# RECLAMATION
*Managing Water in the West*

# Annual Report of Operations For Flaming Gorge Dam Water Year 2012

**U.S. Department of the Interior**
**Bureau of Reclamation**

**October 2013**

# Table of Contents

## Appendices

# Annual Report of Operations for Flaming Gorge Dam

## Water Year 2012

# Introduction

This report details the operations of Flaming Gorge Dam during water year 2012[1], and is produced pursuant to the February 2006 Record of Decision for the Operation of Flaming Gorge Dam (ROD)[2], the Operation of Flaming Gorge Dam Final Environmental Impact Statement (FEIS)[3] and 2005 Final Biological Opinion on the Operation of Flaming Gorge Dam (2005 BO)[4]. This is the seventh year of operations of Flaming Gorge Dam under the ROD and this report is the seventh annual report produced as described in the ROD.

Flaming Gorge Dam, located on the upper main-stem of the Green River in northeastern Utah about 200 miles east of Salt Lake City, is an authorized storage unit of the Colorado River Storage Project. The Green River watershed, located in Utah, Colorado, and Wyoming, is part of the upper Colorado River basin. Below Flaming Gorge, the Green River supports populations of four endangered native fishes. Operation of Flaming Gorge Dam influences downstream flow and temperature regimes and the ecology of the Green River, including native fishes. Downstream of Flaming Gorge Dam the Green River is joined by the Yampa, White and Duchesne Rivers, portions of which have all been designated as critical habitat under provisions of the Endangered Species Act of 1973, (Muth, *et al*., 2000).

The Upper Colorado River Endangered Fish Recovery Program (Recovery Program) was initiated in 1988 by the signing of a cooperative agreement amongst the states of Colorado, Wyoming, and Utah, the Secretary of Interior and the Administrator of the Western Area Power Administration (Western). The goal of the Recovery Program is to recover the endangered fish species while allowing for the continued operation and development of water resources in the Upper Colorado River Basin. The Recovery Program is the forum for discussion of endangered fish response to Flaming Gorge Dam operations and for identification of endangered fish research needs.

In 2000, the Recovery Program issued Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam, (Muth *et al*.,

[1] A water year begins October 1 and ends September 30.
[2] Record of Decision Operation of Flaming Gorge Dam Final Environmental Impact Statement (February 2006
[3] Operation of Flaming Gorge Dam FINAL Environmental Impact Statement (September 2005)
[4] 2005 Final Biological Opinion on the Operation of Flaming Gorge Dam

2000), (Flow Recommendations)[5]. The Flow Recommendations provide the basis for the proposed action described and analyzed in the FEIS. The ROD implements the proposed action by modifying the operations of Flaming Gorge Dam, to the extent possible, to assist in the recovery of endangered fishes, and their critical habitat, downstream from the dam and, at the same time, maintains and continues all authorized purposes of the Colorado River Storage Project, (Reclamation 2006). Table 2.1 in the FEIS summarizes the Flow Recommendations and can be found in Appendix C.

## Operational Decision Process for Water Year 2012

The Flaming Gorge Technical Working Group (FGTWG) was established pursuant to the FEIS as recommended in the Flow Recommendations.[6] The ROD clarified the purpose of the FGTWG as proposing specific flow and temperature targets for each year's operations based on current year hydrologic conditions and the conditions of the endangered fish. The FGTWG was also charged with integrating, to the extent possible, any flow requests received by Reclamation from the Recovery Program into the flow proposal so that Recovery Program research could also be facilitated. This process concurrently fulfills the informal consultation and coordination requirements of the ESA for the action agencies as committed to in the ROD.

Members of the FGTWG include biologists and hydrologists from Reclamation, the U.S. Fish and Wildlife Service (Service), and Western Area Power Administration (Western). Each year, FGTWG's recommendation is presented to the Flaming Gorge Working Group, along with any flow requests or operational requests proposed by other federal or state agencies or stakeholders. The Flaming Gorge Working Group (Working Group) was formed in 1993 to provide interested parties with an open forum to express their views and interests in the operations of Flaming Gorge Dam. The Working Group meets biannually, at a minimum, and functions as a means of providing information to and gathering input from stakeholders and interested parties on dam operations, other resource concerns and research flows.

In 2012, the operational process developed in 2006 was used for making operational decisions at Flaming Gorge Dam. This process was developed based on descriptions provided in the FEIS (Section 1.5) and the ROD (Sections III, VI, and VII), (Reclamation, 2005, Reclamation 2006). A detailed description of this process can be found in Appendix A and a timeline of how this process was implemented in 2012 can be found in Appendix B. The implementation of the four steps of the process in 2012 is described below:

[5] Muth, R. T., et al. (2000). Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Forge Dam. Project FG-53, Upper Colorado River Endangered Fish Recovery Program. Available on line at: http://www.coloradoriverrecovery.org/documents-publications/technical-reports/instream-flow-identification-protection.html

[6] FGTWG meeting summaries and documents are also available at: http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html.

## Step 1: Flow Requests for Research, and Other Federal, State and Stakeholder Input

Reclamation received and provided to the FGTWG a memorandum on March 26, 2012 (Appendix C) from the Director of the Recovery Program stating the Recovery Program's research request for 2012 Green River spring flows. It contained the final Study Plan to Examine the Effects of Using Larval Razorback Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam Peak Releases (*ad hoc* Committee, March 2012;LTSP,(Appendix E).[7] The Recovery Program's spring 2012 Flow Request was to implement the LTSP. The LTSP primary research objective is that "Reclamation use the occurrence of razorback sucker larvae in channel margin habitats (as determined by real-time monitoring) as the "trigger" to determine when peak releases should occur from Flaming Gorge Dam."

Also, the Recovery Program request indicated that they would continue assessing the emigration rates of previously stocked razorback sucker from the Stirrup floodplain to the main stem of the Green River. Previous studies indicated a 30 centimeter (cm) water depth in passages between floodplains and the main river channel (e.g., levee breaches and outlet structures) is required for juvenile and adult Colorado pikeminnow and razorback sucker fish passage. The Recovery Program therefore requested a flow of 15,000 cfs to maintain a minimum depth of 30 cm at the connection channel of Stirrup Floodplain and the Green River for a minimum of five days.

On May 9, 2012, Reclamation received a spring and base flow request from the Service (Appendix F). The Service supported the Recovery Program research request dated March 26, 2012. The Service acknowledged the potential tradeoff between timing of releases for experiments and meeting the Reach 2 targets outlined in the ROD. The Service supported Reclamation following the Recovery Program's 2012 Spring Flow Request, and that doing so would meet Reclamation's responsibility to the ROD objectives in 2012.

The Service further requested that the calculated Reach 1 base flow targets be augmented as much as 40% higher than the average daily base flow for that reach of the Green River during the summer period through September 30. The intent of the request was to negatively impact nonnative fish species (particularly smallmouth bass) and provide benefits to endangered fish. The Service acknowledged that higher summer flows in Reach 1 might require reducing Flaming Gorge Dam flows during winter releases. The Service supported Reclamation reducing the duration of spring peak releases at Flaming Gorge Dam from two weeks to one week and, if necessary, reducing winter base flow releases.

Reclamation received an April 25, 2012 letter on behalf of Vermillion Ranch Ltd. Partnership, requesting that Reclamation not make releases that exceed powerplant capacity from Flaming Gorge Dam. The letter noted that Vermillion has serious concerns that the reoperation of Flaming Gorge Reservoir pursuant to the 2006 ROD may damage its private property. The letter noted that the Colorado River Storage Project Act that authorized Flaming Gorge provides for flood control as a purpose and that neither the Endangered

[7] Study Plan to Examine the Effects of Using Larval Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam (Larval Trigger Study Plan *ad hoc* Committee 2012).

Species Act nor the ROD can be read to amend nor alter the authorized purposes. Reclamation responded that Flaming Gorge does provide flood benefits and that releases up to combined powerplant and bypass do not constitute unusual operations contrary to authorized purposes. The letters may be reviewed in Appendix H.

Western submitted a written request to Reclamation dated August 20, 2012, (Appendix K), requesting that Reclamation add to the winter target release and that the total release for December through February be 80 to 90 thousand acre-feet in order to assist them in meeting their long term electrical service obligations.

### Step 2: Development of Spring Proposal

The FGTWG met on March 8, 2012, to begin the development of a flow proposal for the spring of 2012. The intent of the flow proposal was to integrate the flow request from the Recovery Program into a flow regime consistent with the ROD. The flow proposal for 2012 described three possible flow regimes that were consistent with the ROD and FEIS (see Appendix G for details). Depending upon the outcome of hydrologic conditions during spring runoff, the intent was to achieve one of these proposed flow regimes. Water year 2012 was characterized by moderately dry conditions in the Upper Green and dry conditions in the Yampa River Basin. The Yampa River Basin spring runoff volume was the fourth driest of 90 years of recorded streamflow.

On July 6, 2012, the FGTWG met to discuss the spring and current base flow hydrology, along with spring 2012 larval entrainment findings, and Argonne National Labs backwater survey results. The formal recommendation for targets at Jensen was July: 1,500 cfs; August: 1,500 cfs; and September: 1,300 cfs. In order to achieve those base flows in Reach 2 according to then-current Yampa River forecasts, corresponding Flaming Gorge releases would be 1,300 cfs, 1,300 cfs, and 1,100 cfs. The hydrology continued to decline and it was explained to the group that steady flows around the minimum release of 800 cfs would most likely occur over the winter period.

Western submitted an Interim Base-Flow Proposal, dated June 12, 2012 (Appendix I), to the FGTWG requesting Flaming Gorge releases be set so that flow in the Green River at Jensen, Utah targeted 1,100 cfs. Western further requested revisiting the base flow in early July once backwater topography data and updated hydrologic data were available.

### Step 3: Solicitation of Comments

On April 18, 2012, Reclamation presented the 2012 FGWTG flow proposal (Appendix G) to the Working Group. The presentation at the Working Group meeting clearly described the FGTWG proposed flow regime for the Green River, the intended operation of Flaming Gorge Dam for the spring and summer of 2012, and received comments. Meeting minutes were recorded and written comments were solicited by Ed Vidmar, Chairperson of the Working

Group.[8] Reclamation received additional comments from the public during the 2012 decision-making process and these comments are available for review in Appendix L.

### Step 4: Final Decision

In response to the spring and base flow requests of Western and the Service, and the dry hydrology in the Upper Green and near record-breaking dry hydrology in the Yampa River Basin, Reclamation communicated separately with both the FGTWG and Western on September 19, 2012 regarding each of the base flow requests received. In both cases, Reclamation asserted that it maintains its commitments in the 2006 Record of Decision, including the potential for refinement of the flow and temperature recommendations if relevant new information gained through adaptive management supports that possibility. Reclamation communicated with the FGTWG and decided to implement the LTSP for dry hydrologic conditions and operate Flaming Gorge Dam to increase releases once biologists determine razorback sucker larvae were in the system and ready to be entrained. The Recovery Program targeted Stewart Lake and Old Charlie Wash as the research floodplains of interest. The Old Charlie Wash floodplain connection to the Green River occurs at lower flows than Stewart Lake, and it was assumed that at flows sufficient to entrain larvae at Stewart Lake entrainment of larvae at Old Charlie Wash would occur at the same time. Reclamation agreed to utilize full powerplant capacity and as much bypass capacity as necessary in conjunction with Yampa River flows to meet floodplain connection at Stewart Lake.

Reclamation communicated with the FGTWG regarding the July-September base flow releases (Appendix J). Reclamation agreed to continue releasing 1,100 cfs during September, but acknowledged that the continued dry hydrology impacted Yampa River flows, and it was unlikely that the requested Reach 2 targets would be sustained because of the Yampa River hydrology.

Reclamation communicated with Western and agreed to assist them this winter in meeting anticipated hydropower demands (Appendix K). However, under the dry hydrologic conditions, Reclamation considered it prudent to limit the daily average release during the months of December through February to 1,200 cfs, and that Western's request for a double-peak pattern during the winter months could be met. Reclamation further acknowledged that it would likely release steady 800 cfs during the months of October, November, March and April.

## Basin Hydrology and Operations

### Progression of Inflow Forecasts

Snowpack conditions in the Upper Green River and Yampa River Basins varied significantly throughout the snow accumulation season (November 2011 through April 2012). The Upper Green River Basin snowpack was below average on January 1, 2012, at 69 percent of

[8] Working Group Meeting notes are also available at http://www.usbr.gov/uc/water/crsp/wg/fg/fg_20120418.html and http://www.usbr.gov/uc/water/crsp/wg/fg/fg_20120822.html.

average.[9] On April 1, 2012, the snowpack in the Upper Green River Basin had increased to 73 percent of average, but had decreased to 41 percent of average by May 1, 2012. The Yampa River Basin snowpack was below average on January 1, 2012, at 64 percent of average. On April 1, 2012, the snowpack in the Yampa River Basin had decreased to 49 percent of average, and had decreased to 23 percent of average by May 1, 2012. The Yampa River Basin April through July volume was 37 percent of average and the 4th lowest on record.

The Colorado Basin River Forecast Center (CBRFC), beginning in January every year and continuing through June, issues a monthly forecast of the total volume of anticipated unregulated inflow for the April through July period in thousands of acre-feet (kaf). The progression of Flaming Gorge Reservoir unregulated inflow and the Yampa River forecasts over the 2012 water supply season is shown in Table 1.

**Table 1 – Progression of CBRFC Unregulated Inflow[10] Volume Forecasts for the April through July Water Supply Period**

| Forecast Issuance Month | Flaming Gorge Reservoir | | Yampa River near Maybell, CO | | Little Snake River near Lily, CO | |
|---|---|---|---|---|---|---|
| | Volume (1000 AF) | % of Average | Volume (1000 AF) | % of Average | Volume (1000 AF) | % of Average |
| January | 760 | 78 | 700 | 75 | 260 | 75 |
| February | 880 | 90 | 635 | 68 | 240 | 70 |
| March | 945 | 97 | 715 | 76 | 280 | 81 |
| April | 810 | 83 | 500 | 53 | 185 | 54 |
| May | 630 | 64 | 400 | 43 | 141 | 41 |
| June | 560 | 57 | 370 | 40 | 117 | 34 |
| July | 540 | 55 | --- | --- | --- | --- |
| **Actual** | **570** | **58** | **343** | **37** | **111** | **33** |

## Summary of Flaming Gorge Operations

Releases from Flaming Gorge averaged 2,000 cfs from October 1, 2011 through October 25, when releases decreased to a steady 1,500 cfs for generator maintenance. Maintenance was completed by November 13, 2011, after which the average daily release rate of 1,500 cfs began following a single-peak pattern. Releases increased to 2,400 cfs by January 1, 2012, with hourly release schedules following a double-peak pattern. Western requested a change from a double-peak to a single-peak pattern that was implemented on January 4, 2012.

Releases remained at the daily average release rate of 2,400 cfs through February, when forecasts increased and releases increased to 2,550 cfs, with hourly releases following a double-peak pattern in order to meet the May 1, 2012, elevation target. Releases increased

[9] Percent of average is based on the 1981-2010 period of record.
[10] Unregulated inflow is defined as the actual inflow to the reservoir corrected for change in storage and evaporation in reservoirs upstream. In the case of Flaming Gorge Reservoir, unregulated inflow accounts for change in storage and evaporation at Fontenelle Reservoir only.

again in March from 2,550 cfs to 2,650 cfs following a double-peak pattern. Western requested a change to the hourly release pattern from double-peak to single-peak in April, with average daily releases continuing at 2,650 cfs.

The April forecast dropped 13 percent of average from March, and releases decreased to an average daily release rate of 1,600 cfs, with hourly releases following a single-peak pattern. The Utah Division of Wildlife Resources (UDWR) requested a modification from normal operations on April 16 and 17, 2012, to conduct their spring fishery assessment. Releases were maintained at 1,600 cfs before and after completion of the spring assessment in anticipation of spring runoff.

Flaming Gorge Dam releases under the Flow Recommendations are increased coinciding with the immediate peak and post-peak of the Yampa River spring peak flows to create a spring peak in the Green River at Jensen. Spring runoff in the Yampa River Basin generally produces two distinct peaks (flows above 10,000 cfs) as low elevation snow melts first followed by the mid-level and higher elevation snowmelt. However, Reclamation, considering the Recovery Program request, decided to implement the LTSP and operate Flaming Gorge Dam to coincide with the presence of wild razorback sucker larvae in the Green River system.

May releases were maintained at an average daily release rate of 1,600 cfs until larval detection occurred around May 17, 2012, and releases increased to full power plant capacity and half capacity of the bypass tubes for a total release of 7,420 cfs on May 23, 2012. Releases from Flaming Gorge were reduced to powerplant capacity (~4,600cfs) on Friday May 25th, one day earlier than was previously scheduled because reports from the Recovery Program indicated that additional high releases would add no benefit to Stewart Lake larval entrainment. Beginning May 26, releases decreased at a down ramp rate of 350 cfs/day and by June 4, 2012, reached an average daily release of 1,500 cfs with hourly releases following the single-peak pattern.

Yampa River flows peaked at 5,360 cfs on April 29, 2012, as Flaming Gorge Dam was releasing an average daily rate of 1,600 cfs prior to detection of wild razorback sucker larvae in the Green River system. The Green River at Jensen, Utah peak was 10,200 cfs on May 24, 2012, with total releases of 7,420 cfs from Flaming Gorge Dam augmenting dry Yampa River flows. Flows at Jensen, Utah were above 8,300 cfs for 5 days.

Flaming Gorge Reservoir elevation decreased a total of 11.52 feet (ft) from the maximum elevation of 6032.95 ft on October 1, 2011, to the annual minimum elevation of 6021.43ft on September 30, 2012.

Flaming Gorge Dam releases (blue line), and flows for the Yampa River (green line) and Jensen (orange line) are illustrated in Figure 1.

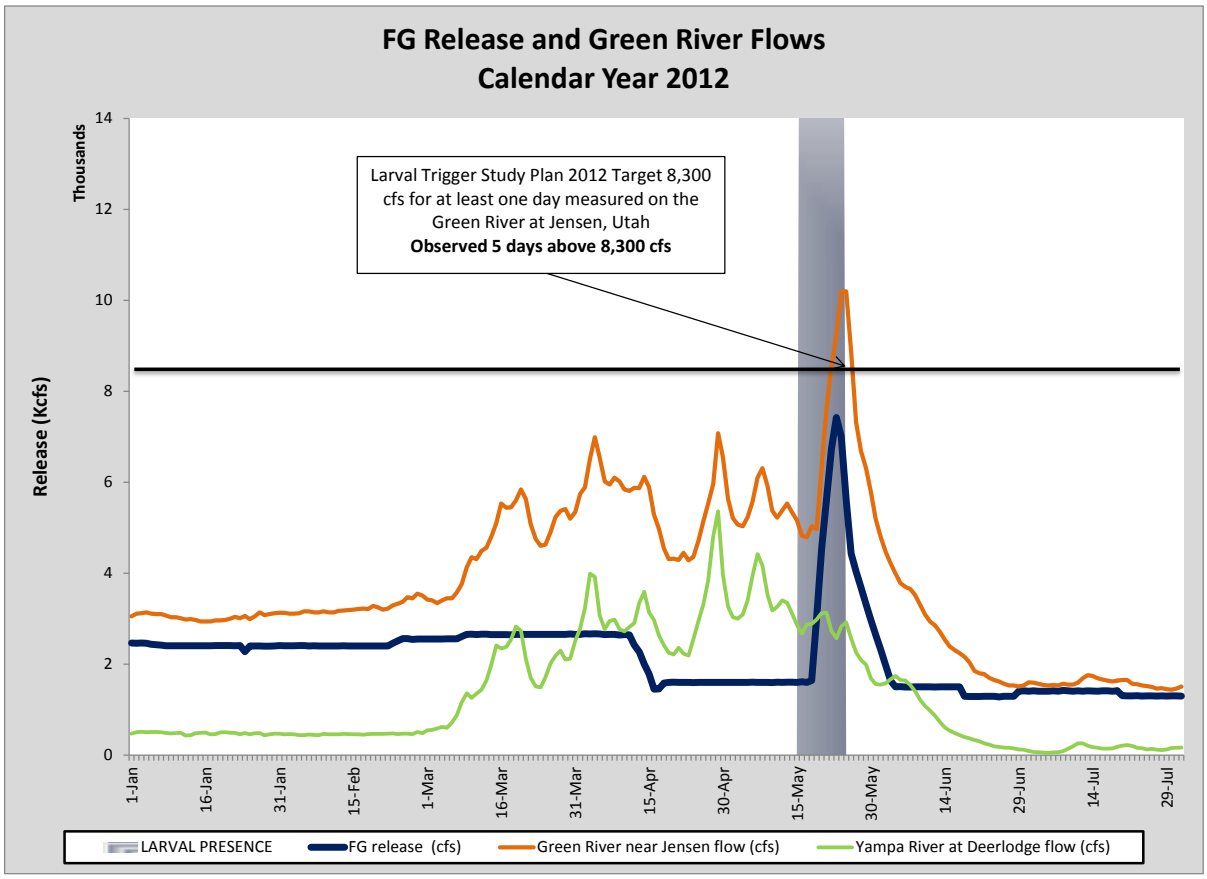



**Figure 1 – 2012 Flaming Gorge Spring Releases and Flows Measured at Yampa River at Deerlodge and Green River at Jensen.**

### Spillway Inspection

The 2005 BO directs Reclamation to provide the results of its annual spillway inspections. During these inspections, inspectors operate gates 1 and 2 through a one-foot open and close cycle during which time they note any unusual or excessive noise or vibration. The spillway inspection occurred on July 23, 2012, at reservoir elevation 6023.19 ft. gates 1 and 2 are both opened one foot at an average rate of one foot per minute. The total volume released was approximately 1.2 acre-feet.

## Flow Objectives Achieved in Water Year 2012

The ROD directs Reclamation to operate to achieve, to the extent possible, the Flow Recommendations as described in the FEIS, (Reclamation 2006). The Flow Recommendations divide the Green River below Flaming Gorge Dam into three river reaches. Reach 1 begins directly below the dam and extends to the confluence with the Yampa River. Reach 2 begins at the Yampa River confluence and continues to the White

River confluence. Reach 3 is between the White River and Colorado River confluences. (Muth et. al 2000)

The Flow Recommendations use five different categories to classify both spring and base flow water year conditions and the Reach 1, 2, and 3 targets associated with that classification (Appendix C). Reach 1 targets are, for the most part, release patterns from Flaming Gorge Dam needed to achieve target peak and base flows identified in Reaches 2 and 3. Reach 2 targets are measured at Jensen, Utah and heavily influenced by Yampa flows. Reach 3 targets, measured at Green River, Utah, are largely dependent on flows targets for Reach 2 and runoff patterns of tributaries. The Flow Recommendations acknowledged that Reach 3 base flows will be subject to natural variation in tributary flows, and this variation should not be compensated for by Flaming Gorge Dam releases, (Muth, *et al*., 2000).

After achievement of the spring flow objectives in Reach 1 and Reach 2, flows are gradually reduced to achieve base flow levels by no later than the date specified in the Flow Recommendation. Base flows in Reaches 1 and 2 should be managed to fall within the prescribed base flow ranges described in the Flow Recommendations based on the observed April through July unregulated inflow into Flaming Gorge Reservoir.

Pursuant to the Flow Recommendations, during the August through November base-flow period, the daily flows should be within ±40 percent of mean base flow. During the December through February base-flow period, the daily flows should be within ±25 percent of the mean base flow.

Additionally, the mean daily flows should not exceed 3 percent variation between consecutive days and daily fluctuations at Flaming Gorge Dam should produce no more than a 0.1-meter daily stage change at Jensen, Utah. On the basis of the stage-flow relationship near Jensen, the maximum stage change that could occur with this level of flow variability over the summer through autumn period would be about 0.4 meters. Flow variability during the winter (December through February) would produce a maximum stage change of about 0.2 meters. This recommendation is based on the fact that the average depth of backwaters occupied by Colorado pikeminnow larvae in Reach 2 is 0.3 m. By restricting within-day variation in flow, conditions critical for young of year fish in backwater habitats should be protected. (Muth, *et al*., 2000).

**Table 2 –**April – July Forecasts and Spring and Base Flow Hydrologic Classifications

| Year | May 1st A-J Unreg Inflow Forecast (1000 AF) | Spring Hydrologic Classification | Observed A-J Unreg Inflow Forecast (1000 AF) | Base Flow Hydrologic Classification |
|---|---|---|---|---|
| 2006 | 1,100 | Average (Abv Median) | 724 | Moderately Dry |
| 2007 | 500 | Moderately Dry | 370 | Dry |
| 2008 | 820 | Average (Blw Median) | 728 | Moderately Dry |
| 2009 | 890 | Average (Blw Median) | 1,197 | Average (Abv Median) |
| 2010 | 515 | Moderately Dry | 705 | Moderately Dry |
| 2011 | 1,660 | Moderately Wet | 1,925 | Wet |
| 2012 | 630 | Moderately Dry | 570 | Moderately Dry |

## Spring Flow Objectives

The spring hydrologic classification is based on the CBRFC May final forecast of April-July unregulated inflow volume into Flaming Gorge Reservoir. The May final forecast for water year 2012 was 630,000 acre-feet (AF) and resulting spring hydrologic classification was moderately dry.[11] The peak-flow magnitudes for Reaches 1, 2, and 3 were 4,600 cfs, 8,300 cfs, and 8,300 cfs, respectively.

The Reaches 1, 2 and 3, Flow Recommendation spring objectives and the desired frequency of achievement are described in Tables 3, 4 and 5. Water year 2012 is the seventh year of operations under the ROD and is the seventh year for establishing the long-term frequencies of these spring flow objectives.

**Table 3 – Reach 2 ROD Flow Objectives Achieved in 2012**

| Spring Peak Flow Objective | Hydrologic Classification | Desired Frequency Percent of Achievement | Achieved in 2012 | Observed Spring Class Frequency %* | Achievement Rate to Date (Cumulative Frequency %)* |
|---|---|---|---|---|---|
| Peak >= 8,600 cfs for at least 1 day | Wet | 10 % | No | 14 % | 14 % |
| Peak >= power plant capacity for at least 1 day | Dry | 100% | Yes | 100 % | 100 % |

*Based on seven years of operation under the ROD and spring hydrologic classification (2006-2012)

[11] Hydrologic classifications are based on Pearson III percentile exceedance volumes for the period of record beginning in 1963 through the previous year hydrology. This calculation results in annual variations in exceedance ranges.

