-year period beyond downlisting:

- a genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult point estimates for the middle Green River and the lower Green River do not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds 2,600 adults; and

- either the upper Colorado River subbasin self-sustaining population exceeds 1,000 adults or the upper Colorado River subbasin self-sustaining population exceeds 700 adults and San Juan River subbasin population is self-sustaining and exceeds 800 adults (numbers based on inferences about carrying capacity) such that for each population (a) the trend in adult point estimates does not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality; and

- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

The Colorado pikeminnow is a long-distance migrator; adults move hundreds of miles to and from spawning areas, and require long sections of river with unimpeded passage. Adults require pools, deep runs, and eddy habitats maintained by high spring flows. These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats. Spawning occurs after spring runoff at water temperatures typically between 18 and 23 °C. After hatching and emerging from spawning substrate, larvae drift downstream to nursery backwaters that are restructured by high spring flows and maintained by relatively stable base flows. Flow recommendations have been developed that specifically consider flow-habitat relationships in habitats occupied by Colorado pikeminnow in the upper basin, and were designed to enhance habitat complexity and to restore and maintain ecological processes. The following is a description of observed habitat uses in the Upper Colorado River Basin.

Colorado pikeminnow live in warm-water reaches of the Colorado River mainstem and larger tributaries, and require uninterrupted stream passage for spawning migrations and dispersal of young. The species is adapted to a hydrologic cycle characterized by large spring peaks of snow-melt runoff and low, relatively stable base flows. High spring flows create and maintain in-channel habitats, and reconnect floodplain and riverine habitats, a phenomenon described as the spring flood-pulse (Junk et al. 1989; Johnson et al. 1995). Throughout most of the year, juvenile, subadult, and adult Colorado pikeminnow use relatively deep, low-velocity eddies, pools, and runs that occur in nearshore areas of main river channels (Tyus and McAda 1984; Valdez and Masslich 1989; Tyus 1990, 1991; Osmundson et al. 1995). In spring, however, Colorado pikeminnow adults use floodplain habitats, flooded tributary mouths, flooded side canyons, and eddies that are available only during high flows (Tyus 1990, 1991; Osmundson et al. 1995). Such environments may be particularly beneficial for Colorado pikeminnow because other riverine fishes gather in floodplain habitats to exploit food and temperature resources, and may serve as prey. Such low-velocity environments also may serve as resting areas for Colorado pikeminnow. River reaches of high habitat complexity appear to be preferred.

Because of their mobility and environmental tolerances, adult Colorado pikeminnow are more widely distributed than other life stages. Distribution patterns of adults are stable during most of the year (Tyus 1990, 1991; Irving and Modde 2000), but distribution of adults changes in late spring and early summer, when most mature fish migrate to spawning areas (Tyus and McAda 1984; Tyus 1985, 1990, 1991; Irving and Modde 2000). High spring flows provide an important cue to prepare adults for migration and also ensure that conditions at spawning areas are suitable for reproduction once adults arrive. Specifically, bankfull or much larger floods mobilize coarse sediment to build or reshape cobble bars, and they create side channels that Colorado pikeminnow sometimes use for spawning (Harvey et al. 1993).

Colorado pikeminnow spawning sites in the Green River subbasin have been well documented. The two principal locations are in Yampa Canyon on the lower Yampa River and in Gray Canyon on the lower Green River (Tyus 1990, 1991). These reaches are 42 and 72 km long, respectively, but most spawning is believed to occur at one or two short segments within each of the two reaches. Another spawning area may occur in Desolation Canyon on the lower Green

River (Irving and Modde 2000), but the location and importance of this area has not been verified. Although direct observation of Colorado pikeminnow spawning was not possible because of high turbidity, radiotelemetry indicated spawning occurred over cobble-bottomed riffles (Tyus 1990). High spring flows and subsequent post-peak summer flows are important for construction and maintenance of spawning substrates (Harvey et al. 1993). In contrast with the Green River subbasin, where known spawning sites are in canyon-bound reaches, currently suspected spawning sites in the upper Colorado River subbasin are at six locations in meandering, alluvial reaches (McAda 2000).

After hatching and emerging from the spawning substrate, Colorado pikeminnow larvae drift downstream to backwaters in sandy, alluvial regions, where they remain through most of their first year of life (Holden 1977; Tyus and Haines 1991; Muth and Snyder 1995). Backwaters and the physical factors that create them are vital to successful recruitment of early life stages of Colorado pikeminnow, and age-0 Colorado pikeminnow in backwaters have received much research attention (e.g., Tyus and Karp 1989; Haines and Tyus 1990; Tyus 1991; Tyus and Haines 1991; Bestgen et al. 1997). It is important to note that these backwaters are formed after cessation of spring runoff within the active channel and are not floodplain features. Colorado pikeminnow larvae occupy these in-channel backwaters soon after hatching. They tend to occur in backwaters that are large, warm, deep (average, about 0.3 m in the Green River), and turbid (Tyus and Haines 1991). Recent research (Day et al. 1999a, 1999b; Trammell and Chart 1999) has confirmed these preferences and suggested that a particular type of backwater is preferred by Colorado pikeminnow larvae and juveniles. Such backwaters are created when a secondary channel is cut off at the upper end, but remains connected to the river at the downstream end. These chute channels are deep and may persist even when discharge levels change dramatically. An optimal river-reach environment for growth and survival of early life stages of Colorado pikeminnow has warm, relatively stable backwaters, warm river channels, and abundant food (Muth et al. 2000).

Threats to the Species

Major declines in Colorado pikeminnow populations occurred during the dam-building era of the 1930s through the 1960s. Behnke and Benson (1983) summarized the decline of the natural ecosystem, pointing out that dams, impoundments, and water use practices drastically modified the river's natural hydrology and channel characteristics throughout the Colorado River Basin. Dams on the mainstem broke the natural continuum of the river ecosystem into a series of disjunct segments, blocking native fish migrations, reducing temperatures downstream of dams, creating lacustrine habitat, and providing conditions that allowed competitive and predatory nonnative fishes to thrive both within the impounded reservoirs and in the modified river segments that connect them. The highly modified flow regime in the lower basin coupled with the introduction of nonnative fishes decimated populations of native fish.

The primary threats to Colorado pikeminnow are stream flow regulation and habitat modification; competition with and predation by nonnative fishes; and pesticides and pollutants (USFWS 2002a). The existing habitat, altered by these threats, has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering. These impairments are described in further detail below.

Stream flow regulation includes mainstem dams that cause the following adverse effects to Colorado pikeminnow and its habitat:

- block migration corridors,
- changes in flow patterns, reduced peak flows and increased base flows,
- release cold water, making temperature regimes less than optimal,
- change river habitat into lake habitat, and
- retain sediment that is important for forming and maintaining backwater habitats

In the Upper Basin, 435 miles of Colorado pikeminnow habitat has been lost by reservoir inundation from Flaming Forge Reservoir on the Green River, Lake Powell on the Colorado River, and Navajo Reservoir on the San Juan River. Cold water releases from these dams have eliminated suitable habitat for native fishes, including Colorado pikeminnow, from river reaches downstream for approximately 50 miles below Flaming Gorge Dam and Navajo Dam. In addition to main stem dams, many dams and water diversion structures occur in and upstream from critical habitat that reduce flows and alter flow patterns, which adversely affect critical habitat. Diversion structures in critical habitat divert fish into canals and pipes where the fish are permanently lost to the river system. It is unknown how many endangered fish are lost in irrigation systems, but in some years, in some river reaches, majority of the river flow is diverted into unscreened canals. High spring flows maintain habitat diversity, flush sediments from spawning habitat, increase invertebrate food production, form gravel and cobble deposits important for spawning, and maintain backwater nursery habitats (McAda 2000; Muth et al. 2000). Peak spring flows in the Green River at Jensen, Utah, have decreased 13–35 percent and base flows have increased 10–140 percent due to regulation by Flaming Gorge Dam (Muth et al. 2000).

To summarize the threat of streamflow regulation to critical habitat, we first consider the direct effects on two of the primary constituent elements: water and physical habitat. The quantity of water of sufficient quality has been reduced during critical periods of the year; most notably during the spring runoff period when high seasonal flows serve to connect floodplain habitats, shape in-channel habitats, and provide important behavioral cues to spawning adult fish. Stream flow regulation affects the quality of water in several ways: a). colder than normal, hypolimnetic releases from main channel impoundments render historically occupied reaches unsuitable for native fish; b). elevated baseflows can result in reduced temperature and changes in the distribution and abundance of shoreline nursery habitats for endangered fish. Stream flow regulation also indirectly affects the third constituent element: the biological environment. A reduction in the magnitude and durations of the spring peak limits floodplain inundation. Floodplain inundation provides a critical seasonal source of nutrients / food items for fish in a big river ecosystem.

Predation and competition from nonnative fishes have been clearly implicated in the population reductions or elimination of native fishes in the Colorado River Basin (Dill 1944, Osmundson and Kaeding 1989, Behnke 1980, Joseph et al. 1977, Lanigan and Berry 1979, Minckley and Deacon 1968, Meffe 1985, Propst and Bestgen 1991, Rinne 1991). Data collected by

Osmundson and Kaeding (1991) indicated that during low water years nonnative minnows capable of preying on or competing with larval endangered fishes greatly increased in numbers. More than 50 nonnative fish species were intentionally introduced in the Colorado River Basin prior to 1980 for sportfishing, forage fish, biological control and ornamental purposes (Minckley 1982, Tyus et al. 1982, Carlson and Muth 1989). Nonnative fishes compete with native fishes in several ways. The capacity of a particular area to support aquatic life is limited by physical habitat conditions. Increasing the number of species in an area usually results in a smaller population of most species. The size of each species population is controlled by the ability of each life stage to compete for space and food resources and to avoid predation. Some life stages of nonnative fishes appear to have a greater ability to compete for space and food and to avoid predation in the existing altered habitat than do some life stages of native fishes. Tyus and Saunders (1996) cite numerous examples of both indirect and direct evidence of predation on razorback sucker eggs and larvae by nonnative species. Introductions of nonnative species affect critical habitat by degrading one of its primary constituent elements; the biological environment. Predation and competition, although considered a normal component of the Colorado River ecosystem, are out of balance due to introduced nonnative fish species.

Threats from pesticides and pollutants include accidental spills of petroleum products and hazardous materials; discharge of pollutants from uranium mill tailings; and high selenium concentration in the water and food chain (USFWS 2002a). Accidental spills of hazardous material into critical habitat, particularly when considering water of sufficient quality as a primary constituent element, can cause immediate mortality when lethal toxicity levels are exceeded. Pollutants from uranium mill tailings cause high levels of ammonia that exceed water quality standards. High selenium levels may adversely affect reproduction and recruitment (Hamilton and Wiedmeyer 1990; Stephens et al. 1992; Hamilton and Waddell 1994; Hamilton et al. 1996; Stephens and Waddell 1998; Osmundson et al. 2000).

Management actions identified in the recovery goals for Colorado pikeminnow (USFWS 2002a) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations;
- provide passage over barriers within occupied habitat to allow adequate movement and, potentially, range expansion;
- investigate options for providing appropriate water temperatures in the Gunnison River;
- minimize entrainment of subadults and adults in diversion canals;
- ensure adequate protection from overutilization;
- ensure adequate protection from diseases and parasites;
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries;
- control problematic nonnative fishes as needed;
- minimize the risk of hazardous-materials spills in critical habitat; and
- remediate water-quality problems.

Status of Colorado pikeminnow and Critical Habitat in the Action Area

Preliminary population estimates presented in the Recovery Goals (USFWS 2002a) for the three Colorado pikeminnow populations (Green River Subbasin, Upper Colorado River Subbasin, San Juan River Subbasin) ranged from 6,600 to 8,900 wild adults. These numbers provided a general indication of the total wild adult population size at the time the Recovery Goals were developed, however, it was also recognized that the accuracy of the estimates vary among populations.

Monitoring of Colorado pikeminnow populations is ongoing, and sampling protocols and the reliability of the population estimates are being assessed by the Service and cooperating entities. A recent draft report on the status of Colorado pikeminnow in the Green River subbasin (Bestgen et al. 2004) presented population estimates for adult (>450 mm total length (TL)) and recruit-sized (400–449 mm TL) Colorado pikeminnow. The Service recognizes that at this time, the report is draft and the analysis of the data is preliminary, however, the Service finds this is the best scientific information available regarding current population status in the Green River subbasin. The draft report suggests that over the study period (2001 to 2003) there was a decline in abundance of Colorado pikeminnow in the Green River subbasin from 3,338 (95 percent confidence interval, 2815 to 3861) animals in 2001 to 2,324 (95 percent confidence interval 1395 to 3252) animals in 2003. In the Yampa River estimates of adult abundance declined from 322 animals in 2000 to 250 animals in 2003. Adult abundance estimates in the White River declined from 1,115 animals in 2000 to 465 animals in 2003 and recruit-sized estimates declined from 44 animals in 2000 to zero in 2003. In the middle Green River (Yampa River confluence to Desolation Canyon) abundance estimates for adults ranged from 1,629 animals in 2000 to 747 animals in 2003 and estimates of abundance of recruit-sized fish ranged from 103 animals in 2000 to 50 animals in 2003. Estimates for the Desolation-Gray Canyon reach of the Green River ranged from 681 adults in 2001 to 585 adults in 2003 and recruit-sized estimates ranged from 162 animals in 2001 to 64 animals in 2003. In the lower Green River (Green River, Utah to the confluence of the Colorado River) abundance estimates were 366 adults in 2001 and 273 adults in 2003 and recruit-sized estimates ranged from 70 in 2001 to 104 in 2003. Studies indicate that significant recruitment of Colorado pikeminnow may not occur every year, but occurs in episodic intervals of several years (Osmundson and Burnham 1998).

All life stages of Colorado pikeminnow in the Green River demonstrate wide variations in abundance at seasonal, annual, or longer time scales, but reasons for shifts in abundance are poorly understood. Bestgen et al. (1998) captured drifting larvae produced from the two main spawning areas in the Green River system and found order-of-magnitude differences in abundance from year to year. They reported that low- or high-discharge years were often associated with poor reproduction but could not ascribe a specific cause-effect mechanism (Bestgen et al. 1998). In general, similar numbers of age-0 fish were found in autumn in the middle Green River, in spite of different-sized cohorts of larvae produced each summer in the Yampa River. Conversely, numbers of Colorado pikeminnow larvae produced in the lower Green River were similar among years but resulted in variable age-0 fish abundance in autumn.

In the Green River subbasin, radio-telemetry studies have shown that distribution of adults changes in late spring and early summer when most mature fish migrate to spawning areas in the lower Yampa River in Yampa Canyon and the lower Green River in Gray Canyon (Tyus and

McAda 1984; Tyus 1985; Tyus 1990; Tyus 1991; Irving and Modde 2000). Those fish remain in spawning areas for 3–8 weeks before returning to home ranges. Because adult Colorado pikeminnow converge on spawning areas from throughout the Green River system to reproduce at these two known localities, migration cues are an important part of the reproductive life history. In general, adults begin migrating in late spring or early summer. Migrations began earlier in low-flow years and later in high-flow years (Tyus and Karp 1989; Tyus 1990; Irving and Modde 2000). Migrations to the Yampa River spawning area occur coincident with, and up to 4 weeks after, peak spring runoff when water temperatures are usually 14–16 °C (Tyus 1990; Irving and Modde 2000). Rates of movement for individuals are not precisely known, but 2 individuals made the approximately 400 km migration from the White River below Taylor Draw Dam to the Yampa River spawning area in less than 2 weeks. Alteration of the natural hydrograph may alter the environmental cues triggering these spawning migrations.

High magnitude flows of infrequent occurrence are necessary to create and maintain spawning habitat. Infrequent intense flooding redistributes and creates spawning bars (O'Brien 1984). Annual lower-level flooding followed by recessional flows dissect and secondarily redistribute gravels, preparing them for spawning (Harvey et al. 1993). These studies conducted at a known spawning location in Yampa Canyon show that both processes are important for habitat maintenance and activities that reduce or re-time the annual peak or reduce the frequency of high magnitude flows are likely to reduce essential spawning habitat in amount and quality.

Similar to adults, distribution of early life stages of Colorado pikeminnow is dynamic on a seasonal basis and linked to habitat in the mainstem Green River downstream of spawning areas. After hatching and emergence from spawning substrate, larvae are dispersed downstream. A larva may drift for only a few days, but larvae occur in main channels of the Yampa and Green rivers for 3–8 weeks depending on length of the annual reproductive period (Nesler et al. 1988; Tyus and Haines 1991; Bestgen et al. 1998). The Yampa River spawning area consistently produces more larvae than the spawning area in the lower Green River (Bestgen et al. 1998).

Currently, two primary reaches of Colorado pikeminnow nursery habitat are present in the Green River system. The upper one occurs from near Jensen, Utah, downstream to the Duchesne River confluence. The lower one occurs from near Green River, Utah, downstream to the Colorado River confluence (Tyus and Haines 1991; McAda et al. 1994a; McAda et al. 1994b; McAda et al. 1997). Larvae from the lower Yampa River are thought to mostly colonize backwaters in alluvial valley reaches between Jensen, Utah, and the Ouray National Wildlife Refuge. Most floodplain habitat along the current-day Green River is concentrated in this reach. Although the density of age-0 fish in autumn was usually higher in the lower than in the middle Green River (Tyus and Haines 1991; McAda et al. 1994a), differences in habitat quantity may have confounded abundance estimates. The reach of the Green River defined mostly by Desolation and Gray Canyons also provides nursery habitat for Colorado pikeminnow (Tyus and Haines 1991; Day et al. 1999b). These backwaters are especially important during the Colorado pikeminnow's critical first year of life.

Backwaters and physical factors that create them are vital to successful recruitment of early life stages of Colorado pikeminnow. Occasional very high spring flows are needed to transport sediment and maintain or increase channel complexity. Sediment transport from the Little Snake

River provides an estimated 60 percent of the total sediment supply to the Green River and is important to maintain equilibrium channel morphology and ensure continued creation and maintenance of backwater nursery habitats for Colorado pikeminnow and humpback chub (Hawkins and O'Brien 2001). During high-discharge events, the elevation of sand bars increases and if high flows persist through summer, few backwaters are formed (Tyus and Haines 1991). Post-runoff low flows sculpt and erode sand bars and create complex backwater habitat critical for early life stages of all native fishes, particularly Colorado pikeminnow. Deeper, chute-channel backwaters are preferred by age-0 Colorado pikeminnow in the Green River (Tyus and Haines 1991; Day and Crosby 1997, Day et al. 1999a; Trammell and Chart 1999). Alterations to the amount and timing of flows defining the natural hydrology and sediment transport processes may inhibit the processes that create and maintain these habitats.

Past research indicated that certain discharge levels may optimize backwater habitat availability below Jensen for age-0 Colorado pikeminnow (Pucherelli et al. 1990; Tyus and Haines 1991; Tyus and Karp 1991). However, many geomorphic processes are dynamic over time and driven by the level of spring flows, the frequency of large floods, and post-peak discharge levels (Bell et al. 1998; Rakowski and Schmidt 1999). Consequently, flows to achieve optimum backwater availability may be different each year and dependent upon year-to-year bar topography (Rakowski and Schmidt 1999).

Muth et al. (2000) summarized flow and temperature needs of Colorado pikeminnow in the Green River subbasin as:

> "...Colorado pikeminnow are widespread in the system, occurring in both the main stem and tributaries. The Green River downstream of its confluence with the Yampa River supports the largest population of adults and nearly all larval and juvenile rearing areas; thus, this portion of the system is critical for sustaining Colorado pikeminnow populations. Reproduction of Colorado pikeminnow occurred in all years studied, and the current abundance of adults is comparatively high.
>
> However, the abundance of larval and age-0 stages is highly variable among years and is currently low compared to the abundance observed in the late 1980s. Recruitment has been low or nonexistent in some reaches and years.
>
> Habitat requirements of Colorado pikeminnow vary by season and life stage. In spring, adults utilize warmer off-channel and floodplain habitats for feeding and resting. Declining flow, increasing water temperature, photoperiod, and perhaps other factors in early summer provide cues for reproduction. Declining flow in summer also removes fine sediments from spawning substrates, and increases in water temperature also aid gonadal maturation. Reproduction begins when water temperatures reach 16–22°C. After hatching and swim-up, larvae drift downstream and occupy channel-margin backwaters. The potential for cold shock to Colorado pikeminnow larvae drifting from the Yampa River and into the Green River in summer could be eliminated or reduced if warmer water was provided in Reach 1 (Flaming Gorge Dam to the Yampa River confluence). Warm water also promotes fast growth of Colorado pikeminnow, which reduces effects of size-dependent regulatory processes such as predation. This warmer water also may provide conditions suitable for spawning in Lodore Canyon of Reach 1 and would enhance growth of early life stages in nursery habitats (e.g., backwaters) throughout Reach 2 (Yampa River to the White River confluence). Low, relatively stable base flows create

warm, food-rich backwaters that are thought to promote enhanced growth and survival of early life stages through autumn and winter. Similarly, low, relatively stable winter flows may enhance overwinter survival by reducing disruption of ice cover and habitat.

In-channel habitats used by Colorado pikeminnow are formed and maintained by spring peak flows that rework existing sediment deposits, scour vegetation from deposits, and create new habitats. The magnitudes of these flows were highly variable prior to flow regulation, and this variability appears to be important for maintaining high-quality habitats. In-channel habitats preferred by young Colorado pikeminnow are relatively deep (mean, 0.3 m) chute-channel backwaters. High peak flows maintain these habitats by periodically removing accumulated sediments and rebuilding the deposits that provide the structure for formation of backwaters after flows recede."

Critical Habitat for Colorado pikeminnow is located throughout Reaches 2 and 3 of the action area. As was discussed above, all primary constituent elements (water, physical habitat, and biological environment) have been affected throughout designated critical habitat on the Green River and in other occupied areas (Reach 1) and could be further influenced through implementation of the proposed action. To date, water quantity and quality has been affected by flow regulation and land management practices (irrigated agriculture), which has resulted in increased concentrations of contaminants (most notably selenium). Physical habitat (spring adult staging areas (floodplain), spawning and nursery habitats) has been affected through flow regulation, land management practices (diking), and encroachment of nonnative vegetation (primarily tamarisk). The biological environment has been altered primarily due to the introduction of numerous species of nonnative fish disrupting the natural balance of competition and predation. All constituent elements of designated Colorado pikeminnow critical habitat along the Green River will be considered in our analysis of the effects of the proposed action.

Razorback Sucker

Species/Critical Habitat Description

Like all suckers (family Catostomidae, meaning "down mouth"), the razorback sucker has a ventral mouth with thick lips covered with papillae and no scales on its head. In general, suckers are bottom browsers, sucking up or scraping off small invertebrates, algae, and organic matter with their fleshy, protrusible lips (Moyle 1976). The razorback sucker is the only sucker with an abrupt sharp-edged dorsal keel behind its head. The keel becomes more massive with age. The head and keel are dark, the back is olive-colored, the sides are brownish or reddish, and the abdomen is yellowish white (Sublette et al. 1990). Adults often exceed 3 kg (6 pounds) in weight and 600 mm (2 feet) in length. Like Colorado pikeminnow, razorback suckers are long-lived, living 40-plus years.

Critical habitat was designated for razorback sucker on March 21, 1994 (59 FR 13374). Designated critical habitat makes up about 49% of the species' original range and occurs in both the Upper and Lower Colorado River Basins (USFWS 1994). The primary constituent elements are the same as those described for Colorado pikeminnow.

River reaches (including the 100-year floodplain) of critical habitat for razorback sucker in the Green River system include the lower 89 km (55 mi) of the Yampa River (i.e., from the mouth of Cross Mountain Canyon to the confluence with the Green River), the Green River between the confluences of the Yampa and Colorado Rivers, the lower 29 km (18 mi) of the White River, and the lower 4 km (2.5 mi) of the Duchesne River.

Colorado: Moffat County. The Yampa River and its 100-year floodplain from the mouth of Cross Mountain Canyon in T. 6 N., R. 98 W., section 23 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).

Utah: Uintah County; and Colorado: Moffat County. The Green River and its 100-year floodplain from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian) to Sand Wash in T. 11 S., R. 18 E., section 20 (6th Principal Meridian).

Utah: Uintah, Carbon, Grand, Emery, Wayne, and San Juan Counties. The Green River and its 100-year floodplain from Sand Wash at river mile 96 at T. 11 S., R. 18 E., section 20 (6th Principal Meridian) to the confluence with the Colorado River in T. 30 S., R. 19 E., section 7 (6th Principal Meridian).

Utah: Uintah County. The White River and its 100-year floodplain from the boundary of the Uintah and Ouray Indian Reservation at river mile 18 in T. 9S., R. 22E., section 21 (Salt Lake Meridian) to the confluence with the Green River in T. 9 S., R. 20 E., section 4 (Salt Lake Meridian).