**Table 4 – Reach 2 ROD Flow Objectives Achieved in 2012**

| Spring Peak Flow Objective | Hydrologic Classification | Desired Frequency Percent of Achievement | Achieved in 2012 | Observed Spring Class Frequency %* | Achievement Rate to Date (Cumulative Frequency %)* |
|---|---|---|---|---|---|
| Peak >= 26,400 cfs for at least 1 day | Wet | 10 % | No | 0 % | 14 % |
| Peak >= 22,700 cfs for at least 2 weeks | Wet | 10 % | No | 0 % | 14 % |
| Peak >= 18,600 cfs for at least 4 weeks | Wet | 10 % | No | 0 % | 14 % |
| Peak >= 20,300 cfs for at least 1 day | Moderately Wet | 30 % | No | 14 % | 29 % |
| Peak >= 18,600 cfs for at least 2 weeks | Average (Wet) | 40 % | No | 29 % | 29 % |
| Peak >= 18,600 cfs for at least 1 day | Average (Wet) | 50 % | No | 57 % | 71 % |
| Peak >= 8,300 cfs for at least 1 day | Average (Dry) | 100 % | Yes | 100 % | 100 % |
| Peak >= 8,300 cfs for at least 1week | Moderately Dry | 90 % | No | 100 % | 86 % |
| Peak >= 8,300 cfs for at least 2 days except in extreme dry years | Dry | 98 % | Yes | 100 % | 100 % |

*Based on seven years of operation under the ROD and spring hydrologic classification (2006-2012)

**Table 5 – Reach 3 ROD Flow Objectives Achieved in 2012**

| Spring Peak Flow Objective | Hydrologic Classification | Desired Frequency Percent of Achievement | Achieved in 2012 | Observed Spring Class Frequency %* | Achievement Rate to Date (Cumulative Frequency %)* |
|---|---|---|---|---|---|
| Peak >= 39,000 cfs for at least 1 day | Wet | 10 % | No | 0 % | 14 % |
| Peak >= 24,000 cfs for at least 2 weeks | Wet | 10 % | No | 0 % | 14 % |
| Peak >= 22,000 cfs for at least 4 weeks | Wet | 10 % | No | 0 % | 14 % |
| Peak >= 24,000 cfs for at least 1 day | Moderately Wet | 20 % | No | 14 % | 43 % |
| Peak >= 22,000 cfs for at least 2 weeks | Average (Wet) | 40 % | No | 29 % | 14 % |
| Peak >= 22,000 cfs for at least 1 day | Average (Wet) | 50 % | No | 57 % | 43 % |
| Peak >= 8,300 cfs for at least 1 day | Moderately Dry | 100 % | Yes | 100 % | 100 % |
| Peak >= 8,300 cfs for at least 1week | Moderately Dry | 90 % | Yes | 100 % | 86 % |
| Peak >= 8,300 cfs for at least 2 days except in extreme dry years | Dry | 98 % | Yes | 100 % | 100 % |

*Based on seven years of operation under the ROD and spring hydrologic classification (2006-2012)

Reclamation agreed to implement the LTSP, which "includes a matrix to be used as a guide in testing hypothesis associated with the larval trigger." (*ad hoc* Committee, March 2012) Implementation of the LTSP occurs over a range of peak flow magnitudes and durations. The experimental timetable is for three years of flows at Jensen, Utah, below 18,600 cfs, and three years above 18,600 cfs, with connecting flows in each of these years of at least seven days duration, as minimally necessary to complete the study.

Water year 2011 is included in the three years of flows above 18,600 cfs. Water year 2012 is included in the three years below 18,600 cfs. Table 6 is a copy of the matrix found in Table 2 of the LTSP. It describes the flow conditions and corresponding targeted wetlands. The peak flow as measured at Jensen, Utah, targeted this year corresponded with the dry hydrologic condition with flows between 8,300 cfs and 14,000 cfs targeted between 1 to 7 days. Flows at Jensen, Utah, were above 8,300 cfs for 5 days, which did not meet the seven-day duration objective for moderately dry years outlined in the LTSP, although it did meet the dry hydrology duration requirements in Table 6 and the ROD duration target of 2 days above 8,300 cfs in extremely dry years.

**Table 6 – LTSP TABLE 2. Matrix to Be Used in Studying the Effectiveness of a Larval Trigger**

| Peak Flow (x) as Measured at Jensen, Utah | Potential Study Wetlands[a,b] | Number of Days (x) Flow Exceeded and Corresponding Hydrologic Conditions [c] | | |
|---|---|---|---|---|
| | | $1 \leq x < 7$ | $7 \leq x < 14$ | $x \geq 14$ |
| $8{,}300 \leq x < 14{,}000$ cfs | Stewart Lake (f), Above Brennan (f), Old Charley Wash (s) | Dry | Moderately dry | Moderately dry and average (below median) |
| $14{,}000 \leq x < 18{,}600$ cfs | Same as previous plus Thunder Ranch (f), Bonanza Bridge (f), Johnson Bottom (s), Stirrup (s), Leota 7 (s) | Average (below median) | Average (below median) | Average (below median) |
| $18{,}600 \leq x < 20{,}300$ cfs | Same as previous | Average (above median) | Average (above median) | Average (above median) |
| $20{,}300 \leq x < 26{,}400$ cfs | Same as previous plus Baeser Bend (s), Wyasket (s), additional Leota units (7a and 4), Sheppard Bottom (s) | Moderately wet | Moderately wet | Moderately wet |
| $x \geq 26{,}400$ cfs | Same as previous | Wet | Wet | Wet |

(a) f = flow-through wetland, s = single-breach wetland
(b) Up to eight wetlands would be sampled in a given year with the three in the lowest flow category being sampled in all years.
(c) Refer to [Appendix C] for exceedance percentages and peak flow recommendations for each hydrologic condition. Note that the hydrologic conditions presented are the driest that could support a particular combination of peak flow magnitude and duration. For any combination, wetter hydrology could also support an experiment.

## Base Flow Objectives

Base flows are classified based on the observed April-July unregulated inflow volume into Flaming Gorge and monthly base flow forecast from the CBRFC. The observed April-July unregulated inflow volume was 570,000 AF and resulting base flow hydrologic classification was moderately dry. Reach 1 flows were reduced to base flows by June 4, 2012. The observed April-July unregulated inflow volume into Flaming Gorge Reservoir, August final forecast and average daily releases needed to achieve the May 1, 2013 elevation target of 6027 feet were used to calculate the Reach 1 daily average base flow of 875 cfs, which is within the base flow range for moderately dry classification as shown in Figure 2.

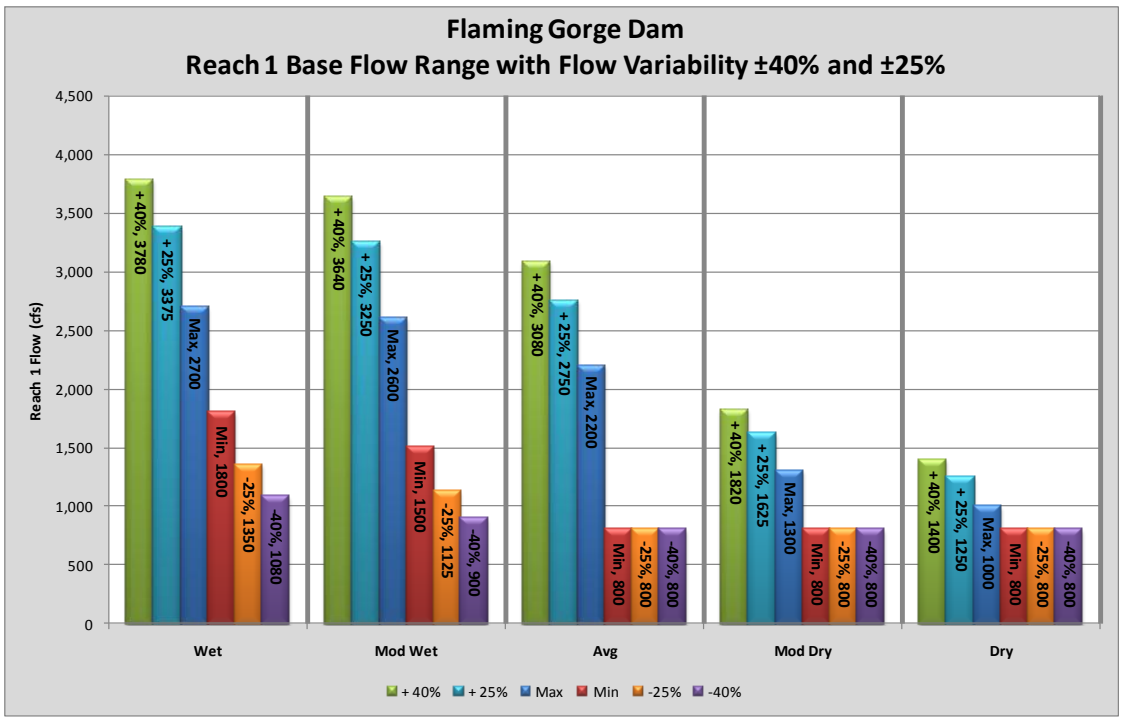



**Figure 2 – Reach 1 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.**

The FGTWG and the Service requested flows in Reach 2 for July and August at 1,500 cfs and September flows at 1,300 cfs, or the maximum variability of +40 percent of the moderately dry base flow classification. Reclamation agreed to implement +40 percent of the moderately dry classification during July through September, and released 1,300 cfs, 1,300, cfs and 1,100 cfs, respectively in an effort to sustain flows in Reach 2 as requested.

Observed August through November base flows in Reach 2 were within 40 percent of the established moderately dry base flow (*i.e.* between 660 cfs to 2,100 cfs). Flaming Gorge Reservoir inflows continued to decrease through the autumn and winter base flow period, and the base flow hydrologic classification moved into dry. Observed December through February base flows for the dry classification in Reach 2 were within 25 percent of the established dry base flow classification (*i.e.* between 675 cfs to 1,375 cfs). The daily fluctuations at Flaming Gorge Dam remained within the 0.1 meter daily stage change at Jensen, Utah parameters. The maximum daily stage change at Jensen was within the limits outlined in the Flow Recommendations.

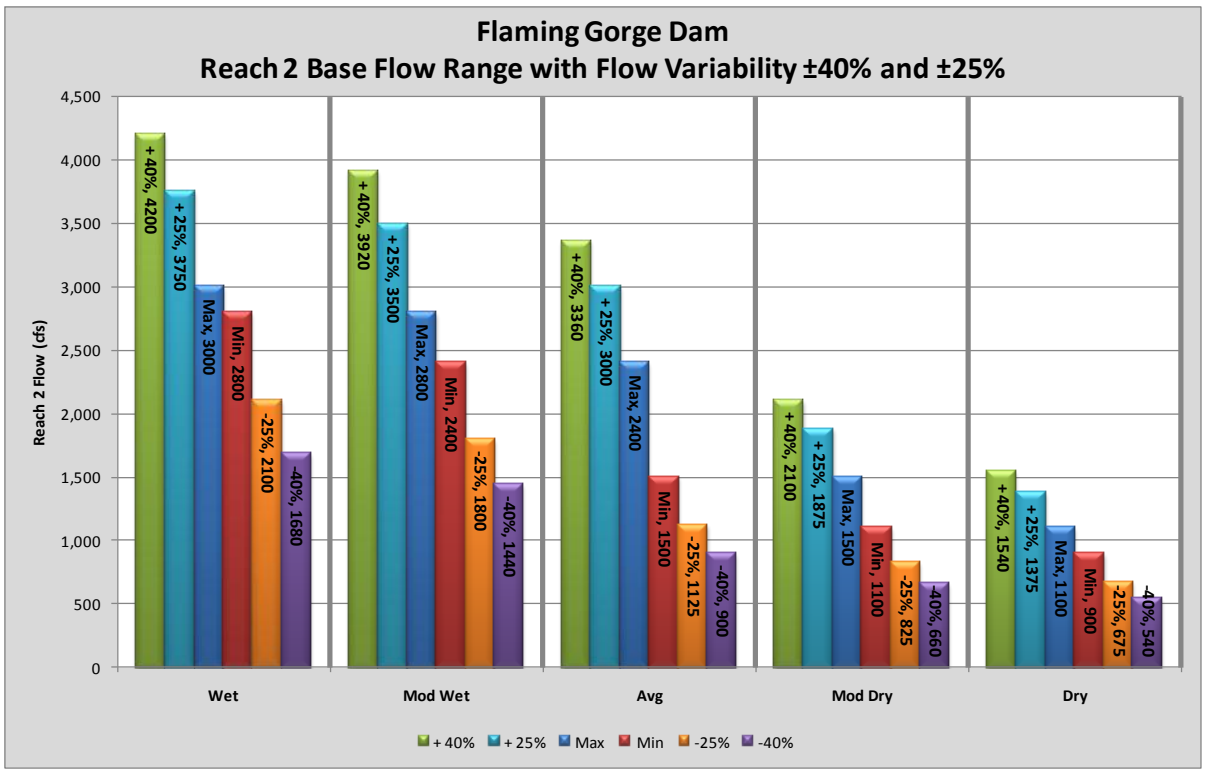



**Figure 3 – Reach 2 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.**

Observed August through November base flows in Reach 3 as measured at the USGS Green River at Green River, Utah stream gage were within 40 percent of the established moderately dry base flow classification (*i.e.* between 900 cfs to 4,760 cfs as shown in Figure 4). Most of the observed December through February base flows in Reach 3 were within 25 percent of the established dry base flow classification (*i.e.* between 975 cfs to 3,250 cfs). The USGS reports that December base flows were affected by ice, and flows during that period fall below 975 cfs. These flows appear to be anomalous and not counted within the dataset of winter base flows.

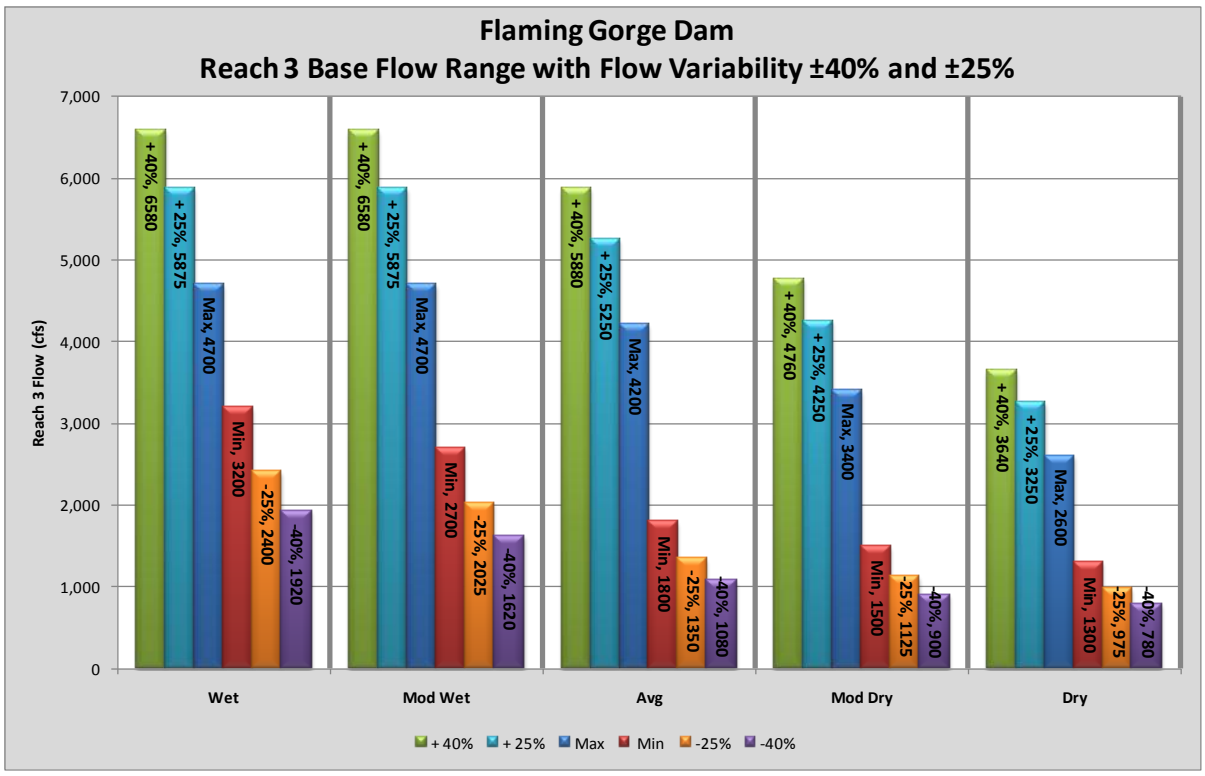



**Figure 4 – Reach 3 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.**

## Temperature Objectives Achieved in Water Year 2012

The Operational Plan for the Flaming Gorge Selective Withdrawal Structure (SWS) was completed by a subset of the FGTWG in June 2007 and was revised in June 2012. The SWS is a series of three gated intake structures that allow water to be drawn from different elevations in the reservoir. During summer months, water temperatures within the reservoir vary according to the reservoir elevation level and the adjustment of the SWS maintains some control over the water temperatures released into the Green River below Flaming Gorge Dam.

The Flow Recommendations indicate that warmer water would provide cues for adults migrating to spawning areas, aid reproductive success of fish in adulthood, enhance the likelihood of reproduction of certain fish in Lodore Canyon (Reach 1), and enhance growth of early life stages of fishes in nursery habitat including those in Echo, Island, and Rainbow Parks (all in Reach 2). Improving conditions in Lodore Canyon also could result in expansion of endangered fish populations into lower Reach 1 and upper Reach 2. The timing of warm water releases is an important component of matching native fish life cycle reproduction and growth.

The operational plan provides guidelines in an attempt to meet the water temperature objectives below Flaming Gorge Dam that are contained within the 2006 ROD and described further in Table 6, below. Operational guidelines direct operators to achieve maximum gate elevation

(40 ft below reservoir surface) by June 15 of each year in order to deliver outflow temperatures of 15-16 degrees Celsius (C) (as measured at the Greendale Gage, USGS 09234500) during the summer months. In WY2012, the elevation target was achieved as scheduled and maintained through December; no adjustments for excessive equipment temperatures were made.

Average daily temperatures at Gates of Lodore (USGS 404417108524900) in 2012 intermittently equaled or exceeded Reach 1 objectives (18 degrees C; Figure 5) for 68 days (7 weeks) beginning on June 28th and continuing through September 2nd.

Reach 2 objectives (difference between Yampa and Green rivers does not exceed 5 degrees C; Figure 6) were achieved during June 1 through September 30, 2012. Releases of water from Flaming Gorge Dam averaged 14 degrees C (58 °F) from June through September 2012 and temperatures in excess of 16 degrees C (61 °F) occurred intermittently for 11 days between July 23 and August 27.

**Table 6. Temperature Objectives for the Green River below Flaming Gorge Dam**

| Temperature Objectives | Reach* | Desired Frequency % | Achieved in 2012 |
|---|---|---|---|
| Temperatures >= 64° F (18° C) for 3-5 weeks from June (average-dry years) or August (moderately wet-wet years) to March 1 | 1 | 100% | 100% |
| Green River should be no more than 9° F (5° C) colder than the Yampa River during the base flow period | 2 | 100% | 100% |

*Reach 1 is from the dam to the Yampa River confluence; Reach 2 is from the Yampa River to Sand Wash, UT.

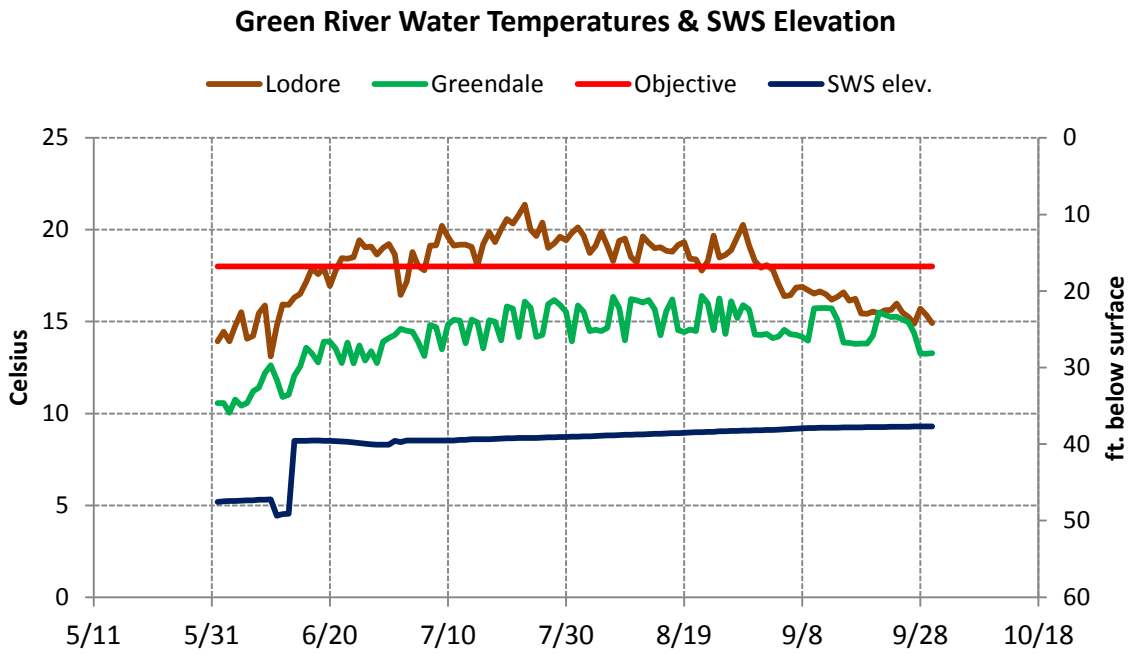



**Figure 5 – Reach 1 Green River Average Daily Temperatures & SWS Elevation**

Recorded temperatures at the Gates of Lodore gage (USGS 404417108524900) (brown series), Greendale gage (USGS 09234500) (green series), Reach 1 objective (red line), and SWS gate depth below reservoir surface (in blue, series correlates to the right hand axis), June-Sept 2012. SWS gate depths depicted are the average of 3 gates.

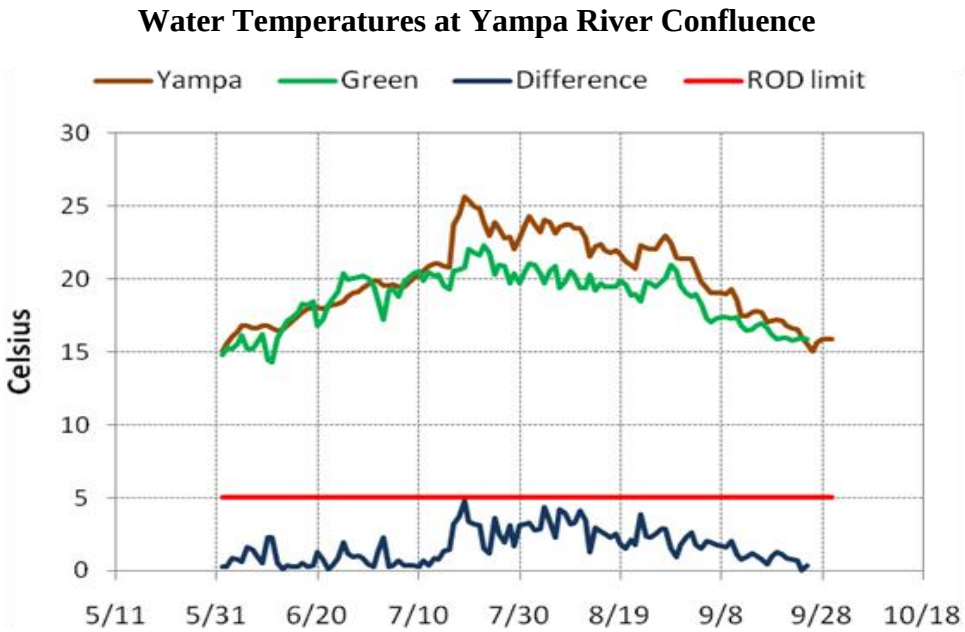



**Figure 6. Green River Temperatures at the Yampa River Confluence**

Temperatures are recorded at the Green River (USGS 404417108524900) (green series) and the Yampa River (USGS 09260050) (brown series), the difference between the two rivers (blue line), and the maximum temperature difference specified in the 2006 ROD (red series line), June-Sept 2012.

# Recommendations

In 2012, Reclamation operated Flaming Gorge Dam and Reservoir to comply with the commitments in the ROD and, to the extent possible, meet the goals and objectives of the Flow Recommendations and the LTSP. This was the second year implementing the LTSP, and the first year under dry conditions. While Reclamation under previous operations increased Flaming Gorge Dam releases in the spring to match the immediate peak and post-peak of the Yampa River, in 2012 it increased releases after the Yampa River had peaked and was on the descending limb of the hydrograph. Additionally, the Yampa River Basin April through July flow volume was 37 percent of average and the 4$^{th}$ lowest on record. Reclamation met the driest Reach 2 flow target of 8,300 cfs for at least 2 days at Jensen, Utah. . Flows at Jensen, Utah in 2012 were above 8,300 cfs for 5 days, which conformed with the duration requirements for dry years outlined in Table 2 of the LTSP (Table 6 in this document; 1-7 days between 8,300 and 14,000 cfs as measured at Jensen, Utah), but not the moderately dry duration target (7-14 days).

Coordination between Reclamation, the Recovery Program, the Service and UDWR occurred regularly and was used to determine the timing of the peak release in 2012Reclamation recommends an email or communication directory be developed and used to make sure that updated data is readily available from all required sources.

**Literature Cited**


Bureau of Reclamation. 2005. Operation of Flaming Gorge Dam Final Environmental Impact Statement. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Bureau of Reclamation. 2006. Record of Decision on the operation of Flaming Gorge Dam Final Environmental Impact Statement. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Bureau of Reclamation. 2012. Flaming Gorge Technical Working Group Proposed Flow and Temperature Objective for 2012. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Bureau of Reclamation. May 21, 2012. Letter to Kent Holsinger regarding Request to Forego Peak Releases From Flaming Gorge Reservoir for the Listed Fish Species, Flaming Gorge Dam, Colorado River Storage Project, Utah. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Bureau of Reclamation. September 19, 2012. Letter to Flaming Gorge Technical Working Group regarding Green River Base Flow Releases and Reach Two Base Flow Targets, Flaming Gorge Dam, Flaming Gorge Unit, Colorado River Storage Project, Utah. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Bureau of Reclamation. September 19, 2012. Letter to Darren Buck regarding Release Volumes During December 2012 Through February 2013, Flaming Gorge Dam, Colorado River Storage Project, Utah. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Holsinger Law, LLC. April 25, 2012. Letter to Larry Walkoviak and Tom Chart regarding a Request to Forego Peak Flows that Could Cause Flooding to Vermillion Ranch Ltd. Partnership from the Reoperation of Flaming Gorge Reservoir for Listed Fish Species.

Larval Trigger Study Plan *ad hoc* Committee. 2012. STUDY PLAN to Examine the Effects of Using Larval Razorback Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam Peak Releases. U.S. Fish and Wildlife Service, Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Muth, R.T., L.W. Crist, K.E. LaGory, J.W. Hayse, K.R. Bestgen, T.P. Ryan, J.K. Lyons, and R.A. Valdez. 2000. Flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam. Final Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Upper Colorado River Endangered Fish Recovery Program. March 26, 2012. Memorandum to Larry Walkoviak and Heather Hermansen. Recovery Program Research Request for 2012 Green River Spring Flows. U.S. Fish and Wildlife Service, Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

U.S. Fish and Wildlife Service. 2005. Final Biological Opinion on the operation of Flaming Gorge Dam (Consultation # 6-UT-05-F-006). U.S. Department of the Interior, Fish and Wildlife Service, Utah Field Office, West Valley City, Utah.

U.S. Fish and Wildlife Service. May 9, 2012. Memorandum to Director, Upper Colorado Region, Bureau of Reclamation and Chair, Flaming Gorge Technical Working Group, Bureau of Reclamation. 2012 Green River Spring and Base Flows to Assist in Recovery of the Endangered Fishes. U.S. Department of the Interior, Fish and Wildlife Service, Utah Field Office, West Valley City, Utah.

Western Area Power Administration. June 12, 2012. Western Area Power Administration. 2012 Interim Base-flow Proposal. Department of Energy, Western Area Power Administration, Colorado River Storage Project, Salt Lake City, Utah.