Utah: Uintah County. The Duchesne River and its 100-year floodplain from river mile 2.5 in T. 4S., R. 3E., section 30 (Salt Lake Meridian) to the confluence with the Green River in T. 5 S., R. 3 E., section 5 (Uintah Meridian).

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of critical habitat (59 FR 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment. The Service gave special consideration to habitats required for razorback sucker reproduction and recruitment when critical habitat was designated.

Status and Distribution

On March 14, 1989, the Service was petitioned to conduct a status review of the razorback sucker. Subsequently, the razorback sucker was designated as endangered under a final rule published on October 23, 1991 (56 FR 54957). The final rule stated "Little evidence of natural recruitment has been found in the past 30 years, and numbers of adult fish captured in the last 10 years demonstrate a downward trend relative to historic abundance. Significant changes have occurred in razorback sucker habitat through diversion and depletion of water, introduction of nonnative fishes, and construction and operation of dams" (56 FR 54957). Recruitment of razorback suckers to the population continues to be a problem.

Historically, razorback suckers were found in the mainstem Colorado River and major tributaries in Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming, and in Mexico (Ellis 1914; Minckley 1983). Bestgen (1990) reported that this species was once so numerous that it was commonly used as food by early settlers and, further, that commercially marketable quantities were caught in Arizona as recently as 1949. In the Upper Basin, razorback suckers were reported in the Green River to be very abundant near Green River, Utah, in the late 1800s (Jordan 1891). An account in Osmundson and Kaeding (1989) reported that residents living along the Colorado River near Clifton, Colorado, observed several thousand razorback suckers during spring runoff in the 1930s and early 1940s. In the San Juan River drainage, Platania and Young (1989) relayed historical accounts of razorback suckers ascending the Animas River to Durango, Colorado, around the turn of the century.

Currently, the largest concentration of razorback sucker remaining in the Colorado River Basin is in Lake Mohave on the border of Arizona and California. Estimates of the wild stock in Lake Mohave have fallen precipitously in recent years from 60,000 as late as 1991, to 25,000 in 1993 (Marsh 1993, Holden 1994), to about 9,000 in 2000 (USFWS 2002b). Until recently, efforts to introduce young razorback sucker into Lake Mohave have failed because of predation by non-native species (Minckley et al. 1991, Clarkson et al. 1993, Burke 1994). While limited numbers of razorback suckers persist in other locations in the Lower Colorado River, they are considered rare or incidental and may be continuing to decline.

In the Upper Colorado River Basin, above Glen Canyon Dam, razorback suckers are found in limited numbers in both lentic (lake-like) and riverine environments. The largest populations of razorback suckers in the upper basin are found in the upper Green and lower Yampa rivers (Tyus 1987). In the Colorado River, most razorback suckers occur in the Grand Valley area near Grand Junction, Colorado; however, they are increasingly rare. Osmundson and Kaeding (1991) reported that the number of razorback sucker captures in the Grand Junction area has declined dramatically since 1974. Between 1984 and 1990, intensive collecting effort captured only 12 individuals in the Grand Valley (Osmundson and Kaeding 1991). The wild population of razorback sucker is considered extirpated from the Gunnison River (Burdick and Bonar 1997).

Razorback suckers are in imminent danger of extirpation in the wild. As Bestgen (1990) pointed out:

> "Reasons for decline of most native fishes in the Colorado River Basin have been attributed to habitat loss due to construction of mainstream dams and subsequent interruption or alteration of natural flow and physio-chemical regimes, inundation of river reaches by reservoirs, channelization, water quality degradation, introduction of nonnative fish species and resulting competitive interactions or predation, and other man-

induced disturbances (Miller 1961, Joseph et al. 1977, Behnke and Benson 1983, Carlson and Muth 1989, Tyus and Karp 1989). These factors are almost certainly not mutually exclusive, therefore it is often difficult to determine exact cause and effect relationships."

The virtual absence of any recruitment suggests a combination of biological, physical, and/or chemical factors that may be affecting the survival and recruitment of early life stages of razorback suckers. Within the Upper Basin, recovery efforts endorsed by the Recovery Program include the capture and removal of razorback suckers from all known locations for genetic analyses and development of discrete brood stocks. These measures have been undertaken to develop refugia populations of the razorback sucker from the same genetic parentage as their wild counterparts such that, if these fish are genetically unique by subbasin or individual population, then separate stocks will be available for future augmentation. Such augmentation may be a necessary step to prevent the extinction of razorback suckers in the Upper Basin.

Recovery goals for the razorback sucker (USFWS 2002b) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and either in the upper Colorado River subbasin or the San Juan River subbasin such that (a) the trend in adult (age 4+; > 400 mm total length) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (300–399 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults (5,800 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- a genetic refuge is maintained in Lake Mohave of the lower basin recovery unit; and

- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and

- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and either in the upper Colorado

River subbasin or the San Juan River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults; and

- a genetic refuge is maintained in Lake Mohave; and
- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and
- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

McAda and Wydoski (1980) and Tyus (1987) reported springtime aggregations of razorback suckers in off-channel habitats and tributaries; such aggregations are believed to be associated with reproductive activities. Tyus and Karp (1990) and Osmundson and Kaeding (1991) reported off-channel habitats to be much warmer than the mainstem river and that razorback suckers presumably moved to these areas for feeding, resting, sexual maturation, spawning, and other activities associated with their reproductive cycle. Prior to construction of large mainstem dams and the suppression of spring peak flows, low velocity, off-channel habitats (seasonally flooded bottomlands and shorelines) were commonly available throughout the Upper Basin (Tyus and Karp 1989; Osmundson and Kaeding 1991). Dams changed riverine ecosystems into lakes by impounding water, which eliminated these off-channel habitats in reservoirs. Reduction in spring peak flows eliminates or reduces the frequency of inundation of off-channel habitats. The absence of these seasonally flooded riverine habitats is believed to be a limiting factor in the successful recruitment of razorback suckers in their native environment (Tyus and Karp 1989; Osmundson and Kaeding 1991). Wydoski and Wick (1998) identified starvation of larval razorback suckers due to low zooplankton densities in the main channel and loss of floodplain habitats which provide adequate zooplankton densities for larval food as one of the most important factors limiting recruitment.

While razorback suckers have never been directly observed spawning in turbid riverine environments within the Upper Basin, captures of ripe specimens (in spawning condition), both males and females, have been recorded (Valdez et al. 1982a; McAda and Wydoski 1980; Tyus 1987; Osmundson and Kaeding 1989; Tyus and Karp 1989; Tyus and Karp 1990; Osmundson and Kaeding 1991; Platania 1990) in the Yampa, Green, Colorado, and San Juan rivers. Sexually mature razorback suckers are generally collected on the ascending limb of the hydrograph from mid-April through June and are associated with coarse gravel substrates (depending on the specific location).

Outside of the spawning season, adult razorback suckers occupy a variety of shoreline and main channel habitats including slow runs, shallow to deep pools, backwaters, eddies, and other relatively slow velocity areas associated with sand substrates (Tyus 1987; Tyus and Karp 1989; Osmundson and Kaeding 1989; Valdez and Masslich 1989; Osmundson and Kaeding 1991; Tyus and Karp 1990).

Habitat requirements of young and juvenile razorback suckers in the wild are not well known, particularly in native riverine environments. Prior to 1991, the last confirmed documentation of a razorback sucker juvenile in the Upper Basin was a capture in the Colorado River near Moab, Utah (Taba et al. 1965). In 1991, two early juvenile (36.6 and 39.3 mm total length (TL)) razorback suckers were collected in the lower Green River near Hell Roaring Canyon (Gutermuth et al. 1994). Juvenile razorback suckers have been collected in recent years from Old Charley Wash, a wetland adjacent to the Green River (Modde 1996). Between 1992 and 1995 larval razorback suckers were collected in the middle and lower Green River and within the Colorado River inflow to Lake Powell (Muth 1995). In 2002, eight larval razorback suckers were collected in the Gunnison River (Osmundson 2002). No young razorback suckers have been collected in recent times in the Colorado River.

Threats to the Species

A marked decline in populations of razorback suckers can be attributed to construction of dams and reservoirs, introduction of nonnative fishes, and removal of large quantities of water from the Colorado River system. Dams on the mainstem Colorado River and its major tributaries have segmented the river system, blocked migration routes, and changed river habitat into lake habitat. Dams also have drastically altered flows, temperatures, and channel geomorphology. These changes have modified habitats in many areas so that they are no longer suitable for breeding, feeding, or sheltering. Major changes in species composition have occurred due to the introduction of numerous nonnative fishes, many of which have thrived due to human-induced changes to the natural riverine system. These nonnative fishes prey upon and compete with razorback suckers.

The primary threats to razorback sucker critical habitat are stream flow regulation and habitat modification (affecting both the water and physical habitat constituent elements); competition with and predation by nonnative fishes; and pesticides and pollutants (USFWS 2002b) (affecting the biological environment). The existing habitat, altered by these threats, has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering. The threats to razorback sucker are essentially the same threats identified for Colorado pikeminnow.

Management actions identified in the recovery goals for razorback sucker (USFWS 2002b) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations;
- provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion;
- investigate options for providing appropriate water temperatures in the Gunnison River;
- minimize entrainment of subadults and adults in diversion/out-take structures;
- ensure adequate protection from overutilization;
- ensure adequate protection from diseases and parasites;
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries;
- control problematic nonnative fishes as needed;
- minimize the risk of hazardous-materials spills in critical habitat;
- remediate water-quality problems; and
- minimize the threat of hybridization with white sucker.

Status of Razorback Sucker and Critical Habitat in the Action Area

The largest concentration of razorback suckers in the Upper Basin exists in low-gradient flat-water reaches of the middle Green River between and including the lower few miles of the Duchesne River and the Yampa River (Tyus 1987; Tyus and Karp 1990; Muth 1995; Modde and Wick 1997; Muth et al. 2000). This area includes the greatest expanse of floodplain habitat in the Upper Colorado River Basin, between Pariette Draw at river mile (RM) 238 and the Escalante Ranch at RM 310 (Irving and Burdick 1995).

Lanigan and Tyus (1989) used a demographically closed model with capture-recapture data collected from 1980 to 1988 and estimated that the middle Green River population consisted of about 1,000 adults (mean, 948; 95 percent confidence interval, 758–1,138). Based on a demographically open model and capture-recapture data collected from 1980 to 1992, Modde et al. (1996) estimated the number of adults in the middle Green River population at about 500 fish (mean, 524; 95 percent confidence interval, 351–696). That population had a relatively constant length frequency distribution among years (most frequent modes were in the 505–515 mm-TL interval) and an estimated annual survival rate of 71 percent. Bestgen et al. (2002) estimated the current population of wild razorback sucker in the middle Green River to be about 100, based on data collected in 1998 and 1999. There are no current population estimates of razorback sucker in the Yampa River due to low numbers captured in recent years.

The lower Yampa River provides adult habitat, spawning habitat, and potential nursery areas occur downstream in the Green River (USFWS 1998a). Modde and Smith (1995) reported that adult razorback suckers were collected between RM 13 and RM 0.1 of the Yampa River. They also reported only one juvenile razorback sucker has been collected in the Yampa River. The single fish (389 mm) was collected at RM 39 in June 1994. The Green River from the confluence with the Yampa River to Sand Wash has the largest existing riverine population of razorback sucker (Lanigan and Tyus 1989, Modde et al. 1996). Razorback suckers are rarely found upstream as far as the confluence with the Little Snake River (McAda and Wydoski 1980 and Lanigan and Tyus 1989). Tyus and Karp (1990) located concentrations of ripe razorback suckers at the mouth of the Yampa River during the spring in 1987-1989. Ripe fish were captured in runs associated with bars of cobble, gravel, and sand substrates in water averaging 0.63 m deep and mean velocity of 0.74 m/s.

Razorback suckers are permanent residents of the Green River below its confluence with the Yampa River and are reliant on in-channel habitat for spawning and flooded off-channel habitats for several aspects of their life history. In turn, these habitats are created and maintained by the natural hydrology and sediment transport provided by the Yampa River.

Spring migrations by adult razorback suckers were associated with spawning in historic accounts (Jordan 1891; Hubbs and Miller 1953; Sigler and Miller 1963; Vanicek 1967), and a variety of local and long-distance movements and habitat-use patterns have been subsequently documented. Spawning migrations (one-way movements of 30.4–106.0 km) observed by Tyus and Karp (1990) included movements between the Ouray and Jensen areas of the Green River and between the Jensen area and the lower Yampa River. Initial movement of adult razorback suckers to spawning sites was influenced primarily by increases in river discharge and secondarily by increases in water temperature (Tyus and Karp 1990; Modde and Wick 1997; Modde and Irving 1998). Flow and temperature cues may serve to effectively congregate razorback suckers at spawning sites, thus increasing reproductive efficiency and success. Reduction in spring peak flows may hinder the ability of razorback suckers to form spawning aggregations, because spawning cues are reduced (Modde and Irving 1998).

Captures of ripe fish and radio-telemetry of adults in spring and early summer were used to locate razorback sucker spawning areas in the middle Green River. McAda and Wydoski (1980) found a spawning aggregation of 14 ripe fish (2 females and 12 males) over a cobble bar at the mouth of the Yampa River during a 2-week period in early to mid-May 1975. These fish were collected from water about 1 m deep with a velocity of about 1 m/s and temperatures ranging from 7 to 16°C (mean, 12°C). Tyus (1987) captured ripe razorback suckers in three reaches: 1) Island and Echo parks of the Green River in Dinosaur National Monument, including the lower mile of the Yampa River; 2) the Jensen area of the Green River from Ashley Creek (RM 299) to Split Mountain Canyon (RM 319); and 3) the Ouray area of the Green River, including the lower few miles of the Duchesne River. The Jensen area contributed 73 percent of the 60 ripe razorback suckers caught over coarse sand substrates or in the vicinity of gravel and cobble bars in those 3 reaches during spring 1981, 1984, and 1986.

Recently, tuberculate or ripe razorback suckers have been collected from reaches of the lower Green River in Labyrinth Canyon near the mouth of the San Rafael River at RM 97 (Tyus 1987, Miller and Hubert 1990, Muth 1995, Chart et al. 1999). Muth et al. (1998) suggested that many of the 439 razorback sucker larvae collected from the lower Green River between RM 28 and 97 during spring and early summer 1993–1996 had been spawned downstream of RM 110 (lower end of the Green River Valley reach), possibly near the mouth of the San Rafael River.

Substantial numbers of razorback sucker adults have been found in flooded off-channel habitats in the vicinity of mid-channel spawning bars shortly before or after spawning. Tyus (1987) located concentrations of ripe fish associated with warm floodplain habitats and in shallow eddies near the mouths of tributary streams. Similarly, Holden and Crist (1981) reported capture of 56 adult razorback suckers in the Ashley Creek-Jensen area of the middle Green River from 1978 to 1980, and about 19 percent of all ripe or tuberculate razorback suckers collected during 1981–1989 ($N = 57$) were from flooded lowlands (e.g., Old Charlie Wash and Stewart Lake Drain) and tributary mouths (e.g., Duchesne River and Ashley Creek) (Tyus and Karp 1990). Radio-telemetry and capture-recapture data compiled by Modde and Wick (1997) and Modde and Irving (1998) demonstrated that most razorback sucker adults in the middle Green River moved into flooded environments (e.g., floodplain habitats and tributary mouths) soon after spawning. Tyus and Karp (1990, 1991) and Modde and Wick (1997) suggested that use of warmer, more productive flooded habitats by adult razorback suckers during the breeding season is related to temperature preferences (23–25°C; Bulkley and Pimental 1983) and abundance of appropriate foods (Jonez and Sumner 1954; Vanicek 1967; Marsh 1987; Mabey and Shiozawa 1993; Wolz and Shiozawa 1995; Modde 1997; Wydoski and Wick 1998). Twelve ripe razorback suckers were caught in Old Charlie Wash during late May–early June 1986, presumably due to the abundant food in the wetland (Tyus and Karp 1991). Eight adult razorback suckers collected from Old Charlie Wash in late summer 1995 entered the wetland when it was connected to the river during peak spring flows (Modde 1996). Reduced spring flooding caused by lower regulated river discharges, channelization, and levee construction has restricted access to floodplain habitats used by adult razorback suckers for temperature conditioning, feeding, and resting (Tyus and Karp 1990; Modde 1997; Modde and Wick 1997; Wydoski and Wick 1998). The fact that these fish actively seek out this habitat suggests that the conditioning it provides them is important to their continued successful reproduction.

Razorback sucker larvae were collected each year in the Green River during 1992–1996. Over 99 percent (N = 1,735) of the larvae caught in the middle Green River during spring and early summer were from reaches including, and downstream of, the presumed spawning area near the Escalante Ranch (Muth et al. 1998). Based on the few larvae ($N = 6$) recorded from collections in the Echo Park reach in 1993, 1994, and 1996, reproduction by razorback suckers at the lower Yampa River spawning site appeared minimal, but sampling efforts in the two reaches immediately downstream of that site were comparatively low (Muth et al. 1998). Mean catch per unit effort (CPUE) was highly variable among years and river reaches but it is unclear whether this was a true measure of population abundance or was biased by differences in sampling efficiency (Muth et al. 1998). Numbers of razorback sucker larvae captured per year ranged from 20 in 1992 to 1,217 in 1994 for the middle Green River and from 5 in 1995 to 222 in 1996 for the lower Green River.

Collections in the lower Green River during 1993–1996 produced the first ever captures of razorback sucker larvae from this section of river. In the lower Labyrinth-upper Stillwater Canyon reach, 363 razorback suckers were caught; all from flooded side canyons, washes, backwaters, and side channels. Razorback sucker larvae were collected in the Echo Park area of the Green River in 1993, 1994, 1996, indicating successful spawning in the lower Yampa River (Muth et al. 1998).

Historically, floodplain habitats inundated and connected to the main channel by overbank flooding during spring-runoff discharges would have been available as nursery areas for young razorback suckers in the Green River. Tyus and Karp (1990) associated low recruitment with reductions in floodplain inundation since 1962 (closure of Flaming Gorge Dam), and Modde et al. (1996) associated years of high spring discharge and floodplain inundation in the middle Green River (1983, 1984, and 1986) with subsequent suspected recruitment of young adult razorback suckers. These floodplain habitats are essential for the survival and recruitment of larval fish. Relatively high zooplankton densities in these warm, productive habitats are necessary to provide adequate zooplankton densities for larval food. Loss or degradation of these productive floodplain habitats probably represents one of the most important factors limiting recruitment in this species (Wydoski and Wick 1998). The importance of these habitats is further underscored by the relationship between larval growth and mortality due to non-native predators (Bestgen et al. 1997). Predation by adult red shiners on larvae of native catostomids in flooded and backwater habitats of the Yampa, Green, or Colorado Rivers was documented by Ruppert et al.(1993) and Muth and Wick (1997). Water depletions and changes in timing of flows may reduce the quantity and availability of floodplain habitat, thus reducing larval growth and recruitment.

Muth et al. (2000) summarized flow and temperature needs of razorback sucker in the Green River subbasin as:

> "Current levels of recruitment of young razorback suckers are not sufficient to sustain populations in the Green River system; wild stocks are composed primarily of older individuals that continue to decline in abundance. Lack of adequate recruitment has been attributed to extremely low survival of larvae and juveniles. Reproduction by razorback suckers in the Green River was documented through captures of larvae each year during 1992□1996, but mortality of larvae was apparently high, possibly as a result of low growth rates and the effect of small body size on competition and the risk of predation. Only six juveniles have been collected from Green River backwaters since 1990, but 73 juveniles were collected from the Old Charlie Wash managed wetland in Reach 2 during 1995/1996.
>
> Floodplain areas inundated and temporarily connected to the main channel by spring peak flows appear to be important habitats for all life stages of razorback sucker, and the seasonal timing of razorback sucker reproduction suggests an adaptation for utilizing these habitats. However, the frequency, magnitude, and duration of seasonal overbank flooding in the Green River have been substantially reduced since closure of Flaming Gorge Dam. Restoring access to these warm and productive habitats, which are most abundant in Reach 2 within the Ouray NWR area, would provide the growth and conditioning environments that appear crucial for recovery of self-sustaining razorback sucker populations. In addition, lower, more stable flows during winter may reduce flooding of low-velocity habitats and reduce the breakup of ice cover in overwintering areas and may enhance survival of adults.
>
> Spring peak flows must be of sufficient magnitude to inundate floodplain habitats and timed to occur when razorback sucker larvae are available for transport into these flooded areas. Overbank flows of sufficient duration would provide quality nursery environments

and may enhance the growth and survival of young fish. Because at least some young razorback suckers entrained in more permanent ponded (depression) sections of floodplains may survive through subsequent winters, spring inundation will need to be repeated at sufficiently frequent intervals to provide access back into the main channel."

Critical Habitat for razorback sucker is located throughout Reaches 2 and 3 of the action area. As was discussed above, all primary constituent elements (water, physical habitat, and biological environment) have been affected throughout designated critical habitat on the Green River and to a lesser extent in other occupied areas (Reach 1). Habitat in those areas could be further affected through implementation of the proposed action. To date, water quantity and quality has been affected by flow regulation and land management practices (irrigated agriculture), which has resulted in increased concentrations of contaminants (most notably selenium). Physical habitat (spring adult staging areas (floodplain), spawning and nursery habitats) has been affected through flow regulation, land management practices (diking), and encroachment of nonnative vegetation (primarily tamarisk). The biological environment has been altered primarily due to the introduction of numerous species of nonnative fish disrupting the natural balance of competition and predation. All constituent elements of designated razorback sucker critical habitat along the Green River will be considered in our analysis of the effects of the proposed action.

Humpback Chub

Species/Critical Habitat Description

The humpback chub is a medium-sized freshwater fish (less than 500 mm) of the minnow family. The adults have a pronounced dorsal hump, a narrow flattened head, a fleshy snout with an inferior-subterminal mouth, and small eyes. It has silvery sides with a brown or olive colored back.

The humpback chub is endemic to the Colorado River Basin and is part of a native fish fauna traced to the Miocene epoch in fossil records (Miller 1946; Minckley et al. 1986). Humpback chub remains have been dated to about 4000 B.C., but the fish was not described as a species until the 1940s (Miller 1946), presumably because of its restricted distribution in remote white water canyons (USFWS 1990). Because of this, its original distribution is not known. The humpback chub was listed as endangered on March 11, 1967.

Until the 1950s, the humpback chub was known only from Grand Canyon. During surveys in the 1950s and 1960s humpback chub were found in the upper Green River including specimens from Echo Park, Island Park, and Swallow Canyon (Smith 1960, Vanicek et al. 1970). Individuals were also reported from the lower Yampa River (Holden and Stalnaker 1975b), the White River in Utah (Sigler and Miller 1963), Desolation Canyon of the Green River (Holden and Stalnaker 1970) and the Colorado River near Moab (Sigler and Miller 1963).

Critical habitat was designated for humpback chub on March 21, 1994 (59 FR 13374). Designated critical habitat makes up about 28% of the species' original range and occurs in both the Upper and Lower Colorado River Basins. Although humpback chub life history and habitat use differs greatly from the other endangered Colorado River fish the Service determined that the primary constituent elements (water, physical habitat, and biological environment) of their critical habitat were the same.

Critical habitat for humpback chub in the Green River system include the Yampa River within Dinosaur National Monument, Green River from its confluence with the Yampa River downstream to the southern boundary of Dinosaur National Monument, and the Green River within Desolation and Gray Canyons.

Colorado, Moffat County. The Yampa River from the boundary of Dinosaur National Monument in T. 6 N., R. 99 W., section 27 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).

Utah, Uintah County; and Colorado, Moffat County. The Green River from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian) to the southern boundary of Dinosaur National Monument in T. 6 N., R. 24 E., section 30 (Salt Lake Meridian).

Utah, Uintah and Grand Counties. The Green River (Desolation and Gray Canyons) from Sumner's Amphitheater in T. 12 S., R. 18 E., section 5 (Salt Lake Meridian) to Swasey's Rapid in T. 20 S., R. 16 E., section 3 (Salt Lake Meridian).

Status and Distribution

Failure to recognize *Gila cypha* as a species until 1946 complicated interpretation of historic distribution of humpback chubs in the Green River (Douglas et al. 1989, 1998). Best available information indicates that before Flaming Gorge Dam, humpback chubs were distributed in canyon regions throughout much of the Green River, from the present site of Flaming Gorge Reservoir downstream through Desolation and Gray canyons (Vanicek 1967; Holden and Stalnaker 1975a; Holden 1991). In addition, the species occurred in the Yampa and White rivers. Pre-impoundment surveys of the Flaming Gorge Reservoir basin (Bosley 1960; Gaufin et al. 1960; McDonald and Dotson 1960; Smith 1960) reported both humpback chubs and bonytails from the Green River near Hideout Canyon, now inundated by Flaming Gorge Reservoir.

Historic collection records of humpback chub exist from the Yampa and White rivers, both tributaries to the Green River. Tyus (1998) verified the presence of seven humpback chubs in collections of the University of Colorado Museum, collected from the Yampa River in Castle Park between 19 June and 11 July 1948. A single humpback chub was found in the White River near Bonanza, Utah, in June 1981 (Miller et al. 1982b), and a possible bonytail-humpback chub intergrade was also captured in July 1978 (Lanigan and Berry 1981).

Present concentrations of humpback chub in the Upper Basin occur in canyon-bound river reaches ranging in length from 3.7 km (Black Rocks) to 40.5 km (Desolation and Gray Canyons). Humpback chubs are distributed throughout most of Black Rocks and Westwater Canyons (12.9 km), and in or near whitewater reaches of Cataract Canyon (20.9 km), Desolation and Gray Canyons (65.2 km), and Yampa Canyon (44.3 km), with populations in the separate canyon reaches ranging from 400 to 5,000 adults (see population dynamics). The Utah Division of Wildlife Resources has monitored the fish community in Desolation and Gray Canyons since 1989 and has consistently reported captures of age-0, juvenile, and adult *Gila,* including humpback chub, indicating a reproducing population (Chart and Lentsch 1999b). Distribution of humpback chubs within Whirlpool and Split Mountain Canyons is not presently known, but it is believed that numbers of humpback chub in these sections of the Green River are low.

The Yampa River is the only tributary to the Green River presently known to support a reproducing humpback chub population. Between 1986 and 1989, Karp and Tyus (1990) collected 130 humpback chubs from Yampa Canyon and indicated that a small but reproducing population was present. Continuing captures of juveniles and adults within Dinosaur National Monument indicate that a population persists in Yampa Canyon (T. Modde, U.S. Fish and Wildlife Service, personal communication). Small numbers of humpback chub also have been reported in Cross Mountain Canyon on the Yampa River and in the Little Snake River about 10 km upstream of its confluence with the Yampa River (Wick et al. 1981; Hawkins et al. 1996).

Recovery goals for the humpback chub (USFWS 2002c) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- the trend in adult (age 4+; > 200 mm total length) point estimates for each of the six extant populations does not decline significantly; and
- mean estimated recruitment of age-3 (150–199 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations; and
- two genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds 2,100 adults (2,100 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and
- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- the trend in adult point estimates for each of the six extant populations does not decline significantly; and
- mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations; and
- three genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds 2,100 adults; and

- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

Unlike Colorado pikeminnow and razorback sucker, which are known to make extended migrations of up to several hundred miles to spawning areas in the Green and Yampa rivers, humpback chubs in the Green River do not appear to make extensive migrations (Karp and Tyus 1990). Radio-telemetry and tagging studies on other humpback chub populations have revealed strong fidelity by adults for specific locations with little movement to areas outside of home canyon regions. Humpback chubs in Black Rocks (Valdez and Clemmer 1982), Westwater Canyon (Chart and Lentsch 1999a), and Desolation and Gray Canyons (Chart and Lentsch 1999b) do not migrate to spawn.

Generally, humpback chub show fidelity for canyon reaches and move very little (Miller et al. 1982a; Archer et al. 1985; Burdick and Kaeding 1985; Kaeding et al. 1990). Movements of adult humpback chub in Black Rocks on the Colorado River were essentially restricted to a 1-mile reach. These results were based on the recapture of Carlin-tagged fish and radiotelemetry studies conducted from 1979 to 1981 (Valdez et al. 1982) and 1983 to 1989 (Archer et al. 1985; Kaeding et al. 1990).

In the Green River and upper Colorado River, humpback chubs spawned in spring and summer as flows declined shortly after the spring peak (Valdez and Clemmer 1982; Valdez et al. 1982; Kaeding and Zimmerman 1983; Tyus and Karp 1989; Karp and Tyus 1990; Chart and Lentsch 1999a, 1999b). Similar spawning patterns were reported from Grand Canyon (Kaeding and Zimmerman 1983; Valdez and Ryel 1995, 1997). Little is known about spawning habitats and behavior of humpback chub. Although humpback chub are believed to broadcast eggs over mid-channel cobble and gravel bars, spawning in the wild has not been observed for this species. Gorman and Stone (1999) reported that ripe male humpback chubs in the Little Colorado River aggregated in areas of complex habitat structure (i.e., matrix of large boulders and travertine masses combined with chutes, runs, and eddies, 0.5–2.0 m deep) and were associated with deposits of clean gravel.

Chart and Lentsch (1999b) estimated hatching dates for young *Gila* collected from Desolation and Gray Canyons between 1992 and 1995. They determined that hatching occurred on the descending limb of the hydrograph as early as 9 June 1992 at a flow of 139 m^3/s and as late as 1 July 1995 at a flow of 731 m^3/s. Instantaneous daily river temperatures on hatching dates over all years ranged from 20 to 22 °C.

Newly hatched larvae average 6.3–7.5 mm TL (Holden 1973; Suttkus and Clemmer 1977; Minckley 1973; Snyder 1981; Hamman 1982; Behnke and Benson 1983; Muth 1990), and 1-month-old fish are approximately 20 mm long (Hamman 1982). Unlike Colorado pikeminnow and razorback sucker, no evidence exists of long-distance larval drift (Miller and Hubert 1990; Robinson et al. 1998). Upon emergence from spawning gravels, humpback chub larvae remain in the vicinity of bottom surfaces (Marsh 1985) near spawning areas (Chart and Lentsch 1999a).

Backwaters, eddies, and runs have been reported as common capture locations for young-of-year humpback chub (Valdez and Clemmer 1982). These data indicate that in Black Rocks and Westwater Canyon, young utilize shallow areas. Habitat suitability index curves developed by Valdez et al. (1990) indicate young-of-year prefer average depths of 2.1 feet with a maximum of 5.1 feet. Average velocities were reported at 0.2 feet per second.

Valdez et al. (1982) Wick et al. (1979) and Wick et al. (1981) found adult humpback chub in Black Rocks and Westwater Canyons in water averaging 50 feet in depth with a maximum depth of 92 feet. In these localities, humpback chub were associated with large boulders and steep cliffs.

Threats to the Species

Although historic data are limited, the apparent range-wide decline in humpback chubs is likely due to a combination of factors including alteration of river habitats by reservoir inundation, changes in stream discharge and temperature, competition with and predation by introduced fish species, and other factors such as changes in food resources resulting from stream alterations (USFWS 1990).

The primary threats to humpback chub are stream flow regulation and habitat modification (affecting constituent elements: water and physical habitat); competition with and predation by nonnative fishes; parasitism; hybridization with other native *Gila* species; and pesticides and pollutants (USFWS 2002c) (all affecting constituent element: biological environment). The existing habitat, altered by these threats, has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering. The threats to humpback chub in relation to flow regulation and habitat modification, predation by nonnative fishes, and pesticides and pollutants are essentially the same threats identified for Colorado pikeminnow.

The humpback chub population in the Grand Canyon is threatened by predation from nonnative trout in the Colorado River below Glen Canyon Dam. This population is also threatened by the Asian tapeworm reported in humpback chub in the Little Colorado River (USFWS 2002c). No Asian tapeworms have been reported in the upper basin populations.

Hybridization with roundtail chub (*Gila robusta*) and bonytail, where they occur with humpback chub, is recognized as a threat to humpback chub. A larger proportion of roundtail chub have been found in Black Rocks and Westwater Canyon during low flow years (Kaeding et al. 1990; Chart and Lentsch 2000), which increase the chances for hybridization.

Management actions identified in the recovery goals for humpback chub (USFWS 2002c) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations,

- investigate the role of the mainstem Colorado River in maintaining the Grand Canyon population,
- investigate the anticipated effects of and options for providing warmer water temperatures in the mainstem Colorado River through Grand Canyon,
- ensure adequate protection from overutilization,
- ensure adequate protection from diseases and parasites,
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries,
- control problematic nonnative fishes as needed,
- minimize the risk of increased hybridization among *Gila* spp, and
- minimize the risk of hazardous-materials spills in critical habitat.

Status of Humpback Chub and Critical Habitat in the Action Area

Monitoring humpback chub populations is ongoing, and sampling protocols and reliability of population estimates are being assessed by the Service and cooperating entities. The humpback chub recovery goals (USFWS 2002c) provided the following preliminary population estimates for adults in the six populations:

Black Rocks, Colorado River, Colorado -- 900–1,500
Westwater Canyon, Colorado River, Utah -- 2,000–5,000
Yampa Canyon, Yampa River, Colorado -- 400–600
Desolation/Gray Canyons, Green River, Utah -- 1,500
Cataract Canyon, Colorado River, Utah -- 500
Grand Canyon, Colorado River and Little Colorado River, Arizona -- 2,000–4,700

Low numbers of humpback chub have been captured in Whirlpool Canyon and Split Mountain Canyon on the Green River in Dinosaur National Monument; however, these fish were considered part of the Yampa River population in the Recovery Goals (USFWS 2002c), and not separate populations.

Tyus and Karp (1991) found that in the Yampa and Green rivers in Dinosaur National Monument, humpback chubs spawn during spring and early summer following peak flows at water temperatures of about 20°C. They estimated that the spawning period for humpback chub ranges from May into July, with spawning occurring earlier in low-flow years and later in high-flow years; spawning was thought to occur only during a 4–5 week period (Karp and Tyus 1990). Similar to the Yampa and Green rivers, peak hatch of *Gila* larvae in Westwater Canyon on the Colorado River appears to occur on the descending limb of the hydrograph following spring runoff at maximum daily water temperatures of approximately 20 to 21°C (Chart and Lentsch 1999a). Tyus and Karp (1989) reported that humpback chubs occupy and spawn in and near shoreline eddy habitats and that spring peak flows were important for reproductive success because availability of these habitats is greatest during spring runoff.

High spring flows that simulate the magnitude and timing of the natural hydrograph provide a number of benefits to humpback chubs in the Yampa and Green rivers. Bankfull and overbank flows provide allochthonous energy input to the system in the form of terrestrial organic matter and insects that are utilized as food. High spring flows clean spawning substrates of fine sediments and provide physical cues for spawning. High flows also form large recirculating eddies used by adult fish. High spring flows (50 percent exceedance or greater) have been implicated in limiting the abundance and reproduction of some nonnative fish species under certain conditions (Chart and Lentsch 1999a, 1999b) and have been correlated with increased recruitment of humpback chubs (Chart and Lentsch 1999b).

Critical habitat for humpback chub includes canyon reaches of the Green River (Whirlpool, Split Mountain, Desolation, and Gray Canyons), which have been affected by stream flow regulation. However, Whirlpool and Desolation Canyons have recently been invaded by high numbers of smallmouth bass changing the biological environment of critical habitat.

Muth et al. (2000) summarized flow and temperature needs of humpback chub in the Green River subbasin as:

> "…The habitat requirements of the humpback chub are incompletely understood. It is known that fish spawn on the descending limb of the spring hydrograph at temperatures greater than 17°C. Rather than migrate, adults congregate in near-shore eddies during spring and spawn locally. They are believed to be broadcast spawners over gravel and cobble substrates. Young humpback chubs typically use low-velocity shoreline habitats, including eddies and backwaters, that are more prevalent under base-flow conditions. After reaching approximately 40□50 mm TL, juveniles move into deeper and higher-velocity habitats in the main channel.
> Increased recruitment of humpback chubs in Desolation and Gray Canyons was correlated with moderate to high water years from 1982 to 1986 and in 1993 and 1995. Long, warm growing seasons, which stimulate fish growth, and a low abundance of competing and predatory nonnative fishes also have been implicated as potential factors that increase the survival of young humpback chubs.
>
> High spring flows increase the availability of the large eddy habitats utilized by adult fish. High spring flows also maintain the complex shoreline habitats that are used as nursery habitat by young fish during subsequent base flows. Low-velocity nursery habitats that are used by young fish are warmer and more productive at low base flows."

Bonytail

Species/Critical Habitat Description

Bonytail are medium-sized (less than 600 mm) fish in the minnow family. Adult bonytail are gray or olive colored on the back with silvery sides and a white belly. The adult bonytail has an elongated body with a long, thin caudal peduncle. The head is small and compressed compared to the rest of the body. The mouth is slightly overhung by the snout and there is a smooth low hump behind the head that is not as pronounced as the hump on a humpback chub.

The bonytail is endemic to the Colorado River Basin and was historically common to abundant in warm-water reaches of larger rivers of the basin from Mexico to Wyoming. The species experienced a dramatic, but poorly documented, decline starting in about 1950, following construction of several mainstem dams, introduction of nonnative fishes, poor land-use practices, and degraded water quality (USFWS 2002d).

Currently, no self-sustaining populations of bonytail are known to exist in the wild, and very few individuals have been caught anywhere within the basin. An unknown, but small number of wild adults exist in Lake Mohave on the mainstem Colorado River. Since 1977, only 11 wild adults have been reported from the upper basin (Valdez et al. 1994).

A total of 499 km (312 miles) of river has been designated as critical habitat for the bonytail in the Colorado River Basin, representing about 14% of the species' historic range (59 FR 13374). River reaches that have been designated as critical habitat in the Green River extend from the confluence with the Yampa River downstream to the boundary of Dinosaur National Monument and Desolation and Gray Canyons. In addition, critical habitat has been designated in the Yampa River from the upstream boundary of Dinosaur National Monument to its confluence with the Green River.

> Colorado, Moffat County. The Yampa River from the boundary of Dinosaur National Monument in T. 6 N., R. 99 W., section 27 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).
> Utah, Uintah County; and Colorado, Moffat County. The Green River from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian) to the boundary of Dinosaur National Monument in T. 6 N., R. 24 E., section 30 (Salt Lake Meridian).
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> Utah, Uintah and Grand Counties. The Green River (Desolation and Gray Canyons) from Sumner's Amphitheater in T. 12 S., R. 18 E., section 5 (Salt Lake Meridian) to Swasey's Rapid (river mile 12) in T. 20 S., R. 16 E., section 3 (Salt Lake Meridian).

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of bonytail critical habitat (59 FR 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment. Recent information collected by the Recovery Program suggests that floodplain habitats may be more important to the survival and recovery of the bonytail than the Service originally thought.

Status and Distribution

The bonytail is the rarest native fish in the Colorado River. Little is known about its specific habitat requirements or cause of decline, because the bonytail was extirpated from most of its historic range prior to extensive fishery surveys. It was listed as endangered on April 23, 1980. Currently, no documented self-sustaining populations exist in the wild. Formerly reported as widespread and abundant in mainstem rivers (Jordan and Evermann 1896), its populations have been greatly reduced. Remnant populations presently occur in the wild in low numbers in Lake Mohave and several fish have been captured in Lake Powell and Lake Havasu (USFWS 2002d). The last known riverine area where bonytail were common was the Green River in Dinosaur National Monument, where Vanicek (1967) and Holden and Stalnaker (1970) collected 91 specimens during 1962-1966. From 1977 to 1983, no bonytail were collected from the Colorado or Gunnison rivers in Colorado or Utah (Wick et al. 1979, 1981; Valdez et al. 1982; Miller et al. 1984). However, in 1984, a single bonytail was collected from Black Rocks on the Colorado River (Kaeding et al. 1986). Several suspected bonytail were captured in Cataract Canyon in 1985-1987 (Valdez 1990). Current stocking plans for bonytail identify the middle Green River and the Yampa River in Dinosaur National Monument as the highest priority for stocking in Colorado and the plan calls for 2,665 fish to be stocked per year over the next six years (Nesler et al. 2003).

Recovery goals for the bonytail (USFWS 2002d) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that (a) the trend in adult (age 4+; > 250 mm total length) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (150–249 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults (4,400 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- a genetic refuge is maintained in a suitable location (e.g., Lake Mohave, Lake Havasu) in the lower basin recovery unit; and

- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults; and

- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults; and

- a genetic refuge is maintained in the lower basin recovery unit; and

- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults; and

- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

The bonytail is considered a species that is adapted to mainstem rivers, where it has been observed in pools and eddies (Vanicek 1967; Minckley 1973). Spawning of bonytail has ne been observed in a river, but ripe fish were collected in Dinosaur National Monument during June and early July suggesting that spawning occurred at water temperatures of about 18°C (Vanicek and Kramer 1969). Similar to other closely related *Gila* species, bonytail probably spawn in rivers in spring over rocky substrates; spawning has been observed in reservoirs ov rocky shoals and shorelines. It has been recently hypothesized that flooded bottomlands ma provide important bonytail nursery habitat. Of five specimens captured most recently in the upper basin, four were captured in deep, swift, rocky canyons (Yampa Canyon, Black Rocks Cataract Canyon, and Coal Creek Rapid), but the fifth was taken in Lake Powell. Since 197 bonytails captured in the lower basin were caught in reservoirs.

Threats to the Species

The primary threats to bonytail are stream flow regulation and habitat modification (affectin constituent elements: water and physical habitat); competition with and predation by nonnati fishes; hybridization with other native *Gila* species; and pesticides and pollutants (USFWS 2002d) (affecting constituent element: biological environment). The existing habitat, altered these threats, has been modified to the extent that it impairs essential behavior patterns, such breeding, feeding, and sheltering. The threats to bonytail in relation to flow regulation and habitat modification, predation by nonnative fishes, and pesticides and pollutants are essentially the same threats identified for Colorado pikeminnow. Threats to bonytail in relation to hybridization are essentially the same threats identified for humpback chub.

Management actions identified in the recovery goals for bonytail (USFWS 2002d) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations;
- provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion;
- investigate options for providing appropriate water temperatures in the Gunnison River;
- minimize entrainment of subadults and adults at diversion/out-take structures;
- investigate habitat requirements for all life stages and provide those habitats;
- ensure adequate protection from overutilization;
- ensure adequate protection from diseases and parasites;
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries;
- control problematic nonnative fishes as needed;
- minimize the risk of increased hybridization among *Gila* spp.;
- minimize the risk of hazardous-materials spills in critical habitat; and
- remediate water-quality problems.

Status of Bonytail and Critical Habitat in the Action Area

Bonytail were extirpated between Flaming Gorge Dam and the Yampa River, primarily because of rotenone poisoning and cold-water releases from the dam (USFWS 2002c). Surveys from 1964 to 1966 found large numbers of bonytail in the Green River in Dinosaur National Monument downstream of the Yampa River confluence (Vanicek and Kramer 1969). Surveys from 1967 to 1973 found far fewer bonytail (Holden and Stalnaker 1975). Few bonytail have been captured after this period, and the last recorded capture in the Green River was in 1985 (USFWS 2002d). Bonytail are so rare that it is currently not possible to conduct population estimates. A stocking program is being implemented to reestablish populations in the upper Colorado River basin.

In the Green River, Vanicek (1967) reported that bonytails were generally found in pools and eddies in the absence of, although occasionally adjacent to, strong current and at varying depths generally over silt and silt-boulder substrates. Adult bonytail captured in Cataract, Desolation, and Gray Canyons were sympatric with humpback chub in shoreline eddies among emergent boulders and cobble, and adjacent to swift current (Valdez 1990). The diet of the bonytail is presumed similar to that of the humpback chub (USFWS 2002d).

The only known bonytail that presently occur in the Yampa River are the individuals recently reintroduced at Echo Park, near the confluence with the Green River. In July of 2000 approximately 5,000 juveniles (5 to 10 cm) were stocked. Between 1998 and 2003, the number of bonytail stocked in the Green River subbasin was 189,438 fish, with majority of the fish being juveniles at the time of stocking.

Critical habitat for bonytail includes canyon reaches of the Green River (Whirlpool, Split Mountain, Desolation, and Gray Canyons), which have been affected by stream flow regulation. However, Whirlpool and Desolation Canyons have recently been invaded by high numbers of smallmouth bass changing the biological environment of critical habitat.

Although sufficient information on physical processes that affect bonytail habitats was not available to recommend specific flow and temperature regimes in the Green River to benefit this species, Muth et al. (2000) concluded that flow and temperature recommendations made for Colorado pikeminnow, razorback sucker, and humpback chub would presumably benefit bonytail and would not limit their its future recovery potential.

Ute Ladies'-Tresses

Species/Critical Habitat Description

The Ute ladies'-tresses is a perennial orchid (family Orchidaceae). Its leaves are up to 1.5 cm (0.6 in.) wide and 28 cm (11 in.) long; the longest leaves are near the base. The usually solitary flowering stem is 20 to 50 cm (8 to 20 in.) tall, terminating in a spike of 3 to 15 white or ivory flowers. Flowering is generally from late July through August. However, depending on location and climatic conditions, it may bloom in early July or may still be in flower as late as early October. No critical habitat has been designated for the species.

Status and Distribution

The current range of Ute ladies'-tresses includes Colorado, Idaho, Montana, Nebraska, Utah, Washington, and Wyoming, with an historical occurrence in Nevada. Ute ladies'-tresses are known from 11 counties in Utah, and 10 counties in Colorado.

Populations of Ute ladies'-tresses orchids are known from three broad general areas of the interior western United States: near the base of the eastern slope of the Rocky Mountains in southeastern Wyoming and adjacent Nebraska and north-central and central Colorado; in the upper Colorado River basin, particularly in the Uinta Basin; and in the Bonneville Basin along the Wasatch Front and westward in the eastern Great Basin, in north-central and western Utah, extreme eastern Nevada and southeastern Idaho. The orchid has recently been discovered in southwestern Montana and in the Okanagan area and along the Columbia River in north-central Washington.

Life History

Ute ladies'-tresses orchid is endemic to moist soils or wet meadows near springs, lakes, or perennial streams. The range in elevation of known Ute ladies'-tresses orchid occurrences in Utah is from 1,300 to 2,100 meters (4,300 to 7,000 feet) (Stone 1993). The orchid occurs along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams. It typically occurs in stable wetland and seepy areas associated with old landscape features within historical floodplains of major rivers. It is also found in wetland and seepy areas near freshwater lakes or springs (U.S. Fish and Wildlife Service 1992b, L. Jordan, U.S. Fish and Wildlife Service, pers. comm., 1998). Jennings (1990) and Coyner (1989) observed that Ute ladies'-tresses orchids seem to require "permanent sub-irrigation," indicating a close affinity with floodplain areas where the water table is near the surface throughout the growing season and into the late summer or early autumn. This observation has been corroborated by ground water monitoring research conducted in Dinosaur National Monument (Martin and Wagner 1992), Boulder, Colorado (T. Naumann, City of Boulder Open Space Department, pers. comm., 1993), and Diamond Fork Canyon, Utah (Black 1998). Soils are generally silty-loam, but occurrences in peat and other highly organic substrates are known (Hreha and Wallace 1994, L. Jordan, U.S. Fish and Wildlife Service, pers. comm., 1998).

The Ute ladies'-tresses orchid occurs primarily in areas where the vegetation is relatively open and not overly dense or overgrown (Coyner 1989 and Jennings 1989, 1990). A few populations in eastern Utah and Colorado are found in riparian woodlands, but generally the species seems intolerant of shade, preferring open, grass, sedge, and forb-dominated sites. Where colonies occur in more wooded areas, plants are usually found on the edges of small openings and along trails. Plants usually occur as scattered groups comprised of a few individuals (5 to 50) and occupy relatively small areas within the riparian system. However, large and dense colonies are known from several of the more stable historic floodplain meadow sites (Stone 1993, L. Jordan, U.S. Fish and Wildlife Service, pers. comm., 1998).

The Ute ladies'-tresses orchid appears to be well adapted to disturbance caused by water movement through floodplains (T. Naumann, City of Boulder Open Space Department, pers. comm., 1992, L. Riedel, National Park Service, pers. comm., 1994). In riparian settings, the species is most typically found in mid-successional habitats (i.e. well established soils and vegetation) within older floodplain features (for example, oxbows and high flow channels). These sites may receive periodic inundation that helps maintain their hydrologic and vegetation characteristics. However, they are generally scoured or significantly reworked by flows that occur at a frequency of approximately 10 years.

Very little is known about the life history and demography of the Ute ladies'-tresses orchid. The orchid first appears aboveground as a rosette of thickened grasslike leaves that is very difficult to distinguish from other vegetation. A distinctive flower stalk appears in late summer (July through September), at which point location, identification, and population size estimates are typically determined. Some individuals remain under ground or do not flower each year (Arft 1993). The percentage of flowering individuals in a population can range from 23% to 79% (Ward and Naumann 1998). Thus, fluctuations in numbers of observed flowering individuals do not necessarily correspond to population fluctuations or indicate habitat alterations. The life span of individuals is unknown.