Western Area Power Administration. August 20, 2012. Email to Larry Walkoviak regarding Release Volumes During December 2012 Through February 2013. Department of Energy, Western Area Power Administration, Colorado River Storage Project, Salt Lake City, Utah.

# Appendix A

## Flaming Gorge Decision Process
## Intended Implementation under the 2006 Flaming Gorge Record of Decision

**Overview** – This document describes the four-step process the Bureau of Reclamation (Reclamation) will use to adaptively manage Flaming Gorge Dam operations and implement the 2006 Record of Decision for the Operation of Flaming Gorge Dam Final Environmental Impact Statement (ROD). These four steps are described in detail below:

1. Recovery Program
2. Flaming Gorge Technical Working Group (FGTWG)
3. Flaming Gorge Working Group (Working Group)
4. Reclamation Operational Plan

In 2000, the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) issued Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam (flow recommendations). The Flow Recommendations provide the basis for the proposed action outlined in the 2005 final environmental impact statement (FEIS). The ROD implements the proposed action by modifying the operations of Flaming Gorge Dam, to the extent possible, to assist in the recovery of endangered fishes, and their critical habitat, downstream from the dam and, at the same time, maintains and continues all authorized purposes of the Colorado River Storage Project.[1]

Reclamation believes that the Recovery Program remains the appropriate forum for discussion of endangered fish response to Flaming Gorge Dam operations, endangered fish research needs, and refinements to the flow recommendations. The purpose of the FGTWG would be limited to proposing annual flow and temperature recommendations as outlined in the FEIS, including research requests by the Recovery Program. The Working Group remains the forum for public information/input.

**1. Recovery Program** – The ROD Environmental Commitment #2 defines the science role of the Recovery Program in the adaptive management process to include design and execution of studies that monitor implementation of the flow recommendations, and testing the outcomes of such studies. This includes conducting research to answer specific questions raised by previous studies, to fill information gaps identified in the Recovery Implementation Program Recovery Action Plan and related documents, and/or to address uncertainties associated with the flow recommendations. For example, effects of specific spring flow elevations on entrainment rates of larval endangered fish and their floodplain habitats is an uncertainty which prompted the Recovery Program to request periods of steady flows during the spring 2005 runoff season. A request for such flows or release temperatures is not necessarily explicit in the flow recommendations, but is necessary to fulfill adaptive

[1] Reclamation, 2006, Record of Decision on the Operation of Flaming Gorge Dam Final Environmental Impact Statement.

management research functions that should be made no later than February of each calendar year.

Beginning each summer, the Recovery Program should begin a process to develop any desired flow request for the Green River for the following year. Maintenance schedules for the dam and powerplant are a critical part of the proposal in order to assure release capability. Reclamation will clearly communicate equipment and maintenance issues to the Recovery Program during development of any Recovery Program request. This communication should include analysis of contingency plans for maintenance issues, system emergencies, equipment failures, or changes in hydrology. The Recovery Program should issue a finalized flow request by the end of February to Reclamation, the U.S. Fish and Wildlife Service (Service), and Western Area Power Administration (Western).

**2. <u>Flaming Gorge Technical Working Group (FGTWG)</u>** - The ROD clarified the purpose of the FGTWG as limited to proposing specific flow and temperature targets for each year's operations based on current year hydrologic conditions and the conditions of the endangered fish. The FGTWG was also charged with integrating, to the extent possible, any flow requests from the Recovery Program into the flow proposal so that Recovery Program research could also be facilitated. Members of the FGTWG include biologists and hydrologists from Reclamation, the Service, and Western. This group also serves as the informal consultation body for Endangered Species Act compliance as has occurred historically and as directed by the ROD.

An annual meeting of the FGTWG should be held in early March to develop a proposed flow and temperature regime for the upcoming spring and base flow season (Proposal). This Proposal should achieve the flow recommendations and/or the Recovery Program flow request for the current year within the current hydrologic conditions and Reclamation's operating parameters.

The FEIS specifically addresses and outlines the content of the Proposal. The Proposal describes the current hydrologic classification of the Green River and Yampa River Basins, including the most probable runoff patterns for the two basins. The Proposal also identifies the most likely Reach 2 flow magnitudes and durations that are to be targeted for the upcoming spring release. It further specifies that

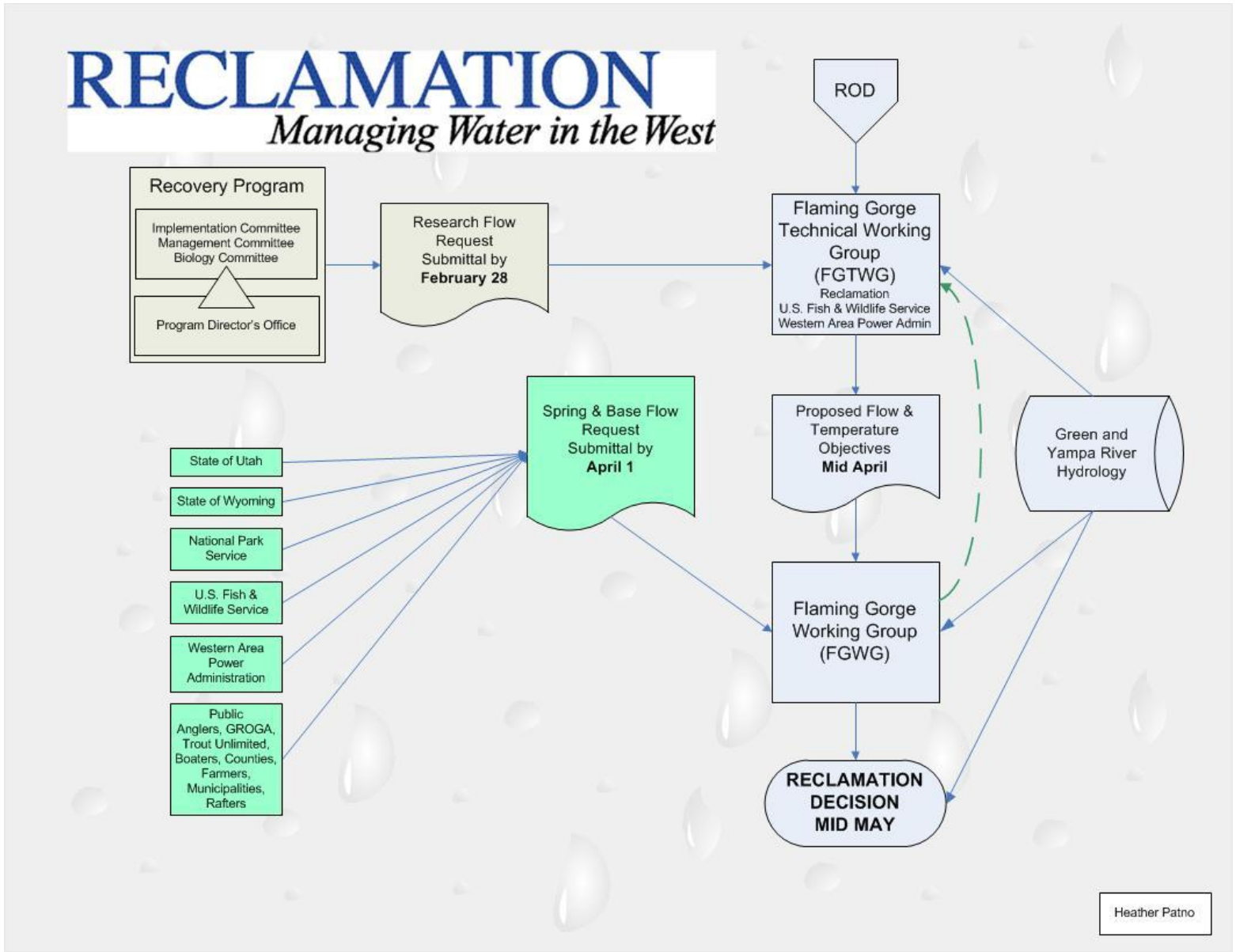
> *Because hydrologic conditions often change during the April through July runoff period, the [Proposal] would contain a range of operating strategies that could be implemented under varying hydrologic conditions. Flow and duration targets for these alternate operating strategies would be limited to those described for one classification lower or two classifications higher than the classification for the current year (FEIS, Section 2.5.3.1).*

The FGTWG proposal should be finalized by early April in time to present to the Working Group.

**3. <u>Flaming Gorge Working Group</u>** – The Working Group was formed in 1993 to provide interested parties with an open forum to express their views and interests in the operations of

Flaming Gorge Dam. The Working Group meets biannually (April and August) and functions as a means of providing information to and gathering input from stakeholders and interested parties on dam operations, other resource concerns and research flows. Reclamation presents the FGTWG Proposal to the Working Group during the April meeting and constitutes the public involvement and public outreach component of the adaptive management process as described in the FEIS (Sections 4.20, 4.21).

**4. <u>Operational Plan</u>** - Reclamation makes the final decision on how to operate Flaming Gorge Dam based on hydrologic conditions, the FGTWG flow proposal, and input from the public received via the Flaming Gorge Working Group.


RECLAMATION
Managing Water in the West
Recovery Program
Implementation Committee
Management Committee
Biology Committee
Program Director's Office
Research Flow Request Submittal by February 28
ROD
Flaming Gorge Technical Working Group (FGTWG)
Reclamation
U.S. Fish & Wildlife Service
Western Area Power Admin
Spring & Base Flow Request Submittal by April 1
Proposed Flow & Temperature Objectives Mid April
Green and Yampa River Hydrology
State of Utah
State of Wyoming
National Park Service
U.S. Fish & Wildlife Service
Western Area Power Administration
Public Anglers, GROGA, Trout Unlimited, Boaters, Counties, Farmers, Municipalities, Rafters
Flaming Gorge Working Group (FGWG)
RECLAMATION DECISION MID MAY
Heather Patno

Appendix A-3

# Appendix B

## Flaming Gorge Decision Process for 2012 – Chronology of Events

**Week of October 1st**
Flaming Gorge releases decreased at a rate of 50 cubic feet per second per day (cfs/day) from a daily average release of 2,450 cubic feet per second (cfs) to 2,000 cfs. Hourly releases follow a single-peak pattern released at an average daily release of 2,000 cfs.

**Week of October 24th**
Flaming Gorge directed releases beginning October 25, 2011, to decrease from 2,000 cfs to 1,500 cfs at a rate of 50 cfs/day for generator maintenance. Hourly releases were steady at 1,500 cfs until the maintenance was completed.

**Week of November 7th**
The generator maintenance was completed with two units available. Flaming Gorge releases remained at an average daily release rate of 1,500 cfs, but on November 13, 2011, the hourly release schedule followed a single-peak pattern.

**Week of December 5th**
Hourly releases from Flaming Gorge Dam were altered on December 8th for maintenance purposes, maintaining an average daily release of 1,500 cfs. Releases were returned to the single-peak hourly release schedule with an average daily release of 1,500 cfs on December 9th.

**Week of December 12th**
The December final forecast continued to show high inflows into Flaming Gorge Dam and the reservoir elevation remained close to 6032 feet. In order to meet the May 1 target elevation of 6027 feet with the current forecasted inflows, Flaming Gorge Dam releases were increased beginning on December 15, 2011, and continuing through January 1, 2012, at a rate of 50 cfs/day. The average daily release increased from 1,500 cfs to 2,400 cfs. Releases were maintained at a daily average rate of 2,400 cfs beginning January 1, 2012, with hourly release scheduled to follow a double-peak pattern.

**Week of January 2nd**
Flaming Gorge was releasing an average daily release rate of 2,400 cfs/day. Western Area Power Administration requested a revision to the hourly scheduled release at Flaming Gorge at the average daily release rate of 2,400 cfs/day from a double-peak to a single-peak release pattern. The request was implemented January 4, 2012.

**Week of February 20th**
Flaming Gorge Dam was releasing an average daily release of 2,400 cfs and the reservoir elevation continued to decrease. Snow accumulation in the Upper Green River Basin was increasing and the next few months were critical in determining spring runoff volumes. In order to continue decreasing the reservoir elevation to meet the May 1 target, releases were

increased from an average daily release rate of 2,400 cfs to 2,550 cfs beginning Thursday, February 25, 2012. Hourly releases followed a double-peak pattern.

**Week of March 5th**

The March spring runoff forecast increased to 96% of average, along with the 92% of average snowpack totals in the Upper Green River Basin. In order to continue decreasing the reservoir elevation to meet the May 1 target, releases increased from an average daily release rate of 2,550 cfs to 2,650 cfs beginning Friday, March 9, 2012. Hourly releases followed a double-peak pattern.

The Flaming Gorge Technical Working Group (FGTWG) met on March 8, 2012, and discussed the dry hydrology in the Upper Green and Yampa River basins. The group then discussed the draft Proposed Flow and Temperature Objectives for 2012, with the draft containing the finalized Larval Trigger Study Plan (LTSP) with the goal of releases from Flaming Gorge Dam timed with the presence of larval razorback sucker in Reach 2 of the Green River. The secondary request, if hydrologically possible, was to continue the Stirrup floodplain research and provide flows in Reach 2 at or above 15,000 cfs for at least five consecutive days.
(See Meeting Records: http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html)

**Week of March 26th**

On March 26, 2012, Reclamation received a memorandum containing the Upper Colorado River Endangered Fish Recovery Program's (Recovery Program) Research Request for 2012 Green River Spring Flows. The Recovery Program attached the Larval Trigger Study Plan (LTSP) as the developed scientific experimental flow regime that they would like to evaluate and test Reclamation's operations to achieve the scenarios contained in the LTSP.

**Week of April 2nd**

Western Area Power Administration requested a revised hourly release pattern from a double-peak to a single-peak in order to maximize hydropower and meet spring electrical demands. The average daily release rate of 2,650 cfs release remained as close as possible to the hourly schedule.

**Week of April 9th**

The FGTWG met and discussed the draft Proposed Flow and Temperature Objectives for 2012. Reclamation also summarized an analysis of three different ranges of operating criteria as compared against historic releases (2006-2012) that would meet both the timing and flow target levels in the LTSP. Because of the dry hydrologic conditions, Reclamation discussed the potential of bypass releases to augment Yampa River flows in order to achieve higher Reach 2 flows during larval presence. The Reach 2 target of $\geq$ 8,300 cfs for at least one week was the target based on the April forecast.

The April final forecast for the April-July volume into Flaming Gorge Dam decreased to 810 thousand acre-feet (kaf), 13% from the March final forecast of 945 kaf. Flaming Gorge Dam releases were reduced to an average daily release rate of 1,600 cfs. Hourly releases followed a single-peak pattern.

The Utah Division of Wildlife Resources (UDWR) requested a modification from normal operations of Flaming Gorge Dam on April 16 and 17, 2012, so that they could conduct the spring fishery assessment. Releases were scheduled during the early evening to early morning hours for the spring fishery assessment. Releases returned to the average daily release rate of 1,600 cfs once the assessment was finished.

**Week of April 18th**

The Flaming Gorge Working Group meeting was held in Vernal, Utah, on April 18, 2012. (http://www.usbr.gov/uc/water/crsp/wg/fg/fg_20120418.html)

**Week of May 7th**

On May 9, 2012, Reclamation received a memorandum from the U.S. Fish and Wildlife Service (Service) on the 2012 Green River Spring and Base Flows to Assist in Recovery of the Endangered Fishes. The Service supported the Recovery Program's 2012 research request and implementation of the LTSP, along with supporting Reclamation's Record of Decision (ROD) operating criteria and the Service's 2005 Biological Opinion. The Service requested that Reclamation augment the base flow target by as much as 40% through September 30, 2012. The Service supported Reclamation following the Recovery Program's 2012 Research Request and LTSP, and considered that doing so met Reclamation's responsibility to the ROD objectives in 2012.

The FGTWG met on May 10, 2012, and discussed the Recovery Program's 2012 research request, the LTSP, and the Service's base flow request for spring 2012.
(See Meeting Records: http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html)

**Week of May 14th**

Larval detection occurred and Reclamation increased releases from Flaming Gorge Dam to combine with the Yampa River and provide the highest flows possible to transport larval fish into nursery habitat along the Green River. Current projections were for the Yampa River to reach at least 3,700 cfs Friday, May 18, with potential to reach 4,000 cfs by May 20-21, 2012. The projected peak at Jensen, Utah, resulting from the combined flows of the Yampa River and Flaming Gorge was above 9,000 cfs. Flaming Gorge Dam releases reached 6,000 cfs (full power plant capacity and 2,000 cfs bypass releases) on Monday, May 21, 2012.

**Week of May 21st**

Flaming Gorge was releasing 6,000 cfs, however, the flows on the Yampa River did not increase as expected. Yampa flows were forecasted to decrease slightly over the next two days. Therefore, in order to provide the highest flows possible to transport larval fish into nursery habitat along the Green River and maintain habitat connectivity, Reclamation further increased releases at Flaming Gorge Dam to a total release of 7,400 cfs for two days (May 22 - 23).

Releases from Flaming Gorge were reduced to powerplant capacity (~4,600cfs) on Friday May 25th, one day earlier than was previously scheduled because reports from the Recovery Program indicated that additional high releases would add no benefit to Stewart Lake for

larval entrainment. Releases were reduced at a rate of 350 cfs/day from powerplant capacity to a base flow release of 1,500 cfs. Beginning June 4th, releases from Flaming Gorge remained at an average daily release of 1,500 cfs and followed the single-peak hourly release pattern.

**Week of June 11th**

Flaming Gorge was releasing an average daily rate of 1,500 cfs. The spring operations season ended and summer baseflow season began resulting in releases being reduced to an average of 1,305 cfs beginning on Monday, June 18th2012. Flaming Gorge releases followed a single-peak hourly pattern.

On June 12, 2012, Western Area Power Administration (Western) submitted its 2012 Interim Base-Flow Proposal requesting Reach 2 releases at Jensen be coordinated at 1,100 cfs. Western further requested revisiting the base flow releases once Argonne National Laboratory had completed its 2012 backwater survey results and had some guidance on optimized critical habitat in Reach 2.

The FGTWG met on June 14, 2012, and discussed the observed spring peak, the LTSP, the Service's and Westerns' base flow proposals. The FGTWG recommended reconvening on July 6th after Argonne had completed its backwater survey and had some results. The group recommended that flows at Jensen be maintained at 1,500 cfs, with Flaming Gorge releases at 1,300 cfs to achieve this flow until after an updated formal recommendation from the FGTWG was made on or after the scheduled July 6, 2012, next meeting date.
(See Meeting Records: http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html)

**Week of June 25th**

Flaming Gorge was releasing an average daily rate of 1,300 cfs and the reservoir elevation was 6023.55 ft. Flows at Jensen, Utah are averaging 1,530 cfs and flows on the Yampa were approximately 165 cfs and forecasted to decrease to between 100-125 cfs over the next week. In order to maintain flows at or above 1,500cfs at Jensen, releases from Flaming Gorge were increased by 100 cfs to a daily average release of 1,403 cfs beginning Friday, June 29th2012. Flaming Gorge releases followed a single-peak hourly pattern.

**Week of July 2nd**

On July 6, 2012, the FGTWG met to discuss the spring and current base flow hydrology, along with spring 2012 larval entrainment findings, and Argonne National Labs backwater survey results.
(See Meeting Records: http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html)

**Week of July 16th**

Flaming Gorge was releasing an average daily rate of 1,403 cfs. Flows measured at the USGS Jensen, Utah stream gage were averaging 1,650 cfs. The current operational strategy was for flows measured at Jensen, Utah to maintain 1500 cfs, along with a 0.1 meter stage change at Jensen, Utah from hourly hydropower fluctuations. In order to conserve reservoir storage under the current dry hydrologic conditions, beginning Friday, July 20, 2012,

Flaming Gorge releases were reduced to 1,302 cfs. Flaming Gorge followed a single-peak hourly pattern.

**Week of July 23rd**

Flaming Gorge was releasing an average daily rate of 1,302 cfs. Western Area Power Administration requested an altered pattern that began ramping up an hour earlier. The altered pattern maintains flows measured at the USGS Jensen, Utah streamgage of at least 1,500 cfs, along with a 0.1 meter stage change at Jensen, Utah from hourly hydropower fluctuations. Beginning Tuesday, July 24, Flaming Gorge Dam released an average daily release of 1,301 cfs. Flaming Gorge releases followed a single-peak hourly pattern.

**Week of August 20th**

Reclamation received a memorandum from Western on August 20, 2012, requesting higher releases to respond to high electrical demand during the months of December through February to be shaped in a similar pattern as last winter.

The Flaming Gorge Working Group Meeting was held in Vernal, Utah, on August 22, 2012. (http://www.usbr.gov/uc/water/crsp/wg/fg/fgcurrnt.html)

UDWR requested a modification from normal operations of Flaming Gorge Dam on September 4 and 5, 2012, so that they could conduct the fall fishery assessment. In order to accommodate their request, Flaming Gorge releases were scheduled to assist the spring fishery assessment. Releases returned to the average daily release rate of 1,302 cfs once the assessment was finished.

**Week of September 5th**

The FGTWG met on July 6, 2012, and recommended higher summer releases through Flaming Gorge Dam during July through September. Reclamation had released an average of 1,300 cfs during July and August pursuant to the recommendations discussed at the FGTWG.

The recommended releases during the month of September were 1,100 cfs. Flaming Gorge was releasing an average daily rate of 1,300 cfs and the reservoir elevation is 6022.13 ft. Flows at Jensen, Utah were averaging 1,440 cfs and flows on the Yampa were below 100 cfs and expected to remain at that level . Reclamation reduced releases from 1,300 cfs to 1,100 cfs by September 10, 2012. Flaming Gorge releases followed a single-peak pattern.

**Week of September 17th**

Reclamation formalized its final decision on the FGTWG request for Reach 2 flows of 1,500 cfs, 1,500 cfs, 1,300 cfs in July, August and September, respectively.

Reclamation responded to Western's August 20, 2012 request for daily average releases of 1,500 cfs during the months of December through February.

# Appendix C

## Flaming Gorge Final Environmental Impact Statement

### Table 2.1: Recommended Magnitudes and Durations Based on Flows and Temperatures for Endangered Fishes in the Green River Downstream from Flaming Gorge Dam as Identified in the 2000 Flow and Temperature Recommendations

**Table 2-1.—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[1] | | | | |
|---|---|---|---|---|---|---|
| | | Wet[2] (0–10% Exceedance) | Moderately Wet[3] (10–30% Exceedance) | Average[4] (30–70% Exceedance) | Moderately Dry[5] (70–90% Exceedance) | Dry[6] (90–100% Exceedance) |
| Reach 1 Flaming Gorge Dam to Yampa River | Maximum Spring Peak Flow | • 8,600 cfs (244 cubic meters per second [$m^3/s$]) | • 4,600 cfs (130 $m^3/s$) | • 4,600 cfs (130 $m^3/s$) | • 4,600 cfs (130 $m^3/s$) | • 4,600 cfs (130 $m^3/s$) |
| | 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 degrees Fahrenheit (°F) (18 degrees Celsius [°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[7] (527 $m^3/s$)<br>• 8,300 cfs[8] (235 $m^3/s$) | • 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 flows18,600 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 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 | 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 $m^3/s$) |
| 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[9] (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 $m^3/s$) |

# Appendix D

## March 26, 2012, Memorandum from the Recovery Program Director containing the Research Request for 2012 Green River Spring Flows

Stephen D. Guertin, Chairman
Implementation Committee

Upper Colorado River Endangered Fish Recovery Program

Thomas E. Chart, Director
Recovery Program

U.S. Fish and Wildlife Service•P.O. Box 25486•Denver Federal Center•Denver, CO 80225•(303) 969-7322•Fax (303) 969-7327
FWS/CRRP
K3a1
Mail Stop 65115

MAR 2 6 2012

Memorandum

To: Larry Walkoviak, Director, Upper Colorado Region, Bureau of Reclamation

Heather Hermansen, Chair, Flaming Gorge Technical Working Group, Bureau of Reclamation

From: Thomas Chart, Director, Upper Colorado River Endangered Fish Recovery Program Tom Chart

Subject: Recovery Program's Research Request for 2012 Green River Spring Flows

The Upper Colorado River Endangered Fish Recovery Program (Recovery Program) supports the Bureau of Reclamation's (Reclamation) operations at Flaming Gorge Dam in 2012 consistent with the 2005 biological opinion (U.S. Fish and Wildlife Service 2005) and 2006 record of decision (ROD; U.S. Department of Interior 2006). As in 2011, the primary objective of our request this year is to build on past research (Bestgen et al. 2011) to benefit the razorback sucker population throughout the Green River by timing floodplain connection with the presence of wild-produced razorback sucker larvae. A secondary objective is to achieve a target flow at the Stirrup floodplain site as part of a specific project conducted by the Utah Division of Wildlife Resources (UDWR) to continue investigations of recruitment behavior of juvenile razorback sucker stocked from 2007-2009 and bonytail stocked in 2011.

At a Recovery Program Management Committee meeting in Cheyenne, Wyoming on August 11, 2011, Reclamation's Beverley Heffernan asked that the Recovery Program clarify if and how the larval trigger would factor into future flow requests. In response to those questions, the Recovery Program has developed the attached: *Study Plan to Examine the Effects of Using Larval Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam* (LTSP). In the LTSP we describe the range of experimental floodplain connection scenarios we would like to study and how we would evaluate the results of Reclamation's operations to achieve those scenarios. More specifically, our Study Design matrix (Table 2 in the LTSP) details the range of experimental conditions we would like to assess with recognition that more than one cell of that matrix could be accomplished in a single year. Minimally, to complete the experiment, the

Recovery Program requests three years with flows < 18,600 cfs and three years with flows ≥ 18,600 cfs and with connecting flows in each of these years of at least seven days duration.

In 2011, Yampa River flows combined with Reclamation's Flaming Gorge operations resulted in 19 days of significant floodplain connectivity (continuous flow >18,600 cfs) after larval razorback sucker were detected in the Green River. Spring flows in 2011 provided some of the wettest experimental conditions called for in our LTSP. Fortunately, the Recovery Program was able to augment our standardized larval sampling program last year to gather larval entrainment data in many floodplain habitats (results not yet fully analyzed) and to conduct fall sampling in the same habitats as is called for in the LTSP. Importantly, researchers detected Age-0, wild-produced razorback suckers in the fall in two floodplain habitats (Wyasket Lake and the Leota-4 unit of the Leota Bottoms floodplain complex) (Webber and Jones 2011). Evidence of over-summer survival of razorback sucker is a very rare event, which certainly lends credence to the importance of matching spring operations to connect floodplains with presence of wild produced larvae. Although sampling conducted in 2011 was not as rigorous as is identified in the LTSP, the Recovery Program intends to incorporate all pertinent data collected last year in our evaluation of LTSP operations.

The Recovery Program is prepared to gather the necessary information called for in the LTSP. Two new studies (one specific to Stewart Lake which connects at flows of approximately 7,500 cfs, and another that focuses on habitats that connect at higher flows) have been designed to specifically address Topics 1 and 2 in the LTSP and are funded in 2012 and out years. In addition, we have expanded our larval sampling and larval fish identification efforts to evaluate Reclamation's larval triggered dam releases.

With regard to annual implementation of the LTSP, the Recovery Program may request specific attention to certain aspects of the Study Design matrix in future flow request letters, however in general we assume that specific annual spring flow requests would be developed by the Flaming Gorge Technical Work Group (FGTWG) based on the best available spring flow forecast information.