Ute ladies'-tresses orchid requires pollinators for reproduction. Because of the unique anatomy of orchid flowers, only certain insects can affect pollination. To date, both bumblebees (*Bombus* spp.) and anthophorans (*Anthophora* spp.) (Sipes and Tepedino, 1995a, 1995b) have been identified as species able to accomplish pollination. These insects visit the orchids for the nectar and pollination is accomplished incidentally. Because these pollinators require both pollen and nectar to nourish their young, other flowering species (that provide pollen) must also be available in the same area and at the same time. Furthermore, these insects must have suitable habitat nearby.

Population estimates are generally based upon observations of flowering individuals, although on occasion it is possible to observe and count non-flowering individuals that have produced vegetative aboveground growth (basal rosette). Information on establishment, recruitment, and longevity is lacking. Therefore, it is usually undeterminable whether a marked individual that fails to flower has died or is merely dormant. Criteria have not been established for determining mortality based on the number of seasons without appearance of aboveground parts.

Apparent population numbers, based on flowering individuals, fluctuate greatly, confounding at least short-term estimates of population trends. For example, in Diamond Fork Canyon in Utah, one colony was counted as 203 individuals in 1992 and 2,214 individuals in 1993. Another colony had 27 individuals in 1992, 615 individuals in 1993, and 91 individuals in 1994 (Central Utah Water Conservancy District 1998) The Van Vleet colony at City of Boulder Open Space had nearly 5,500 flowering individuals in 1986, only about 200 in 1987, and over 3,000 in 1992 (Arft 1995). Without a better understanding of life history and species response to environmental factors, it would likely require decades of monitoring at a site to determine long term population dynamics.

Although the range of the orchid is large, it typically occurs as localized clusters of colonies. Most colonies are small, with fewer that 100 individuals, and many fewer than 10. A few colonies have large numbers of individuals, in some cases between 5,000 and 10,000 individuals, however, these large colonies may be the only occurrence of the orchid in that portion of its range. In 1995, the total estimated population size was 20,500 individuals. With discoveries since 1995, population estimates have increased. However, as of the date of this document, the total population size of Ute ladies'-tresses orchid is estimated at less than 60,000 individuals.

Threats to the Species

The Ute ladies'-tresses was federally listed as threatened on January 17, 1992 (USFWS 1992b). As stated and documented in the final listing rule, this action was taken, in part, because of (1) the threats of habitat loss and modification and (2) because the orchid's small population and low reproductive rate make it vulnerable to other threats.

Threats to populations of Ute ladies'-tresses include modification of riparian habitats by urbanization, stream channelization and other hydrologic changes, conversion of lands to agriculture and development, heavy summer livestock grazing, and hay mowing during the flowering period. Most populations are small and vulnerable to extirpation by habitat changes or local catastrophic events (USFWS 1992b). Several historic populations in Utah and Colorado have been extirpated.

Status of Ute's Ladies-Tresses in the Action Area

A large number of colonies of Ute ladies'-tresses occur along the Green River within Reach 1. The occurrence of Ute ladies'-tresses is influenced by river-channel geometry, hydrology, and depositional and erosional patterns (Ward and Naumann 1998). Surveys conducted in 1999 located colonies of Ute ladies'-tresses at 10 sites in Red Canyon, 23 sites in upper Browns Park, and two sites in lower Browns Park (Grams et al. 2002). Surveys in 1998 had identified colonies at the two sites in lower Browns Park and at 81 sites in Lodore Canyon (Ward and Naumann 1998). The numbers of Ute ladies'-tresses at these locations were generally low, ranging from one to 50; however, several sites in Lodore Canyon contained hundreds of flowering individuals.

Within Reach 1, most Ute ladies'-tresses occur on the post-dam floodplain and intermediate bench geomorphic surfaces; both of these features formed in response to Flaming Gorge Dam operations (Ward and Naumann 1998; Grams et al. 2002). The post-dam floodplain is a relatively flat surface that is inundated annually by 130 m^3/s (4,600 cfs) flows, and averages 0.8 m (2.6 ft) above the elevation of base flow (23 m^3/s [800 cfs]). The intermediate bench which is also a relatively flat surface, is higher in elevation, is a greater distance from the river margin, and averages 1.9 m (6.2 ft) above base flow. The intermediate bench is inundated only by flows that exceed powerplant capacity, such as occurred in 1997 (244 m^3/s [8,600 cfs]) and 1999 (308 m^3/s [10,900 cfs]) (Grams et al. 2002). Nearly all of the occupied sites in Red Canyon and upper Browns Park occur at or just downstream of rapids or riffles, and most occur on the intermediate bench (Grams et al. 2002).

In Lodore Canyon, Ute ladies'-tresses occurs most commonly on channel expansion cobble bars, which are located downstream of tributary debris fans. As in Browns Park, Lodore Canyon substrates supporting Ute ladies'-tresses typically consist of cobbles in a sand matrix or a sand veneer over cobbles. Species associated with Ute ladies'-tresses include wild licorice, redtop (*Agrostis stolonifera*), marsh paintbrush (*Castilleja exilis*), sea milkwort (*Glaux maritima*), Western evening primrose (*Oenothera elata*), and silverweed cinquefoil (*Potentilla anserina*) (Ward and Naumann 1998). Otherwise suitable surfaces that have been invaded by tamarisk may support few or no Ute ladies'-tresses.

Within Reach 2, Green River flows are strongly influenced by flows from the Yampa River, and suitable habitat for Ute ladies'-tresses is less common (Ward and Naumann 1998). In Island Park and Rainbow Park, Ute ladies'-tresses typically occurs on post-dam floodplain and intermediate bench surfaces, which are inundated more frequently than in Reach 1. In this portion of the river, the post-dam floodplain averages 1.3 m (4.3 ft) above base flow and is inundated at about 455 m^3/s (16,100 cfs), the post-dam 2-year flood. The intermediate bench averages 2.4 m (7.9 ft) above base flow and likely is inundated by flows above 600 m^3/s (20,000 cfs). Most occurrences of Ute ladies'-tresses were found on surfaces approximately 1 m (3 ft) above the 93 m^3/s (3,300 cfs) elevation. In this reach, nine colonies of Ute ladies'-tresses were found in Island and Rainbow Parks in 1998, and two colonies were found below Split Mountain Canyon (Ward and Naumann 1998). An additional three colonies were found below Split Mountain Canyon in 1999 (Grams et al. 2002). Species associated with Ute ladies'-tresses in Reach 2 include wild licorice, prairie cordgrass (*Spartina pectinata*), coyote willow, western goldenrod (*Solidago occidentalis*), common dogbane, common scouring rush (*Equisetum hyemale*), common reed, and marsh paintbrush. Although terraces dominated by Fremont cottonwood and box elder are generally too dry for Ute ladies'-tresses, and average 4.2 m (14 ft) above base flow, a small colony of Ute ladies'-tresses (about 20 individual plants) was located on such a terrace in Island Park. The site showed no evidence of inundation (Ward and Naumann 1998). No Ute ladies'-tresses have been found in Reach 3.

ENVIRONMENTAL BASELINE

The environmental baseline represents the past and present impacts of all Federal, State, or private actions and other human activities in an action area, the anticipated impacts of all proposed Federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process (USFWS and NMFS 1998b). Environmental baselines do not include the effects of the Federal action(s) under review in the consultation. As such, the environmental baseline for this biological opinion is represented by the current physical and biological conditions within the Green River. For the purposes of this consultation baseline hydrology is considered to be those flows that would be released to meet the flow objectives for the 1992 FGBO which has also been defined as the No Action Alternative in the FGEIS. The hydrologic model developed by Clayton and Gilmore (2002) provides the baseline flow conditions for the Green River under existing (No Action) conditions and the proposed action.

The current condition of the physical environment and status of the listed species considered in this opinion also reflect the effects of past and ongoing activities and events. Consequently, the description of the environmental baseline presented herein includes a description of the changes that have occurred in the environment (including those resulting from flow regulation) and how those changes have affected listed species and their habitats.

General Description of the Green River subbasin

The Green River subbasin occupies a total area of 115,800 km^2 (45,000 mi^2) in Wyoming, Colorado, and Utah. The Green River originates in the Wind River Range of Wyoming and flows south about 1,230 km (764 mi) through Colorado and Utah, joining the Colorado River in Canyonlands National Park. The Green River is the largest tributary of the Colorado River. Nearly half of the flow of the Colorado River at its confluence with the Green River is from the Green River subbasin.

Precipitation varies considerably across the Green River subbasin. In the semiarid rangelands, which make up most of the basin's area, annual precipitation is generally less than 25 cm (10 in.). In contrast, many of the mountainous areas that rim the upper portion of the basin receive, on average, more than 1.0 m (3.3 ft) of precipitation per year.

Most of the total annual stream flow in the Green River subbasin is provided by snowmelt. Because of this, natural flow is very high in late spring and early summer and diminishes rapidly in midsummer. Although flows in late summer through autumn can increase following rain events, natural flow in late summer through winter is generally low.

Dams and reservoirs have been constructed in the basin mainly to supply water for irrigated agriculture. The largest depletion in the Green River subbasin occurs in the Duchesne River Basin. In addition to depleting flow volume, reservoirs modify the pattern of flow in the Green River to meet demands of irrigation, power generation, recreation, and other uses. Of the reservoirs in the basin, Flaming Gorge, which is capable of storing approximately twice the annual inflow, has the largest effect on Green River flow patterns.

Historic and current operations of Flaming Gorge Dam have reduced the sediment load in the river downstream. This reduction results primarily from the presence of the dam, which traps sediment. Following completion of the dam, Andrews (1986) estimated that mean annual sediment discharge at the USGS gage near Jensen, Utah, decreased by 54% compared with the average annual pre-dam suspended sediment load. Similarly, the decrease in mean-annual sediment load at the USGS gage near Green River, Utah, was estimated to be 48% following completion of Flaming Gorge Dam (Andrews 1986). Andrews (1986) also noted that the decrease in mean annual suspended sediment load at Jensen is approximately equal to the incoming sediment load to Flaming Gorge Reservoir. At Green River, Andrews (1986) noted that the decrease in suspended sediment load following reservoir closure greatly exceeded the amount of sediment trapped in the reservoir. Sediment inflow to the Green River downstream from the Duchesne River exceeds the transport of sediment out of Reach 3 (Andrews 1986).

Description of the Green River Downstream of Flaming Gorge Dam

The longitudinal profile of the Green River downstream from Flaming Gorge Dam includes steep- and low-gradient segments, and the gradients of these segments do not systematically decrease in a downstream direction. In general, low-gradient reaches of the river have sandy substrates, while steeper-gradient segments have gravel or cobble substrates (Schmidt 1996).

Reach 1, between Flaming Gorge Dam and the Yampa River confluence, is about 104 km (65 mi) long (Figure 1). Reach 1 is straight to meandering and, with the exception of Browns Park, tightly confined by the adjacent steep-walled canyon topography of Red Canyon and Lodore Canyon. Except for usually minor flow contributions from tributary streams, flow in Reach 1 is completely regulated by Flaming Gorge Dam. The mean annual discharge (about 60 m^3/s [2,100 cfs]) has not been affected by Flaming Gorge Dam operations, but the pattern of flow has changed. Prior to regulation, the seasonal flow pattern for Reach 1 featured high spring flows and low summer, autumn, and winter base flows. Releases for power generation have resulted in relatively more uniform monthly release volumes but greater within-day variation.

Reach 2, between confluences with the Yampa River and White River, is about 158 km (98 mi) long (Figure 1). This reach is relatively long and meandering, with numerous segments that hav different geomorphic characteristics. Included in this reach are Whirlpool Canyon, Rainbow Park, Island Park, Split Mountain Canyon, and the alluvial areas of the Uinta Basin. Bed materials range from cobbles to sand, and vegetated and unvegetated islands are common. The Uinta Basin portion of Reach 2 contains important nursery habitats for the Colorado pikeminno (in-channel backwaters) and razorback sucker (inundated floodplains). Reach 2 exhibits a more natural flow and sediment regime than Reach 1 because of inputs from the relatively unregulate Yampa River. Despite this input, the magnitude of the mean annual flood at the Jensen gage has decreased 26% since closure of Flaming Gorge Dam. The Yampa River adds about 1.7 million metric tons (1.9 million tons) of sediment to the Green River annually.

Reach 3, between the White River and Colorado River confluences, is about 394 km (245 mi) long (Figure 1). The White and Duchesne Rivers, at the upper end of Reach 3, add considerable sediment (about 4.4 million metric tons or 4.9 million tons per year) to the Green River. A portion of the flow of the Duchesne River is diverted out of the Green River subbasin. Before entering Desolation and Gray Canyons in Reach 3, the Green River meanders through the Uinta Basin. Numerous sandbars occur in this portion of the reach at low flow, and low-elevation floodplain areas are prominent. In Desolation and Gray Canyons, gravel bars are abundant, and many of the banks are composed of coarse debris-flow material or talus. Recirculating eddies are also prevalent, and there are many regions of stagnant flows in these canyons. The lower 148 km (92 mi) of the Green River flows through the low gradient Labyrinth and Stillwater Canyons.

Green River Flows

Flow in the Green River is dominated by snowmelt; consequently, there was a great deal of seasonal variability in the flow regime prior to regulation. Regulation has resulted in a reduction of flows from April through July and an increase in flows from August through March (Table 2). Reach 1, whose flow is dominated by releases from Flaming Gorge Dam, has been most affected (Figure 2). The effects of regulation are reduced in Reaches 2 and 3, because intervening tributaries, especially the Yampa River, contribute flows with seasonal distributions that are less affected by regulation. Nevertheless, flow variability in the system has been reduced in all three reaches.

TABLE 2 Percent Change in Mean Monthly Flow of the Green River Because of Regulation

	Percent Change in Mean Flow											
River Reach/Gage	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Reach 1/Greendale	+80	+120	+246	+214	+143	+8	-30	-50	-70	-46	+16	+72
Reach 2/Jensen	+52	+71	+140	+121	+82	+6	-13	-17	-35	-32	+10	+54
Reach 3/Green River	+31	+39	+89	+83	+53	+6	-10	-13	-27	-28	+2	+34

The magnitude of annual spring peak flows has been reduced since construction of Flaming Gorge Dam(Figure 2). Before construction of Flaming Gorge Dam, median spring peak flow in Reach 1 was about 330 m^3/s (11,700 cfs); it was reduced to about 85 m^3/s (3,000 cfs) after the dam was built. Releases greater than 200 m^3/s (7,000 cfs) have occurred five times since the dam was completed; such releases occurred in 1983, 1984, 1986, 1997, and 1999. The Flaming Gorge hydrology model (Clayton and Gilmore 2002) predicted that under baseline operations to meet the requirements of the existing 1992 FGBO, safe evacuation of water from the reservoir during wetter years would necessitate use of the bypass tubes in 23% of all years and use of the spillway in 5% of all years.

The frequency of high peak flows also has been reduced by regulation. The difference between regulated and unregulated flows is greatest in Reach 1, with effects of regulation diminishing downstream (Figure 2). At the Jensen gage (Reach 2), the median peak flow was 669 m^3/s (23,625 cfs) without regulation and 448 m^3/s (15,820 cfs) with regulation (Table 3). At the Green River gage (Reach 3), the median peak flow has been reduced from 788 m^3/s (27,800 cfs) to 575 m^3/s (20,300 cfs). The percent reduction in peak flows is provided in Table 5.

The duration and timing of peak flows have also been affected by regulation. Unregulated flows of 475 and 575 m^3/s (16,800 and 20,300 cfs) were exceeded at the Jensen gage 8% and 4% of the time, respectively. With regulation, however, these two flows are exceeded only 3% and 1% of the time. On average, peak flows now occur earlier in the year than they did before regulation. For Reaches 2 and 3, regulated peak flows generally occur about a week earlier than unregulated peak flows.

TABLE 3 Probabilities of Exceedance for Regulated and Unregulated Flows of the Green River at the USGS Stream Gages near Jensen (Reach 2) and Green River, Utah (Reach 3), 1963–1996

Probability of Exceedance (%)	Recurrence Interval (years)	Flow at Jensen Gage (m^3/s)[a]		Flow at Green River Gage (m^3/s)[a]	
		Regulated	Unregulated	Regulated	Unregulated
50	2	448	669	575	788
20	5	618	934	836	1,132
10	10	727	1,076	1,003	1,321
5	20	827	1,192	1,158	1,477
1	100	1,045	1,396	1,495	1,753

[a] To convert from m^3/s to cfs, multiply by 35.3.

TABLE 4 Percent Reduction in Annual Peak Flows of the Green River because of Regulation at Various Exceedance Values, 1963–1996

River Reach/Gage	Percent Flow Reduction Because of Regulation at Various % Exceedance Values								
	10	20	30	40	50	60	70	80	90
Reach 1/Greendale	-61	-73	-70	-67	-63	-61	-60	-58	-52
Reach 2/Jensen	-32	-34	-34	-34	-33	-32	-30	-28	-23
Reach 3/Green River	-24	-26	-27	-27	-27	-26	-25	-23	-19

About 70% of the annual natural flow of the Green River occurs between April and July as a result of melting snow. During the remainder of the year, natural flows (base flows) are generally low. The source of unregulated base flows is predominately groundwater, with occasional augmentation by rain and snowmelt. Regulation and the establishment of the 23-m^3/s (800-cfs) minimum release from Flaming Gorge Reservoir have resulted in higher base flows than occurred pre-dam.

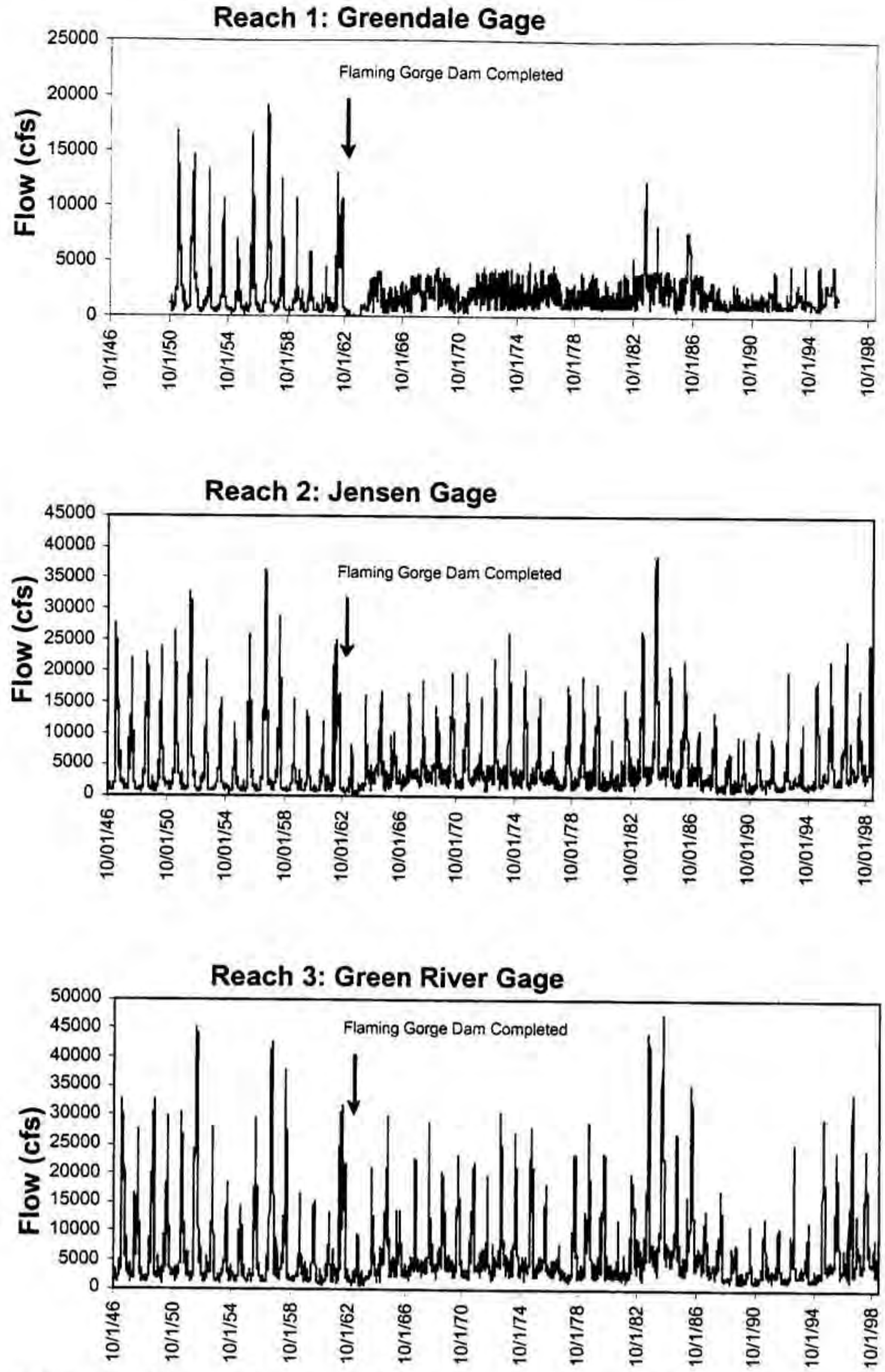

FIGURE 2 Mean Daily Flows in Reaches 1, 2, and 3 of the Green River

Although unregulated base flows in the Green River are generally considered stable, variability in flows occurs during the base-flow period even without hydropower-induced fluctuations. Variability can occur at a number of different time scales, including between years, within years, between days, and within days. Between-year variability in base flows is largely related to annual hydrologic conditions, with higher base flow in wetter years than in drier years. Within-year variability in base flow as measured at the Jensen gage in Reach 2 was higher during the pre-dam period (48% coefficient of variation [CV]) than during the post-dam period (25% CV). Variability during both pre-dam and post-dam periods was less in the winter (December through February) than in the summer and autumn (August through November). During the pre-dam period there was less within-year variability in drier years than in wetter years. Between-day differences in base flows were about 3% (range, 0 to 68%) pre-dam and 5% (range, 0 to 139%) post-dam.

Water-surface elevation (stage) is dependent on flow, but the nature of that relationship varies along the river and is strongly influenced by channel morphology. Stage-flow relationships at the Greendale, Jensen, and Green River gages are presented in Figure 3. This figure illustrates the differences in the relationship at these different locations and the asymptotic nature of each relationship (i.e., as flow increases, the relative incremental increase in stage lessens). Differences in channel width and floodplain characteristics at each location are reflected in the shape of the curves depicted in Figure 3. The river is considerably wider at the Jensen and Green River gages than at Greendale; consequently, as flow increases, the rate of stage change at Jensen and Green River gages is less than the rate at the Greendale gage.

Variations in channel morphology along the river and tributary inputs serve to dampen flow and stage fluctuations that result from hydropower operations at Flaming Gorge Dam. The degree of attenuation of operations-induced fluctuations also depends on specific release parameters, including the ramp rate (the rate of change from minimum and maximum flow expressed as m^3/s/h or cfs/h), minimum and maximum flow levels, and duration of peak releases. This dampening, or attenuation, becomes greater at increasing distances from the dam.

Immediately downstream of Flaming Gorge Dam, flows can change from 23 m^3/s to 130 m^3/s (800 to 4,600 cfs) within a 24-hour period during maximum power-plant-capacity operations. This daily fluctuation would become attenuated downstream, and, under the same operational regime, flows would vary from 62.3 to 141.6 m^3/s (2,200 to 5,000 cfs) at the Jensen gage. These releases would produce daily stage changes of 1.5 m (5 ft) at Greendale and 0.6 m (2 ft) at Jensen (Yin et al. 1995). During August and September, operations that comply with the 1992 FGBO produce flows within a day that vary from 28 to 85 m^3/s (1,000 to 3,000 cfs) at Greendale and 38 to 48 m^3/s (1,300 to 1,700 cfs) at Jensen. These daily flow changes produced stage changes of 90 cm (36 in.) at Greendale and 10 cm (4 in.) at Jensen (Yin et al. 1995). Further attenuation occurs between Jensen and Ouray in Reach 2, and hydropower-related fluctuation effects are difficult to detect by Green River, Utah, in Reach 3.