THE RECOVERY PROGRAM'S SPRING 2012 FLOW REQUEST:

**Implement the LTSP.** The Recovery Program requests that the FGTWG match Recovery Program research needs identified in the LTSP with the best available spring flow forecast information to develop a specific Reach 2 floodplain connection scenario. The Recovery Program Director's office will distribute the pertinent FGTWG recommendation to the Biology and Management Committees and Principal Investigators as quickly as possible.

The Recovery Program will provide a real-time assessment of larval presence through ongoing Recovery Program monitoring efforts (Project No. 22f). Based on information provided in Bestgen et al. 2011, waiting for this larval trigger will likely cause Reclamation to make spring releases from Flaming Gorge Dam after the Yampa River has peaked, which may necessitate releases in excess of power plant capacity in order to meet the flow magnitude thresholds (see Table 2 in the LTSP). As addressed in the LTSP, the Recovery Program is prepared to direct sampling efforts each year to the appropriate floodplain habitats based on hydrologic forecasting

and the FGTWG request. Please refer to the LTSP for a list of ongoing or new Recovery Program studies we will use to evaluate Reclamation's operations to meet this spring 2012 flow request.

As the FGTWG develops their 2012 Reach 2 floodplain connection scenario, we ask that they also (secondarily) consider the Recovery Program's site specific Project No. C6 RZ-Recr: Razorback Emigration from the Stirrup Floodplain. In this study UDWR deploys a stationary PIT tag antenna in the levee breach at the Stirrup floodplain site to monitor movement of all previously PIT tagged fish entering and exiting this habitat. This information may contribute to LTSP Topic 2 information needs. The Recovery Program has determined that 15,000 cfs (as measured at the Jensen, Utah gage) is the minimum needed to provide an adequate connection (30 cm depth in the breach channel) at the Stirrup floodplain site provided the floodplain habitat is full when the river connects. Therefore, and again secondary to the more comprehensive LTSP objectives, the Recovery Program requests five consecutive days of flows $\geq$ 15,000 cfs in Reach 2 to assist in meeting C6 RZ-Recr project objectives.

The Recovery Program fully recognizes the importance of using the spillway (releases in excess of 8,600 cfs) in the future to assist in the recovery of the endangered fish. However, and as was the case in 2011, the Recovery Program requests that Reclamation limit their spring release magnitudes to full bypass flows up to 8,600 cfs, i.e., not release water over the spillway, in deference to possible entrainment of nonnative burbot. Based on what we know at this time, the Recovery Program believes a cautionary approach is advised to avoid, to the best of our ability, establishing another problematic invasive species within critical habitat. To address this uncertainty, in 2012, the Recovery Program Director's office, the National Park Service, and UDWR will initiate a risk assessment of burbot entrainment associated with Flaming Gorge spring operations (as referenced in the LTSP).

Base Flow Requests

The Recovery Program will pursue experimentation outlined in the LTSP for the foreseeable future. We understand that spring operations could affect water availability for base flow operations. We reserve the right to discuss 2012 base flow operations at a later time.

In closing, the Recovery Program appreciates Reclamation's efforts in the past to achieve the flow and temperature recommendations and assist in recovery of the endangered fishes. We recognize that greater reliance on the biological trigger (presence of larval razorback sucker) may require considerably greater volumes of water during the spring in some years, but we believe this experiment is more in keeping with the intent of Muth et al. 2000 and is necessary to assist in the recovery of the endangered fish. Thank you for considering this Recovery Program request for spring flows.

**Literature Cited**

Bestgen, K.R., G.B. Haines, and A.A. Hill. 2011. Synthesis of floodplain wetland information: timing of razorback sucker reproduction in the Green River, Utah, related to streamflow, water temperature, and floodplain wetland availability. Final Report to the Upper Colorado River Endangered Fish Recovery Program. Larval Fish Laboratory Contribution 163.

Muth, R.T., L.W. Crist, K.E. LaGory, J.W. Hayse, K.R. Bestgen, T.P. Ryan, J.K. Lyons, and R.A. Valdez. 2000. Flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam. Final Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

U.S. Department of the Interior. 2006. Record of Decision on the operation of Flaming Gorge Dam Final Environmental Impact Statement. U.S. Department of the Interior, Bureau of Reclamation, Salt Lake City, Utah.

U.S. Fish and Wildlife Service. 2005. Final Biological Opinion on the operation of Flaming Gorge Dam. U.S. Fish and Wildlife Service, Denver, Colorado.

Webber, A. and T. Jones. 2011. Rearing razorback sucker in Baeser Bend wetland of the Green River. Recovery Program Annual Report - Project C6-Baeser.

cc: Malcolm Wilson, Chief, Water Resources Group, USBR, Salt Lake City, Utah
Beverley Heffernan, Manager Environmental Resources Division, USBR, Salt Lake City, Utah
Julie Lyke, Deputy Assistant Regional Director – Ecological Service, USFWS
John Shield, Chair, UCREFRP - Management Committee, Wyoming State Engineer Office, Cheyenne, Wyoming
Harry Crockett, UCREFRP - Biology Committee, Colorado Parks and Wildlife, Fort Collins, Colorado
Melissa Trammell, Chair, UCREFRP - Biology Committee, National Park Service, Salt Lake City, Utah.

Attachment: LTSP

# Appendix E

## March 26, 2012, Study Plan to Examine the Effects of Using LarvalRazorback Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam Peak Releases

**STUDY PLAN TO EXAMINE THE EFFECTS OF USING LARVAL RAZORBACK SUCKER OCCURRENCE IN THE GREEN RIVER AS A TRIGGER FOR FLAMING GORGE DAM PEAK RELEASES**


**Prepared by the Larval Trigger Study Plan Ad Hoc Committee**

Kirk LaGory, Argonne National Laboratory
Tom Chart, Upper Colorado River Endangered Fish Recovery Program
Kevin Bestgen, Colorado State University, Larval Fish Laboratory
Jerry Wilhite, Western Area Power Administration
Shane Capron, Western Area Power Administration
David Speas, Bureau of Reclamation
Heather Hermansen, Bureau of Reclamation
Kevin McAbee, U.S. Fish and Wildlife Service
Jana Mohrman, U.S. Fish and Wildlife Service
Melissa Trammell, National Park Service
Brandon Albrecht, Environmental Group Representative

**Coordinated by**

The Upper Colorado River Endangered Fish Recovery Program



Final Report March 2012

**TABLE OF CONTENTS**

## EXECUTIVE SUMMARY

Flow recommendations were developed for the Green River below Flaming Gorge Dam by Muth et al. (2000) to assist with conservation and recovery of endangered fishes. These flow recommendations identified annual peak flow magnitudes and durations needed to connect the river to razorback sucker floodplain nursery habitats in the middle Green River (Table 1). In order to achieve these recommended peak flow magnitudes and durations, the Bureau of Reclamation (Reclamation) has timed the release of water from Flaming Gorge Reservoir to match the peak flow in the Yampa River. A primary purpose of those spring operations at Flaming Gorge Dam is to provide nursery habitat for endangered razorback sucker (*Xyrauchen texanus*) in the middle Green River so early life stages (larvae) can access productive floodplain wetlands via connections with the river. Despite successfully meeting or exceeding peak flow magnitudes and durations in the targeted reach, consistent and substantial razorback sucker recruitment has not been observed. In a recently completed synthesis report (Bestgen et al. 2011), researchers concluded that in most years since 1993, releases from Flaming Gorge Dam occurred too early relative to presence of razorback sucker in the Green River. They recommended that the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) and Reclamation implement a schedule of altered timing of flow releases from Flaming Gorge Dam to coincide more closely with presence of razorback sucker larvae, or perhaps, presence of abundant larvae, in the middle Green River. The Recovery Program has proposed that Reclamation use the occurrence of razorback sucker larvae in channel margin habitats (as determined by real-time monitoring) as the "trigger" to determine when peak releases should occur from Flaming Gorge Dam. Determining the effectiveness of this larval trigger in recruiting razorback suckers is the primary focus of this study plan, but other potential effects would also be evaluated.

Evaluating the effectiveness of operating Flaming Gorge Reservoir using a larval trigger requires a targeted hypothesis-based monitoring and research program that examines aspects of the life cycle and recruitment limitations of razorback sucker. The topics to be examined under the study plan, hypotheses to be tested within each, and the general methods to be employed are described here. Five topics are included in this plan: (1) entrainment and retention of larval razorback suckers in floodplain wetlands; (2) survival of larvae and escapement of juvenile and adult fish entrained as larvae into floodplain wetlands; (3) availability of young-of-the-year Colorado pikeminnow habitat at base flow; (4) sediment mobilization and channel maintenance; and (5) fish community response. Studies associated with Topics 1 and 2 are considered the highest priority because these studies address razorback sucker entrainment and recruitment, which are the intended benefits of using a larval trigger. Information from other species, particularly co-evolved native catostomids, as well as historical information, will be used to support patterns observed for razorback sucker particularly if their larvae are rare in some years. Topics 3, 4, and 5 address other potential consequences of using a larval trigger, and, although important, are considered lower priority for testing the efficacy of using a larval trigger. A total of nine hypotheses are identified under Topics 1 and 2; an additional eight hypotheses are identified under Topics 3, 4, and 5.

Wetlands that hold the greatest promise for entraining and recruiting razorback suckers, and that are representative of other wetlands in the system should be the focus of studies

developed under this plan. Because study wetlands connect with the main channel at different flow levels, some can only be studied at higher peak flows. Under the study plan, up to eight wetlands would be sampled in a given year with the three in the lowest flow category (Stewart Lake, Above Brennan, and Old Charley Wash) being sampled in all years. As practicable, proposed studies should address a range of flow magnitudes and durations, and we consider three years with flows < 18,600 cfs and three years with flows ≥ 18,600 cfs, with connecting flows in each of these years of at least seven days duration, as minimally necessary to complete the study.

The specific objectives, tasks, and expected outcomes for individual studies developed under this plan will be identified in statements of work approved by the Recovery Program. These projects and the resulting project reports will go through the standard Recovery Program review protocols. It is anticipated that in addition to an annual review of the data collected, a synthesis report will be developed that summarizes results from individual projects, integrates results, summarizes conclusions, and makes recommendations for future implementation of a larval trigger. As for any study plan, additional knowledge will be gained during implementation, and it will be important to have enough flexibility to adjust studies and overall approaches in response to this new information. Toward this end, the results of studies will be evaluated each year to determine the need for modification.

This Study Plan was drafted by an *ad hoc* Committee, which included representatives from Reclamation, Western Area Power Administration, Colorado State University, U.S. Fish and Wildlife Service, National Park Service, Argonne National Laboratory, and environmental interests. Development of the Study Plan was coordinated by the Recovery Program and benefited greatly from input by members of the Biology Committee and principal investigators conducting studies in the Green River Subbasin.

# 1 INTRODUCTION

The razorback sucker (*Xyrauchen texanus*), an endemic species of the Colorado River Basin, is federally listed as endangered. A critically important population of this species inhabits the middle Green River, Utah, between the confluence of the Yampa River downstream to the head of Desolation-Gray Canyon. Razorback suckers congregate in spring at two spawning areas in the upstream portion of the reach, at Razorback (river kilometer [RK] 500.9) and Escalante (RK 493.7) spawning bars, and have successfully reproduced from 1992-2011, as evidenced by annual collections of larval fish downstream of spawning areas (Bestgen et al. 2011; annual Recovery Program reports, Project 22f). However, very few naturally produced razorback suckers recruit from the larval stage to sexual maturity. Researchers believe that in order to successfully recruit, young-of-the-year (YOY) need to overwinter for one or more years in off-channel floodplain nursery habitats before returning to the main channel (Muth et al. 2000). Because the river must reach a specific height before each nursery habitat is connected to the main channel, recruitment of larval razorback suckers to adulthood is closely tied to high spring peak flows.

Flow recommendations (Muth et al. 2000) were developed for the Green River downstream of Flaming Gorge Dam to provide the necessary flows to support recovery of the razorback sucker and three other endangered fishes in the Green River (Colorado pikeminnow, *Ptychochelius lucius*; humpback chub, *Gila cypha*; and bonytail, *G. elegans*). These flow recommendations identified annual peak flow magnitudes and durations, as measured at the Jensen, Utah gage (U.S. Geological Survey [USGS] gage 09261000), needed to connect the river to razorback sucker floodplain nursery habitats in the middle Green River (Table 1). Although connection of these habitats to the river appears to be critical to razorback sucker recovery, connection is only biologically meaningful if it occurs when razorback sucker larvae are drifting in the water column and available for transport into floodplain habitats. In addition, floodplain wetland habitats must consistently offer suitable habitat (i.e., sufficient size, depth, and water quality) to support fish until subsequent annual peak flows reconnect habitats to the river and allow for escapement of subadults.

Following the Record of Decision for the Flaming Gorge environmental impact statement published in 2006, the Bureau of Reclamation (Reclamation), as operator of Flaming Gorge Dam, and in collaboration with the interagency Flaming Gorge Technical Work Group, has provided annual peak flows that meet or exceed the annual peak flow recommendations presented in Muth et al. (2000). In order to achieve these recommended peak flow magnitudes and durations, Reclamation has timed the release of water from Flaming Gorge Reservoir to match the peak flow in the Yampa River, thus, minimizing the amount of released water needed to achieve the peak flow targets. Although this operational approach is consistent with the recommendations in Muth et al. (2000), a recent synthesis by Bestgen et al. (2011) suggests that it may not be accomplishing its intended biological purpose, i.e., to provide for successful recruitment of razorback suckers. Razorback sucker recruitment has not been observed since the Record of Decision despite successfully meeting or exceeding target peak flow magnitudes and durations.

**TABLE 1. Spring Peak Flow Recommendations for the Green River between the Confluences of the Yampa and White Rivers (Muth et al. 2000).[(a)]**

| | Hydrologic Condition | | | | |
|---|---|---|---|---|---|
| | **Wet (0 to 10% Exceedance)** | **Moderately Wet (10 to 30% Exceedance)** | **Average (30 to 70% Exceedance)** | **Moderately Dry (70 to 90% Exceedance)** | **Dry (90 to 100% Exceedance)** |
| ***General recommendation*** | Peak flows should be of the magnitude, timing, and duration to provide floodplain inundation in the Ouray portion of the river for at least 2 weeks in 4 of 10 years and at least bankfull flows in 1 of 2 years. In all years, peak flows should be of sufficient magnitude and duration to provide at least some in-channel habitat maintenance throughout the reach. No upper limits are placed on recommended peak flows in any hydrologic condition. The duration of peak flows less than 527 $m^3/s$ (18,600 cfs) should be limited, because neither floodplain nor backwater habitats are available at these flows. | | | | |
| ***Peak-flow magnitude*** | $\geq$ 748 $m^3/s$ (26,400 cfs) | $\geq$ 575 $m^3/s$ (20,300 cfs) | $\geq$ 527 $m^3/s$ (18,600 cfs) in 1 of 2 average years; $\geq$ 235 $m^3/s$ (8,300 cfs) in other average years | $\geq$ 235 $m^3/s$ (8,300 cfs) | |
| ***Peak-flow duration*** | Flows > 643 $m^3/s$ (22,700 cfs) should be maintained for 2 weeks or more, and flows greater than 527 $m^3/s$ (18,600 cfs) for 4 weeks or more. | Flows > 527 $m^3/s$ (18,600 cfs) should be maintained for 2 weeks or more. | Flows > 527 $m^3/s$ (18,600 cfs) should be maintained for at least 2 weeks in at least 1 of 4 average years. | Flows >235 $m^3/s$ (8,300 cfs) should be maintained for at least 1 week. | Flows > 235 $m^3/s$ (8,300 cfs) should be maintained for 2 days or more except in extremely dry years ($\geq$ 98% exceedance). |
| ***Peak-flow timing*** | Peak flows should coincide with peak and immediate post-peak spring flows in the Yampa River. | | | | |

(a) All flow targets are as measured at the Jensen, Utah gage (USGS 09261000).

Bestgen et al. (2011) evaluated the effectiveness of matching Yampa River Peak flows with high releases from Flaming Gorge Dam, and found that after 1993 releases were premature relative to larval razorback sucker drift. They found that by the time razorback sucker larvae were drifting, peaks flows were often receding, which limited the number of days of connection to floodplain nursery habitats and reduced the opportunity for entrainment of larvae. This led them to conclude that

> "*Longer duration and especially, higher magnitude flows, timed to occur when razorback sucker larvae were present, may be minimally sufficient conditions to enhance recruitment of razorback suckers in the middle Green River, Utah.*"

Bestgen et al. (2011) provided a number of recommendations related to developing a better understanding of the relationships between the timing of drift, entrainment rates of larvae

in floodplain wetland habitats, the ability of different floodplain wetland habitats to overwinter fish, and timing peak flows to coincide with larval drift periods. Recommendations, paraphrased from the original text, included:

- Study early life history of razorback sucker in the Green River Basin to better understand the role of altered spring thermal ecology on timing of spawning, development of embryos, and emergence of razorback sucker larvae, as well as the potential effects on spawning of nonnative fishes.

- Determine timing of spawning, hatching, emergence, habitat use, and survival of razorback sucker larvae in the lower Green River [Reach 3 of Muth et al. 2000]. This may be especially important if timing of releases from Flaming Gorge Dam, or flow magnitude or duration, is altered.

- Evaluate utility of floodplain wetlands as recruitment habitat for early life stages of razorback sucker. Important aspects include colonization/entrainment rates of larvae into single-breach wetlands, utility of terrace wetlands as temporary habitat for razorback sucker larvae, and sedimentation of breaches.

- Evaluate utility of floodplain wetlands as overwinter habitat for young razorback sucker, and develop plans to enhance fish overwintering capability of key wetlands.

- Consider utility and feasibility of scheduling filling of gated wetlands with Green River water only when high densities of razorback sucker larvae are present.

- Develop a simple population dynamics tool to assist with modeling entrainment and survival rates of early life stages of razorback suckers in various floodplain wetlands.

- Implement a schedule of altered timing of flow releases from Flaming Gorge Dam to coincide more closely with presence of razorback sucker larvae, or perhaps, presence of abundant larvae, in the middle Green River. Reliable real-time monitoring is already in place to guide timing of releases. In lieu of that, develop relationships based on physical attributes, mostly water temperature and time of year, which would predict timing of emergence.

- Investigate the feasibility of increased magnitude and duration of spring flow releases from Flaming Gorge Dam, after razorback sucker larvae are present, to maintain connections with floodplain wetlands and increase entrainment rates. Subsequent effects on base flow levels, among other biotic and abiotic factors, will also need to be considered.

On the basis of the findings and recommendations in Bestgen et al. (2011), the U.S. Fish and Wildlife Service's (USFWS) Upper Colorado River Endangered Fish Recovery Program (Recovery Program) requested that releases from Flaming Gorge Reservoir in the spring of 2011 be experimentally timed to coincide with the occurrence of razorback sucker larvae in the middle Green River. Unusually high Yampa River flows, inflows to Flaming Gorge Reservoir, and Flaming Gorge Dam releases resulted in extended periods of connection between river and

floodplain habitats during the larval drift period of 2011. Flows were continuously ≥ 18,600 cfs for more than 40 days in 2011, and razorback sucker larvae were present for at least 19 of those days (Recovery Program annual report, project 22f; K. R. Bestgen, unpublished data).

The Recovery Program has proposed that Reclamation use the occurrence of razorback sucker larvae in channel margin habitats (an indication that larval drift is occurring in the river) as the "trigger" to determine when peak releases should occur from Flaming Gorge Dam. This "larval trigger" would initially be implemented during an experimental period of about six years, depending on flows conditions realized, and is consistent with the Muth et al. (2000) flow recommendations in which initial appearance of larval suckers was identified as one of several examples of real-time information to be considered when determining the onset of spring peak flows (see Table 5.3 of Muth et al. 2000). Determining the effectiveness of this larval trigger in recruiting razorback suckers is the primary focus of this study plan, but other potential effects are also evaluated. Based on information in Bestgen et al. (2011), using the larval trigger would shift the timing of Flaming Gorge peak releases to later in the runoff period. For the 1993 to 2008 period examined in Bestgen et al. (2011), the shift in timing of releases relative to peak Yampa River flows could be earlier, about the same, or as much as 17 days later if the first detection of larvae was used as the trigger, based on comparison of timing of flow releases in that period relative to first occurrence of larvae for those 16 years.

## 2 PROPOSED MONITORING AND RESEARCH

The Green River Study Plan (Green River Study Plan *ad hoc* Committee 2007), identified studies to evaluate the effectiveness of the flow recommendations of Muth et al. (2000). One of these recommended studies was the floodplain synthesis performed by Bestgen et al. (2011). This larval trigger study plan is a consequence of the findings of studies identified in the original Green River Study Plan, and is considered an important next step by the Recovery Program Biology Committee towards refining the implementation of the flow recommendations.[1]

Evaluating the effectiveness of operating Flaming Gorge Reservoir under a "larval trigger" scenario requires a targeted hypothesis-based monitoring and research program. The topics to be examined under the study plan, hypotheses to be tested within each, and the general methods to be employed are described here. Five topics are included in this plan: (1) entrainment and retention of larval razorback suckers in floodplain wetlands; (2) survival and eventual escapement of larvae entrained in floodplain wetlands; (3) availability of YOY Colorado

[1] This next step in refining the implementation of the flow recommendations is consistent with the expression of Reclamation's intent in the 2006 Record of Decision (ROD) "to work through the Upper Colorado Endangered Fish Recovery Program, along with the cooperating agencies on the EIS and the interested public, to assess the possibility of improving connectivity of floodplain habitats, identifying ways to improve entrainment of larval razorback suckers into floodplain habitats, maintain the river channel, restore natural variability of the river system, and meet other goals of the Flow and Temperature Recommendations at lower peak flow levels where feasible." The 2006 ROD also recognizes that "such additional knowledge gained through the adaptive management process may result in future refinement of the 2000 Flow and Temperature Recommendations that would maintain or improve conditions for the four endangered fish species while minimizing negative effects to the authorized purposes of Flaming Gorge Dam."

pikeminnow habitat at base flow; (4) sediment mobilization and channel maintenance; and (5) fish community response. Studies associated with Topics 1 and 2 are considered the highest priority because these studies address razorback sucker entrainment and recruitment, which are the intended benefits of using a larval trigger. Information from other species, particularly co-evolved native catostomids, will be used to support patterns observed for razorback sucker particularly if razorback larvae are rare in some years. Topics 3, 4, and 5 address potential other consequences of using a larval trigger, and, although important, are considered lower priority for testing the efficacy of using a larval trigger. It is important to note that the priorities assigned to topics in this study plan are relative to their importance to testing the effectiveness of implementing the larval trigger and not to overall priorities of the Recovery Program. Wherever possible, the study plan identifies existing projects that could be modified or expanded to test hypotheses, in order to capitalize on well-established protocols.

Floodplain wetlands in the middle Green River consist of terrace and depression wetlands (Irving and Burdick 1995; Valdez and Nelson 2004). Floodplain depressions hold water for an extended period of time because they are separated from the river by higher ground (natural or manmade levees), but terrace wetlands do not hold water, and fill and drain as the river rises and falls. Some depression wetlands may provide important nursery habitat for the entire period between sequential annual peak flows, thus augmenting recruitment of juveniles and sub adults into riverine habitats. Because of this ability to hold water for extended periods, the study plan focuses on depression wetlands only.

Depression wetlands are single-breach or multiple-breach floodplain wetlands (also called flow-through) based on the number of inlets and/or outlets that exist at elevations above the initial connecting flow. Hedrick et al. (2009) and Bestgen et al. (2011) suggested that there were important differences between these two depression wetland types in terms of entrainment rates, in that flow-through wetlands entrain far greater volumes of water than single-breach types. This study plan proposes examinations of differences between these two wetland types.

Table 2 presents a proposed study matrix to be used as a guide in testing hypotheses (Table 3) associated with the larval trigger. Table 2 identifies key single-breach and flow-through wetlands that should be evaluated. As indicated in Table 2, studies should be implemented over a range of peak flow magnitudes and durations to test the effectiveness of using a larval trigger under a variety of conditions. Flow magnitudes less than 18,600 cfs should be evaluated as suggested in Table 2 because some levees have been breached to allow connection at lower flows and several wetlands (e.g., Stewart Lake) have manually operated inlet gates that allow connection at lower flows.

**TABLE 2. Matrix to Be Used in Studying the Effectiveness of a Larval Trigger**

| Peak Flow (x) as Measured at Jensen, Utah | Proposed Study Wetlands[a, b] | Number of Days (x) Flow to Be Exceeded and Corresponding Hydrologic Conditions [c] | | |
|---|---|---|---|---|
| | | $1 \leq x < 7$ | $7 \leq x < 14$ | $x \geq 14$ |
| $8{,}300 \leq x < 14{,}000$ cfs | Stewart Lake (f), Above Brennan (f), Old Charley Wash (s) | Dry | Moderately dry | Moderately dry and average (below median) |
| $14{,}000 \leq x < 18{,}600$ cfs | Same as previous plus Thunder Ranch (f), Bonanza Bridge (f), Johnson Bottom (s), Stirrup (s), Leota 7 (s) | Average (below median) | Average (below median) | Average (below median) |
| $18{,}600 \leq x < 20{,}300$ cfs | Same as previous | Average (above median) | Average (above median) | Average (above median) |
| $20{,}300 \leq x < 26{,}400$ cfs | Same as previous plus Baeser Bend (s), Wyasket (s), additional Leota units (7a and 4), Sheppard Bottom (s) | Moderately wet | Moderately wet | Moderately wet |
| $x \geq 26{,}400$ cfs | Same as previous | Wet | Wet | Wet |

(a) f = flow-through wetland, s = single-breach wetland

(b) Up to eight wetlands would be sampled in a given year with the three in the lowest flow category being sampled in all years.

(c) Refer to Table 1 for exceedance percentages and peak flow recommendations for each hydrologic condition. Note that the hydrologic conditions presented are the driest that could support a particular combination of peak flow magnitude and duration. For any combination, wetter hydrology could also support an experiment.

Wetlands that hold the greatest promise for entraining and recruiting razorback suckers, and that are representative of other wetlands in the system should be the focus of studies developed under this plan. Based on discussions with researchers and information presented in Valdez and Nelson (2004), Tetra Tech (2005), Hedrick et al. (2009), and Bestgen et al. (2011), the authors identified candidate study wetlands (Table 2). Because study wetlands connect with the main channel at different flow levels, some can only be studied at higher peak flows (Table 2). Under the study plan, up to eight wetlands would be sampled in a given year with the three in the lowest flow category (Stewart Lake, Above Brennan, and Old Charley Wash) being sampled in all years.

Table 3 summarizes hypotheses, variables to be measured, related studies, and priorities for each. Hypotheses, variables, and related studies are described for each topic in the remainder of this section; priorities are discussed further in Section 3. Additional details on related studies are presented in the Appendix.

**TABLE 3. Larval Trigger Study Plan Topics, Hypotheses, Variables, Related Studies, and Priorities**

| Hypotheses | Variables | Related Studies and Data [(a)] |
|---|---|---|
| ***Topic 1: Entrainment and Retention of Razorback Sucker Larvae in Floodplain Wetlands (Priority: High)*** | | |
| $H_1$: Entrainment and retention of larvae in floodplain wetlands are not related to the timing of connecting flows relative to the timing of larval drift (Priority: High) | Timing, duration, and abundance of larvae in the main channel (Priority: High) | Ongoing and expanded project 22f and new floodplain studies (projects FR-164 and FR-165). New modeling effort to predict the timing of larval drift. |
| | Timing of connecting flows (Priority: High) | New field study needed. Related to ongoing project C6-hydro. |
| | Volume of water entrained into wetlands during the period of larval drift (Priority: High) | New field study needed. Related to completed project FR-FP synthesis, and ongoing project C6-hydro and flow gage data. |
| | Larval presence and relative abundance in wetlands after flows recede and connection with the main channel has ended (Priority: High) | Ongoing and expanded project 22f, and new floodplain studies (projects FR-164 and FR-165) |
| $H_2$: Entrainment and retention of larvae in floodplain wetlands are not related to the magnitude of connecting flows when larvae are present (Priority: High) | Same as $H_1$ plus:<br>Magnitude of connecting flows (Priority: High) | Ongoing and expanded project 22f, new floodplain studies (projects FR-164 and FR-165), completed project Cap-6 rz/entr, and ongoing C6-hydro. |
| $H_3$: Entrainment and retention of larvae in floodplain wetlands are not related to the duration of connecting flows when larvae are present (Priority: High) | Same as H1 plus:<br>Duration of connecting flows (Priority: High) | Ongoing and expanded project 22f, new floodplain studies (projects FR-164 and FR-165), ongoing C6-hydro, and completed project Cap-6 rz/entr. |
| $H_4$: Entrainment and retention of larvae in floodplain wetlands are not related to floodplain wetland characteristics (e.g., single-breach and flow-through, location of wetland, breach/connection elevation) (Priority: High) | Same as H1 plus:<br>Physical characteristics of study wetlands (Priority: High) | New field study needed. Related to ongoing project C6-hydro. |
| ***Topic 2: Survival and Escapement of Entrained Razorback Suckers (Priority: High)*** | | |
| $H_1$: Relative abundance and condition of YOY razorback suckers in autumn are not related to floodplain wetland characteristics (e.g., single-breach and flow-through, breach/connection elevation, surface area, and depth) (Priority: High) | Relative abundance and condition of YOY suckers in floodplain wetlands in autumn (Priority: High) | Ongoing and expanded project 22f, new floodplain studies (projects FR-164 and FR-165), ongoing efforts at the Stirrup floodplain (projects Cap-6 RZ/recr), and past studies (Cap-6 rz/bt, Cap-6 bt/rz, and data collected in 2011). |

**Table 3 (Cont.)**

| Hypotheses | Variables | Related Studies and Data[a] |
|---|---|---|
| $H_2$: Relative abundance and condition of age 1 and other razorback suckers at the end of the winter period are not related to floodplain wetland characteristics (Priority: High) | Relative abundance and condition of age 1 and other razorback suckers in floodplain wetlands at the end of winter prior to peak runoff (Priority: High) | New floodplain study (FR-164). Related to the recently completed portion of projects Cap-6 RZ/recr, and past studies (Cap-6 rz/bt, and Cap-6 bt/rz). |
| $H_3$: Number of razorback suckers that are able to escape floodplain wetland habitats to the main channel river is not related to floodplain wetland characteristics (Priority: High) | Number of razorback suckers escaping from floodplain wetlands during peak flows (Priority: High) | PIT tag arrays will be deployed at the Stirrup floodplain (Cap-6 RZ/recr) and at Stewart Lake (new study FR-165). Ongoing projects 123a, 123b, 128, 138, and 158 (currently funded through 2012) could detect escaped fish. |
| | Degree of connection in subsequent years that would provide an opportunity for escapement (Priority: High) | New modeling study needed similar to FR-FP synthesis. Related to recently completed portions of project Cap-6 RZ/recr as well as ongoing deployment of PIT tag array, and ongoing project C6-hydro. |
| $H_4$: Floodplain wetlands are not different in terms of surface area, depth, and cover at peak, post-peak, autumn, and end of winter (Priority: High) | Surface area, depth, and cover of floodplain wetlands post-peak, in autumn, and at end of winter (Priority: High) | New field study needed and/or supplement new floodplain studies (FR-164 and FR-165). Related to completed project Cap-6 bt/rz and ongoing project C6-hydro. |
| $H_5$: Floodplain wetlands are not different in terms of water quality through the summer and winter (Priority: High) | Water quality in floodplain wetlands through the summer and winter period (Priority: High) | New field study needed, and/or supplement new floodplain studies (FR-164 and FR-165). Related to completed project Cap-6 bt/rz. |
| ***Topic 3: Availability of Colorado Pikeminnow Habitat (Priority: Medium)*** | | |
| $H_1$: Base flow magnitude is not affected by the use of a larval trigger (Priority: Medium) | Base flow magnitude (Priority: Medium) | Ongoing USGS gage data collection. |
| $H_2$: The amount of backwater habitat available for Colorado pikeminnow during the base flow period is not affected by the use of a larval trigger (Priority: Medium) | Surface area, volume, and depth of backwaters at base flow (Priority: Medium) | Ongoing Argonne/Western backwater study. |
| $H_3$: The number of Colorado pikeminnow found in backwater nursery habitats in late summer is not affected by the use of a larval trigger (Priority: Medium) | Number of Colorado pikeminnow captured in backwater habitats in late summer/early autumn (Priority: Medium) | Ongoing projects 138 and 158. |

**Table 3 (Cont.)**

| Hypotheses | Variables | Related Studies and Data[(a)] |
|---|---|---|
| ***Topic 4: Sediment Mobilization and Channel Maintenance (Priority: Medium)*** | | |
| $H_1$: The amount of suspended sediment transport is not affected by the use of a larval trigger (Priority: Medium) | Suspended sediment transport rates (Priority: Medium) | New field study may be needed. Related to completed project 85f. |
| $H_2$: Bedload transport is not affected by the use of a larval trigger (Priority: Medium) | Bedload transport rates (Priority: Medium) | New field study may be needed. Related to completed project 85f. |
| $H_3$: Channel width and complexity are not affected by the use of a larval trigger (Priority: Medium) | Channel width (Priority: Medium) | New field study needed (aerial photography). |
| | Channel complexity including the size and number of sandbars that provide backwater habitats (Priority: Medium) | New field study needed (aerial photography). |
| ***Topic 5: Fish Community Response (Priority: Low)*** | | |
| $H_1$: The diversity and abundance of native and nonnative fish established in floodplain wetlands is not affected by the use of a larval trigger (Priority: Low) | Native and nonnative fish diversity and abundance in floodplain wetlands (Priority: Low) | New field study needed. Related to completed project Cap-6 RZ/recr, Cap-6 rz/bt, and Cap-6 bt/rz. |
| $H_2$: The diversity and abundance of native and nonnative fish in main channel habitats is not affected by the use of a larval trigger (Priority: Low) | Native and nonnative fish diversity and abundance in main channel habitats (Priority: Low) | Related to completed project 144, and ongoing projects 123a, 123b, 138, and 158. |
| | Main channel water temperatures (Priority: Low) | Ongoing water temperature gage data collection. |
| | Entrainment of burbot through power turbines, bypass or spillway (Priority: High) | Risk Assessment review conducted by NPS, NNF coordinator and Utah. |

(a) Ongoing and completed projects are described in the Appendix.

## Topic 1: Entrainment and Retention of Razorback Sucker Larvae in Floodplain Wetlands

Topic 1 addresses factors that may affect entrainment and retention of larval razorback suckers in floodplain wetlands. Included under this topic is an examination of the role of peak flow characteristics (e.g., timing, magnitude, and duration of connecting flows relative to the timing of larval drift) and floodplain wetland characteristics (e.g., single-breach and flow-through, location of wetland, breach/connection elevation) in relation to the entrainment and

retention of razorback sucker larvae in floodplain wetlands. To evaluate this topic, peak releases and connecting flows would be timed to coincide with the presence of larvae, but there could be significant variation in abundance during the peak release period. Data collected for this portion of the study would be compared to historical data (i.e., Bestgen et al. 2011) collected when the Yampa River trigger was used.

Hypotheses[2] to be tested under Topic 1 include:

$H_1$: Entrainment and retention of larvae in floodplain wetlands are not related to the timing of connecting flows relative to the timing of larval drift.

$H_2$: Entrainment and retention of larvae in floodplain wetlands are not related to the magnitude of connecting flows when larvae are present.

$H_3$: Entrainment and retention of larvae in floodplain wetlands are not related to the duration of connecting flows when larvae are present.

$H_4$: Entrainment and retention of larvae in floodplain wetlands are not related to floodplain wetland characteristics (e.g., single-breach and flow-through, location of wetland, breach/connection elevation).

To test hypotheses for Topic 1 (Table 3), a variety of data should be collected, and some data will be useful for testing more than one of the hypotheses listed above. Data needs, related existing studies, and, where applicable, the need for new studies are presented next. Although separate hypotheses are considered for the potential effects of timing, magnitude, and duration of flows, it may be difficult to separate the effects of these variables since they can effect entrainment both collectively and individually.

- *Timing, duration, and abundance of larvae in the main channel.* Ongoing project 22f would be used to gather these data. Bestgen et al. (2011) also suggested that it may be possible to develop relationships based on physical attributes (e.g., water temperature and time of year) to predict the timing of larval drift. Such modeling would be useful for operational planning and should be developed and used to predict the first occurrence of larvae, but should not replace direct measurements of drift to test this hypothesis.

- *Timing, magnitude, and duration of connecting flows*. A new field study would be needed to collect these data, but could tier from ongoing project C6-hydro to assess actual connection flow (i.e., when river flow begins to enter wetlands) at each study wetland at the beginning of the study, and perhaps every year thereafter until study completion. It may be necessary to develop new river flow and entrainment relationships at the beginning of the study, and periodically during the study, if breach elevations are altered by annual high flows. Green River researchers have noted the poor concordance between published (i.e., Valdez and Nelson 2004; Bestgen et al. 2011) connecting flows and actual connecting flows following high-flow years. These differences between actual and

[2] All hypotheses are written as null hypotheses, i.e., that there is no effect or difference between the elements compared.

published connecting flows may be especially noticeable following the very high flows in 2011. Thus, it would be important to assess breach condition and elevations prior to spring peak flow in 2012, if possible.

- *Volume of water entrained into wetlands during the period of larval drift*. Data collected to determine connection flows, flow gage data, and the relationships developed by Bestgen et al. (2011) should be used to determine annual water volume entrained into wetlands. The relationships used may need to be modified annually or occasionally if breach elevations are altered by annual high flows.

- *Larval presence and abundance in wetlands after flows recede and connection with the main channel has ended.* Modifications to existing project 22f and new studies by UDWR and USFWS in floodplain wetlands will provide sampling needed to inform this information need. Those studies follow aspects of sampling protocols used in 2011 to evaluate larval presence in floodplain wetlands. Based on experience in 2011, it may be difficult to accurately assess the presence and abundance of larvae in wetlands after flows recede. This is at least partly a result of the large size of some of the study wetlands, sampling effort, and the number of larvae entrained. For this reason, it is recommended that even if larvae were not detected initially in study wetlands, these wetlands be sampled again before the subsequent spring peak to determine if razorback suckers had been entrained. Abundance estimates should be quantified to the extent possible, but may need to rely on effort-based estimates or estimates of relative abundance. In addition, a research project using marked individuals (e.g., Hedrick et al. 2009) could be used to better quantify abundance of larvae in light trap samples and calibrate sampling effort and results accordingly. *Physical characteristics of study wetlands. Important physical characteristics of study wetlands include (1)* number of inlets/outlets, (2) breach/connection elevations, and (3) distance from spawning areas. Some of the physical characteristics of potential study area wetlands are well known (e.g., number of inlets/outlets and distance from spawning areas), but, as mentioned above, breach/connection elevations should be assessed initially and annually if possible following protocols in project C6-hydro.

## Topic 2: Survival and Escapement of Entrained Razorback Suckers

Topic 2 addresses factors that may affect the survival of razorback suckers entrained as larvae into floodplain wetlands and their eventual escapement from those wetlands into the main channel of the river. Survival of larvae and eventual escapement of subadults are essential elements of the razorback sucker life cycle (e.g., Muth et al 2000.). Entrainment into wetlands that cannot support razorback suckers through at least one and potentially several years provides no benefit to the species, and could have a negative effect if these wetlands functioned as sinks from which suckers could not re-enter the main channel. Studies would focus on evaluating the abundance and condition of YOY and subadult fish as related to floodplain wetland characteristics that could affect their suitability to serve as nursery and overwinter habitats, while also allowing escapement to the main channel. Wetland characteristics to evaluate under Topic 2 include floodplain wetland type (e.g., the number of connections (single-breach vs. flow-through), breach/connection elevation, surface area, depth, cover, and water quality, particularly

temporal patterns of dissolved oxygen. When evaluating each study wetland, there should be consideration of whether or not the wetland had been reset in previous years (i.e., drained or dried sufficiently to eradicate nonnative resident fish). Note that the relative abundance of YOY will also depend on entrainment rates, and, therefore, testing the hypotheses of Topic 2 will require controlling for previous entrainment rates.

Hypotheses to be tested under Topic 2 include:

$H_1$: Relative abundance and condition of YOY razorback suckers in autumn are not related to floodplain wetland characteristics (e.g., single-breach and flow-through, breach/connection elevation, surface area, depth, and cover).

$H_2$: Relative abundance and condition of age 1 and other razorback suckers at the end of the winter period are not related to floodplain wetland characteristics.

$H_3$: Number of razorback suckers that are able to escape floodplain wetland habitats to the main channel is not related to floodplain wetland characteristics.

$H_4$: Floodplain wetlands are not different in terms of surface area, depth, and cover at peak, post-peak, autumn, and end of winter.

$H_5$: Floodplain wetlands are not different in terms of water quality through the summer and winter.

To test hypotheses for Topic 2 (Table 3), a variety of data should be collected. Data needs, related existing studies, and, where applicable, the need for new studies are presented next.

- *Relative abundance and condition of YOY suckers in floodplain wetlands in autumn.* Two new studies conducted by USFWS (project FR-164) and UDWR (project FR-165), which will sample floodplain wetlands in the post-connection period, and an expanded project 22f have been funded to accommodate these data needs. Other related projects that have been completed, but that could be tiered from include Cap-6 RZ/recr, Cap-6 rz/bt, and Cap-6 bt/rz. Abundance estimates should be quantified to the extent possible, but may need to rely on effort-based estimates. Condition of individual fish should be based on calculations of relative weight or length-weight relationships; otherwise, qualitative assessments of condition should be recorded.

- *Relative abundance and condition of age 1 and other razorback suckers in floodplain wetlands at the end of winter prior to peak runoff.* Two new studies conducted by USFWS (project FR-164) and UDWR (project FR-165), which will sample floodplain wetlands in the post-connection period, and expanded project 22f have been funded to accommodate these data needs. Sampling will be similar to that conducted in autumn. .

- *Number of razorback suckers escaping from floodplain wetlands during peak flows.* To gather these data, a new study would be needed that tags fish captured in autumn and pre-peak spring samples using Passive Integrated Transponder (PIT) tags and uses PIT tag

antenna arrays in breaches and points of connection to determine escapement. These studies will complement other tag-recapture studies including projects 123a, 123b, and 128, and the new floodplain studies (projects FR-164 and FR-165). This study could tier from completed project Cap-6 RZ/recr. In addition, an evaluation of recaptures in subsequent years in ongoing main-channel sampling (e.g., projects 123b, 128, and 138) would provide information on the ultimate fate of fish escaping from floodplain wetlands.

- *Degree of connection in subsequent years that would provide an opportunity for escapement.* A post-hoc evaluation of escapement opportunity would be conducted using gage-based estimates of river elevation, previously derived estimates of breach/connection elevation, and previously reported fish passage criterion (Burdick 1997) to determine the duration of escapement opportunity in any given year.

- *Surface area, depth, and cover of floodplain wetlands post-peak, in autumn, and at end of winter.* To gather these data, a new study would be needed, possibly as an expansion of project C6-hydro or Cap-6 bt/rz. The purpose of this study would be to gather information on the physical characteristics of floodplain wetlands that are most important in determining the ability of floodplain wetlands to provide for survival and escapement of razorback suckers. Although detailed survey-grade quantification of surface area and depth would be of greatest value, less detailed information, if representative and unbiased, could be gathered and used instead.

- *Water quality in floodplain wetlands through the summer and winter period.* Eutrophication during the summer and a reduction in free water in the winter could result in a reduction in dissolved oxygen levels in floodplain wetlands that affect fish health and survivorship. A new study would be needed to monitor water quality through summer and winter and should focus on critical periods when water quality is considered potentially limiting. The study could tier from completed project Cap-6 bt/rz.

### Topic 3: Availability of Colorado Pikeminnow Habitat

It is possible that using a larval trigger could have consequences on other components of the Green River ecosystem. Topic 3 addresses the effect of using a larval trigger on base flows and Colorado pikeminnow nursery habitats. As mentioned in Bestgen et al. (2011), using a greater release volume to meet peak-flow targets could result in less water available for base flows, and, consequently, less Colorado pikeminnow nursery habitat through the summer and autumn. The analysis of this topic would include a comparison of new data and historical data.

Hypotheses to be tested under Topic 3 include:

$H_1$: Base flow magnitude is not affected by the use of a larval trigger.

$H_2$: The amount of backwater habitat available for Colorado pikeminnow during the base flow period is not affected by the use of a larval trigger.

$H_3$: The number of Colorado pikeminnow found in backwater nursery habitats in late summer is not affected by the use of a larval trigger.

Data needs, related existing studies, and, where applicable, the need for new studies (e.g., Table 3) to address these hypotheses are presented next.

- *Base flow magnitude.* Flows during the base flow period as measured at the Jensen gage would be used in this analysis. Comparisons would be made to historical data collected in years with comparable hydrology when a larval trigger was not used.

- *Surface area, volume, and depth of backwaters at base flow*. These data would be collected as part of the ongoing backwater topography and modeling project conducted annually by Argonne National Laboratory and Western Area Power Administration. Comparisons would be made to historical data collected in years with comparable hydrology when a larval trigger was not used.

- *Number of Colorado pikeminnow in backwater habitats in late summer.* Ongoing project 138 and perhaps project 158 (ongoing through 2012 and perhaps beyond) would be used to determine effort-based catch rates of YOY Colorado pikeminnow. Comparisons would be made to historical data collected in years when a larval trigger was not used.

### Topic 4: Sediment Mobilization and Channel Maintenance

It is possible that using a larval trigger could have consequences on other components of the Green River ecosystem. Topic 4 addresses the effect of using a larval trigger on sediment mobilization and channel maintenance. Using a larval trigger could result in an overall reduction in annual peak flow magnitude in the middle Green River, because Flaming Gorge releases would not coincide with and add to Yampa River flows. This reduction in peak flow magnitude in this reach could result in less sediment transport and channel maintenance. It is also possible that using a larval trigger could result in longer peak-flow duration in this reach, but lower magnitude peaks that affect erosion and deposition patterns.

Hypotheses to be tested under Topic 4 include:

$H_1$: The amount of suspended sediment transport is not affected by the use of a larval trigger.

$H_2$: Bedload transport is not affected by the use of a larval trigger.

$H_3$: Channel width and complexity are not affected by the use of a larval trigger.

Data needs, related existing studies, and, where applicable, the need for new studies (see Table 3) to address these hypotheses are presented next.

- *Suspended sediment transport rates*. Collection of these data would require a new study or renewal of elements of the recently completed project 85f, but it may be possible to

use existing sediment transport equations from project 85f to estimate suspended sediment transport under different flow conditions.

- *Bedload transport rates*. Similar to the previous variable, collection of these data would require a new study or renewal of elements of the recently completed project 85f, but it may be possible to use existing sediment transport equations from project 85f to estimate bed load sediment transport under different flow conditions.

- *Channel width*. Collection of these data would require a new study that builds on existing aerial photography

- *Channel complexity, including the size and number of sandbars that provide backwater habitats*. Similar to the previous variable, collection of these data would require a new study that builds on existing aerial photography.

## Topic 5: Fish Community Response

It is possible that using a larval trigger could have consequences on other components of the Green River ecosystem. Topic 5 addresses the effect of using a larval trigger on native non-endangered fishes, particularly co-evolved catostomids, and nonnative fish populations in floodplain wetlands and in the main channel. Using a larval trigger could result in a positive response by other native fishes as well as nonnative fishes, at least in part because annual peak flows that are thought to suppress nonnative fish populations may be lower if a larval trigger is used. The risk of entraining nonnative burbot (*Lota lota*) through power turbines, bypass tubes, or spillway has not been assessed and may increase with increased use of bypass during peak releases. These analyses would include a comparison of new data and historical data.

Hypotheses to be tested under Topic 5 include:

$H_1$: The diversity and abundance of nonnative fish established in floodplain wetlands is not affected by the use of a larval trigger.

$H_2$: The diversity and abundance of nonnative fish in main channel habitats is not affected by the use of a larval trigger.

Data needs, related existing studies, and, where applicable, the need for new studies (Table 3) to address these hypotheses are presented next.

- *Native and nonnative fish diversity and abundance in floodplain wetlands*. Two new studies conducted by USFWS (project FR-164) and UDWR (project FR-165), which will sample in floodplain wetlands in the post-connection period, and expanded project 22f have been funded to partially accommodate these data needs. Data collection will include fishes captured and measures of relative abundance (catch per unit effort [CPUE]) in floodplain wetland habitats. The study could tier from completed projects Cap-6 RZ/recr, Cap-6 rz/bt, and Cap-6 bt/rz.

- *Native and nonnative fish diversity and abundance in main channel habitats*. These data are being collected under ongoing projects 123a, 123b, 138, and 158 (at least through 2012).
- *Entrainment of burbot through power turbines, bypass tubes or spillway.* A literature review, and risk assessment will be completed by the NPS, Utah, and the Nonnative Fish coordinator in 2012.
- *Main channel water temperatures.* Existing water temperature gages would be used to monitor main channel temperature through the year. Comparisons would be made to historical data collected in years with comparable hydrology when a larval trigger was not used.

# 3 RESEARCH PRIORITIES AND IMPLEMENTATION

As described in Section 2, five topics are included in this study plan: (1) entrainment and retention of larval razorback suckers in floodplain wetlands; (2) survival and eventual escapement of entrained larvae in floodplain wetlands; (3) availability of Colorado pikeminnow habitat; (4) sediment mobilization and channel maintenance; and (5) fish community response. Studies associated with Topics 1 and 2 are considered the highest priority because these studies address the objectives of using a larval trigger (i.e., razorback sucker entrainment and recruitment). Topics 3, 4, and 5 address potential other consequences of using a larval trigger, and are considered lower priority. It is important to note that the priorities assigned to topics in this study plan are relative to their importance to testing the effectiveness of implementing a larval trigger and not to overall priorities of the Recovery Program. Studies identified as low priority here could be high priority for other Program elements.

Table 3 summarizes hypotheses, variables to be measured, related studies, and priorities for each topic addressed in the study plan. Overall priorities are categorized as high, medium, or low based on the perceived relationship between the topic and the larval trigger, and the importance of the information in understanding that relationship and testing specific hypotheses.

Within topics, certain hypotheses and variables are considered higher priority than others (Table 3). For Topic 1, all hypotheses and variables are considered high priority and essential for interpretation of the effectiveness of the larval trigger in achieving recovery of razorback suckers. For Topic 2, obtaining useful information on abundance and condition of fish in both the autumn and after the winter period prior to peak runoff is considered high priority. Numbers and condition in autumn would be useful for determining survival and growth during the summer, and could be used to interpret pre-peak numbers, but only winter data would enable a determination of the usefulness of wetlands for completing the cycle from entrainment to escapement. It is considered a high priority to measure the opportunity for escapement, but direct measurements of escapement using a PIT tag antenna array may be considered on an as-needed basis. Escapement should also be inferred from captures of wild-spawned subadults or adults in the main channel during ongoing survey projects (e.g., 123b and 138). Under Topic 2, measurements of wetland surface area and depth are considered most important at times when these variables would be at their minimum (i.e., limiting) values (e.g., at the end of the summer). Water quality data are considered high priority, because this information is relatively easily obtained and could be used to identify issues that could limit the value of floodplain wetland habitats.

The remaining topics are considered to be medium (Topics 3 and 4) or low (Topic 5) priority for purposes of testing the effectiveness of the larval trigger. These topics were identified in the Green River study plan (Green River Study Plan *ad hoc* Committee 2007) and will be evaluated as part of that process. Topic 3 would be evaluated using field data collected annually under existing ongoing projects. Thus, even though the topic is considered to be medium priority for this study plan, it could be evaluated with minimal new or additional work, and it is recommended that this topic be evaluated. Topic 4 would require potentially expensive new field studies to measure sediment transport (unless transport relationships developed in project 85f could be used to estimate transport under different flow regimes), and collect aerial photography.

Topic 5 is considered low priority for this study plan, but ongoing studies would provide much of the data needed to test relevant hypotheses. To further evaluate the effects of using a larval trigger, Reclamation will conduct a retrospective analysis of dam release hydrographs that may have occurred since 2006 if the larval trigger had been implemented along with existing peak- and base flow objectives specified in the 2006 Record of Decision. This modeling will be used primarily by the Flaming Gorge Technical Work Group to inform their flow planning process in future years.

As practicable, proposed studies should address the flow magnitude and duration bins shown in Table 2, but three years with flows < 18,600 cfs and three years with flows ≥ 18,600 cfs and with connecting flows in each of these years of at least seven days duration are considered necessary to complete the study. Although it could be possible to complete the study in six years, ultimately the length of the study will be dependent on annual hydrologic conditions. Figure 1 shows a decision tree to be used when determining the need for monitoring actions in any given year.

Under the study plan, up to eight wetlands would be sampled in a given year. Only wetlands that are thought to hold the greatest promise for recruiting razorback suckers and that are representative of other wetlands in the system should be chosen for study (see Table 2 for wetlands identified as candidates for study). Some additional evaluation may be needed prior to selecting study wetlands to verify the flows at which wetlands connect to the main channel, and to determine their suitability as nursery habitat. In order to make meaningful statistical inferences from the data, it will be important to study the same wetlands each year to the extent possible.

The specific objectives, tasks, and expected outcomes for individual studies developed under this plan will be identified in statements of work approved by the Recovery Program. These projects and the resulting project reports will go through the standard Recovery Program review protocols. It is anticipated that a synthesis report will be developed that summarizes results from individual projects, integrates results, summarizes conclusions, and makes recommendations for future implementation of a larval trigger.

As for any study plan, additional knowledge will be gained during implementation, and it will be important to have enough flexibility to adjust studies and overall approaches in response to this new information. Emerging data gaps regarding the relative effects of flow magnitude, duration and timing on larval entrainment should also help guide the direction of research. The topics, hypotheses, variables, and priorities presented here are a starting point, rather than a fixed path forward.