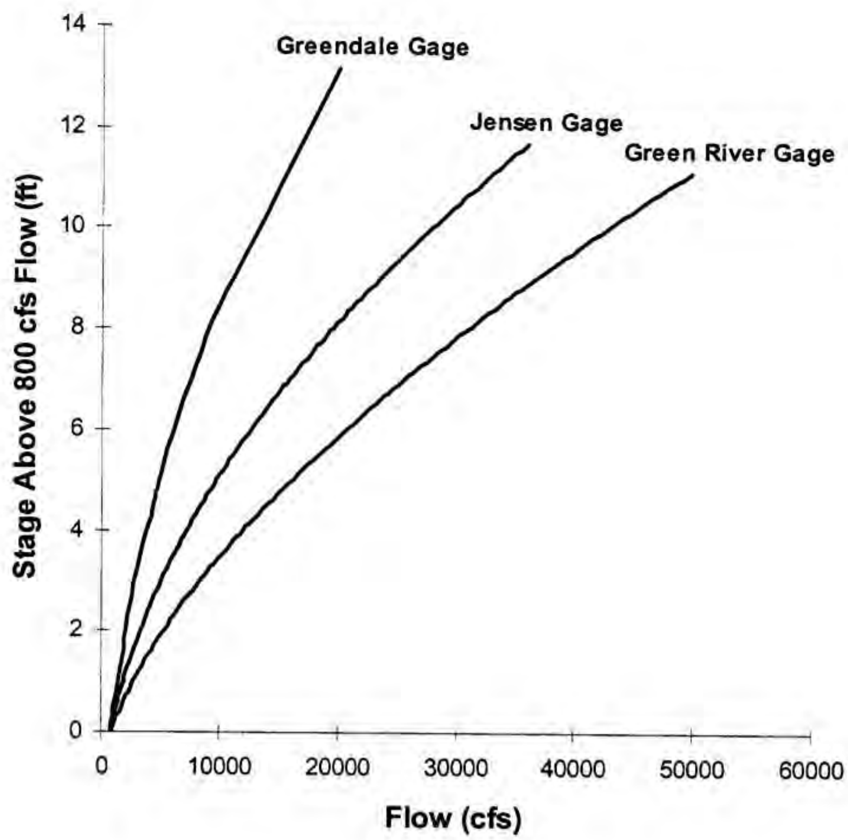

FIGURE 3 Relationships between Stage and Flow in the Green River at the USGS Stream Gages near Greendale, Jensen, and Green River, Utah

Green River Water Temperatures

Winter snows accumulate in the Green River subbasin from October through mid-April. When air temperatures in the basin begin to rise in March and April, snowmelt and runoff begin. As flow increases, the cold water gets warmer as a result of interactions with the channel bed, the atmosphere, and direct solar radiation.

Summer water temperature is important to the endangered fishes because temperature affects the productivity of the aquatic food base, growth and survival of larval fish, and conditioning of adult fish. Summer water temperature is a function of specific weather conditions and the volume and temperature of releases from Flaming Gorge Dam during this period.

As a general rule, in water years[2] with more snowmelt and runoff, the water temperatures remain colder into summer. Water years in which snowmelt and runoff occur early (such as in water

2 A "water year" begins on October 1 and extends through September 30 of the next calendar year.

year 1962, when the peak flow occurred from mid-April to mid-May) are exceptions. During water year 1995, which had a high volume of water with long peak-flow duration, water temperatures stayed low well into July. During water years with less water, water temperatures get warmer earlier in the season because base flows are low and are reached earlier in the year.

The dominant factor influencing water temperature in Reach 1 is the temperature of water released from Flaming Gorge Dam. Release temperature is adjusted through the use of a selective withdrawal structure. During typical winter operations, water is drawn from deep within the reservoir. Released water is 4°C (39°F) and is the warmest available at this time of year. During spring (beginning in late May), warmer water from nearer the surface is released. Reservoir operators adjust the withdrawal system to find a layer of water with a temperature of 13°C (55°F) throughout the summer, so that a constant temperature of release water is maintained until mid-October, when the released water is colder. Because temperatures of water that can be released through the selective withdrawal structure are affected by the rate at which the reservoir stratifies and warms, releases through the selective withdrawal structure are cooler from June through August than pre-dam water temperatures in the Green River, but are warmer during September and October. During the autumn, warmer release temperatures persist later than would have occurred in the river before the dam was constructed.

Air temperature strongly affects water temperature, but this effect is influenced by flow volume (Bestgen and Crist 2000). At higher flows, the water is slower to respond to air temperatures than it is at lower flows. Thus, in summer, higher flows tend to be colder and slower to warm than lower flows. The influence of ambient air temperature increases in importance in a downstream direction. Because ambient air temperature has such a large effect, annual variations in regional weather patterns play an important role in determining the thermal regime of the Green River downstream of Flaming Gorge Dam.

As the river flows through Browns Park, it widens and water temperature increases. From Browns Park, the river enters Lodore Canyon, which has a north-south orientation that limits exposure to direct solar radiation. Summer water temperature in the Green River from the Gates of Lodore to the confluence with the Yampa River typically increases about 2°C (4°F) as the rock mass of the canyon radiates heat to the air and water.

Thermal mixing at the confluence of the Green and Yampa Rivers is seasonally dynamic and has an important effect on Green River water temperatures. During winter, water released from Flaming Gorge Dam is warmer than Yampa River water. Although the Yampa River begins to get warmer in spring, temperature in the Green River remains low and stable as a result of cool Flaming Gorge Dam releases. From the beginning of spring runoff through mid-summer, the temperature of the Green River downstream of the confluence is strongly influenced by the temperature of the relatively large spring flows from the Yampa River. During late summer, the situation reverses as the temperature is controlled by the cooler, higher-volume releases from Flaming Gorge Dam.

From the Yampa River confluence, the Green River flows west into Whirlpool Canyon and then into Island and Rainbow Parks. Water temperature increases in Island and Rainbow Parks during the summer because the river slows down and spreads out, exposing the water to a large channel and radiant solar energy. From Rainbow Park, the river drops into Split Mountain Canyon, where it is shaded by canyon walls and where its water velocity increases. Consequently, the water temperature changes little through this canyon. The Green River enters the Uinta Basin near Jensen, Utah. Through this broad alluvial area, the river spreads out into a wide meandering channel, and, during summer, the water temperature further increases.

The Duchesne and White Rivers join the Green River near Ouray, Utah, but do not appreciably change the temperature of the Green River. Several miles downstream from the confluence of the Green River with the White and Duchesne Rivers, the Green River enters Desolation and Gray Canyons, where diel fluctuations in water temperature are moderated by warmth from the canyon walls radiating to the air and water at night.

Downstream from Gray Canyon, the Green River enters a second large alluvial plain, where the city of Green River, Utah, is located. The river channel widens in this area, water velocity decreases, and water temperature increases slightly. Below Green River, the increase in solar radiation is significant; day and night temperatures are higher and the river is warmer here than upstream.

Flaming Gorge flow and temperature recommendations (Muth et al. 2000) state that temperatures in upper Lodore Canyon should reach at least 18 C (64 F) for two to five weeks at the beginning of the base flow period and that Green River water temperatures should not be more than 5 C (9 F) colder than water from the Yampa River at the confluence of the Green and Yampa Rivers during the summer base flow period. Maximum daily water temperatures in Browns Park have occasionally met or exceeded the 18 C (64 F) target during June, July, and August, but only in July was the temperature target met or exceeded on more than 10% of days. Water measurements made in the Green and Yampa Rivers near the confluence since 1998 indicate that the mean difference between water temperatures of the two streams at the confluence was less than 5 C (9°F) during the months of June through July. However, maximum differences during all months exceeded 5 C (9 F).

Geomorphic Processes in the Green River

Channel Morphology

The Green River downstream of Flaming Gorge Dam consists of a series of linked segments of three channel planform types without a systematic downstream change from one planform to the next. The channel planform types are restricted meanders, fixed meanders, and canyons with abundant debris fans.

Restricted meanders occur in broad alluvial terraces that are bounded by relatively more resistant geology. Valleys in which restricted meanders occur are relatively wide (greater than 1.5 km [1 mi]), and only the outside bends are in contact with bedrock. Restricted meanders occur in Reach 1 (Browns Park) and much of Reach 2.

Fixed meanders are confined by resistant geology on both outside and inside bends and result from symmetrical incision associated with rapid down cutting through the geologic formation. Labyrinth Canyon in Reach 3 is characterized by fixed meanders.

Typical elements of fixed and restricted meanders include the channel, vegetated islands, unvegetated bank-attached compound bars, unvegetated island-attached compound bars, and unvegetated mid-channel compound bars. Permanent islands are less common in fixed meanders than in restricted meanders. In-channel deposits are typically sand, although gravel bars sometimes occur. Typically, bank-attached compound bars occur on alternating sides of the river. Shoreward from these bars is the vegetated floodplain at the edge of the "bankfull" channel (i.e., the channel that can accommodate stream flow without overtopping the banks), and streamward from the bars is the meandering thalweg.

At low discharge, exposed compound bars have an irregular topography caused by chute channels that dissect the bar platform. Chute channels are oriented in a downstream direction, crossing from the streamward to shoreward side at the upstream end of the bar and from the shoreward to streamward side at the downstream end of the bar. The topography of a bar is more complex where there are more chute channels. At some sites and in some years, secondary bars become attached to the shoreward margins of these compound bars. At the downstream end of most compound bars, chute channels may converge into one persistent and deep secondary channel that separates the downstream end of the compound bar from the floodplain. The remainder of the bars consists of broad, level platforms and linear ridges that may be partly vegetated.

As flow recedes from the annual peak discharge, higher-elevation portions of the bar platform are exposed, and small areas of separated flow develop in the lee of these islands. At these discharges, chute channels actively transport sediment. Upon further recession of flow, chute channels at the upstream end of the compound bar become exposed, and flow in the secondary channel ceases. Thereafter, the secondary channel becomes an area of mostly stagnant water. These low-velocity areas (backwaters) provide important nursery habitats for larval fish, especially the Colorado pikeminnow.

Canyons consist of relatively straight sections of river with resistant geology on both sides of the river. Debris fans are areas of coarse sediment deposits at the mouths of tributaries; these sediments are delivered to the main channel during high-flow events in tributaries. In canyons, debris fans form a sequence of conditions that includes (1) a slack-water area upstream from the debris fan, (2) a channel constriction at the debris fan, (3) an eddy or eddies and associated bars in the expansion area downstream from the fan, and (4) a downstream gravel bar (Schmidt and Rubin 1995). These debris fan-eddy complexes exist at the mouths of nearly all tributaries. Downstream of Flaming Gorge Dam, canyons with abundant debris fans include Lodore Canyon (Reach 1), Whirlpool and Split Mountain Canyons (Reach 2), and Desolation and Gray Canyons (Reach 3).

Many debris fans in Desolation Canyon (Reach 3) are large. Only the small, active portion of the fan delivers sediment that restricts flow and causes rapids and eddies in the modern channel, whereas the main portion of the debris fan is so large that it acts more like a meander bend as the river flows around the fan (Orchard and Schmidt 2000).

Within a particular reach, shoreline complexity is affected by sediment-deposition processes and geologic conditions. Consequently, shoreline complexity varies considerably among different planform types. An understanding of shoreline complexity is important because it affects the distribution and suitability of habitats, including backwaters and other low-velocity habitats used as nursery areas by the endangered fishes, especially Colorado pikeminnow and humpback chub.

Shoreline complexity is greatest at those discharges when the bar surface is partly inundated and where chute channels are inactive. At a very low river stage, complexity is determined by the topography of the bar margins, which are typically simpler in shape than are the upper-bar surfaces. When higher discharges inundate the bar surface, complexity is determined by the planform of the floodplain edge. Olsson and Schmidt (1993) showed that the elevation of greatest shoreline complexity changes from year to year because the elevation and topographic complexity of bars change depending on the hydrologic regime during spring runoff.

Restricted meanders have considerable shoreline complexity at bankfull discharge because of the presence of vegetated mid-channel islands. In contrast, fixed meanders have relatively little available habitat at bankfull discharge because the banks are relatively smooth and there are few permanent mid-channel islands. At intermediate stages, complexity increases dramatically, and some segments have significantly more complexity than other segments. At a very low stage, there is little difference in habitat complexity between fixed and restricted meanders, but these segments have higher habitat complexity than canyons (Schmidt 1996).

Except at very low flow, shoreline-complexity indices can be relatively high in canyons with abundant debris fans. In contrast to alluvial reaches, whose banks typically have smooth transitions from one orientation to another, debris-fan segments have banks that are composed of coarse, angular deposits where bank orientations have sharp angles. These divergences give rise to low-velocity habitats even at high river stage.

An important component of shoreline complexity is backwater habitat, which comprises areas of low or no velocity that serve as important nursery habitats for young fishes. After the 1987 spring peak, Pucherelli et al. (1990) found that the total area of backwater habitat in Reach 2 was maximized at flows between 37 and 55 m^3/s (1,300 and 1,900 cfs). The relationship to flow at two study areas within Reach 3 was less clear. Later measurements made by Bell (undated) indicated that flows that optimized habitat availability varied from year to year, and that annual peak flows had an important influence on the relationship between habitat availability and flow. Rakowski and Schmidt (1999) supported Bell's findings and concluded that establishing a single target flow intended to maximize habitat availability every year is inappropriate because bar topography, and therefore habitat availability, changes annually in response to the passage of peak flows.

Eddies are another important component of low-velocity habitat in the Green River, but these habitats form behind geomorphic features (e.g., debris fans, large rocks) that are more resistant than sediment bars to annual peak flows. In Desolation and Gray Canyons, increases in flow change the distribution and type of eddy habitat present, but the total area of eddy habitat changes little (Orchard and Schmidt 2000). At any given flow, approximately 25% of the shorelines occur within eddies.

Although the availability of low-velocity shoreline habitat apparently changes little in Desolation and Gray Canyons with changes in flow, habitat conditions as determined by substrate characteristics in those habitats may change considerably (Orchard and Schmidt 2000). Low flows produce highly complex shoreline habitats with mostly bare sand and gravel substrates. Higher flows submerge these bars and substantially increase the amount of inundated vegetation along shorelines. The amount of talus shorelines in eddies peaked near 198 m^3/s (7,000 cfs) and declined at higher flows.

Flooded side canyons also provide low-velocity habitats used by fish; the relationship between the area of flooded side-canyon habitat and flow in Reach 3 was examined by FLO Engineering, Inc. (1996). Flooding of side canyons begins at a discharge of about 198 m^3/s (7,000 cfs). At greater flows, the area of flooded side-canyon habitat increases linearly until bankfull discharge of 1,104 m^3/s (39,000 cfs) is reached; at this flow, only 2 ha (5 acres) of flooded side-canyon area is available.

Sediment Dynamics

Sediment characteristics and dynamics are important factors that affect the availability and quality of habitat for listed species. Flow patterns have an important influence on sediment dynamics. Flow regulation reduces the dynamics of sediment deposition and erosion patterns. Each year, sediment deposits exposed during base flows are colonized by vegetation, and if subsequent floods do not scour these areas, a process of channel narrowing and increasing bank elevation can occur. At some point, this process becomes difficult to reverse because older, deeper-rooted vegetation is difficult to remove by all but the most extreme flood events.

Andrews (1986) described a sequence of degradation, equilibrium, and aggradation downstream from Flaming Gorge Dam that has developed in response to flow and sediment regulation by the dam. The degrading portion of the Green River channel, where sediment outflow exceeds sediment inflow, occurs just below Flaming Gorge Dam in Reach 1. Equilibrium conditions, where sediment inflow equals sediment outflow, occur in Reach 2. Aggradation, where sediment inflow is greater than sediment outflow, occurs in Reach 3, especially just downstream of the confluences with the White River and Duchesne River.

Andrews (1986) described channel narrowing in Reach 2 as a response to changes in sediment load and flooding caused by Flaming Gorge Dam operations. He determined that, on average, the channel had narrowed by 13% from 213 to 186 m (700 to 610 ft) since dam closure and that further narrowing would continue for another 30 years. Lyons et al. (1992) conducted additional analyses and arrived at somewhat different conclusions. Their results indicated that, in Reach 2, channel narrowing in response to construction of the dam had stopped by 1974 and that a 6% reduction from 217 to 204 m (712 to 670 ft) had occurred. The large floods from 1983 to 1986 reversed some of this narrowing and produced an average channel width of 208 m (680 ft), a 4% reduction from pre-dam width.

Merritt and Cooper (1998) examined channel changes in Browns Park in Reach 1. Three stages of channel change were identified. Stage 1 (channel narrowing and development of banks) occurred initially after closure of the dam. Stage 2 (channel widening, subaqueous bar formation, braided channel) was observed from 1977 to 1994. Stage 3 (bar stabilization, fluvial marsh development, and continued channel widening) has been observed since 1994. Merritt and Cooper (1998) projected that channel widening in Browns Park could continue for several decades but that coalescence of islands will lead to formation of a smaller meandering channel over a longer time span.

High releases in 1997 resulted in significant redistribution of sand in Lodore Canyon in Reach 1 and at least some reversal of the long-term trend of channel narrowing and vegetation encroachment (Martin et al. 1998). Measurements indicated that sediment transport at 244 m^3/s (8,600 cfs) was more than 3 times higher than sediment transport at 130 m^3/s (4,600 cfs).

Orchard and Schmidt (2000) determined that the active channel through Desolation and Gray Canyons decreased an average of 19% since the beginning of the century. They identified two episodes of channel narrowing as evidenced by two new surfaces along the channel. The cottonwood terrace is an abandoned floodplain that began to stabilize between 1922 and 1936 as a result of drier weather conditions. After closure of Flaming Gorge Dam, a second lower surface has become densely colonized by riparian vegetation and is accumulating sediment through vertical accretion. This process is continuing and appears to be contributing to a loss of in-channel fish habitat.

Allred (1997) studied channel narrowing and vertical accretion at the Green River gage in Utah and described the process by which in-channel deposits become stabilized. The stabilization process includes the following steps: (1) emplacement and accretion of a lateral bar as large amounts of sediment are moved through the system; (2) low flood magnitude in years following bar emplacement; (3) rapid encroachment of riparian vegetation onto the exposed bar surface; (4) stabilization of the bar through extensive root system development; and (5) continued vertical accretion of the bar surface during periods of inundation when existing vegetation captures additional sediment.

Channel narrowing occurred at the Green River gage from 1930 to 1938; rapid accretion occurred from 1957 to 1962; and further narrowing occurred after 1962 (Allred 1997; Allred and Schmidt 1999). That research indicates that channel narrowing occurred in response to weather changes and as vegetation (primarily tamarisk) invaded and stabilized newly formed inset floodplain deposits. The large floods of 1983 and 1984 did not reverse the narrowing trend at this site but instead resulted in the deposition of sediments at higher elevations.

Cobble and gravel deposits free of silt and sand are preferred spawning areas of the endangered fishes, and the suitability of these areas for spawning is affected by sediment-transport and depositional patterns. Two spawning areas have been studied to date: a bar used by razorback suckers upstream of Jensen, Utah, in Reach 2, and a bar used by Colorado pikeminnow at the head of Gray Canyon in Reach 3. High flows are responsible for forming both bars, and recessional flows clean the bars of fine sediment, thus making them suitable for spawning by these species (Wick 1997; Harvey and Mussetter 1994)

Floodplain Inundation

Floodplains develop along rivers where the valley floor is extensively covered with alluvium. The normal-flow channel, carved in the alluvium, is flanked by this low-relief surface that becomes part of the riverbed during high-flow periods. The natural integrity of large-river ecosystems is dependent on this interaction (Welcomme 1995, Junk et al. 1989 and Wydoski and Wick 1998). Interrelations between overbank flows and the floodplain provide a conduit for the exchange of nutrients and maintain physical habitat components of the system (Annear et al. 2004). Restricting river-floodplain interaction reduces the ecological integrity of the system and limits the growth, conditions and abundance of fishes dependent on that environment. The frequency and extent of floodplain inundation vary considerably along the Green River, largely in response to site-specific channel morphology (including the presence or absence of natural or manmade levees).

Irving and Burdick (1995) conducted an inventory, largely on the basis of aerial photography, of potential flooded bottomland habitats in the Green River. They determined that approximately 644, 3,500, and 3,300 ha (1,590, 8,650, and 8,150 acres) were present in Reaches 1, 2, and 3, respectively. In Reach 3, about 1,100 ha (2,700 acres) was present between the White River confluence and Pariette Draw, and about 760 ha (1,880 acres) was present in Canyonlands National Park in the lower portion of the reach. The highest priority bottomlands for endangered fishes are in Reach 2 and the upper portion of Reach 3 (Escalante Ranch to Pariette Draw).

In the Ouray portion of Reach 2, significant inundation of floodplain areas occurs at about 527 m^3/s (18,600 cfs). At this flow, and with artificial levees in place, a total of 514 ha (1,270 acres) of floodplain area is inundated. The area of inundated habitat increases greatly as flow exceeds 527 m^3/s (18,600 cfs): 1,457 ha (3,600 acres) is inundated at 575 m^3/s (20,300 cfs); 3,238 ha (8,000 ac) at 643 m^3/s (22,700 cfs); and 3,561 ha (8,800 acres) at 748 m^3/s (26,400 cfs) (FLO Engineering, Inc. 1996). Recently, removal or modification of artificial levees in important habitat areas has allowed flooding to be initiated at flows of 368 m^3/s (13,000 cfs).

Most of the floodplain habitat in Reach 3 is located in the upper portion of the reach just downstream of the confluences with the White and Duchesne Rivers, and this habitat is contiguous with the floodplain habitats of Reach 2. In the upper portion of Reach 3 examined by Bell et al. (1998), the total areas of floodplain inundation were 265, 425, and 767 ha (655, 1,050, and 1,895 ac) at 623, 680, and 920 m^3/s (22,000, 24,000, and 32,500 cfs), respectively, as measured at the USGS gage near Green River, Utah.

Floodplain habitats in Reaches 2 and 3 of the Green River can be classified as depression floodplains or terrace floodplains. Depression floodplains are usually separated from the main channel by an elevated levee (natural or constructed) and typically retain water for a relatively long time after river flows recede. Terrace floodplains are sloping features that fill and drain with changes in river stage (Valdez and Nelson 2004). Both of these floodplain habitat types may become inundated during annual spring peak flows and provide a variety of direct biological benefits to the endangered fishes. Colorado pikeminnow and razorback sucker utilize both types of floodplain habitats for growth resting and conditioning, particularly for adult fish preparing to migrate In addition both types of floodplain habitats but in particular depression floodplains appear to provide nursery habitat for the razorback sucker (Birchell et al. 2002). Overbank flows that inundate depression and terrace floodplain habitats also provide allochthonus energy input to the river system in the form of terrestrial organic matter and insects that are utilized directly and indirectly by the endangered fishes in the river.

As peak flows recede, depression floodplain habitats retain water at an elevation determined by the elevation of associated levee features. During the base-flow period, the amount of water in depression floodplains will usually decrease due to evaporation and percolation losses. The length of time that water is retained in depression floodplains is often site-specific, and some depression floodplains can hold water through one or more years. For these habitats, subsequent spring peak flows of sufficient magnitude will reconnect the floodplain to the main channel before the water in the wetland has been depleted. In contrast, terrace floodplains drain as flows recede; and therefore do not serve as nursery habitat for razorback suckers once peak flows recede.

Valdez and Nelson (2004) identified 16 priority floodplain sites (Figure 4) in the Split Mountain to Desolation Canyon reach of the Green River (Reach 2 and upper Reach 3) and evaluated the potential importance of each of these sites as razorback sucker nursery areas. Important floodplain characteristics considered by Valdez and Nelson (2004) included the type of floodplain (e.g., depression or terrace), the flow at which the floodplain becomes inundated, the potential area of inundation, and the distance from the known razorback sucker spawning bar in the Green River, which is located upstream in Dinosaur National Monument. Characteristics of these priority floodplains for razorback sucker are summarized in Table 6.