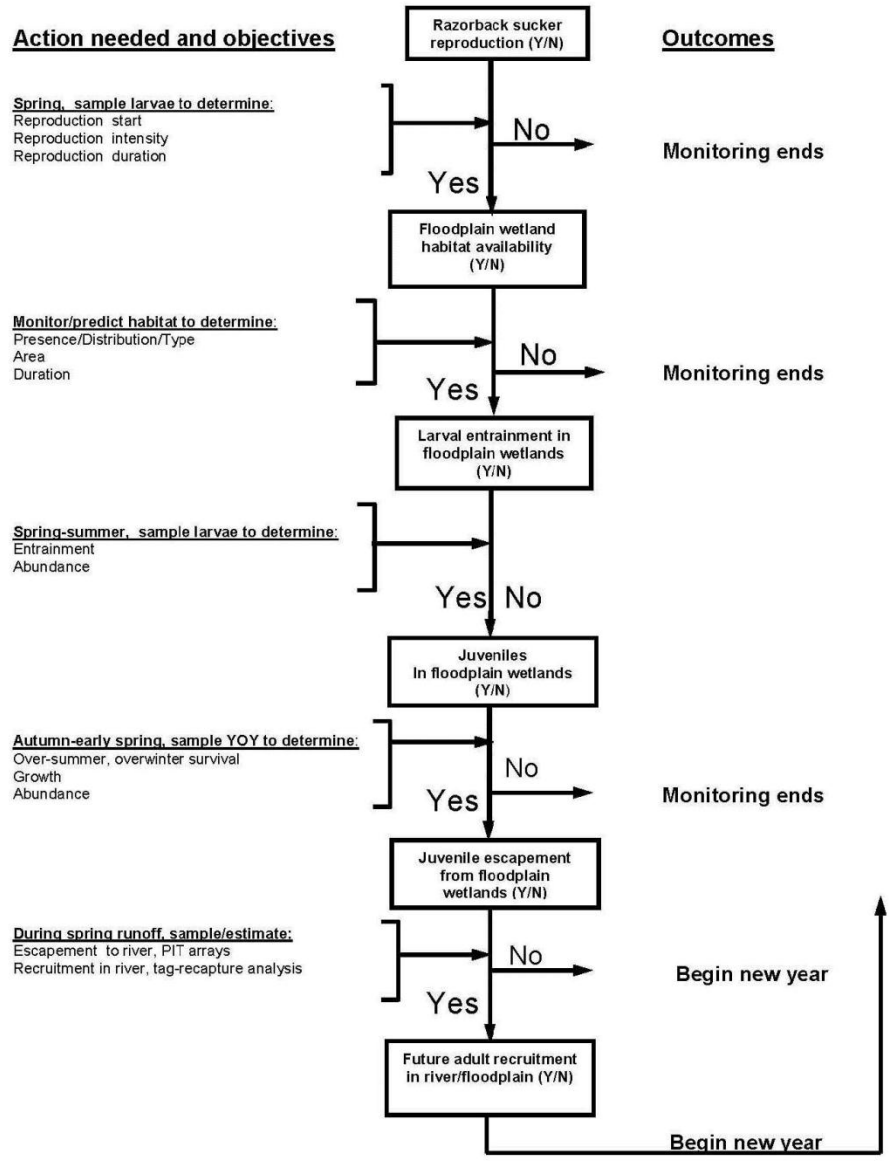



**FIGURE 1. Monitoring Decision Tree to Be Used in Evaluating the Larval Trigger**

## 4 REFERENCES

Bestgen, K.R., G.B. Haines, and A.A. Hill. 2011. *Synthesis of Flood Plain Wetland Information: Timing of Razorback Sucker Reproduction in the Green River, Utah, Related to Stream Flow, Water Temperature, and Flood Plain Wetland Availability*. Final Report, Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Burdick, B. D. (1997). Minimum Flow Recommendation for Passage of Colorado Squawfish and Razorback Sucker in the 2.3-Mile Reach of the Lower Gunnison River: Redlands Diversion Dam to the Colorado River Confluence, Colorado River Recovery Program.

Green River Study Plan *ad hoc* Committee. 2007. *Study Plan for the Implementation and Evaluation of Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam.* Final Report.

Hedrick, T.N., K.R. Bestgen, and K.D. Christopherson. 2009. *Entrainment of Semi-Buoyant Beads and Razorback Sucker (*Xyrauchen texanus*) Larvae into Flood Plain Wetlands of the Middle Green River, Utah.* Final Report, Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Irving, D.B. and B.D. Burdick. 1995. *Reconnaissance Inventory and Prioritization of Existing and Potential Bottomlands in the Upper Colorado River Basin, 1993–1994.* Final Report, Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Muth, R.T., L.W. Crist, K.E. LaGory, J.W. Hayse, K.R. Bestgen, J.K. Lyons, T.P. Ryan, and R.A. Valdez. 2000. *Flow Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam*, Final Report, Upper Colorado River Endangered Fish Recovery Program Project FG-53, Denver, Colo.

Tetra Tech, Inc. 2005. *Floodplain Habitat Restoration, 2005 Monitoring Final Report, Green River, Utah.* Upper Colorado River Endangered Fish Recovery Program, Project Number C6-Hydro, Denver, Colo.

Valdez, R.A. and P. Nelson. 2004. *Green River Subbasin Floodplain Management Plan.* Upper Colorado River Endangered Fish Recovery Program, Project Number C-6, Denver, Colo.

**APPENDIX**

**RECOVERY PROGRAM PROJECTS RELATED TO THIS STUDY PLAN**

**TABLE A-1. Ongoing and Completed Recovery Program Studies Identified in Table 3 and in the Text that Will Contribute Information to Hypotheses Testing.**

| Project No. | Project Title[a] | Comments |
|---|---|---|
| 22f | Interagency Standardized Monitoring Program (ISMP) assessment of endangered fish reproduction in relation to Flaming Gorge Dam operations in the middle Green and lower Yampa Rivers. | Long-term (since 1992) standardized main channel light trapping for larval razorback suckers, which will provide real time information to trigger Reclamation's experimental operations. Study was expanded to incorporate larval sampling in floodplain habitats. Addresses Topic 1 hypotheses. |
| FR-164 | Middle Green River floodplain sampling. | New study in 2012 (complements larval sampling covered in project 22f). Sample wetlands in spring to determine overwinter survival of razorback sucker; qualitatively describe fish community in wetlands; document entrainment and recruitment of razorback sucker in fall; collect water quality information at wetlands. Addresses Topic 1 and 2 hypotheses. |
| FR-165 | Use of the Stewart Lake floodplain by larval and adult endangered fishes | New study in 2012. Monitor entrainment of larval endangered fishes during high flows; examine fish community composition and habitat characteristics post floodplain connection; monitor escapement of native and nonnative fishes from Stewart Lake. Addresses Topic 1 and 2 hypotheses. |
| C-6 hydro | Physical evaluation of floodplain habitats restored/enhanced to benefit endangered fishes of the Upper Colorado River basin. | This ongoing study will need to be revised to address study plan information needs at floodplain habitats in Green River subbasin. Addresses Topics 1 and 2 hypotheses. |
| FR-FP synthesis | Synthesis of flood plain wetland information. | Completed study, which serves as a basis for the Larval Trigger Study Plan. Addresses Topic 1 hypotheses. Results summarized in Bestgen et al. (2011). |
| Cap-6 rz/entr | Entrainment of larval razorback sucker. | Completed study, which serves as a basis for the Larval Trigger Study Plan. Addresses Topic 1 hypotheses. Results summarized in Hedrick et al. (2009). |
| C-6 | Green River Subbasin Floodplain Management Plan. | Completed study, which provides background information related primarily to Topic 2 hypotheses. Results summarized in Valdez and Nelson (2004). |
| Cap-6 rz/bt | Larval razorback and bonytail survival in Baeser. | Completed study, which provides background information related primarily to Topic 2 hypotheses. Results summarized in Brunson and Christopherson (2005). Larval razorback sucker and bonytail survival and growth in the presence of nonnative fish in the Baeser floodplain wetland of the middle Green River. |

**Table A-1 (Continued)**

| Project No. | Project Title[a] | Comments |
|---|---|---|
| Cap-6 bt/rz | Larval bonytail and razorback sucker survival in floodplain habitats. | Completed study, which provides background information related primarily to Topic 2 hypotheses. Results summarized in Modde and Haines (2005). Survival and growth of stocked razorback sucker and bonytail in multiple floodplain wetlands of the middle Green River under reset conditions. |
| Cap-6 RZ/recr | Razorback sucker survival and emigration from the Stirrup floodplain | Research aspects of this study have been completed: Hedrick et al. (2012). Razorback sucker survival and emigration from the Stirrup floodplain, Middle Green River, Utah 2007-2010. UDWR will continue to deploy a PIT tag array during floodplain connection and monitor/augment water quality as needed at the Stirrup floodplain in 2012 and beyond. Primarily addresses Topic 2 hypotheses. |
| 128 | Abundance estimates for Colorado pikeminnow in the Green River Basin, Utah and Colorado | These ongoing efforts comprise many hours of main channel electrofishing, which can detect razorback suckers escaping from floodplains, i.e. Topic 2 hypotheses. Projects 123(a) and (b) can also evaluate changes in main channel fish community, i.e. address Topic 5 hypotheses. |
| 123b | Nonnative fish control in the middle Green River | |
| 123a | Nonnative Fish Control in the Echo Park to Split Mountain Reach of the Green River, Utah | |
| 138 | Annual fall monitoring of YOY Colorado pikeminnow and small-bodied native fishes. | This ongoing study provides a long term assessment of the small bodied fish community in backwater habitats throughout the middle Green River. Addresses Topic 3 hypotheses |
| 144 | Green River native fish response to nonnative control | Completed study, which provides background information related primarily to Topic 5 hypotheses. Draft report in review. |
| 158 | Assessment of larval Colorado pikeminnow presence and survival in low velocity habitats in the middle Green River | Ongoing study with final year of field work scheduled in 2012 (may be extended). Verify that larval pikeminnow are arriving in nursery habitat; document abundance of larval Colorado pikeminnow in backwaters as season progresses; determine success of removing and excluding nonnative fish from backwaters using various blocking techniques and depletion treatments; assess small-bodied fish community effects from removing nonnative fishes from backwaters. Addresses Topic 3 and 5 hypotheses. |
| FR-BW synthesis | Historical assessment of factors affecting young Colorado pikeminnow abundance and physical habitat availability in the Green River, Utah. | This synthesis (in preparation) incorporates long-term age-0 pikeminnow collection data (e.g., project 138) and sandbar topography (Argonne National Laboratory) to describe physical and biological habitat responses to middle Green River flows. Provides a baseline for Topics 3 and 4 hypotheses. |

**Table A-1 (Continued)**

| Project No. | Project Title[a] | Comments |
|---|---|---|
| 85f | Gunnison and Green River sediment monitoring | Completed study, report in final revision; sediment transport equations could be used to address Topic 4 hypotheses. Results presented in Williams et al. (2011). Application of Sediment Characteristics and Transport Conditions to Resource Management in Selected Main-Stem Reaches of the Upper Colorado River, Colorado and Utah, 1967–2007. |
| FR-115 | Monitoring effects of Flaming Gorge Dam releases on the Lodore/Whirlpool fish community | This ongoing fish community monitoring study will provide some evaluation of effects of Reclamation's releases to meet the larval trigger in upstream reaches. Addresses Topic 5 hypotheses. |

(a) Full scopes of work are available at: http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/project-scopes-of-work.html#I. Completed studies are available at: http://www.coloradoriverrecovery.org/documents-publications/technical-reports/habitat-restoration.html.

# Appendix F

## May 9, 2012, Memorandum from the U.S. Fish and Wildlife Service for the 2012 Green River Spring and Base Flows to Assist in Recovery of Endangered Fishes

United States Department of the Interior
FISH AND WILDLIFE SERVICE
UTAH FIELD OFFICE
2369 WEST ORTON CIRCLE, SUITE 50
WEST VALLEY CITY, UTAH 84119

May 09, 2012

In Reply Refer To:
FWS/R6
ES/UT
08-FA-0180

Memorandum

To: Director, Upper Colorado Region, Bureau of Reclamation
Chair, Flaming Gorge Technical Working Group, Bureau of Reclamation

From: Field Supervisor, Utah Field Office, U.S. Fish and Wildlife Service

Subject: 2012 Green River Spring and Base Flows to Assist in Recovery of the Endangered Fishes

This letter describes our recommendations for 2012 spring and base flows in Reach 2 of the Green River for discussion by the Flaming Gorge Technical Working Group (FGTWG) in development of recommendations for Flaming Gorge Dam operations. Our intent is to work with other FGTWG members to ensure consistency with the 2005 biological opinion (BO; U.S. Fish and Wildlife Service 2005) and 2006 record of decision (ROD; U.S. Department of Interior 2006), which call for flows to protect and assist in recovery of endangered fishes. The following recommendations are subject to forecasted and real-time May – July hydrologic conditions in the upper Green River drainage, with recognition that trade-offs of spring and base flows should be considered and used to adjust operations as deemed appropriate.

Spring-runoff research flow

We support the Upper Colorado River Endangered Fish Recovery Program's (Recovery Program) 2012 Spring Flow Request, as explained in their March 26, 2012 letter. We believe their primary objective, to time Flaming Gorge releases and resultant floodplain connection with the presence of wild produced razorback sucker larvae, is consistent with the intent of the Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam (Flow Recommendations; Muth et al. 2000), the 2005 BO, and the 2006 ROD. Specifically, the objectives and criteria presented in their letter are consistent with the common goal of the Flow Recommendations, BO and ROD: to use the best available science to guide Flaming Gorge operations and recovery actions in an adaptive management framework.

The Recovery Program, in an effort to scientifically evaluate the results of operating Flaming Gorge concurrent with the presence of larval razorback sucker, developed the *Study Plan to Examine the Effects of Using Larval Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam* (Larval Trigger Study Plan or LTSP). The Study Design matrix (Table 2 in the LTSP) details the range of experimental conditions the Recovery Program would like to assess with recognition that more than set of flow conditions of that matrix could be accomplished in a single year. This is an important document that will assist in consistent evaluation into how Flaming Gorge operations are benefiting razorback sucker.

The LTSP and updated flow release is supported by the most recent scientific research into endangered fish ecology and floodplain management (Bestgen et al. 2011). As the Recovery Program described in the LTSP, the Bestgen et al. (2011) report synthesized long term data, evaluated the ability to operate Flaming Gorge Dam for the purpose of entraining wild razorback larvae into floodplain habitats, and created a set of conclusions and recommendations to guide future management. The Flow Recommendations recommended utilizing up-to-date research and monitoring, such as the Bestgen et al. (2011) draft report:

> "the collection of additional data on endangered fishes and their habitats should focus on the evaluation and possible modification of our recommendations by following an adaptive-management process" (Muth et al. 2000, p. 5-39);

as well as biological information to guide the onset of spring peak flow:

> "Examples of real-time and other year-specific information to be considered in determining annual patterns of releases . . .
>
> - Initial appearance of larval suckers in established reference sites in Reach 2 (e.g., Cliff Creek)" (Muth et al. 2000, p. 5-9, Table 5.3).

Similarly, the 2005 BO calls for adaptive management in implementing the proposed action (operations of Flaming Gorge Dam) (U.S. Fish and Wildlife Service 2005, p. 16) and set forth this process as a conservation measure:

> "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" (U.S. Fish and Wildlife Service 2005, p. 17);

and

> "[Bureau of] Reclamation, Western [Area Power Administration], and the [U.S. Fish and Wildlife] Service will use any new information collected in these studies to determine the need for management actions or modification of operations as determined appropriate" (U.S. Fish and Wildlife Service 2005, p. 17)

Therefore, we believe that the Recovery Program's 2012 Spring Flow Request and implementation of the LTSP is supported by the 2005 BO and we support the Bureau of Reclamation's (BOR) implementation of this request. The Recovery Program has determined that a minimum of six study years are needed to meet the objectives of the LTSP. Unless otherwise specifically stipulated, this letter conveys the Service's interpretation of ESA compliance under the 2005 BO as it relates to BOR's future LTSP-related spring operations. We recognize that BOR's targeting of a biological trigger (presence of larval razorback sucker) rather than a hydrological one (Yampa River flows) deviates from past operations and may require greater volumes of water in some years. However, we conclude that this experiment is consistent with the intent of the Flow Recommendations and will assist in the recovery of the endangered fish.
We further recognize that timing releases from Flaming Gorge Dam consistent with the Recovery Program's 2012 Spring Flow Request and the LTSP may require the hydrologic tradeoff of not meeting the 2000 Flow and Temperature Recommendations for Reach 2. Nevertheless, we support Reclamation following the Recovery Program's 2012 Spring Flow Request and LTSP, and consider that doing so will meet Reclamation's responsibility to the ROD objectives in 2012

Base flow operations

Because of projected drier than average year conditions, we believe that base flow augmentation is a very important consideration for 2012. Base flows are important for a variety of ecological reasons. We propose the following approach to base flow operations in 2012, which mirrors our suggested approach in 2010. The 2010 proposal relied on the most up-to-date research available and biological data collected that year indicated that numbers of Colorado pikeminnow collected continue to improve.

Our understanding is that BOR will pick a Reach 1 base flow target commensurate with the April – July hydrologic condition in accordance with the ROD and the BO. BOR selects a Reach 1 target that creates a flow condition in Reach 2 that falls within the appropriate base flow range when coupled with projected Yampa River base flows (Muth et al. 2000). For reasons mentioned below, we request that BOR release higher flows than the scheduled base flow target through September 30, 2012, with the understanding that BOR may need to release less than the base flow target through the remainder of the base flow period (October to March) to balance annual operations.

Specifically, we request that BOR augment the Reach 1 calculated base flow target by as much as 40%. For example, if BOR determines that a release of 1,100 cfs is necessary to comply with the ROD and BO, then we request that up to 1,540 cfs be released through Sept 30, 2012. This augmentation is in accordance with the Reach 2 summer - autumn seasonal flow variability recognized in the Flow Recommendations.

We believe that the Flow Recommendations intended that seasonal variability be incorporated into dam operations to assist in the recovery of the species and accommodate natural variability, but not allow for manipulation that targets a specific operational pattern. Our 2012 base flow proposal, which complies with the ROD and the BO, is consistent with

the intent of the flow recommendations, is based on information gathered by the Recovery Program, and responds to current biological conditions in the Green River system.

Our rationale for requesting elevated base flows through September 30 is similar to our request in 2008, 2009, 2010, and 2011, and is intended to accomplish two goals:

1) provide improved nursery conditions for age-0 (young-of-year) Colorado pikeminnow in Reach 2; and
2) hinder nonnative smallmouth bass in Reaches 1 and 2 by delaying their spawning time and decreasing growth of the age-0 cohort.

*Goal 1: Habitat conditions for age-0 Colorado pikeminnow*

Since 2000, there has been a wide range of base flow conditions in Reach 2. Many of the lower base flow years coincided with low age-0 Colorado pikeminnow catch rates as determined each autumn via Recovery Program Project 138[1] – Interagency Standardized Monitoring Program (Table 1). For example, during the summers of 2001, 2002, 2003, 2006, and 2007 base flows in Reach 2 dropped below 1,000 cfs for varying periods of time and age-0 Colorado pikeminnow catch rates were in the single digits (Badame et al. 2010, p. 8).

Contrastingly, in 2009 and 2010, Reach 2 experienced average base flows that exceeded 2,000 cfs for the second and third consecutive year, and for only the second and third time in the most recent eleven year period. Those same years, Utah Division of Wildlife Resources (UDWR) biologists reported the highest catches of age-0 pikeminnow since 1991 (Badame et al. 2010, p. 8; Table 1). We understand that there are many variables that could contribute to the increased catch of age-0 CPM, such as numbers of spawning adults, densities of nonnative fish throughout the larval drift zone, densities of nonnatives in backwaters, productivity of backwaters, and sampling efficiency. However, we believe that the higher base flows (approximately 2,400 to 2,600 cfs) in Reach 2 in 2008, 2009, and 2010 played an important role in this increase.

In 2011, the Green River and its tributaries had very wet conditions, which in some cases were the wettest on record. While these flows facilitated ecological function for floodplains and larval sucker production, they likely exceeded the ecological threshold for successful Colorado pikeminnow recruitment. Data collected in 2011 bears this prediction out, as zero age-0 Colorado pikeminnow were collected. Average flows during the base flow period were 8,660, which is much higher than those in years with high age-0 Colorado pikeminnow collections (approximately four times higher).

However, predicted 2012 conditions are much drier than average, indicating that this year, the FGTWG must again attempt to provide adequate base flow conditions for Colorado pikeminnow and prevent the base flows from dropping to levels not compatible with age-0 Colorado pikeminnow survival.

---

[1] Can be found online at : http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2010/rsch/138.pdf

Most above-average Colorado pikeminnow recruitment events in the middle and lower Green River occur when summer flows ranged from about 1,800 to 2,700 cfs (Bestgen 1997; in Muth et al. 2000). The relationship between base flow elevations and quality of nursery habitat is an information need identified in the Green River Study Plan (Green River Study Plan ad hoc group 2007) and is currently being investigated through a Recovery Program project entitled "Historical assessment of factors affecting young Colorado pikeminnow abundance and physical habitat availability in the Green River, Utah."

| Year | # of age-0 Colorado pikeminnow collected | Average flow between July 15 and September 30 | Years base flows dropped below 1000 cfs |
|---|---|---|---|
| 2000 | 31 | 1423 | |
| 2001 | 8 | 1073 | X |
| 2002 | 0 | 876 | X |
| 2003 | 2 | 1101 | X |
| 2004 | 60 | 1367 | |
| 2005 | 8 | 1958 | |
| 2006 | 5 | 1213 | X |
| 2007 | 3 | 1122 | X |
| 2008 | 18 | 2376 | |
| 2009 | 325 | 2610 | |
| 2010 | 454 | 2244 | |
| 2011 | 0 | 8660 | |

**Table 1. Age-0 Colorado pikeminnow (CPM) standardized catch and corresponding flow conditions in Reach 2 as measured by the USGS at their Jensen, Utah gage**

*Goal 2: Hinder smallmouth bass reproduction*

Information continues to indicate that higher and cooler base flows delay smallmouth bass spawning and reduce growth of the age-0 smallmouth bass cohort. This information was gathered on the Yampa River and on the Green River in Reaches 1 and 2.

The effect of flow and temperature on the onset of smallmouth bass spawning is clearly demonstrated with data collected in Lodore Canyon, Green River (Figure 1). During a relatively wet and cool year (2005), smallmouth bass spawning occurred nearly 3 weeks later than during a drier, warmer year (2007). The same relationship was observed in related investigations on the Yampa River.

Also, preliminary information from Yampa River studies (Recovery Program Project #s 115 and 140) indicate that age-0 smallmouth bass measured in September 2005 were on average 30 millimeter smaller than those collected in September 2007. Thus, high flows and associated cool temperatures appear to not only delay spawning but also slow

the growth rates of age-0 smallmouth bass which in turn decreases their likelihood for overwinter survival (Shuter at al. 1980).

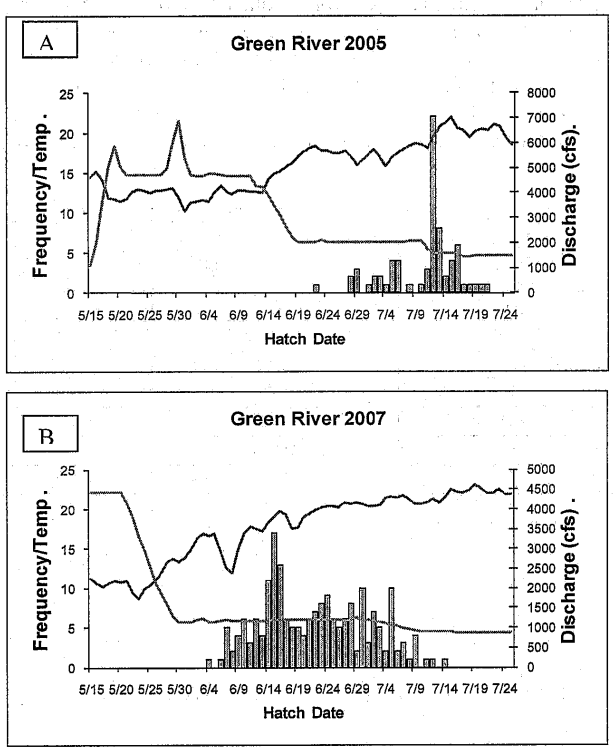



**Figure 1. A comparison of flow (green), temperature (purple), and smallmouth bass hatching dates (bars) in Lodore Canyon (Green River - Reach 1).** A) 2005 conditions included higher base flows and cooler temps; B) 2007 conditions included lower base flows and warmer temps. Figures excerpted from Recovery Program Project #115 2009 Annual Report (preliminary information)[2]

Conclusion

In summary, we request that BOR operate Flaming Gorge Dam as follows:

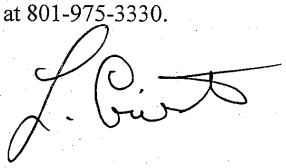
- Time spring flow releases to correspond with the presence of wild produced razorback sucker larvae according to the LTSP in order to improve entrainment success; and

[2] Available online at: http://coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2009/nna/115.pdf

- Enhance summer base flows at the expense of winter base flows to continue to improve Colorado pikeminnow nursery conditions, support age-0 Colorado pikeminnow, and disadvantage smallmouth bass.

We believe that data gathered by the Recovery Program make a strong case for these proposed operations in 2012 and should benefit young life stages of endangered fish. We hope that hydrology conditions in the Upper Green and Yampa River drainages will supply sufficient water to meet these needs. We understand that hydrologic conditions are ever-changing and the BOR may need to adjust operations accordingly.

We thank BOR for the opportunity to provide this input and look forward to participating in the Flaming Gorge Technical Working Group process. If you have any questions or concerns, please contact Kevin McAbee or Paul Abate at 801-975-3330.



## Literature Cited


Badame, P., K. Creighton, T. Hedrick, L. Monroe, and K. Bestgen. 2010. Young-of-the-year Colorado pikeminnow monitoring. FY 2010 Annual Project Report, Colorado River Recovery Program Project Number 138.

Bestgen, K. R. 1997. Interacting effects of physical and biological factors on recruitment of age-0 Colorado squawfish. Doctoral Dissertation. Colorado State University, Fort Collins, CO.

Bestgen, K.R., G.B. Haines, and A.A. Hill. 2011. Synthesis of floodplain wetland information: timing of razorback sucker reproduction in the Green River, Utah, related to streamflow, water termperature, and floodplain wetland availability. Final Report to the Upper Colorado River Endangered Fish Recovery Program. Larval Fish Laboratory Contribution 163.

Green River Study Plan ad hoc Group. 2007. Study plan for the implementation and evaluation of flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam. Upper Colorado Basin Endangered Fish Recovery Program, Lakewood, CO.

Muth, R.T., L.W. Crist, K.E. LaGory, J.W. Hayse, K.R. Bestgen, T.P. Ryan, J.K. Lyons, R.A. Valdez. 2000. Flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam. Upper Colorado River Endangered Fish Recovery Program, Denver, CO.

Shuter, B.J., J.A. MacLean, F.E.J. Fry, and H.A. Regier. 1980. Stochastic simulation of temperature effects of first-year survival of smallmouth bass. Transactions of the American Fisheries Society 109:1-34.

U.S. Department of the Interior. 2006. Record of Decision on the operation of Flaming Gorge Dam Final Environmental Impact Statement. U.S. Department of the Interior, Bureau of Reclamation, Salt Lake City, Utah.

U.S. Fish and Wildlife Service. 2005. Final Biological Opinion on the operation of Flaming Gorge Dam. U.S. Fish and Wildlife Service, Denver, Colorado.

# Appendix G

## Flaming Gorge Technical Working Group – Proposed Flow and Temperature Objectives for 2012

RECLAMATION
*Managing Water in the West*

Flaming Gorge Technical Working Group
Proposed Flow and Temperature Objectives for 2012

**Current Hydrologic Classification**

For the purposes of implementing the 2006 Flaming Gorge Record of Decision (ROD) in 2012, an evaluation has been made of the current hydrologic conditions in the Upper Green River (*i.e.* above Flaming Gorge Dam). The evaluation centered on the historical unregulated inflow statistics for Flaming Gorge Dam during the period from 1964 through 2011. Based on these statistics and the May 1, 2012, forecast of 630,000 acre-feet for Flaming Gorge, the hydrologic classification will be moderately dry (70% to 90% exceedance) for spring 2012. The combined April through July forecast of the Yampa River at Maybell and Little Snake at Lily is 541,000 acre-feet. This forecast would fall into the dry hydrologic classification of the ROD.

Utilizing the flexibility in the ROD to designate a hydrologic classification two classifications higher or one lower based on conditions in the Yampa River, the official hydrologic classification will be dry (>90% exceedance). Appendix A illustrates the May 1, 2012, final forecast for Flaming Gorge Reservoir and the Yampa River Basin in relation to the hydrologic categories described in the Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam (Muth, et al, 2000) (Flow Recommendations).

**Green River Basin Hydrology**

The May 1, 2012, forecast of April through July unregulated inflow (current forecast) for Flaming Gorge Reservoir is 630,000 acre-feet (64% of 30-year average). This forecast falls at approximately 82% exceedance based on the historic unregulated inflow record (1963-2011). Figure 1 shows the current forecast in relation to the historic unregulated inflow volumes.

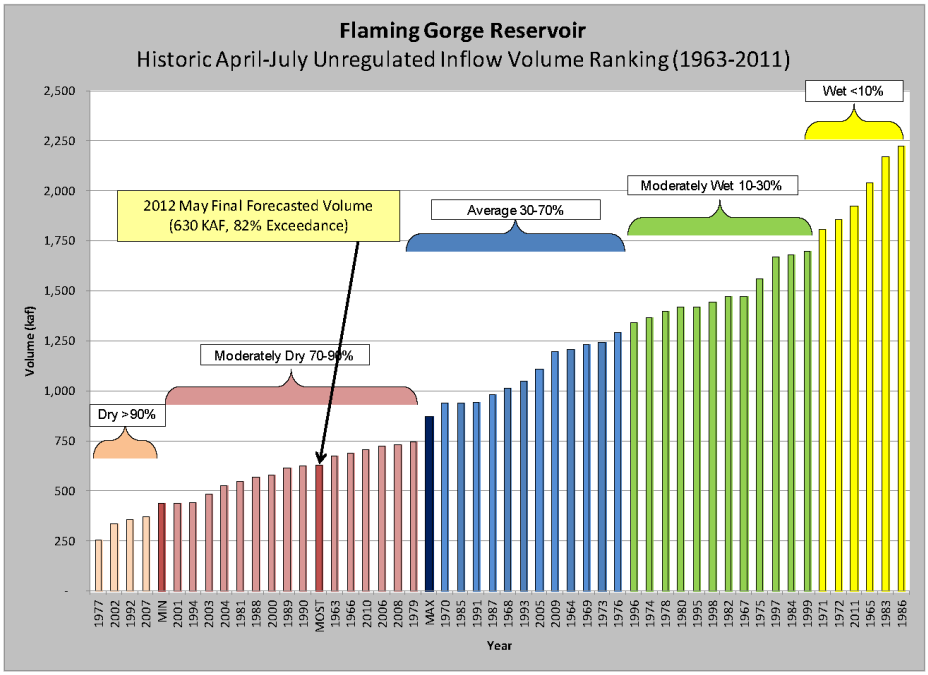



FIGURE 1—Flaming Gorge Reservoir March final forecast and ranked historic unregulated April through July inflow volume for years 1963-2011.

Flaming Gorge Reservoir currently has a water surface elevation of approximately 6026.23 feet above sea level. There is approximately 3.21 million acre-feet of live storage (85% storage capacity) in Flaming Gorge and approximately 0.539 million acre-feet of space.

**Yampa River Basin Hydrology**

The current forecast for the Little Snake River and Yampa River combined (Little Snake at Lily plus Yampa at Maybell) is 541,000 acre-feet (43% of 30-year average). This forecast falls at approximately 86% exceedance based on a ranking of the historic record (1922-2011). Figure 2 below shows the current forecast in relation to historic flow volumes.

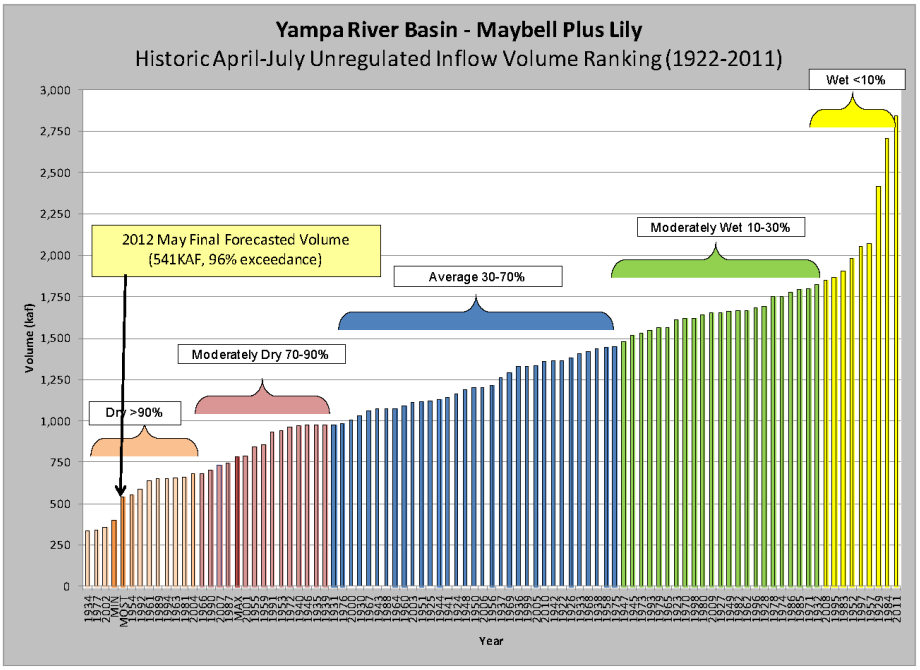



FIGURE 2—Yampa River Basin (Maybell plus Lily) current forecast and ranked historic unregulated April through July inflow volume for years 1922-2011.

Hydrologic conditions in the Yampa River Basin are dry and spring runoff conditions will likely have a significant effect on the efficiency of the 2012 spring peak.

**Probabilities of Flow Events for Spring 2012**

The Flaming Gorge unregulated inflow and Yampa River forecasts are average and trending solidly toward moderately dry. Conditions this year are significantly lower than the record-setting hydrology in 2011. An analysis was completed to assist in the determination of appropriate flow objectives for spring and summer 2012. The ten most similar historic years for the Yampa River Basin (Maybell plus Lily) compared to the current forecast (Table 1) were analyzed assuming a normal distribution. Table 2 presents the percent exceedance of cumulative days greater than or equal to various flow levels at Yampa River (Maybell plus Lily). The current analysis indicates that it is unlikely Yampa River flows above 10,000 cfs will be achieved this year.

**Table 1**
**Yampa River (Maybell plus Lily) – April through July Unregulated Volume**
**Ten Similar Years to the May 1, 2012 Final Forecast**
**Thousand Acre-Feet (KAF)**

| Year | April-July Unreg Inflow Volume (KAF) |
|---|---|
| MIN | 408 |
| MOST | 541 |
| 1954 | 555 |
| 1992 | 587 |
| 1961 | 635 |
| 1989 | 650 |
| 1994 | 651 |
| 1963 | 658 |
| 1981 | 659 |
| 2004 | 678 |
| 1966 | 679 |
| 1990 | 703 |
| MAX | 780 |

**Table 2**
**Spring 2012 – Days above Specific Flow Thresholds in the Yampa River (Maybell plus Lily)**
**Based on the May 1, 2012, Final Forecast**
**Percent Exceedance (%)**

| April Final Forecast | % Exceed | Days above 10,000 cfs | Days above 11,000 cfs | Days above 12,000 cfs | Days above 13,000 cfs | Days above 14,000 cfs | Days above 15,000 cfs | Days above 16,000 cfs |
|---|---|---|---|---|---|---|---|---|
| YAMPA | 25% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 75% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Record of Decision Spring Flow Objectives**

If the April through July unregulated inflow into Flaming Gorge Reservoir remains in the range from 795 KAF to 1,349 KAF the hydrological classification would be average. The ROD spring flow objectives for average years are:

**Average Spring Flow Objectives**

| Reach | Spring Peak Magnitude (cfs) | Spring Peak Duration |
|---|---|---|
| Reach 1 | ≥ 4,600 cfs | That necessary to achieve duration target in Reach 2 |
| Reach 2 | ≥ 18,600 cfs in 50% of average years | Two weeks (i.e. 14 days) in 25% of all average years |
| | ≥ 8,300 cfs in 50% of average years | One week (i.e. 7 days) in 50% of average years |

Flow Recommendations and FEIS

It is likely that hydrologic conditions into Flaming Gorge Reservoir will change before implementation of the proposed 2012 flow objectives. In the event conditions become drier and the Flaming Gorge Reservoir unregulated inflow forecast for April through July falls below 795 KAF, the hydrological classification would be moderately dry. ROD spring flow objectives for moderately dry years are:

**Moderately Dry Spring Flow Objectives**

| Reach | Spring Peak Magnitude (cfs) | Spring Peak Duration |
|---|---|---|
| Reach 1 | ≥ 4,600 cfs | That necessary to achieve duration target in Reach 2 |
| Reach 2 | ≥ 8,300 cfs | 1 week (i.e. 7 days) |

Flow Recommendations and FEIS

If conditions become drier than the current forecast at Flaming Gorge Reservoir and the April through July forecast decreases below 431 KAF, the hydrological classification would be dry. ROD spring flow objectives for dry years are:

**Dry Spring Flow Objectives**

| Reach | Spring Peak Magnitude (cfs) | Spring Peak Duration |
|---|---|---|
| Reach 1 | ≥ 4,600 cfs | that necessary to achieve duration target in Reach 2 |
| Reach 2 | ≥ 8,300 cfs | 2 days or more except in extremely dry years (>98% exceedance) |

Flow Recommendations and FEIS

**Recovery Program Research Request**

Reclamation and the Flaming Gorge Technical Working Group received a memorandum dated March 26, 2012 from Tom Chart, Director of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program). In 2012, the Recovery Program intends to continue the assessment of emigration rates of razorback sucker stocked in the Stirrup floodplain to the main stem of the Green River. Studies have identified a 30 cm water depth in passages between floodplains and the main river channel (e.g., levee breaches and outlet structures) is required for juvenile and adult Colorado pikeminnow and razorback sucker fish passage. The request from the Recovery Program for a spring peak flow is 15,000 cfs, or greater, for a minimum of five consecutive days in Reach 2 of the Green River under current hydrologic conditions.

The Recovery Program request includes the recommendations by the Larval Trigger Study Plan ad hoc committee (LTSP). The LTSP uses a recent synthesis of the Flow Recommendations by Bestgen, et al, (2011) that suggests that it may not be accomplishing its intended biological purpose, i.e., to provide for successful recruitment of razorback suckers. Razorback sucker recruitment has not been observed since implementation of the ROD despite successfully meeting or exceeding target peak flow magnitudes and durations. Bestgen et al. (2011) evaluated the effectiveness of Reclamation peak-flow release strategy, and found that, since 1993, releases were made too early relative to larval razorback sucker drift.

Bestgen et al. (2011) recommends timing the releases from Flaming Gorge Dam such that the magnitude and duration coincide with the occurrence of razorback sucker larvae in the middle Green River. The Recovery Program proposes using the occurrence of razorback sucker larvae in channel margin habitats (an indication that larval drift is occurring in the river) as the "trigger" to determine when peak releases should occur from Flaming Gorge Dam. This "larval trigger" would initially be implemented on an experimental basis, but is consistent with the Flow Recommendations in which initial appearance of larval suckers was identified as one of several examples of real-time information to be considered when determining the onset of spring peak flows (see Table 5.3 of Muth et al. 2000). Determining the effectiveness of this larval trigger in recruiting razorback suckers is the primary focus of this study plan, but other potential effects are also evaluated. Based on information in Bestgen et al. (2011), using the larval trigger would most often shift the timing of Flaming Gorge peak releases to later in the runoff period. For the 1993 to 2008 period examined in Bestgen et al. (2011), the shift in timing of releases relative to peak Yampa River flows could be earlier, about the same, or as much as 17 days later if the first detection of larvae was used as the trigger.

The Recovery Program will continue studies to assess the effects of the flow and temperature recommendations on the fish community in the Green River. Through those efforts the Recovery Program is gathering a better understanding how nonnative smallmouth bass reproduction (time of spawn and first year growth) is affected by base flow magnitude and main channel temperatures in the Yampa and Green rivers. In the future, in conjunction with a specific Scope of Work, the Recovery Program will likely request specific base flow targets or release patterns for Flaming Gorge Dam releases to: a) hinder smallmouth bass reproduction, and b) benefit Colorado pikeminnow reproduction. The Recovery Program will continue to coordinate with the U.S. Fish and Wildlife Service's Utah Field Station on all future research flow requests, and specifically as the Service develops their 2012 base flow request to assist in the recovery of the endangered fish.

**Proposed Flow Objectives for Spring 2012**

The 2005 Operations of Flaming Gorge Dam Final Environmental Impact Statement (FEIS) specifically addresses the content of this operating plan in Section 2.5.3.1. The operating plan is to describe the current hydrologic classification of the Green River and Yampa River Basins, including the most probable runoff patterns for the two basins. This information has been provided above. The operating plan is also to identify

the most likely Reach 2 flow magnitudes and durations that are to be targeted for the upcoming spring release. It further specifies that "[b]ecause 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."

The potential classifications for 2012 are as follows:

Dry Classification

The current forecast of 630 KAF into Flaming Gorge reservoir is moderately dry and the 541 KAF for the Yampa River Basin would fall into the dry category of the Flow Recommendations. The following proposed flow objectives apply to a dry hydrologic classification as determined by the May 1, 2012 final forecasted unregulated inflows for the April through July period into Flaming Gorge Reservoir. In accordance with the operational flexibility outlined in the ROD to achieve objectives one classification lower than the actual classification established, it is proposed that flows would be managed under the ROD spring flows objectives for dry hydrologic conditions.

Proposed Reach 1 flows should be managed to accommodate the Recovery Program spring peak research request, timed coincident with larval presence in Reach 2 of the Green River. Based on the dry conditions in the Yampa River, it is unlikely the Recovery Program spring peak research request to achieve at least 15,000 cfs in Reach 2 for a minimum duration of five days will be achieved. Once the spring peak flows have been achieved in Reach 2, Reach 1 flows should be gradually reduced at a rate of 350 cfs/day to base flow levels.

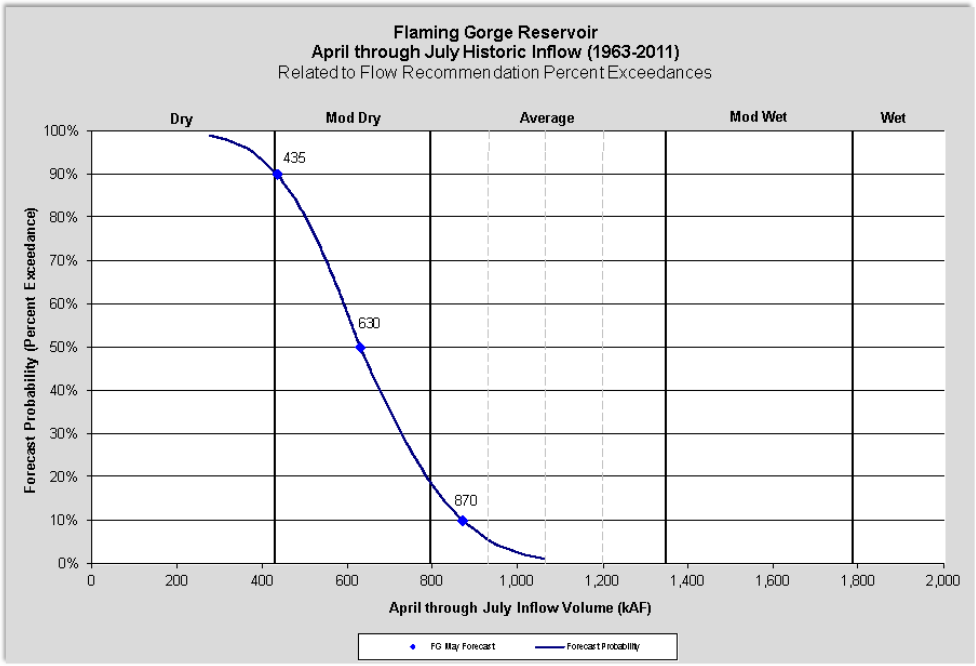
**Proposed Base Flow and Temperature Objectives for Base Flows 2012**

After the spring flow objectives in Reach 1 and Reach 2 have been achieved, flows should be gradually reduced to achieve base flow levels by no later than June 15, 2012. Base flows in Reaches 1 and 2 should be managed to fall within the prescribed base flow ranges described in the Flow Recommendations based on the observed April through July unregulated inflow into Flaming Gorge Reservoir. Pursuant to the Flow Recommendations, during the August through November base-flow period, the daily flows should be within ±40% of mean base flow. During the December through February base-flow period, the daily flows should be within ±25% of the mean base flow. Additionally, the mean daily flows should not exceed 3% variation between consecutive days and daily fluctuations at Flaming Gorge Dam should produce no more than a 0.1 meter daily stage change at Jensen, Utah.

Additionally, the temperature of flows should be managed to be at least 18° C for 2 to 5 weeks in Upper Lodore Canyon during the beginning of the base flow period. Water temperatures in the Green River should also be managed to be no more than 5° C colder than those of the Yampa River at the confluence of the Green and Yampa Rivers for the summer period of 2012 (June through August).

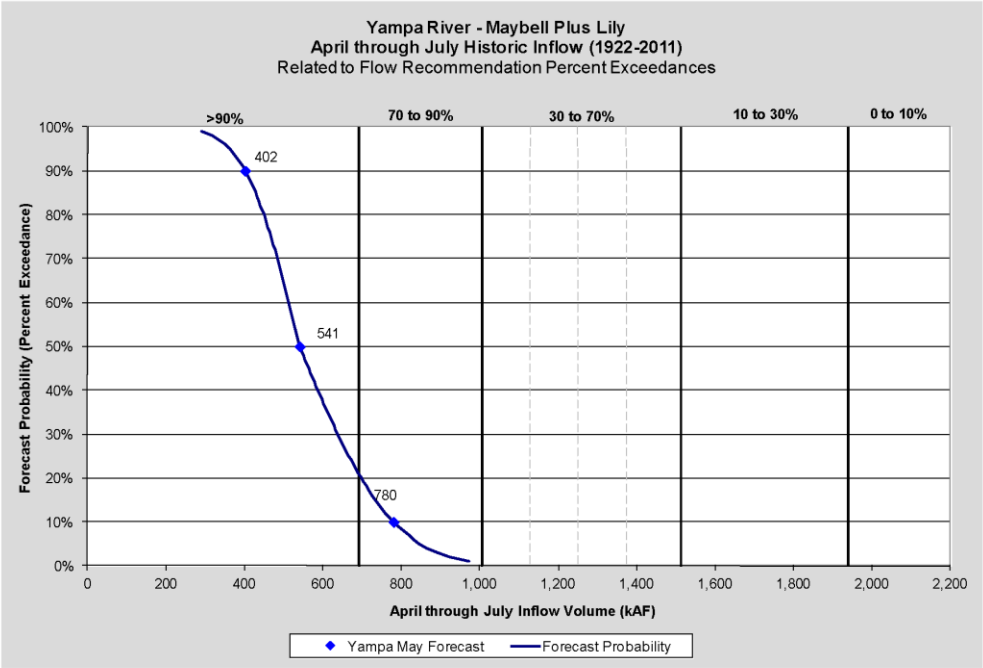
APPENDIX A

May 1, 2012 Final Forecasted April through July Inflow Volumes for Flaming Gorge Reservoir, Yampa River (Maybell plus Lily) and Jensen, Utah (sum of Flaming Gorge and Yampa)



**APPENDIX A**

**May 1, 2012 Final Forecasted April through July Inflow Volumes for Flaming Gorge Reservoir, Yampa River (Maybell plus Lily) and Jensen, Utah (sum of Flaming Gorge and Yampa)**



# Appendix H

## April 25, 2012, Holsinger Law, LLC Letter Regarding Request to Forego Peak Flows that Could Cause Flooding to Vermillion Range Ltd. And May 21, 2012, Reclamation Response

**Holsinger Law, LLC**
lands, wildlife and water law

April 25, 2012

Larry Walkoviak
Regional Director
Upper Colorado River Region
Bureau of Reclamation
125 South State Street, Room 6107
Salt Lake City, UT 84138-1102

Tom Chart
Director
Upper Colorado River Endangered
Fish Recovery Program
P.O. Box 25486, DFC
Denver, CO 80225-0486

*Via Electronic Mail*

**Re: Request to Forego Peak Flows that Could Cause Flooding to Vermillion Ranch Ltd. Partnership from the Reoperation of Flaming Gorge Reservoir for Listed Fish Species**

Dear Larry and Tom:

I am writing on behalf of Vermillion Ranch Ltd. Partnership ("Vermillion"). Vermillion has long supported the purposes and goals of the Upper Colorado River Endangered Fish Recovery Program ("Recovery Program"). Vermillion has serious concerns that the reoperation of Flaming Gorge dam pursuant to the February, 2006 Record of Decision ("ROD") may damage to its private lands due to downstream flooding. Given the hydrologic conditions and the potential damage to Vermillion lands, we urge you not to make reservoir releases that exceed powerplant bypasses in 2012.

The ROD provides that operations are to, "protect and assist in recovery of the populations and designated critical habitat of the four endangered fishes, while maintaining all authorized purposes of the Flaming Gorge Unit of the Colorado River Storage Project (CRSP)...." The Action Alternative under the ROD expressly recognizes that releases from Flaming Gorge would be patterned to meet flow recommendations "to the extent possible" and while "maintaining and continuing all authorized purposes of Flaming Gorge Dam and Reservoir." Reoperations do not equate to CRSP authorization to make reservoir releases for fish and wildlife purposes.

As you know, Section 1 of the CRSP expressly provides for flood control as an authorized purpose. Neither the Endangered Species Act nor the ROD can be read to amend nor alter an agency's statutory purposes. *See Defenders of Wildlife v. National Association of Home Builders*, 551 U.S. 644 (2007).

Kent Holsinger
Jack Silver, Of Counsel
Laura L. Chartrand
Alyson Meyer Gould

P: (303) 722-2828
F: (303) 496-1025
www.holsingerlaw.com
104 Broadway
Third Floor
Denver, CO 80203

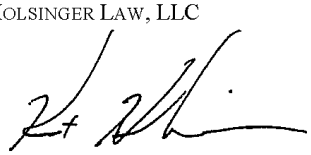
Vermillion appreciates the commitment from the Recovery Program to do a site visit and requests that we implement a plan to address these issues that works for Reclamation, the Recovery Program and Vermillion.

For example, the flow recommendations could be revised to recognize the removal of levees on the river subsequent to their adoption. Since signing the ROD in 2006, Reclamation committed to study these issues with the Recovery Program and to incorporate findings on meeting the goals at lower peak levels where feasible. This would be an opportune time to consider and implement such changes.

While Vermillion appreciates the benefits of the Recovery Program, Vermillion should not have to suffer damage to its private lands due to reservoir reoperations. Please confirm that Vermillion will be included on the Flaming Gorge Working Group list and let us know how Reclamation and the Recovery Program intend to proceed at your earliest convenience. Thank you.

Sincerely,

HOLSINGER LAW, LLC



Kent Holsinger

cc: T. Wright Dickinson, Vermillion Ranch Ltd. Partnership
The Hon. Scott Tipton
The Hon. Cynthia Loomis
The Hon. Bob Bishop
Ted Kowalski, CWCB
Karen Kwon, Office of the Colorado Attorney General

United States Department of the Interior
BUREAU OF RECLAMATION
Upper Colorado Regional Office
125 South State Street, Room 6107
Salt Lake City, Utah 84138-1102

IN REPLY REFER TO:

MAY 21, 2012

UC-430
WTR-4.03

VIA ELECTRONIC MAIL ONLY

Mr. Kent Holsinger
Holsinger Law, LLC
104 Broadway
Denver, CO 80203

Subject: Request to Forego Peak Releases From Flaming Gorge Reservoir for the Listed Fish Species, Flaming Gorge Dam, Colorado River Storage Project, Utah

Dear Mr. Holsinger:

Thank you for your letter of April 25, 2012, sharing the concerns of Vermillion Ranch regarding the operation of Flaming Gorge Dam. We understand from your letter and clarifying email, that Vermillion Ranch is concerned about potential releases in excess of the Flaming Gorge powerplant capacity of 4,600 cubic feet per second (cfs).

The existence and operations of Flaming Gorge Dam do provide flood benefits. Last year, during one of the highest runoff years on record, the Bureau of Reclamation limited the releases of inflows to the combined capacity of powerplant and bypass tubes to no more than 8,600 cfs for 39 days. During this period, inflows reached a peak of 15,070 cfs. Thus the existence of the reservoir reduced the flows past Vermillion Ranch by at least 6,470 cfs during peak flows last year. Releases in excess of powerplant capacity of 4,600 cfs are not unusual in the course of spring operations and more frequent use of the bypass tubes was anticipated in the selected alternative in the 2005 Final Environmental Impact Statement on the Operation of Flaming Gorge Dam. While we are sympathetic to the concerns of Vermillion Ranch, Reclamation does not believe that potential releases of up to combined powerplant and bypass capacity this year constitute unusual operations that are contrary to Flaming Gorge's authorized purposes.

We appreciate Vermillion Ranch's support of the purposes and goals of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program). While we understand Vermillion Ranch's concerns, the Recovery Program has requested that Reclamation make releases in excess of powerplant capacity, if necessary, to support the Larval Trigger Study Program experiment in the spring of 2012.

As you note, in the February 2006 Record of Decision on Operation of Flaming Gorge Dam Final Environmental Impact Statement (2006 ROD) Reclamation committed to implement the proposed action by modifying the operations of Flaming Gorge Dam, to the extent possible, to

achieve the flows and temperatures recommended by the Recovery Program, and at the same time maintain and continue all authorized purposes of the Colorado River Storage Project Act of 1956 (CRSPA). Section 1 of the CRSPA states that in order to initiate the comprehensive development of the water resources of the Upper Colorado River Basin for purposes including making possible for the states of the Upper Basin to utilize their Colorado River Compact apportionments and flood control, the Secretary of Interior is authorized to construct and operate the CRSPA facilities.

The Recovery Program was developed in response to and signed by the Upper Basin states to facilitate the continued development of their compact apportionments in light of the Endangered Species Act of 1973 (ESA) concerns. The Recovery Program includes an ESA Section 7 agreement wherein program actions and sufficient progress toward recovery constitute a reasonable and prudent alternative for existing and future depletions of water development that might jeopardize the continued existence of the endangered fishes. The Recovery Program issued Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam (2000, Muth et al.) (2000 Flow and Temperature Recommendations) as part of the scientific literature to address recovery of endangered fishes. Reclamation's implementation of the 2000 Flow and Temperature Recommendations is intended to avoid jeopardy and assist in recovery. Thus consistent with the authorized purposes of CRSPA, Reclamation's commitment to implement the 2000 Flow and Temperature Recommendations supports the continued use and development of the states compact apportionments and Upper Basin users including Vermillion Ranch. The 2006 ROD states "[m]oreover, that specific authorized purposes of a Unit may not be fully maximized for limited durations in certain year types does not invalidate the actions of the Secretary, as long as the overall purposes of CRSPA are met." In the 2006 ROD, Reclamation concluded that it expects the purposes will be met and that operations consistent with the 2000 Flow and Temperature Recommendations are within the authorization in Section 1 of CRSPA.