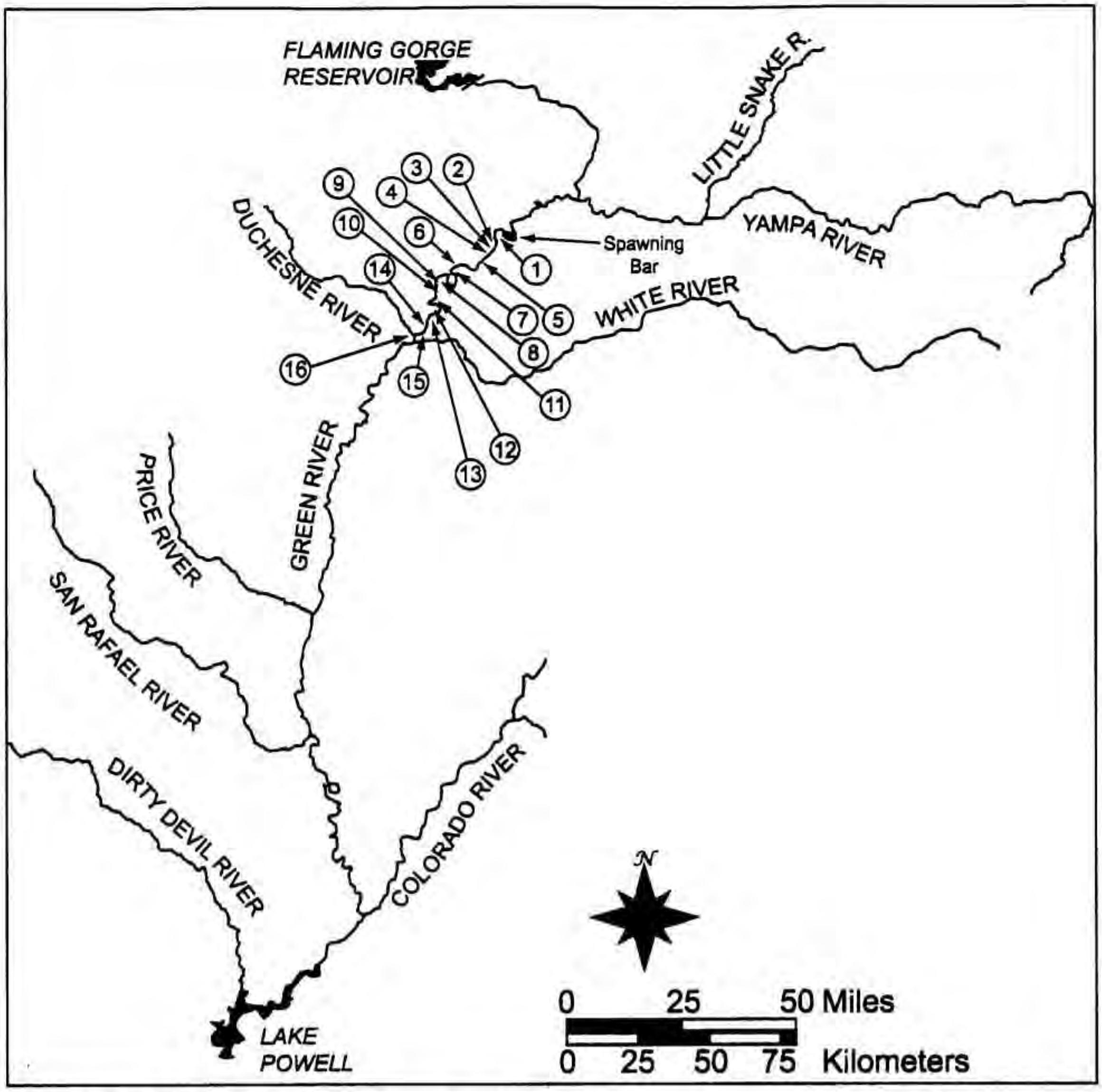

FIGURE 4 Priority Floodplain Areas in the Middle Green River. Refer to Table 6 for a key that matches numbered locations to names for individual floodplain areas. (Source: Valdez and Nelson 2004).

TABLE 6 Floodplain Type, Connecting Flow, Inundated Area, and Distance from the Razorback Spawning Bar for Sixteen Priority Wetlands

Site No.[a]	Floodplain Site	Type[b]	Connecting Flow (cfs)	Inundated Area at Connecting Flow (ac)	Distance from Spawning Bar (river mi)
1	Thunder Ranch	D	13,000[c]	330	5
2	IMC	T	18,600	4	8
3	Stewart Lake	D	7,500	570	11
4	Sportsman's Lake	D	20,000	132	14
5	Bonanza Bridge	D	13,000	23	21
6	Richens/Slaugh	T	18,600	45	25
7	Horseshoe Bend	D	13,000	17	27
8	The Stirrup	D	13,000	20	36
9	Baeser Bend	D	13,000	38	38
10	Above Brennan	D	13,000	41	45
11	Johnson Bottom	D	13,000	146	47
12	Leota Ponds	D	13,000	1,016	52
13	Wyasket Lake	T/D[d]	18,600	850	55
14	Sheppard Bottom	D[e]	25,300	1,[illegible]50	58
15a	Old Charley Wash (Main)	D	14,000	336	60
15b	Old Charley Wash (Diked)	T	13,000	56	60
16	Lamb Property	T	18,600	463	70

[a] Corresponds to numbered locations on Figure 4

[b] D = depression, T = terrace

[c] Inundation flows with notched levees as identified in Muth (2000). Valdez and Nelson (2004) reported that levee removal would allow inundation of the Thunder Ranch floodplain at 16,900 cfs.

[d] Wyasket Lake has little potential to hold water throughout the year and, except for a deep trench and a small depression, acts largely as a terrace floodplain (Valdez and Nelson 2004).

[e] Although much of the area within Sheppard Bottom acts as terrace floodplain (Valdez and Nelson 2004), the entire area identified as floodable has been considered a depression floodplain in this table.

Native and Nonnative Fishes of Flaming Gorge Reservoir

The fish community of Flaming Gorge Reservoir consists of the following nonnative species: lake trout (*Salvelinus namaycush*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki*), kokanee salmon (*Oncorhynchus nerka*), white sucker (*Catostomus commersoni*), smallmouth bass (*Micropterus dolomieu*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*),Utah chub (*Gila atraria*), redside shiner (*Richardsonius balteatus*), and the Bear Lake sculpin (*Cottus extensus*). It also supports small numbers of some native fish species, including flannelmouth sucker (*Catostomus latipinnis*), mountain whitefish (*Prosopium williamsoni*), and the mottled sculpin (*Cottus bairdi*).

Since the reservoir was filled, rainbow trout have been stocked annually, are the most sought-after species by anglers, and provide the bulk of the harvest. Kokanee salmon and smallmouth bass were stocked during the mid 1960s and have since developed naturally reproducing fisheries. After rainbow trout, kokanee salmon are typically second in harvest and popularity with anglers. Other sport fish occasionally stocked in the reservoir include brown trout and channel catfish.

Lake trout, which drifted into Flaming Gorge from the upper Green River drainage, have also become established as a wild population. Lake trout are managed as a trophy fishery in Flaming Gorge Reservoir. Regulations are designed to keep lake trout numbers in balance with populations of kokanee salmon and Utah chubs, their primary prey.

Smallmouth bass are found in rocky shoreline habitat throughout Flaming Gorge Reservoir. A dense population dominated by smaller fish exists from the dam north to Linwood Bay. From the Antelope Flats area north, fewer but larger bass are found. Smallmouth bass in Flaming Gorge Reservoir feed almost exclusively on crayfish. They spawn from late May through early July, and during this period, mature fish move into shallow water. Smallmouth bass were introduced into Flaming Gorge Reservoir to promote growth of kokanee salmon by reducing the Utah chub population (Tuescher and Luecke 1996).

Native and Nonnative Fishes of the Green River

Twelve native fish species have been reported from reaches of the mainstem of the Green River between Flaming Gorge Dam and the Colorado River confluence and from lower portions of the river's tributaries. This assemblage of fishes includes warm-water species that prefer or require large-river habitats (e.g., razorback sucker and Colorado pikeminnow), species that prefer cool- or cold-water streams or smaller river channels (e.g., Colorado River cutthroat trout [*Oncorhynchus clarki pleuriticus*], mountain whitefish, and mottled sculpin), and species with more generalized habitat requirements (e.g., roundtail chub [*Gila robusta*], speckled dace [*Rhinichthys osculus*], and bluehead sucker [*Catostomus discobolus*]).

Twenty-five nonnative fish species have been reported from the Green River between Flaming Gorge Dam and the Colorado River confluence. The red shiner (*Cyprinella lutrensis*), common carp, sand shiner (*Notropis stramineus*), fathead minnow (*Pimephales promelas*), channel catfish, and smallmouth bass are widespread and common to abundant (Tyus et al. 1982; Jackson and Badame 2002). Salmonids are generally restricted to Reach 1 and are most abundant in the tailwaters of Flaming Gorge Dam.

Nonnative fishes dominate the ichthyofauna of the Colorado River Basin and have been implicated as contributing to reductions in the distribution and abundance of native fishes as a result of competition and predation (Carlson and Muth 1989; Lentsch et al 1996; Tyus and Saunders 1996). Behnke and Benson (1983) attributed the dominance of nonnative fishes to dramatic changes in flow regimes, water quality, and habitat characteristics. They reported that water development has converted a turbulent, highly variable river system into a relatively stable system, with flow and temperature patterns that allowed for the proliferation of nonnative fish species. Hawkins and Nesler (1991) identified red shiner, common carp, fathead minnow, channel catfish, northern pike (*Esox lucius*), and green sunfish (*Lepomis cyanellus*) as the nonnatives considered to be of greatest concern because of their suspected or documented negative interactions with native fishes. White sucker may affect populations of some species of native suckers, including the endangered razorback sucker, through hybridization.

Recently, considerable concern has been expressed regarding the potential for smallmouth bass to adversely affect native fish populations, and the Recovery Program is currently evaluating methods to control this species in the Green River. Smallmouth bass prey on native species, especially young, and also compete with native fish for food and cover. They occur in Lodore Canyon in small numbers (Bestgen and Crist 2000), and increase in abundance further downstream.

Riparian Communities

Riparian vegetation occurs along most of the Green River below Flaming Gorge Dam. Riparian vegetation is found along all portions of the river except in those areas where sheer rock walls abut the river. Before construction of Flaming Gorge Dam, the vegetation along the river occupied two distinct zones (Fischer et al. 1983). Nearest the river, flooding occurred each year during the spring, and plants in this flood zone were predominantly annuals or scour-tolerant perennials such as wild licorice (*Glycyrrhiza lepidota*), common dogbane (*Apocynum cannibinum*), and sedges (*Carex* spp.). Dominant species above the flood zone included box elder (*Acer negundo*), squawbush (*Rhus trilobata*), Fremont cottonwood (*Populus deltoides. wislizenii*), and coyote willow (*Salix exigua*) (Holmgren 1962). After construction of the dam and the elimination of annual floods, riparian vegetation from adjacent riparian and upland areas colonized much of the old flood zone. Species that spread by underground stems (such as wild licorice, common reed [*Phragmites australis*], and scouring rush [*Equisetum* spp.]) formed dense stands along the shoreline in some areas. These plants stabilize sediment deposits, and this process appears to be gradually making the channel narrower and deeper with steep banks.

Below Flaming Gorge Dam, the Green River alternately flows through narrow canyons and broad valleys that support different riparian communities. The moderate to steep slopes of canyons are vegetated with pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), Douglas-fir (*Pseudotsuga menziesii*), or ponderosa pine (*Pinus ponderosa*). The riparian zone occurs on a predominantly rocky substrate (mostly cobble and boulder, with sand and gravel becoming more common farther downstream). Vegetation at the summer water level to about 2 m above consists of wild licorice, redtop (*Agrostis stolonifera*), marsh paintbrush (*Castilleja exilis*), sea milkwort (*Glaux maritima*), western evening primrose (*Oenothera elata*), and silverweed cinquefoil (*Potentilla anserina*). Ute ladies'-tresses occurs in this zone. Above the normal high-water line, grasses; scouring rush; giant whitetop (*Cardaria draba*); wild licorice; and a variety of woody species, including box elder, coyote willow, tamarisk (*Tamarix ramosissima, T. chinensis,* or a hybrid of the two), and Fremont cottonwood, are common.

Through the wide valley areas (e.g., Browns Park), the river meanders within a broad, open floodplain of mostly sand and silt (and gravel in upstream areas). Steep cutbanks are common, and in some areas almost all banks are cut and severely eroded. The surrounding uplands support sagebrush (*Artemisia* spp.), desert shrubs, and, in some areas, pinyon pine and Utah juniper. Islands and backwaters are frequent throughout these sections of the river. The riparian zone is relatively broad (up to 60 m [200 ft] wide) and extends to 5 to 6 m (15 to 20 ft) above the low-water level. In the higher elevation portions of the riparian zone, grasses, coyote willow, wild licorice, giant whitetop, and scouring rush are common. Large stands of mature Fremont cottonwood occur on high terraces. These stands became established under pre-dam conditions. Mature cottonwoods are now prone to premature decay, which is likely a result of the reduction in inundation frequency that has occurred since dam construction (Williams 2000). Maintenance of these elevated riparian woodlands is a concern, especially in Reach 1, because reproduction requires occasional high flows for seedling establishment, but normal dam operations reduce the frequency of such flows.

Summary

The Service has consistently concluded in previous consultations that water depletions and the operation of infrastructure associated with those depletions are a major factor contributing to the reductions in the populations of the Colorado pikeminnow, humpback chub, bonytail, and razorback sucker. Impacts of depletions and associated storage infrastructure such as dams and reservoirs have resulted in changes in flow and temperature regimes which in turn affect endangered species and their habitat. Removing water from the river and stabilizing the system through regulation reduces the ability of the river to create and maintain important habitats and reduce the frequency and duration of availability of these habitats. Food supply, predation, and competition are important elements of the biological environment. Food supply is a function of nutrient supply and productivity. High spring flows inundate bottomland habitats and increase the nutrient supply and productivity of the river environment. Reduction of high spring flows by water storage reservoirs that store water during spring peak flows may reduce food supply. Other major factors impacting the endangered fishes include competition from and predation by nonnative fishes. These reductions in populations and loss of habitat caused the Service to list these species as endangered and to implement programs to conserve the species. Implementation of the proposed action in conjunction with other activities by the Recovery Program is designed to offset various depletion impacts to the Green and Colorado River and to provide a suitable flow and temperature regime for the endangered fishes in the Green River downstream of Flaming Gorge Dam.

EFFECTS OF THE ACTION

The proposed action would have beneficial effects on the four listed Colorado River fishes and their critical habitats within the action area. These benefits include: Increased frequency and duration of relatively high spring flows will inundate floodplain habitats, which will help maintain the ecological integrity of the river system and provide warm, food-rich environments for subadult and adult Colorado pikeminnow, bonytail and Razorback sucker as well as for young razorback sucker. Increased peak flows and proposed variability in peak flows is expected to maintain spawning areas for the endangered fishes and lead to increased in-channel habitat complexity through formation and reworking of in-channel sediment deposits. Scaling of baseflows to the hydrologic conditions will help favor the formation of low velocity shoreline nursery habitats in Reach 2 and 3. In general, implementation of a flow regime that more closely resembles the natural flow regime of the river will provide benefits to all the endangered fishes and the habitats on which they depend.

Analyses for Effects of the Action

The flow recommendations on which the proposed action is based are intended to meet the habitat requirements of the four endangered fishes by providing adequate flows. Flow regimes that would be produced under the proposed action differ from those of the environmental baseline in several important ways. The most important differences between the new flow recommendations and flows called for under the 1992 FGBO or No Action Alternative are (1) the magnitude and duration of spring peak flows, (2) the level of variability in peak and base flows between and within years, and (3) recommended winter base flows (Muth et al. 2000).

The Flaming Gorge hydrology model (Clayton and Gilmore 2002) was developed to evaluate the long-range effects of operating Flaming Gorge Dam to achieve the Green River flow objectives of the proposed action. Model results (especially predicted flow exceedance values) serve as the basis for much of the effects analysis in this biological opinion. The model includes all relevant river features (reservoirs, river reaches, confluences, diversions, etc.) from Fontenelle Reservoir, upstream of Flaming Gorge Reservoir, to the confluence of the Green and Colorado Rivers. In developing the model, emphasis was placed on details of river features directly below Flaming Gorge Reservoir and on the Yampa River. The model simulates the year-round operation of Flaming Gorge Dam to meet flow recommendations and predicts flows at the USGS streamflow gage on the Green River at Jensen, Utah approximately 150 km (93 mi) downstream of Flaming Gorge Dam. Flows are predicted that would occur over a 39-yr period, beginning in January of 2002.

A model ruleset was developed for the proposed action which incorporated the logic and decision-making processes for achieving the flow objectives. The ruleset was used primarily to calculate the volume of water to be released from Flaming Gorge Dam so that the flow objectives are achieved in Reaches 1 and 2. The ruleset controlled the reservoir elevation for safe operation of the dam, maximized reservoir storage, and minimized bypass releases, while attempting to meet the flow objectives during the spring peak release as well as during the base-flow period. For Reaches 1 and 2, the model indicates that the minimum target recommendations could be met for all flows, durations, and frequencies. The model predicted that more frequent use of the bypass tubes and spillway at Flaming Gorge Dam would occur under the proposed action than under the baseline. The model predicted that the bypass tubes would be used in 50% of all years, under the proposed action, and the spillway would be used in 29% of all years. In comparison, under baseline conditions, the bypass tubes would be used in 23% of all years, and the spillway would be used in 5% of all years. The predicted increased use of the bypass tubes and spillway under the proposed action is primarily attributable to meeting the recommendation to achieve flows of 18,600 cfs for at least 2 weeks in 40% of years. Additional information regarding the model results can be found in Clayton and Gilmore (2002).

The predicted future flows in Reach 3 were estimated (Clayton and Gilmore 2003) by combining the Reach 2 flows predicted by the Flaming Gorge Model with estimated inflows corresponding to the historic input from all Reach 2 and 3 tributaries, as well as losses occurring along the channel due to evaporation, infiltration, and depletions. This estimate was obtained by subtracting the historic flows recorded at the Greendale, Utah, gage (in Reach 1) from the flows recorded at the Green River, Utah, gage (in Reach 3), with an estimated lag period of 5 days. The recommended target of 10% frequency for a single day peak flow of 1,100 m^3/s (39,000 cfs) in Reach 3 would not be achieved by predicted flows under the proposed action; however, all other recommended flows, durations, and frequencies would be met.

A review of the hydrology model by Reclamation and Argonne National Laboratory (see EIS section 2.4) found that while the model performs well in dry, moderately dry and average years, it appeared to bypass or spill more water in moderately wet and wet years. Reclamation acknowledged in the FGEIS that the hydrology model by Clayton and Gilmore (2003) may overstate bypasses necessary to meet the Proposed Action (2000 Flow and Temperature Recommendations)

Critical Habitat Response to the Proposed Action

The primary constituent elements of critical habitat for the Colorado River endangered fishes are water, physical habitat, and the biological environment (59 F.R. 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are also important elements of the biological environment.

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

Under the proposed action, releases from Flaming Gorge Dam in most years would be patterned to provide recommended flows in Reaches 2 and 3 rather than achieve specific targets in Reach 1, but releases would be high enough in wetter years to provide significant channel maintenance (i.e., rework and rebuild in-channel sediment deposits, increase habitat complexity, and prevent or reverse channel narrowing) in Lodore Canyon (Muth et al. 2000). Increased channel maintenance would improve in-channel habitat conditions for endangered fishes, reduce vegetation encroachment of channel-margin sediment deposits, and, thus, create a more natural, dynamic riparian corridor.

Under the proposed action, some flow fluctuation would result in Reach 1 from Flaming Gorge Dam hydropower operations. These flow fluctuations would be limited to the extent necessary to achieve recommended levels of variability in Reach 2. Target water temperatures of 18 °C (64 °F) for two to five weeks in the beginning of the base flow period in upper Lodore Canyon are expected to be achieved in most years by targeting release temperatures of 13 to 14 °C (55 to 57 °F) during the midsummer. During high runoff years it may not be possible to meet target temperatures due to the lack of warm water available for release from Flaming Gorge Reservoir (Muth et al. 2000). These temperatures are warmer, and more suitable for native fish than those of the environmental baseline. In addition, temperature modeling conducted for the EIS analysis suggests that a difference of less than 5 °C (9 °F) between waters from the Green and Yampa Rivers will be achieved more consistently under the proposed action than have occurred since implementing operations to meet the 1992 FGBO.

Peak flows in Reach 2 would be sufficient to provide significant inundation of floodplain habitat and off-channel habitats (e.g., tributary mouths and side channels) in wet and moderately wet years (30% of years) (Muth et al. 2000). This inundation would establish river-floodplain connections and provide warm, food-rich environments for growth and conditioning of fishes. In wetter years, peak flows in Reach 2 under the proposed action would also rework and rebuild in-channel sediment deposits (including spawning substrates), increase habitat complexity, form in-channel sand bars, and prevent or reverse channel narrowing.

In Reach 2, significant inundation of floodplain habitat and off-channel habitat would also occur in at least one of four average years, with some flooding of off-channel habitats occurring in all average years (Muth et al. 2000). Significant channel maintenance would occur in at least one of two average years.

Under the proposed action, no floodplain inundation would be expected in Reach 2 during moderately dry and dry years, but some flooding of off-channel habitat would still occur. In addition, some sediment transport would occur in all moderately dry and dry years because peak flows would exceed the incipient-motion threshold of the sand substrate. These flows would prevent vegetation establishment within the river channel.

Under the proposed action, base flows in Reach 2 would more closely approximate pre-dam levels of magnitude, duration, and variability than occur under current operations. Flows under the proposed action would favor the formation of low-velocity shoreline habitats that would be more stable and increase productivity of the river ecosystem. Higher water temperatures would occur at lower base flows in average and drier years (70% of all years) and would enhance ecological productivity.

Expected effects of the proposed action on physical and ecological conditions in Reach 3 would approximate those described above for Reach 2 (Muth et al. 2000). However, floodplain habitat in Reach 3 is more isolated from the river because of vertical accretion of banks and vegetation encroachment. As a result, less floodplain habitat would be inundated in Reach 3 than in Reach 2 under the proposed action. Nonetheless, the frequency and duration of floodplain inundation in Reach 3 are expected to be greater under the proposed action than under current conditions.

Species Response to the Proposed Action

Colorado Pikeminnow

It is anticipated that Colorado pikeminnow would benefit from the proposed action in several ways. The frequency and duration of relatively high spring flows is expected to increase under the proposed action. Floodplain habitats in the Uinta Basin portion of Reach 2 and 3 would be inundated for at least two weeks in four of ten years, and bankfull flows would be achieved in one of two years. These high flows would result in substantial inundation of floodplains, tributary mouths, and side channels in Reach 2 and upper Reach 3 that would provide warm, food-rich environments for growth and conditioning of subadult and adult Colorado pikeminnow prior to spawning. The increased duration of floodplain inundation would prolong the potential benefits provided by these habitats to juvenile and adult Colorado pikeminnow. High peak flows could also result in significant reworking and rebuilding of in-channel sediment deposits, leading to increased habitat complexity and formation of in-channel sandbars behind with associated backwater habitats. Although little or no floodplain inundation would occur in drier years, some off-channel habitats (e.g., side channels and tributary mouths) in Reaches 2 and 3 would be inundated and could benefit juvenile and adult Colorado pikeminnow in those years.

Habitats in Lodore Canyon that are occupied by Colorado pikeminnow could be improved and maintained by the relatively frequent high flows of the proposed action. The Flaming Gorge hydrology model (Clayton and Gilmore 2002) predicted that peak flows would exceed powerplant capacity in about 50% of all years, compared with about 23% of all years under baseline (current) operations. The model also predicted that spillway releases (flows above 244 m^3/s or 8,600 cfs) would occur in about 29% of years under the proposed action compared to about 5% of all years under current operations. The sediment reworking that would occur could improve conditions on cobble beds that could subsequently serve as spawning sites.

Larval pikeminnow drift downstream from spawning bars to occupy nursery habitats found in Reaches 2 and 3. Colorado pikeminnow use backwater nursery areas during their first year of life throughout the base-flow period. These backwaters are characteristically low velocity areas associated with main channel sand bars. Rakowski and Schmidt (1999) conducted a study in Reach 2 to describe the process by which backwaters were formed and maintained. They concluded that a single base flow target from year to year was inappropriate because the shape of sand bars varied based on magnitude of the preceding annual spring flood.

Under the proposed action, base-flow magnitudes would be based on hydrological conditions, and variability in flows around the mean base flow would be greater than under baseline conditions during the base-flow season. Scaling base flows to hydrologic condition and the antecedent peak flow should favor the formation of backwaters and other low-velocity shoreline nursery habitats in Reaches 2 and 3. Maintaining the magnitude of annual mean base flows during summer, autumn, and winter under the proposed action should promote favorable conditions for Colorado pikeminnow in low-velocity habitats. Although the level of fluctuation restriction needed to fully protect low-velocity habitats is uncertain (Muth et al. 2000), it is believed that keeping hydropower-induced changes in mean base flows at Ouray within the recommended levels of seasonal and within-day variability throughout the summer, autumn, and winter would promote favorable conditions for young Colorado pikeminnow in low-velocity nursery habitats in Reach 2. Hydropower-induced fluctuations in flow are largely attenuated by the time flows reach the Ouray portion of Reach 2.

Under the proposed action, warmer water would be released from Flaming Gorge Dam during portions of the base-flow period in most years. As a result, summer water temperatures in Lodore Canyon would typically be higher under the proposed action than under baseline conditions. These warmer summer temperatures could increase the suitability of Lodore Canyon for spawning by Colorado pikeminnow (Muth et al. 2000). In addition, the resulting decrease in the difference between water temperatures in the Green River and the Yampa River at the Echo Park confluence during July would reduce the possibility of cold shock to Colorado pikeminnow larvae drifting out of the Yampa River and into the Green River. Under the proposed action, the recommendation to reduce the temperature difference between the Yampa and Green Rivers at the confluence could be met more often than under baseline conditions. Water temperatures in the lower portions of Reach 2 and throughout Reach 3 under the proposed action would not differ substantially from those under existing baseline conditions.

In addition to the potential benefits of the proposed action to the Colorado pikeminnow described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. Increased escapement of this species through spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish. Even if escapement from the reservoir does not result in increased numbers of nonnative fishes downstream, there is a potential for increased survival, reproduction, and expansion of nonnative fish species in Lodore Canyon due to increased water temperatures alone.

Razorback Sucker

Access to floodplain habitat is considered critical for providing larval and juvenile razorback suckers with nursery habitat. Razorback sucker spawning has occurred at several locations, but is concentrated in an area 154 to 172 km (96 to107 mi) downstream of Flaming Gorge Dam in Reach 2. This spawning area is located immediately upstream of most of the floodable habitat in the vicinity of the Ouray National Wildlife Refuge. Under the proposed action, flows in Reach 2 would reach or exceed 527 m^3/s (18,600 cfs) for at least two weeks in 41% of years, as opposed to only 16% of years under baseline conditions. Timing peak flows to coincide with peak flows in the Yampa River would result in an overlap between the inundation period and the period when drifting razorback sucker larvae are typically present in most years, and would allow larval razorback suckers to be entrained into inundated areas. Because the proposed action would result in bankfull or greater flows in one of two years, there would be sufficiently frequent reconnection of depression wetlands (that maintain water throughout the year) with the main channel that razorback suckers would be able to reenter the main channel after growing to a suitable size.

It is anticipated that peak flows under the proposed action would also regularly inundate floodplains in the upper portion of Reach 3 (e.g., between the White River confluence and the upstream end of Desolation Canyon) and would provide some in-channel habitat maintenance throughout the reach in all years. In most years, the proposed peak flows would also inundate tributary mouths and side channels that provide warm, food-rich environments for growth and conditioning by subadult and adult razorback sucker before and after spawning. Although peak flows of 527 m^3/s (18,600 cfs) or greater would inundate floodplain habitats as described above, recent modifications to existing levees allow flooding of some habitats at lower flows.

Under the proposed action, peak flows are expected to be of sufficient frequency, magnitude, and duration to rework and rebuild in-channel sediment deposits in portions of Lodore Canyon that may be occasionally used by subadult or adult razorback suckers and would remove fine sediments from spawning bars used by razorback suckers in Reaches 2 and 3.

Base flow magnitudes would be established each year according to hydrological conditions, and variability in flows around the mean base flow would be consistent with pre-dam variability throughout the base-flow season. Scaling base flows to hydrologic condition and the antecedent peak flow would favor the development of backwaters and other low-velocity shoreline habitats in Reaches 2 and 3 that are sometimes used by young razorback suckers. Maintaining the magnitude of annual mean base flows during summer, autumn, and winter periods under the proposed action should promote favorable conditions for razorback sucker in low-velocity habitats (Muth et al. 2000).

Under the proposed action, warmer water would be released from Flaming Gorge Dam during the base-flow period. As a result, summer water temperatures in Lodore Canyon and the upper portion of Reach 2 would typically be higher under the proposed action than under current operations. These warmer temperatures could improve razorback sucker growth in those areas in most years. Water temperatures in the lower portion of Reach 2 and throughout Reach 3 would not differ substantially from those under baseline conditions.

In addition to the potential benefits of the proposed action to the razorback sucker described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. In addition, there is a potential for white suckers, a species known to hybridize with the razorback sucker, to be released into the Green River. Increased escapement of these species through spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish. Even if escapement from the reservoir does not result in increased numbers of nonnative fishes downstream, there is a potential for increased survival, reproduction, and expansion of nonnative fish species in Lodore Canyon due to increased water temperatures alone.

Humpback Chub

Under the proposed action, the magnitude, frequency, and duration of high spring releases from Flaming Gorge Dam would increase relative to the environmental baseline. The Flaming Gorge hydrology model (Clayton and Gilmore 2002) predicted that peak flows would exceed powerplant capacity in about 50% of all years, compared with about 23% of all years under baseline (current) operations. Spillway releases would occur in about 29% of years under the proposed action compared to about 5% of years under current operations.

Humpback chub currently do not occur in Reach 1, and no direct effects of the proposed action in that reach are anticipated. If humpback chub should become established within Reach 1 as a result of implementing the proposed action, peak flows would help maintain in-channel habitat areas by reworking sediment deposits in Lodore Canyon in wetter years. The peak flows that would occur under the proposed action are also expected to mobilize in-channel sediment deposits in currently occupied portions of Reach 2 and 3 (Whirlpool, Split Mountain, Desolation, and Gray Canyons). The proposed action would benefit humpback chub in these areas by helping prepare and maintain substrates in spawning areas, increasing habitat complexity, and preventing or reversing channel narrowing. Although significant changes in channel morphology are not anticipated, peak flows of the proposed action are expected to scour and maintain the large recirculating eddies that are used as resting and feeding habitats by adults.

If humpback chub should become established within Reach 1, it is anticipated that the base flows under the proposed action would provide suitable summer, autumn, and winter conditions for humpback chub. These base flows would be appropriate for development of recirculating eddies and for promoting development of complex shoreline habitat in Whirlpool, Split Mountain, Desolation, and Gray Canyons. In addition, maintaining the seasonal, daily, and within-day variability of flows within the ranges identified in the proposed action would maintain stability of conditions in the shoreline habitats that are preferred by young fish.

Higher summer water temperatures in most years could encourage movement and establishment of humpback chub in the lower portions of Lodore Canyon and could enhance growth and survival of young humpback chub in Whirlpool Canyon. Temperature regimes in Split Mountain Canyon and further downstream will be largely unaffected by the proposed action. Water temperatures in Reach 3 under the proposed action are expected to be indistinguishable from those that occur under baseline conditions. Summer water temperatures in Desolation and Gray Canyons would continue to reach the desired humpback chub spawning temperature of at least 17°C (62.6°F) during the descending limb of the spring peak in most years.

In summary, the proposed action is expected to benefit humpback chub in the Green River by improving habitat conditions for all life stages. The proposed action would result in flows that would maintain and improve conditions in the currently occupied canyon reaches. The proposed action would increase the temperature of water released during summer months in most years. Warmer summer water temperatures would improve conditions for growth and survival of humpback chub in Whirlpool Canyon and could result in expansion of the population into Lodore Canyon.

In addition to the potential benefits of the proposed action to the humpback chub described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from

Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. Increased escapement of this species through spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish. Even if escapement from the reservoir does not result in increased numbers of nonnative fishes downstream, there is a potential for increased survival, reproduction, and expansion of nonnative fish species in Lodore Canyon due to increased water temperatures alone.

Bonytail

Little is known of the habitat requirements of the bonytail because it was extirpated from most of its historic range before studies were conducted. In the Green River, Vanicek (1967) generally found bonytail in pools and eddies with low velocities, although these habitat features were often located adjacent to areas of strong current. Similarly, Valdez (1990) reported that bonytail captured in Desolation and Gray Canyons were sympatric with humpback chub in shoreline eddy habitat with boulders and cobble. It has been recently hypothesized that flooded bottomlands may provide important bonytail nursery habitat. The Recovery Program has been building their stocking program to achieve a target release of 5,330 hatchery produced bonytail (target size of 200 mm) in the upper and lower Green River each year for six years. In excess of 20,000 bonytail (many < 200mm) have already been stocked in Reaches 1 and 2 since 2000.

The peak flows that would occur under the proposed action would rework and rebuild in-channel sediment deposits in potential bonytail habitat found in Echo Park, Whirlpool and Split Mountain Canyons in the upper portion of Reach 2. These peak flows would similarly rework and rebuild in-channel sediment deposits in Desolation and Gray Canyons in Reach 3, where bonytail have historically been found. These proposed peak flows could benefit reintroduced bonytail in these areas by preparing and maintaining substrates in spawning areas, promoting increased habitat complexity, and preventing or reversing channel narrowing during wetter years. The proposed peak flows would also scour and maintain eddies. The proposed peak flows would periodically inundate flooded bottomland habitats and would allow access to such areas by bonytail larvae in some years.

Base flows that would occur under the proposed action would be scaled to annual hydrologic conditions. These flows would provide eddies and complex shoreline habitat in Echo Park, Whirlpool, Split Mountain, Desolation, and Gray Canyons.

Higher summer water temperatures in most years could encourage movement and establishment of bonytail within lower portions of Lodore Canyon and could enhance growth and survival of bonytail in Whirlpool Canyon. As occurs under current baseline conditions, summer water temperatures in Desolation and Gray Canyons would reach the desired humpback chub spawning temperature of at least 17°C (62.6°F) during the descending limb of the spring peak in most years. It is assumed that such temperatures would also be suitable for reproduction and growth of bonytail.

Although a great deal of uncertainty remains regarding bonytail habitat requirements, the proposed action is expected to benefit bonytail reintroduced into the Green River and is expected to provide appropriate conditions for survival and recruitment of this species. The proposed action would result in flows that would maintain and improve substrate conditions in historically occupied canyon reaches. In addition, the proposed action would increase the temperature of water released during summer months in most years, resulting in improved potential for spawning, growth, and survival of bonytail in Whirlpool Canyon.

In addition to the potential benefits of the proposed action to the bonytail described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. Increased entrainment of this species in spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish.

Ute Ladies'-Tresses

The distribution and abundance of Ute ladies'-tresses is affected by changes in the frequency and duration of inundation and by changes in patterns of erosion or deposition. Under the proposed action, the magnitude and duration of peak flows would generally be higher than those of the environmental baseline, especially in wet years. Higher peak flows would result in greater depth and duration of inundation in areas below the existing annual peak flow elevation, such as the post-dam floodplain, along with potential increases in flow velocity. Higher elevation surfaces, such as the intermediate bench or cottonwood-box elder terrace, could be inundated more frequently than under the existing flow regime. Depending on local geomorphic characteristics, sites supporting existing Ute ladies'-tresses colonies may experience a range of effects from increased sediment deposition to increased erosion.

Under the proposed action, annual peaks in Reach 1 would generally be higher than under existing baseline conditions, and geomorphic surfaces supporting Ute ladies'-tresses would generally be inundated more frequently. Results of the Flaming Gorge Hydrologic Model (Clayton and Gilmore 2002) indicate that, under the proposed action, the post-dam floodplain in Reach 1 (inundated at 130 m^3/s [4,600 cfs]) would be inundated in all years by the peak releases of at least one day duration, as under baseline conditions. This surface would be inundated in about 74% of years by flows of two weeks duration, up from about 46% under baseline, and in about 55% of years by flows of four weeks duration, up from about 27% under baseline. The intermediate bench (inundated at about 244 m^3/s [8,600 cfs]) would be inundated in about 30% of years by the peak releases of at least one day duration under the proposed action, and about 7% of years under baseline conditions. The intermediate bench would be inundated in about 8% of years by flows of two weeks duration, slightly up from about 7% under baseline, and in about 2% of years by flows of four weeks duration, slightly down from about 3% under baseline.

Ute ladies'-tresses are able to tolerate occasional periods of extended inundation. The post-dam floodplain surfaces in Reach 1 are sometimes inundated for a duration of up to eight weeks. All Ute ladies'-tresses colonies inventoried in Red Canyon and Browns Park in 1999 were inundated that year by peak flows of 308 m^3/s (10,900 cfs), and most were inundated for at least 32 days (Grams et al. 2002). These survived an average of 0.7 m (2.3 ft) inundation, and up to 1.2 m (3.9 ft) at some sites. On average, sites supporting Ute ladies'-tresses are inundated from a few days to 10 days per year under environmental baseline conditions (1 to 3% of the time) (Grams et al. 2002). Post-dam floodplain sites would be inundated for somewhat longer periods, with two and four week inundations occurring in more years than under baseline conditions. In Red Canyon and Browns Park, approximately 6% of the Ute ladies'-tresses colonies occur on the post-dam floodplain, while about 23% occur on an undifferentiated post-dam floodplain/intermediate bench surface. Intermediate bench sites may be inundated more frequently, with the largest difference from baseline being in the flow durations of at least one day. Approximately 71% of the Ute ladies'-tresses colonies in Red Canyon and Browns Park occur on Intermediate bench surfaces, with 23% on the undifferentiated post-dam floodplain/intermediate bench surfaces. In extreme wet years, high flows could result in some mortality on lower elevation surfaces (e.g., post-dam floodplain sites) greater than what now occurs under the environmental baseline.

Erosion and deposition that could be caused by peak flows would likely be low at many occupied sites. The amount of sediment deposited during the high flows of 1999 at occupied sites in Red Canyon and Browns Park ranged from none (most of the sites) to less than 5 cm (2 in.) of very fine sediment (Grams et al. 2002). Total post-dam deposition at these sites apparently averaged 11 cm (4.3 in.). Sediment deposition was greater on unoccupied post-dam floodplain and intermediate bench surfaces. Deposition also occurred on some post-dam floodplain and intermediate bench surfaces in Lodore Canyon, some of which were occupied. Partial and complete burial of Ute ladies'-tresses were recorded. On channel margin deposits, as well as on islands and expansion bars, in Lodore Canyon, sand deposition and/or erosion was observed on 70% of post-dam floodplain and intermediate bench surfaces examined following the 1999 peak flow (Grams et al. 2002). Intermediate bench and the downstream portions of post-dam floodplain features tended to be subject to deposition, with ranges of several centimeters to over one meter observed.

Under the proposed action, sediment deposition could increase on some occupied sites, such as in Lodore Canyon. However, occupied Ute ladies'-tresses sites in Red Canyon and Browns Park tend to be located in positions with low rates of sediment deposition. Ute ladies'-tresses are able to tolerate some sediment deposition. One colony in Lodore Canyon flowered and produced seed after partial burial in 1999. However, some mortality of buried individuals could be expected.

Erosion at sites occupied by Ute ladies'-tresses in Red Canyon and Browns Park is generally absent or minor. Erosion was observed in Lodore Canyon, however, as a result of 308 m^3/s

(10,900 cfs) flows in 1999. Scouring resulted in habitat loss on upstream portions of channel margin deposits, islands, and expansion bars, especially at the post-dam floodplain level. Ute ladies'-tresses were lost as a result. Increased peak flows under the proposed action could result in increased erosion of these Ute ladies'-tresses sites.

Post-dam floodplain or intermediate bench surfaces that experience erosion or deposition and become available for development of early seral stage vegetation could be colonized by Ute ladies'-tresses, and new reproductive colonies could become established. However, some of those new colonies might be only temporary. For example, some areas that are subject to frequent disturbance from flooding (such as some post-dam floodplain surfaces), might not be stable for the length of time required for Ute ladies'-tresses to become established and to reproduce (10 to 20 years) and might not develop beyond early seral stage communities. In addition, some new sites that are relatively stable for extended periods, (such as some intermediate bench surfaces) might become colonized by native woody species, such as coyote willow or cottonwood, or invasive species, such as tamarisk, giant whitetop, yellow sweetclover (*Melilotus officinalis*), or common reed. Such sites might eventually become unsuitable for survival of Ute ladies'-tresses because of decreased light as a result of excess shading by other species.

New colonies could become established on higher-elevation sites in Red Canyon, upper Browns Park, or Lodore Canyon. Studies indicate that Ute ladies'-tresses became established on the higher pre-dam cottonwood-box elder terrace in Island Park after high flows in 1983 or 1984 (Grams et al. 2002). Deposition of fine sediments and increased frequency of inundation at these higher elevations might increase site suitability for Ute ladies'-tresses. However, some of these areas may currently support other plants whose shade might prevent Ute ladies'-tresses establishment or survival.

Sites that support Ute ladies'-tresses typically have a shallow water table during August and are positioned 0.5 to 0.9 m (1.5 to 2.8 ft) above the normal flow elevation (Grams et al. 2002). Under the proposed action, base flows during August and the remainder of the growing season, would be higher in all but the driest years than under baseline conditions and would be expected to support colonies at existing elevations as well as at slightly higher elevations. The average monthly flow in Reach 1 during August under the proposed action would be approximately 45 m^3/s (1,600 cfs). This would be about 11 m^3/s (380 cfs) above baseline operations in August. Under the proposed action, the highest base flow in Reach 1 would be 76 m^3/s (2,700 cfs) and would occur in wet years. Because base flows may vary from targeted flows by as much as 40% during this period under the proposed action, the maximum base flow expected in Reach 1 would be 106 m^3/s (3,760 cfs), which is below the level of the post-dam floodplain and intermediate bench. Although flows in May, at the beginning of the growing season, may be somewhat lower under the proposed action than under baseline conditions, the growth or survival of Ute ladies'-tresses would not be affected as the difference would be small, and flows would be considerably higher than base flows, ascending to a peak in June. Relatively low base flows during dry years (about 1 m^3/s [25 cfs] lower than baseline August operations) would not be expected to adversely affect Ute ladies'-tresses unless an extended sequence of dry years occurred.

Effects of flow changes in Reach 2 would be similar to those described for Reach 1. Model results indicate that, under the proposed action, the post-dam floodplain in Reach 2 (inundated at approximately 455 m^3/s [16,100 cfs]) would be inundated in about 72% years by the peak releases of at least one day duration, as under baseline conditions. This surface would be inundated in about 47% of years by flows of two weeks duration, up from about 35% under baseline, and in about 19% of years by flows of four weeks duration, slightly up from about 18% under baseline. The intermediate bench (inundated at about 600 m^3/s [21,000 cfs]) would be inundated in 39% of years by the peak releases of at least one day duration under the proposed action, as under baseline conditions. This surface would be inundated in about 14% of years by flows of two weeks duration, up from about 9% under baseline, and in about 5% of years by flows of four weeks duration, as under baseline.

In Reach 2, the largest differences from baseline are in the flows of two-week duration or more during the spring-peak period. Sites occupied by Ute ladies'-tresses in Island Park and downstream of Split Mountain might be subject to extended inundation, increased deposition, or increased erosion. The magnitude of effects on occupied sites might be limited in most years, although peak flows in wet years could result in some mortality of Ute ladies'-tresses. There are far fewer colonies in Reach 2 than in Reach 1, however.

As in Reach 1, sites suitable for establishment of Ute ladies'-tresses could become available at higher elevations in Island and Rainbow Parks, if suitable sediments are deposited. However, high peak flows in Reach 2 caused by Yampa River input might decrease the potential suitability of some new sites on post-dam surfaces, such as intermediate bench surfaces. Sites that are subject to frequent disturbance from high flows may not be stable for long enough periods for Ute ladies'-tresses establishment and reproduction.

Under the proposed action, base flows in Reach 2 in August and the remainder of the growing season would be higher in most years and would be expected to support colonies at existing elevations as well as at slightly higher elevations. The average monthly flow in Reach 2 during August, under the proposed action, would be approximately 57 m^3/s (2,000 cfs). This would be about 11 m^3/s (400 cfs) above baseline operations in August. The highest target base flow in Reach 2 would be 85 m^3/s (3,000 cfs), and would occur in wet years. Because base flows may vary from targeted flows by as much as 40% during this period, the maximum base flow expected in Reach 2 would be 119 m^3/s (4,200 cfs), which is below the level of the post-dam floodplain and intermediate bench where Ute ladies'-tresses occur. Relatively low base flows during dry years under the proposed action would not be expected to adversely affect Ute ladies'-tresses in Reach 2 unless an extended sequence of dry years occurred.

It is possible that the proposed action will facilitate the spread and vigor of invasive species such as tamarisk into occupied or potentially suitable habitat of Ute ladies'-tresses orchid. However, the rate and extent of invasion and habitat change is unknown. Tamarisk is an aggressive opportunist and persists in habitats they invade (i.e., are resistant to natural vegetation succession). Invasion tamarisk would result in significant detrimental impacts to habitat and some colonies could be threatened with eventual extirpation.

In summary, Ute ladies'-tresses is well adapted to changing conditions in riparian floodplains. It typically occurs where streams exit steep terrain, retain moderate velocity, and begin to create a meander floodplain corridor. It's occurrence in a steep-walled canyon such as Lodore is considered to be an artifact of Flaming Gorge operation where both high and low flows have been attenuated. This is corroborated by failure to find the species or suitable habitat conditions along the Yampa River. In Reach 1, Ute ladies'-tresses occurs on landforms just below debris fans, conditions which replicate emergence of streams from steep terrain into more moderate terrain. Historically, it is likely that the orchid did not occur in Lodore Canyon, but rather in various locations upstream of Flaming Gorge Dam, and possibly in Browns, Island, and Rainbow parks. While reoperation of Flaming Gorge Dam will more nearly replicate natural flow conditions than historical or baseline operation, it will be insufficient to recreate riparian habitat dynamics and complexity in areas such as Browns, Island, and Rainbow parks due to the excessive sediment buildup in those areas since the dam was built. Thus, we do not expect that suitable potential habitat will be created and sustained in those areas. In addition, it has been speculated that an increase in the frequency and duration of bypasses and spills from Flaming Gorge Dam could adversely effect populations in Reach 1 that were established under prior dam operations.

Uncertainties

In their Biological Assessment, Reclamation and Western, identified a number of uncertainties associated with the proposed action and offered a list of actions to reduce potential adverse effects to the listed species. We summarize those discussions below:

Uncertainties Associated with Hydrology

Reclamation and Western point out the limitations of the Flaming Gorge Hydrology Model (Clayton and Gilmore 2002). The Service recognizes that the Flaming Gorge Model is not an operations model, but was a tool developed to conduct comparative analyses of impacts / effects of alternatives in the environmental compliance arena. Under the proposed action, the Service, through it's involvement on the Technical Working Group and the Flaming Gorge Working Group, would work closely with Reclamation in recommending dam operations to meet the flow and temperature recommendations. In our ITS, we identify the type of information we expect to be included in Reclamation's Annual Operations Report. A thorough accounting of operations will help the Service and others evaluate the extent to which the recommendations were met in the most recent year and how that relates to previous years of operation.

Uncertainty with Selective Withdrawal Operations

Reclamation included a conservation measure in their proposed action that addressed operational uncertainty in their ability to meet the temperature recommendations. We have addressed Reclamation's concern in our ITS by requiring Reclamation to develop a selective withdrawal operations plan, which addresses their uncertainties and outlines a process to resolve them.

Uncertainties Associated With Increased Spillway Use

Based on past experiences, Reclamation foresees potential structural damages to the FGD spillway each time it is used, and therefore commit to inspecting the structure after each spill event. In the biological assessment, Reclamation states that if the amount of damage was deemed unacceptable they would limit use of the spillway to those times it was hydrologically necessary. The Service expects Reclamation to report the results of their post-spill spillway inspections in their annual operations report (see ITS Term and Condition #6). Should Reclamation determine that the increased use of the spillway under the proposed action was unacceptable the Service will consider if re-initiation of Section 7 consultation is necessary.

We encourage Reclamation to coordinate with the State of Utah's ongoing tailrace trout population monitoring to evaluate the level of nitrogen super-saturation associated with use of the spillway. If results of those ongoing efforts in a change in Reclamation's operations to meet the flow recommendations, the Service would determine if re-initiation of this Section 7 consultation was necessary.

The Service recognizes and agrees with Reclamation's concern that spills from Flaming Gorge Dam could result in unacceptable levels of entrainment of nonnative reservoir fish species. We have addressed these concerns by providing the framework for an adaptive management process that evaluates the proposed action (including entrainment) in our ITS.

Uncertainties in Fish Responses to Flow and Temperature Modifications

Reclamation and Western in their biological assessment expressed concern over how the fish community and in particular nonnative species might respond to aspects of the flow and temperature recommendations. Whereas, the action agencies and the Service recognize that the intention of the proposed action is to benefit the endangered fish in the long-term, the Service shares the concern that implementation of the proposed action could result in both temporal and spatial short-term benefits to some nonnative species. Evaluating the effects of the proposed action on the fish community will be of critical importance in determining how to best manage the system for recovery of the endangered fish species. In our ITS (RPM #1 and T&C #1) we identify the need for the action agencies and the Service to work with the Recovery Program to develop a Study Plan that evaluates this proposed action. We recommend that the Recovery Program consider uncertainties, identified by the authors of Muth et al (2000) and as identified by Reclamation through their NEPA process, in the development of that study plan. The Service agrees with the action agencies that the Recovery Program is the appropriate science body to take the lead in developing and implementing that plan. It is the Service's opinion that implementation of that study plan within the context of the Recovery Program and full communication of that plan with interested parties via the Flaming Gorge Working Group represents an appropriate adaptive management solution to these fish community uncertainties.

Uncertainties Associated With Floodplain Inundation

In their biological assessment, Reclamation and Western have brought into question the need for some of the dam releases (based on results of hydrologic modeling presented in Reclamation'

EIS) to meet Reach 2 floodplain magnitude and duration targets as identified in Muth et al (2000) to benefit larval razorback suckers. Reclamation and Western's position on this issue is based primarily on information that was presented in the Recovery Program sponsored Floodplain Management Plan for the Green River Subbasin (Valdez and Nelson 2004). It is the Service's opinion that based on the best available information Muth et al (2000) should be implemented, however the specific questions raised by the action agencies in their biological assessment regarding floodplain inundation should be considered through the adaptive management process outlined in RPM #1, T&C #1 of the ITS.