Reclamation also recognized in the 2006 ROD that additional knowledge may result in refinement of the 2000 Flow and Temperature Recommendations. Recent research conducted by the Recovery Program resulted in a Larval Trigger Study Plan which recommended that adjusting the timing of the Flaming Gorge spring peak releases to coincide with the presence of razorback sucker larvae in the middle Green River would potentially improve recovery of the endangered fishes and the success of the Recovery Program. This recommended experimentation involving a shift in timing is considered to be within the anticipated refinements of the 2000 Flow and Temperature Recommendations as discussed in the 2006 ROD. For 2012, the Recovery Program submitted a request that Reclamation shift the timing of peak releases to coincide with the presence of razorback larvae and noted that this may result in releases in excess of powerplant capacity and up to the combined capacity of the powerplant and the bypass tubes of 8,600 cfs. As mentioned above, the Recovery Program has specifically requested that Reclamation limit the releases to this amount and not use the spillway. Reclamation feels that this is an appropriate request.

Ms. Beverley Heffernan of the Upper Colorado Regional Office conducted a site visit with Mr. Dickinson at the Vermillion Ranch during last year's high flows and has committed to return to further discuss Mr. Dickinson's concerns; our understanding is that Mr. Tom Chart, Director of the Recovery Program, will also be coordinating further with Mr. Dickinson.

We have checked our records, note that Mr. Dickinson is on the Flaming Gorge Working Group email list, and has attended meetings for the past several years. This working group has been open to the public and has been meeting two to three times per year since 1993; it is an important venue for us to provide information on Flaming Gorge Dam operations and hear the concerns of our stakeholders and the interested public. We will continue to keep all working group participants fully informed regarding operations at Flaming Gorge Dam. Thank you for your interest and we look forward to continued dialogue with Mr. Dickinson to explore resolution of this issue. If you have any further questions, please contact Mr. Malcolm Wilson of my staff at 801-524-3691.

Sincerely,

/s/ Anamarie Gold (For)

Larry Walkoviak
Regional Director

cc: Mr. Tom Chart
Director
Upper Colorado River Endangered
Fish Recovery Program
P.O. Box 25486
Denver, CO 80225-0486

# Appendix I

## JUNE 12, 2012, WESTERN AREA POWER ADMINISTRATION INTERIM BASE-FLOW PROPOSAL

Western Area Power Administration
2012 Interim Base-flow Proposal
June 12, 2012

Western requests base-flow releases from Flaming Gorge Dam be set so that flow in the Green River at Jensen is 1,100 cfs. Implementation of this request would require monitoring of Yampa River flows in order to adjust releases from Flaming Gorge Dam. Further, Western requests that base flow be revisited in early July, once backwater topography data and updated hydrologic data are available. This request is prudent based on current dry hydrologic conditions; is consistent with implementation of *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (Flow Recommendations; Muth et al. 2000), the preferred alternative in the 2005 final environmental impact statement (FEIS; U.S. Department of Interior 2005), and the 2006 record of decision (ROD; U.S. Department of Interior 2006); and conserves water until real-time data are available to modify flows to maximize near shore habitat important for endangered fishes.

Based on the May 1st April – July inflow forecast for the Upper Green River (82% exceedence) and Yampa River (96% exceedence) basins, the hydrologic classification for 2012 spring peak flow was dry. Currently, hydrologic conditions do not appear to be improving, and it appears likely the classification for the summer base-flow period will remain dry. Western's request for a base flow of 1,100 cfs at the Jensen gage is supported by the recommendation for dry years (900-1,100 cfs with up to 40% variation around the mean daily flow) in the Flow Recommendations and the FEIS. The extreme dry conditions in the Yampa River Basin and the Green River Basin trending solidly towards drier conditions warrant a dry classification and a conservative approach to determining base flows.

Compounding the need for a conservative approach is the implementation of the *Study Plan to Examine the Effects of Using Larval Razorback Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam Peak Releases* (LTSP), a study plan to scientifically evaluate the effectiveness of modifying the timing of spring peak releases from Flaming Gorge Dam to coincide with the presence of larval razorback sucker (Larval Trigger Study Plan *ad hoc* committee 2012). Conditions this year, especially in the Yampa River Basin, resulted in spring peak flows in the Green River being primarily driven by releases from Flaming Gorge Dam. To meet flow targets this year, five days of bypass release (up to 7,400 cfs) was necessary, resulting in much higher releases than stated in the Flow Recommendations. The impacts of the increased volume of water required as a result of implementing the study plan are not understood at this time, especially in the dry conditions experienced thus far this year.

Creation of backwater habitat was a primary factor considered by Muth et al. (2000) in developing recommendations for base flows. Backwater habitat is especially important for larval and young Colorado pikeminnow (CPM). The importance of backwater habitat for early life stages of CPM was apparent in survey data collected by the Recovery Program. In 2010, Argonne National Laboratory conducted a correlation analysis of factors affecting young CPM catch data collected by Badame et al. (2009). They found surface area of backwaters was the best predictor of YOY Colorado pikeminnow catch rate (Figure 1; unpublished data), but area of backwater habitat was not correlated with

magnitude of flow (Figure 2; unpublished data). Further, Tyus and Haines (1991) found an inverse relationship between size and abundance of young CPM and mean flow in August and September.

Variability of sand bar topography, inherent in a complex river system such as the Green River, makes establishing an optimum base flow difficult. This difficulty is further evidenced in results reported by LaGory et al. (2009), where they found the relationship between backwater characteristics and discharge complex and variable from year to year. Establishing an optimum base flow this year may be especially difficult since it is a dry year following an unusually wet year in 2011.

Muth et al. (2000) recommended base flows be tied specifically to hydrologic conditions (i.e., higher in wet years) and the magnitude of peak flows. However, they acknowledged uncertainty with their base-flow recommendations and the difficulty in establishing an optimum base flow due to unpredictable sediment processes and associated variability in sandbar topography from year to year. They advocated for the collection of real-time biological and physical data each year and using this information to adaptively implement base-flow recommendations. Table 5.3 in Muth et al. (2000) lists elevation of sandbars in nursery areas as an example of real-time information to be considered when developing base-flow magnitude.

Argonne National Laboratory will be collecting sandbar topography data beginning June 25, 2012, and these data and the resulting relationships between flow and backwater surface area, volume, and depth will be available by July 6, 2012. The availability of this information will provide a real-time understanding of the current physical conditions within the middle Green River allowing for establishment of a suitable base flow. Until these topographic data are available, it is prudent to establish an interim base flow that conserves water but also has been demonstrated to create backwater habitat.

A review of topographic data from 2003 – 2008 indicated a flow of 1,100 cfs consistently created suitable backwater habitat (LaGory et al. 2009). While 1,100 cfs did not create the optimum surface area, it did create backwater area comparable to flows of 1,540 cfs (the maximum allowable in the Flow Recommendations in a dry year) without the risk of overtopping some backwaters as was observed in 2003. Therefore, an interim flow of 1,100 cfs at the Jensen gage should be suitable until real-time topographic data become available. The base flow should be revisited and modified using available real-time topographic and hydrologic data in early July to establish appropriate base flows for the remainder of the base-flow period.

Western believes a sensible base flow for the duration of the base-flow period cannot be established at this time. We believe an interim flow of 1,100 cfs until early July is the most logical approach to determining base flows for 2012. This approach adheres to the Flow Recommendations, FEIS, and ROD; is reasonable considering dry hydrologic conditions; and is supported by available scientific data.

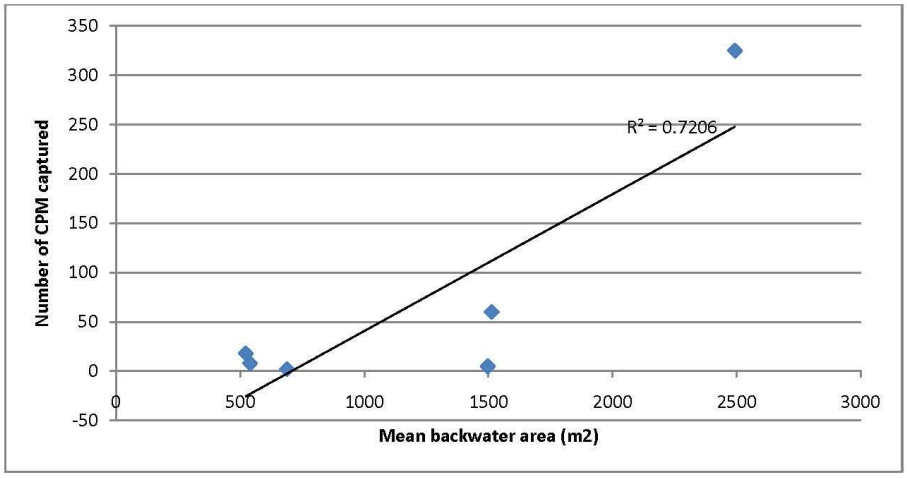



Figure 1. Relationship of mean backwater area to number of YOY Colorado pikeminnow captured in the Middle Green River derived from backwater topographic mapping conducted 2003-2009 (figure provided by Dr. Kirk LaGory, Argonne National Laboratory).

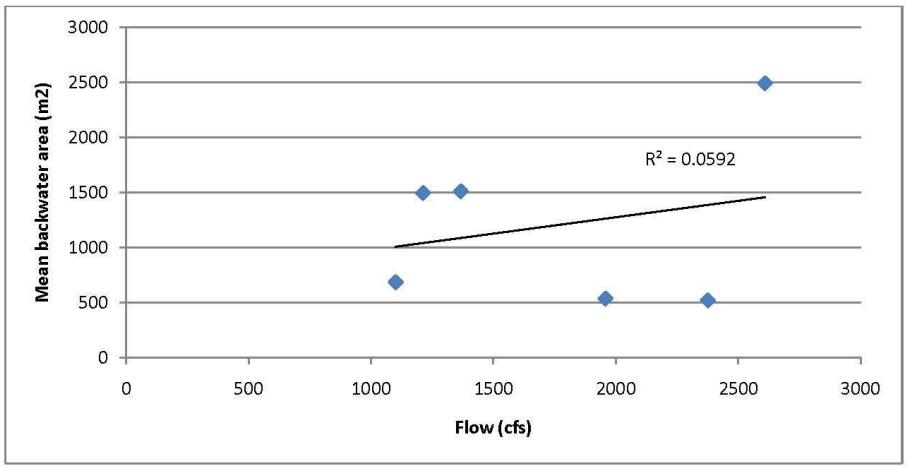



Figure 2. Relationship of flow to mean backwater area for the Middle Green River derived from backwater topographic mapping conducted 2003-2009 (figure provided by Dr. Kirk LaGory, Argonne National Laboratory).

**Literature Cited**


Badame, P., K. Creighton, T. Hedrick, L. Monroe, and K. Bestgen. 2009. Young-of-the-year Colorado pikeminnow monitoring. FY 2009 Annual Project Report, Colorado River Recovery Program Project Number 138.

LaGory, K. E., J. W. Hayse, and C. Weber. 2009. Relationships between flow and physical characteristics of backwater nursery habitats in the middle Green River, Utah. Report to the Upper Colorado River Endangered Fish Recovery Program, Project Number FR-BW-TOPO. Environmental Science Division, Argonne National Laboratory, Argonne, Illinois.

Larval Trigger Study Plan *ad hoc* Committee. 2012. Study plan to examine the effects of using larval razorback sucker occurrence in the Green River as a trigger for Flaming Gorge Dam peak releases. Upper Colorado River Endangered Fish Recovery Program, Lakewood, Colorado.

Muth, R. T., L. W. Crist, K. E. LaGory, J. W. Hayse, K. R. Bestgen, T. P. Ryan, J. K. Lyons, R. A., and R. A. Valdez. 2000. Flow and temperature recommendations for endangered fishes in the Green River downstream from Flaming Gorge Dam. Upper Colorado River Endangered Fish Recovery Program, Lakewood, Colorado.

Tyus, H. M., and G. B. Haines. 1991. Distribution, habitat use, and growth of age-0 Colorado squawfish in the Green River Basin, Colorado and Utah. Transactions of the American Fisheries Society 120:79-89.

U.S. Department of Interior. 2005. Operations of Flaming Gorge Dam final environmental impact statement. U.S. Department of Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

U.S. Department of Interior. 2006. Record of decision operation of Flaming Gorge Dam final environmental impact statement. U.S. Department of Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

# Appendix J

## September 19, 2012, Reclamation Letter to the Flaming Gorge Technical Working Group

United States Department of the Interior

BUREAU OF RECLAMATION
Upper Colorado Regional Office
125 South State Street, Room 6107
Salt Lake City, UT 84138-1102

IN REPLY REFER TO:
UC-436
WTR-1.10

SEP 19 2012

Interested Parties (See Enclosed List)

Subject: Green River Base Flow Releases and Reach Two Base Flow Targets, Flaming Gorge Dam and Reservoir, Flaming Gorge Unit, Colorado River Storage Project, Utah

Dear Interested Parties:

On July 6, 2012, the Flaming Gorge Technical Working Group (FGTWG) met and proposed Reach Two base flow targets in the Green River at Jensen, Utah, for the 2012 base flow period. The FGTWG proposed to the Bureau of Reclamation that flows at Jensen be maintained for the months of July, August, and September as closely as possible to the following:

| Targets at Jensen, Utah: | |
|---|---|
| July: | 1,500 cfs |
| August: | 1,500 cfs |
| September: | 1,300 cfs |

Reclamation estimated at the time that the Yampa River would provide flows such that releases required from Flaming Gorge Dam to sustain these flows would be:

| Flaming Gorge Releases: | |
|---|---|
| July: | 1,300 cfs |
| August: | 1,300 cfs |
| September: | 1,100 cfs |

Flaming Gorge operates under a 2006 Record of Decision (ROD) on the Operation of Flaming Gorge Dam Final Environmental Impact Statement. Under the ROD, Reclamation committed to an adaptive management process that relies on the Recovery Program for monitoring and studies to test the outcomes of modifying the flows. Reclamation further committed to coordinate through the FGTWG to propose an initial flow regime to the Flaming Gorge Working Group (Working Group), which provides public comments and input related to a broad range of resource concerns. Reclamation considers the information received through the FGTWG and Working Group in developing the operational plan for Flaming Gorge Dam and Reservoir. Reclamation has considered all of the comments and input we have received from our stakeholders in developing the operational plan for the 2012-2013 summer and winter base flow seasons.

Reclamation has released 1,300 cubic feet per second (cfs) from Flaming Gorge Dam during the months of July and August. However, Yampa River flows have continued to decrease and flows at Jensen are currently averaging 1,230 cfs. The Yampa River hydrologic condition has been extremely dry with current flows at the Yampa River at Deerlodge Park, Colorado, below 100 cfs. These Yampa River flows are within the 10th percentile of the U.S. Geological Survey historic record and are forecasted to remain at this level through the winter. The observed unregulated inflow into Flaming Gorge in August was 29,000 AF (33 percent of average). The September forecasted unregulated inflow volume is 18,000 AF (33 percent of average), which falls below the 95 percent exceedance range, and well within the dry hydrologic classification as defined in the 2000 Flow and Temperature Recommendations.

The FGTWG discussed the possibility of flows dropping below 1,500 cfs later in the summer, and the U.S. Fish and Wildlife Service (Service) requested maintaining flows at Jensen above 1,400 cfs at least through September 30, 2012. Reclamation expressed concern that such releases from Flaming Gorge to sustain the Service's request would be high given this dry hydrologic year, but agreed to provide the higher releases listed above with the understanding that the Yampa River would provide the necessary flows to sustain the targets at Jensen. However, declining flows on the Yampa River have impacted the ability for the requested Jensen targets to be sustained with the provided Flaming Gorge releases.

Reclamation will continue to provide releases of 1,100 cfs through September, and will continue to rely on the Yampa River to augment flows at Jensen. We are aware that it is unlikely that the flow targets at Jensen will be achieved due to the extremely dry conditions on the Yampa River. We anticipate that there will be continued discussions as anticipated by Reclamation's ROD that support specific threshold levels. We thank the FGTWG for their valuable input and look forward to future discussions.

If you have any questions, please call Ms. Heather Hermansen, Chair of the FGTWG, at 801-524-3883.

Sincerely,

Larry Walkoviak
Regional Director

Enclosure

# Appendix K

## August 20, 2012, Western Area Power Administration Letter Regarding Release Volumes during December 2012 through February 2013 and September 19, 2012, Reclamation Letter to Western Area Power Administration

**Department of Energy**
Western Area Power Administration
150 East Social Hall Avenue, Suite 300
Salt Lake City, UT 84111-1580

AUG 20 2012

E-mail

Mr. Larry Walkoviak
Regional Director - Upper Colorado Region
U.S. Bureau of Reclamation
125 South State Street, Room 6107
Salt Lake City, UT 84138
(lwalkoviak@usbr.gov)

Dear Mr. Walkoviak:

Water year 2012 will probably be one of the driest years on record. We know this puts a strain on water deliveries and on the operations of dams managed by the Bureau of Reclamation (Reclamation). It also puts a strain on the ability of Western Area Power Administration (Western) to meet its contractual commitments for long-term electrical service. In particular, our estimates indicate that we will be purchasing significantly larger amounts of electrical power in order to "firm" to our obligations and meet our contractual requirements for proving electrical service.

These purchases are anticipated to be especially significant in the winter season, including the peak power months of December, January and February. The main reason for this is the dry hydrological conditions across the Basin that result in minimal power operations on the Aspinall Units and other smaller CRSP units.

Western requests that Reclamation add to the target release volume at Flaming Gorge during December, January and February. We also request that the total release for each of these months be 80 to 90 thousand acre-feet. Western will shape the additional electrical output into a daily pattern similar to last winter. Doing this will assist us in meeting our long-term electrical service obligations in these months. I understand that this will likely result in a lower lake elevation in the spring, but could be offset by improved hydrological conditions in the coming year.

Please telephone me at (801) 524-5493 if you would like to discuss this request further. Thank you for your consideration.

Sincerely,

for Julia L. Kyriss
CRSP Manager

cc:
Mr. Malcolm Wilson
Upper Colorado Region
U.S. Bureau of Reclamation
125 South State Street, Room 6107
Salt Lake City, UT 84138
(mmwilson@usbr.gov)

Ms. Jane Blair
Upper Colorado Region
U.S. Bureau of Reclamation
125 South State Street, Room 6107
Salt Lake City, UT 84138
(jblair@usbr.gov)

# United States Department of the Interior

BUREAU OF RECLAMATION
Upper Colorado Regional Office
125 South State Street, Room 6107
Salt Lake City, UT 84138-1102

IN REPLY REFER TO:

UC-436
WTR-1.10

SEP 19 2012

VIA OVERNIGHT MAIL

Mr. Darren Buck
Colorado River Storage Project
Department of Energy
Western Area Power Administration
150 East Social Hall Avenue, Suite 300d
Salt Lake City, UT 84111-1580

Subject: Release Volumes During December 2012 Through February 2013, Flaming Gorge Dam, Colorado River Storage Project, Utah

Dear Mr. Buck:

The Bureau of Reclamation received Western Area Power Administration's (Western) August 20, 2012, letter requesting additional release volumes from Flaming Gorge Dam during the peak power months of December, January, and February to be shaped into a similar pattern as last winter. We agree with you that water year 2012 will likely be among the driest years on record and acknowledge the impact the dry hydrology is having on the entire Colorado River Storage Project system, including the Aspinall Unit in Colorado.

The observed unregulated inflow into Flaming Gorge in August was 29,000 acre-feet (AF) or 33 percent of average. The September forecasted volume is 18,000 AF (33 percent of average), which falls below the 95 percent exceedance range and well within the dry hydrologic classification as defined in the 2000 Flow and Temperature Recommendations (Flow Recommendations). While dry conditions exist at Flaming Gorge Dam, Reclamation is willing to assist Western in its efforts to meet hydropower demands during this dry year.

Flaming Gorge Dam operates under a 2006 Record of Decision (ROD) on the Operation of Flaming Gorge Dam Final Environmental Impact Statement. Under the ROD, Reclamation committed to an adaptive management process that relies on the Recovery Program for monitoring and studies to test the outcomes of modifying the flows. Reclamation further committed to coordinate through the Flaming Gorge Technical Working Group (FGTWG) to propose an initial flow regime to the Flaming Gorge Working Group (Working Group), which provides public comments and input related to all resource concerns. Reclamation considers the information received through the FGTWG and Working Group in developing the operational plan for Flaming Gorge Dam and Reservoir. Western participates in both processes and has provided information to Reclamation through the FGTWG and the Working Group.

Reclamation has considered all of the comments and input we have received from Western and other stakeholders in developing the operational plan for the 2012-2013 summer and winter base flow seasons.

The Flow Recommendations adopted under the ROD provide some variability for flows and thus reallocation of monthly volumes through the baseflow period. Given the hydrologic classification and allowable variability, Reclamation anticipates the maximum daily average release from Flaming Gorge will be 1,200 cubic feet per second (cfs) during the 2012–2013 winter months of December through February.

Western's August 20, 2012, letter requested total release volumes for December, January, and February between 80,000 and 90,000 AF. This corresponds to a daily average release of approximately 1,500 cfs. While Reclamation is willing to assist Western this winter in meeting anticipated hydropower demands, under the current hydrologic conditions Reclamation considers it prudent to and will reallocate monthly release volumes so that the volumes released during December, January, and February will be in the range between 65,000 and 75,000 AF. This corresponds to an average daily release of 1,200 cfs. Reclamation would likely have released a steady 800 cfs minimum throughout the winter, and will likely be releasing 800 cfs during the months of October, November, March, and April.

Reclamation appreciates working with Western as we continue to coordinate water and hydropower. We feel that our coordination efforts have been productive and look forward to a continued positive relationship in the future.

If you have any questions, please call Mr. Malcolm Wilson, Chief of the Water Resources Group, at 801-524-3709.

Sincerely,

LARRY WALKOVIAK

Larry Walkoviak
Regional Director

bc: UC-430, UC-436, UC-600, UC-700, FCCD-100, PRO-400, PRO-774

WBR:HHermansen:abaker:9/19/2012:801-524-3883
T:\WRG\Heather\20120918 Response_WAPA_winter_mmw.docx

# Appendix L

## Comment Letters Received through the Flaming Gorge Working Group Process

GARY R. HERBERT
*Governor*
GREGORY S. BELL
*Lieutenant Governor*

**State of Utah**
**DEPARTMENT OF NATURAL RESOURCES**
MICHAEL R. STYLER
*Executive Director*
**Division of Wildlife Resources**
JAMES F. KARPOWITZ
*Division Director*

March 1, 2012

Heather Hermansen
Bureau of Reclamation
Hydraulic Engineer
125 South State Street, UC-436
Salt Lake City, UT 84138-1147

Dear Heather:

We have tentatively scheduled our spring 2012 tailwater fishery assessment (electrofishing), contingent on flows being approved for the operation. The following flow request is similar to previous years:

| DATE | FLOW (cfs) | TIME (MDST) | OBJECTIVE |
|---|---|---|---|
| April 16-17 | 1600 | 1900-0200 | Electrofishing |
| April 17 | 1600 | 1600-2300 | Electrofishing |

All times are in Mountain Daylight Savings Time and not hour-ending. We may need to schedule a make-up electrofishing flow in the event that we are unable to complete the sampling during the scheduled two nights.

Please consider this request in light of all other constraints and respond at your earliest convenience. Contact me if you have any questions and once again we appreciate your continued support with our fishery monitoring efforts.

Sincerely,

Matt McKell
Flaming Gorge Aquatic Biologist
PO Box 145
Dutch John, UT 84023
Office (435)885-3164
Cell (435)790-2068

1594 West North Temple, Suite 2110, PO Box 146301, Salt Lake City, UT 84114-6301
telephone (801) 538-4700 • facsimile (801) 538-4709 • TTY (801) 538-7458 • www.wildlife.utah.gov

GARY R. HERBERT
*Governor*
GREGORY S. BELL
*Lieutenant Governor*

# State of Utah
**DEPARTMENT OF NATURAL RESOURCES**
MICHAEL R. STYLER
*Executive Director*
**Division of Wildlife Resources**
JAMES F. KARPOWITZ
*Division Director*

July 30, 2012

Heather Hermansen
Bureau of Reclamation
Hydraulic Engineer
125 South State Street
Salt Lake City, UT 84138-1102

Dear Heather:

We have tentatively scheduled our fall 2012 tailwater fishery assessment (electrofishing), contingent on flows being approved for the operation. Our following flow request is similar to previous years:

| DATE | FLOW (cfs) | TIME (MDST) | OBJECTIVE |
|---|---|---|---|
| Sept 4-5 | 1600 | 1900-0200 | Electrofishing |
| Sept 5 | 1600 | 1600-2300 | Electrofishing |

All times are in Mountain Daylight Savings Time and not hour-ending. We may need to schedule a make-up electrofishing flow in the event that we are unable to complete the sampling during the scheduled two nights.

Please consider this request in light of all other constraints and respond at your earliest convenience. Contact me if you have any questions and once again we appreciate your continued support with our fishery monitoring efforts.

Sincerely,

Ryan Mosley
Flaming Gorge Project Leader
PO Box 145
Dutch John, UT 84023
Office (435)885-3164
Cell (435)790-4097

1594 West North Temple, Suite 2110, PO Box 146301, Salt Lake City, UT 84114-6301
telephone (801) 538-4700 • facsimile (801) 538-4709 • TTY (801) 538-7458 • *www.wildlife.utah.gov*

# United States Department of the Interior

BUREAU OF RECLAMATION
Upper Colorado Regional Office
125 South State Street, Room 6107
Salt Lake City, UT 84138-1102

IN REPLY REFER TO:
UC-436
WTR-1.10

AUG 0 9 2012

Mr. Ryan Mosley
Flaming Gorge Project Leader
P.O. Box 145
Dutch John, UT 84023

Subject: Approval of Flow Request From Flaming Gorge Dam, Colorado River Storage Project, Utah

Dear Mr. Mosley:

We received your July 30, 2012, letter requesting approval of specific releases from Flaming Gorge Dam to assist in your fall 2012 tailwater fishery assessment (electrofishing). The requested releases of 1,600 cubic feet per second span 2 days beginning on September 4-5, 2012, during 1900-0200 hours, and again on September 5, 2012, during 1600-2300 hours. All times requested are Mountain Daylight Time and not hour-ending.

We have coordinated your request with interested stakeholders and all the responses have been positive. The Bureau of Reclamation approves your requested electrofishing flows. We also appreciate working with you and look forward to many positive encounters. If you have any questions, please contact me at 801-524-3883

Sincerely,

/s/ Heather Hermansen

Heather Hermansen
Hydraulic Engineer

bc: UC-430, UC-435, UC-436, UC-732, FG-100, PRO-400, PRO-774

WBR:HHermansen:abaker:8/8/2012:801-524-3883
T:\WRG\Heather\Response_UDWR_FallElectrofishing.docx