Uncertainties Associated with Riparian Vegetation

There are uncertainties associated with the response of invasive plant species to the proposed action. Recent research suggests that the flood flows may prevent additional tamarisk establishment on post-dam floodplain surfaces in Lodore Canyon, but may push establishment to higher elevations. Information is lacking on the degree to which these responses would occur.

Uncertainties related to the response of certain native plant communities to the proposed action include duration and magnitude of flood flows necessary to stimulate a positive response in mature cottonwoods and response of wetland species to higher base flows of late summer and lower base flows of winter and early spring.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Endangered Species Act. In the action area, the Green River flows mostly through federal land. No future state or private actions are known to be in the planning stage in the action area that would not require Section 7 consultation. For this reason, no cumulative effects are anticipated on the endangered species or designated critical habitat in the action area.

CONCLUSION

After reviewing the current status of the endangered fishes and the Ute ladies'-tresses, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the proposed action is not likely to jeopardize the continued existence of the Colorado pikeminnow, humpback chub, bonytail, razorback sucker or Ute ladies'-tresses and will not result in the destruction or adverse modification of critical habitat of these species. The implementation of the proposed action is expected to result in overall beneficial effects to the species and critical habitat in the Green River downstream from Flaming Gorge Dam and induce a positive species response, particularly with the endangered fishes due to a more natural hydrologic regime. The basis for the determination of no jeopardy and no adverse modification of critical habitat for each listed species is summarized below.

Colorado Pikeminnow

The Service concludes that although some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the proposed action will result in long-term positive benefits for the Colorado pikeminnow and critical habitat. Positive effects of the proposed action include; increased inundation and access to floodplains which would provide warm, food rich environments for adult and subadult Colorado pikeminnow, peak flows of sufficient magnitude to maintain main channel habitats for adult fish including spawning bars, base flows that would encourage development and maintenance of backwaters and other low velocity shoreline habitats favorable for young fish and a temperature regime that would reduce temperature shock to drifting Colorado pikeminnow larvae at the confluence of the Green and Yampa rivers and potentially improve growth of adult fish in lower Reach 1 and the upper portion of Reach 2.

Razorback Sucker

The Service concludes that although some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the proposed action will result in long-term positive benefits for the razorback sucker and critical habitat. Positive effects of the proposed action include; increased inundation and access to floodplains for young razorback suckers, peak flows of sufficient magnitude to maintain main channel habitats for adult fish, base flows that would encourage backwater development and other low velocity shoreline habitats favorable for razorback suckers and a temperature regime that could improve razorback sucker growth in lower Reach 1 and the upper portion of Reach 2.

Humpback Chub

The Service concludes that although some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the proposed action will result in long-term positive benefits for the humpback chub. Positive effects of the proposed action include; peak flows of sufficient magnitude to maintain main channel habitats for adult fish, base flows that would encourage development of complex low velocity shoreline habitats and a temperature regime that could enhance growth and survivability of young humpback chub in Whirlpool Canyon in Reach 2.

Bonytail

Although there is uncertainty about some aspects of bonytail life history and some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the Service concludes that the proposed action will result in long-term positive benefits for the bonytail and critical habitat by providing conditions appropriate for survival and recruitment. Positive effects of the proposed action include; increased inundation and access to floodplains for young bonytail, peak flows of sufficient magnitude to maintain main channel habitats for adult fish, base flows that would encourage backwater development and other low velocity shoreline habitats and a temperature regime that could improve the potential for spawning and growth of bonytail in the Whirlpool Canyon portion of Reach 2.

Ute Ladies'-tresses

The Service concludes that the proposed action is not likely to jeopardize the Ute ladies'-tresses or result in the destruction or adverse modification of critical habitat since no critical habitat has been designated for this species. Along the Green River, Ute ladies'-tresses occur on surfaces that formed in response to construction and past operations of Flaming Gorge Dam. Most colonies are located in Reach 1, but several have also been found in Reach 2. Most individuals occur on post-dam floodplain surfaces, near the annual peak-flow elevation, or on the intermediate bench, which is at a slightly higher elevation. These sites are located within a zone that is inundated between 1% and 3% of the time. Under the proposed action, mean annual peak flows would increase, and the frequency of larger peak flows would increase. While occupied sites might be subject to some erosion, deposition, or extended inundation, direct effects on Ute ladies'-tresses colonies as a result of these flow changes are expected to be small because of site characteristics that often are protective, such as landscape position and substrate composition. The 1 to 3% inundation zone may shift to a slightly higher position along the river margin, potentially resulting in reductions in the number of individuals at lower elevations, such as on some post-dam floodplain surfaces. Locations at elevations slightly above the existing zone of 1 to 3% inundation may become more suitable for Ute ladies'-tresses establishment. The indirect effects of the proposed action include potential changes in location, distribution, vigor, and competitive ability of both native and non-native invasive species, which may in turn adversely affect the ability of Ute ladies'-tresses to occupy suitable habitat.

Ute ladies'-tresses is adapted to and requires occasional disturbance to maintain its preferred seral stage; proposed-action flows would provide this occasional disturbance while maintaining appropriate soil-moisture conditions during the growing season. Implementation of the proposed action may result in some losses of individual plants at currently occupied sites due to erosion or deposition during high flow events. New colonies of Ute ladies'-tresses may become established at higher elevations and offset these losses. However, increased vigor or competitiveness of native and non-native invasive species may preclude or impede orchid establishment and long term sustainability in occupied and potentially suitable habitat.

There are several large populations of Ute ladies'-tresses throughout it 7 state range, and many small populations. Although the population in Reach 1 and 2 is considered significant, anticipated adverse impacts are unlikely to result in extirpation either of this population or of the species throughout its range.

INCIDENTAL TAKE

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent act or omission that creates the likelihood of injury to listed wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken so that they become binding conditions of any Federal discretionary activity, for the exemption in section 7(o)(2) to apply. The following reasonable and prudent measures and terms and conditions are intended to be largely consistent with the 2004 Recovery Implementation Program Recovery Action Plan (RIPRAP) of the Upper Colorado River Endangered Fish Recovery Program[3] (Recovery Program) and will be implemented according to the RIPRAP schedule. This incidental take statement, however, also contains several terms and conditions not included in the 2004 RIPRAP. For these terms and conditions Reclamation and Western will either work with the Recovery Program to include them in future RIPRAP revisions or may assume responsibility for their implementation. The participating Federal Agencies have a continuing duty to monitor the activity covered by this incidental take statement. If Reclamation and Western through the Recovery Program or as individual agencies 1) fail to assume and implement the terms and conditions or 2) fail to retain oversight to ensure compliance with the terms and conditions, the protective coverage of section 7(o)(2) may lapse for the projects covered by this incidental take statement. In order to monitor the impact of incidental take, Reclamation and Western must report to the Service as specified in the incidental take statement [50 CFR 402.14(i)(3)] (see TC#5-annual report).

AMOUNT OR EXTENT OF TAKE

The Service believes that managing reservoir releases to be consistent with the flow recommendations is necessary for the survival and recovery of the endangered fish. The Proposed Action is fully intended to benefit the endangered Colorado River fish, and the Service expects an overall, long-term beneficial effect to result from implementation. However, the Proposed Action also has the potential to cause increases in nonnative fish within the action area. Increases in nonnative fish may result in incidental take in the form of harm through predation on and competition with the endangered fish (Hawkins and Nesler 1991; Lentsch et al. 1996; Tyus and Saunders 1996). Incidents of predation by northern pike on endangered fishes have been

[3] The Recovery Program was established in 1988 when the Secretary of Interior; Governors of Wyoming, Colorado and Utah; and the Administrator of the Western Area Power Administration signed a cooperative agreement to implement the program. The purpose of the Recovery Program is to recover the endangered fishes in the Colorado River system while providing for existing and new water development in the Upper Basin. The Recovery Program is also intended to serve as a reasonable and prudent alternative to avoid the likelihood of jeopardy to the continued existence of the endangered fishes and to avoid the likely destruction or adverse modification of critical habitat in Section 7 consultations on depletion impacts related to new projects and all impacts (except contaminants) associated with historic water projects in the Upper Basin.

observed in both the Yampa and Green rivers. Other nonnative predators, such as smallmouth bass and channel catfish, also present a threat to endangered fishes due to both predation and competition for food and space. A rapidly expanding population of smallmouth bass in the Yampa River during the recent drought years was blamed for precipitous declines in the abundance of juvenile native fish (Anderson 2002). Smallmouth bass have also recently expanded into the Green River above its confluence with the Yampa River (Bestgen pers. comm.). Small-bodied nonnative species such as red shiner, sand shiner, and fathead minnow may also negatively interact (competition and predation) with early life stages of native species.

Mechanisms by which populations of nonnative fish may be increased as a result of the Proposed Action include:

1. Release of water through the spillway as identified in the Proposed Action may result in the entrainment of nonnative fish. Use of the spillway and/or bypass tubes and the resulting high flows during the spring may inhibit some nonnative fish populations in the Green River in Reach 1. However, spillway releases will also likely result in the entrainment of nonnative fish, particularly smallmouth bass from Flaming Gorge Reservoir into the Green River during high water years.
2. Increased inundation of the floodplain (duration and magnitude) in Reach 2 and 3 provides important habitats preferred by both native and nonnative species
3. Increased release temperatures from Flaming Gorge Dam create habitat conditions in Reach 1 that could benefit nonnative fish species as well as the native endangered fishes.

The Service is unable to determine the exact level of incidental take that would result from increases in nonnative fish populations due to implementation of the Proposed Action. Estimating the incidental take of individual listed fish associated with a possible increase in nonnative fish populations due to spills, temperature modification and increased floodplain inundation is difficult to quantify for the following reasons: 1) quantifying the amount of predation is extremely difficult due to large extent of the action area and the difficulty of estimating fish populations and predation rates, 2) estimates of nonnative predators in Flaming Gorge Reservoir that are potentially subject to entrainment during a spill are unknown as well as survival rates of fish that are entrained, 3) much of the floodplain inundation that will occur in the future is dependent on the uncontrolled Yampa River spring flows, i.e., the incremental amount of take that could be attributed to Reclamation's operations to fully meet the spring flow recommendations is unquantifiable, and 4) the amount of take directly attributable to the proposed action is confused by a Lodore Canyon fish community that is rapidly changing in response to drought conditions and nonnative species invading from the Yampa River.

In addition to take associated with nonnative fish, the Service expects that an unquantifiable level of take may occur as a result of drifting Colorado pikeminnow larvae in the Yampa River being exposed to thermal shock of differing water temperature in the Green River at their confluence. As larvae drift out of the Yampa River into the Green River they are exposed to cold water released from Flaming Gorge Dam. Take is difficult to quantify since effects of cooler water temperatures on the survival of Colorado pikeminnow larvae are largely unknown. However, Berry (1988) and Tyus (1991) suggested that higher recruitment of Colorado pikeminnow occurred in years when the temperature differences between the two rivers was 2°C or less and Muth et al. (2000) stated that temperature differences of 5-10°C are common and may cause indirect mortality. The Proposed Action is to meet the temperature recommendation of 5°C difference or less at the confluence of the Green and Yampa River during the time when pikeminnow larvae are present. Temperature monitoring, however, at the Yampa / Green Rivers confluence has not been conducted long enough to assess Reclamation's ability to achieve the recommendation.

According to Service policy, as stated in the Endangered Species Consultation Handbook (USFWS 1998b) (Handbook), some detectable measure of effect should be provided, such as the relative occurrence of the species or a surrogate species in the local community, or amount of habitat used by the species, to serve as a measure for take. Take also may be expressed as a change in habitat characteristics affecting the species, such as water quality or flow (USFWS 1998b). Because estimating the number of individuals of the four listed fishes that could be taken by nonnative fishes and by thermal shock of Colorado pikeminnow larvae in this biological opinion is difficult, we have developed a surrogate measure to estimate the amount of anticipated take to listed fish in the form of harm. The surrogate we are using is flows in the Green River below Flaming Gorge Dam. Flows of a magnitude, timing and duration consistent with the Proposed Action and the Flow Recommendations (Muth et al. 2000) provide the short and long-term habitat conditions in the Green River suitable for the survival and recovery of the endangered fish. Take would be exceeded if the Service, after consultation with the action agencies, determined that flows in the Green River below Flaming Gorge Dam were not consistent with the flow recommendations as identified in the Proposed Action and there was evidence of harm to listed species. This would include significant habitat modification or degradation when it kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding or sheltering from failure to meet the flow recommendations. We exempt all take in the form of harm that would occur from normal operations including spills and modified temperature releases from Flaming Gorge Dam operations that are consistent with the Proposed Action to meet the flow recommendations provided the action agencies, working in cooperation with the Recovery Program, comply with the reasonable and prudent measures and the implementing terms and conditions of this Incidental Take Statement.

EFFECT OF THE TAKE

In the accompanying biological opinion, the Service determined that the anticipated level of incidental take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

The Service, in cooperation with the Recovery Program, developed the flow and temperature recommendations (Muth et al. 2000) with the although the proposed flows would improve endangered fish habitat that there will be times and situations where warm water nonnative species could benefit and drifting larval Colorado pikeminnow may be impacted at the confluence. Therefore, the Service believes that the reasonable and prudent measures to minimize incidental take associated with the propose action need to be focused on evaluating the effects of implementation of the flow and temperature recommendations (Proposed Action) and understanding and managing negative interactions between native and nonnative fish.

Through implementation of the proposed action, Reclamation and Western intend to protect and assist in the recovery of the populations and designated critical habitat of the four endangered fishes, while maintaining all purposes of the Flaming Gorge Unit of the CRSP, particularly those related to the development of water resources. As part of their proposed action, Reclamation and Western included a list of environmental commitments in their biological assessment (identified as conservation measures in this biological opinion). Some of those conservation measures stemmed from uncertainties associated with the proposed action that Reclamation identified in their NEPA process and as were identified by Muth et al. (2000). As some of those uncertainties are linked to potential take of the endangered fish, they serve as the basis for the following Reasonable and Prudent Measures. The Service believes the following reasonable and prudent measures are necessary and appropriate to avoid and minimize the impacts of incidental take of the listed Colorado River fishes:

1. Implementation and refinement of the proposed action will occur through an adaptive management process. Reclamation, Western and the Service will work through the Recovery Program to implement appropriate monitoring and research studies to test the result of implementing the proposed action and identify the potential for modifying or refining flows and temperatures from Flaming Gorge Dam. The Service considers the Recovery Program the appropriate science body to develop and implement monitoring and research studies that would address uncertainties associated with the proposed action. In accordance with the Section 7 agreement, Reclamation, the Service, and Western will work with the Recovery Program to revise the RIPRAP as necessary to incorporate the approved studies deemed necessary to evaluate the proposed action.

2. The Recovery Program will assess the need for and implement as necessary nonnative fish control programs in the Green and Yampa River systems in accordance with the RIPRAP and scopes of work approved by the Recovery Program.

3. Reclamation has committed to develop a process for operating the selective withdrawal structure consistent with the objectives of improving temperature conditions for the endangered fish (see Description of the Proposed Action).

4. Reclamation and the Recovery Program should determine if temperature gaging in Reach 1 and Reach 2 is adequate to ensure temperature recommendations are met

5. Reclamation will produce a summary report each year to document annual operations and the information used to develop those operations. Over time, it is expected that these data would be of benefit in determining if flow recommendations are being met and correlating and analyzing conditions for the endangered fish species and their habitat downstream from Flaming Gorge Dam.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the following terms and conditions, which implement the reasonable and prudent measures described above, must be satisfied. These terms and conditions are nondiscretionary.

In order to implement RPM #1 Reclamation will:

A.) Establish the Technical Working Group, as detailed in Section 2.5.3 of the EIS, consisting of biologists and hydrologists involved with endangered fish recovery issues. The Technical Working Group will meet at various times throughout the year to provide input and feedback concerning current and past operations on endangered fish needs and provided recommendations to Reclamation on its operational plan for Flaming Gorge Dam. A representative from the Service's Utah Field Office will participate on the Technical Working Group.

B.) Consistent with the Recovery Program RIPRAP Item No. I.D. in the Green River Mainstem Action Plan which states: *Evaluate and revise as needed, flow regimes to benefit endangered fish populations* - Reclamation, Western and the Service will work through the Recovery Program technical committees to develop a Study Plan to evaluate the Flaming Gorge Flow and Temperatures Recommendations. The Study Plan should be completed within one year of the finalization of this biological opinion and should focus on previously identified uncertainties related to floodplain inundation, nonnative impacts, effects of elevated temperatures and geomorphic processes. Whereas the intent of this Study Plan is to guide future evaluation of the Flaming Gorge Flow and Temperature Recommendations, it should draw heavily on the direction provided in section 7 consultation documents including the biological assessment and biological opinion, Recovery Program guiding documents:

- Strategic Plan for Geomorphic Research and Monitoring (LaGory et al. 2003)
- Green River Sub-basin Floodplain Management Plan (Valdez and Nelson 2004)

and ongoing field studies:

- Gunnison and Green River Sediment Monitoring: Project # 85F
- Cumulative Effects of Flaming Gorge Dam Releases since 1996 on the Fish Community in Lodore and Whirlpool Canyons: Project 115
- Floodplain Habitat Surveys: Project Cap-6 HYD
- Razorback sucker migration / recruitment from floodplain habitat: Cap-6 RZ
- Larval bonytail and razorback sucker survival in floodplain habitats: Cap-6 bt/rz
- Larval razorback and bonytail survival in Baeser; Cap-6 rz/bt
- Entrainment of larval razorback sucker cap6-rz/entr
- Native fish response to nonnative control efforts in Utah: new study
- Yampa and Middle Green River razorback sucker and Colorado pikeminnow larval survey for Flaming Gorge operations: Project 22f
- Population Estimation for Colorado pikeminnow in the Green River (Project 128) and for humpback chub in the Green River (Project 129)

- Annual Fall Monitoring for CPM YOY: Project 138).
- Nonnative Control in the Yampa and Green Rivers (Projects 109; 110; 98a-c; 123)

The study Plan will be structured to provide a framework that demonstrates how past, ongoing and future Recovery Program efforts can be used to test objectives of the flow and temperature recommendations and to address uncertainties identified in the Flaming Gorge EIS and by Muth et al. (2000). These uncertainties include the potential impacts related to the escapement of nonnative fishes from Flaming Gorge Reservoir from the increased frequency of spillway use. Reclamation and Western working through the Recovery Program and within the context of the study plan should also assess and prioritize the possibility of improving connectivity of floodplain habitats and identifying ways to improve entrainment of larval razorback suckers into floodplain habitats at lower peak flow levels. A timeline for producing periodic evaluations (e.g. 5-yr assessments) of the Flaming Gorge Flow and Temperature Recommendations will be provided. In accordance with the Section 7 agreement, Western, Reclamation, and the Service will request the Recovery Program to modify the RIPRAP to incorporate approved studies following standard Recovery Program procedures.

In order to implement RPM #2 Reclamation, Western, and the Service will support the Recovery Program in active implementation of the following RIPRAP items:

From the Green River Action Plan: Mainstem

- III.A.4. Develop and implement control programs for nonnative fishes in river reaches occupied by the endangered fishes to identify required levels of control. Each control activity will be evaluated for effectiveness, and then continued as needed.
- III.A.4.a. Northern pike in the middle Green River.
- III.A.4.c. Channel catfish (e.g. Deso./Gray Canyons) to protect humpback chub populations, and in the middle Green River to protect razorback sucker and Colorado pikeminnow.

From the Green River Action Plan: Yampa and Little Snake Rivers

- III.A.1.b. Control northern pike
- III.A.1.b.(1) Remove and translocate northern pike and other sportfishes from Yampa River.
- III.A.1.b.(2) Reduce northern pike reproduction in the Yampa River.
- III.A.1.b.(2)(a)
- Identify and evaluate natural and artificial spawning/nursery habitats for northern pike in the Yampa River for exclusion devices.
- III.A.1.b.(2)(b) Implement remedial measures to reduce pike reproduction in Yampa River.
- III.A.1.c. Control channel catfish
- III.A.1.d. Remove and translocate smallmouth bass.

The Recovery Program is actively pursuing both nonnative control and native fish response studies in the Green and Yampa Rivers. The Yampa River is outside the action area, but is a primary source of smallmouth bass and northern pike supplying Reaches 1,2, and 3 of the Green River and is therefore referenced here.

In order to implement RPM #3 Reclamation will:

A.) Draft a selective withdrawal operation plan within one year of finalization of this biological opinion. This plan will describe operations to meet the temperature recommendations, describe limitations of meeting the temperature recommendations (physical, budgetary, manpower) and propose experimental solutions to these limitations as needed.

B.) Reclamation's accumulated thermal unit analysis in the EIS indicated that dam releases of 16°C during average and wetter hydrologies increased the potential to benefit adult Colorado pikeminnow in Lodore Canyon and minimized the potential impacts of cold shock to drifting Colorado pikeminnow larvae at the Yampa/Green River confluence. Through development and implementation of an operations plan (T&C #3A) to meet the temperature recommendations, Reclamation should experiment with releases of 16°C during appropriate hydrologies. Such experimentation would not require structural modification of equipment of operation changes affecting hydropower generation.

In order to implement RPM #4:

Reclamation, Western and the Service will work with the Recovery Program to determine the need for real-time temperature gages at the downstream terminus of Lodore Canyon and on the lower Yampa River to assist in their operation of the selective withdrawal device to meet the temperature recommendations. This activity is consistent with tasks in Recovery Program Project No. 19B (Hydrology Support for Biological Research). If a need for real-time temperature gages is determined to exist, the Service will approach the Recovery Program in accordance with the Section 7 agreement to propose installation of such gage(s).

In order to implement RPM #5:

Reclamation will provide to the Service and Recovery Program a concise annual operations report. A primary purpose of the annual report is to provide an assessment of how well operations at Flaming Gorge Dam contributed to meeting flow targets. In addition, the annual report will provide a record of operations as identified under the incidental take statement. Basic information that should be summarized includes the following:

a. A review of the April-July unregulated inflow forecasts provided by the National Weather Service via the River Forecast Center that were used to classify Green River hydrology.
b. Additional factors that were used to determine which flow recommendation hydrologic category was targeted (e.g. Flaming Gorge Reservoir elevation, Yampa hydrology, past operations, power needs, Technical Working Group conversations, etc.),

c. An accounting of actual flows and operations: spring flows and baseflows (reference USGS gages at Yampa River at Deerlodge, Green River at Greendale, Ut at Jensen, Ut, and near Green River, Ut),
d. Results from Reclamation's spillway inspections,
e. A summary of daily and seasonal fluctuations at Jensen, Utah,
f. An overview of Reclamation's operations to meet thermal targets,
g. An accounting of the actual thermal regime in upper and lower Lodore Canyon and the lower Yampa River based on available information.
h. Recommendations to refine operations

The Service recognizes that the Recovery Program may adjust dates and time frames for RIPRAP activities referenced in the terms and conditions in this biological opinion. These changes are made through revisions to the RIPRAP and are subject to Service approval as part of the Recovery Program process. To the extent that such revisions affect dates in this biological opinion, these adjustments are recognized by the Service as modifying dates for those activities in the biological opinion.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service is recommending the following conservation actions:

1. Install additional SNOTEL sites in the headwater reaches of the Yampa River, Upper Green River and Little Snake River. Additional sites will increase the accuracy and precision of runoff forecasts and increase Reclamation's capability to time releases to meet the flow recommendations.

2. Based on implementation of the flow recommendations, reanalyze economic feasibility of retrofitting the bypass tubes with turbines and implement if viable.

3. Participate with members of the Ute ladies'-tresses/riparian vegetation work group and other entities to identify means, devise strategies, and help implement remediation or mitigation measures for Ute ladies'-tresses recommended by the work group as a result of information gathered through research and monitoring.

In order for the Service to be . ept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the subject action. As provided in 50 CFR sec. 402.16, reinitiation of formal consultation is required for projects where discretionary Federal Agency involvement or control over the action has been retained (or is authorized by law) and under the following conditions:

1. The amount or extent of take specified in the incidental take statement for this opinion is exceeded.

2. New information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion. In preparing this opinion, the Service describes the positive and negative effects of the action it anticipates and considered in the section of the opinion entitled "EFFECTS OF THE ACTION." New information would include, but is not limited to, not achieving significant portions of the flow and temperature recommendations or unanticipated effects of implementing the proposed action.

3. The section 7 regulations (50 CFR 402.16 (c)) state that reinitiation of consultation is required if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion.

4. The Service lists new species or designates new or additional critical habitat, where the level or pattern of depletions covered under this opinion may have an adverse impact on the newly listed species or habitat. If the species or habitat may be adversely affected by depletions, the Service will reinitiate consultation on the biological opinion as required by its section 7 regulations.

If the Service reinitiates consultation, it will first provide information on the status of the species and recommendations for improving population numbers to the Recovery Program. Only if the Recovery Program does not implement recovery actions to improve the status of the species, will the Service reinitiate consultation with individual projects.

□

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