

RECLAMATION

Managing Water in the West

Annual Report of Operations For Flaming Gorge Dam Water Year 2013



Table of Contents

Annual Report of Operations for Flaming Gorge Dam	1
Operational Decision Process for Water Year 2013	2
Step 1: Flow Requests for Research, and Other Federal, State and Stakeholder Input	2
Step 2: Development of Spring Proposal.....	4
Step 3: Solicitation of Comments	4
Step 4: Final Decision.....	4
Basin Hydrology and Operations.....	5
Progression of Inflow Forecasts.....	5
Summary of Flaming Gorge Operations.....	6
Spillway Inspection.....	8
Flow Objectives Achieved in Water Year 2013	8
Spring Flow Objectives.....	10
Number of Days (x) Flow Exceeded and Corresponding Hydrologic Conditions ^(c)	13
Base Flow Objectives	14
Temperature Objectives Achieved in Water Year 2013	16
Recommendations.....	19

Appendices

Appendix A – Flaming Gorge Decision Process – Intended Implementation under the 2006 Flaming Gorge Record of Decision

Appendix B – Flaming Gorge Decision Process for 2013 – Chronology of Events

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

Appendix D – February 26, 2013, Memorandum from the Recovery Program
Director containing the Research Request for 2013 Green River Spring Flows

Appendix E – March 26, 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 (LTSP)

Appendix F – May 14, 2013, Memorandum from the U.S. Fish and Wildlife Service
for the 2013 Green River Spring and Base Flows to Assist in Recovery of
Endangered Fishes

Appendix G – Flaming Gorge Technical Working Group – Proposed Flow and
Temperature Objectives for 2013

Appendix H – Comment Letters Received through the Flaming Gorge Working
Group Process

Annual Report of Operations for Flaming Gorge Dam

Water Year 2013

Introduction

This report details the operations of Flaming Gorge Dam during water year 2013¹, 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 eighth year of operations of Flaming Gorge Dam under the ROD and this report is the eighth 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 system is part of the upper Colorado River basin in Utah, Colorado, and Wyoming. 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.*, 2000; Flow Recommendations). The Flow Recommendations provide the basis for the proposed action described and analyzed in the FEIS. The ROD implements the proposed

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](#)

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 2013

The Flaming Gorge Technical Working Group (FGTWG) was established pursuant to the FEIS as recommended in the Flow Recommendations.⁵ 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 inputs from stakeholders and interested parties on dam operations, other resource concerns and research flows.

In 2013, 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 2013 can be found in Appendix B. The implementation of the four steps of the process in 2013 is described below:

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

Reclamation received a memorandum on February 26, 2013 (Appendix D) from the Director of the Recovery Program stating the Recovery Program's research request for 2013 Green River spring flows. It referenced 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*

⁵ FGTWG meeting summaries and documents are also available at: <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>.

*Releases (ad hoc Committee, March 2012; LTSP, Appendix E).*⁶ The Recovery Program's spring 2013 Flow Request was to establish a release regime that would facilitate further research under the LTSP. The LTSP primary research objective is the request 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."

The Recovery Program requested that the FGTWG consider and propose matching research needs identified in the LTSP with the best available spring flow forecast information to develop a specific Reach 2 floodplain connection scenario. The LTSP describes a range of floodplain scenarios to study and how the results would be evaluated. Additionally, the 2013 Spring Flow Request's primary objective was to build on past research to benefit the razorback sucker population throughout the Green River by timing the river-floodplain connection with the presence of wild-produced razorback sucker larvae (2013 Spring Flow Request). The 2013 Spring Flow Request supported operations consistent with the 2005 BO and ROD.

The 2013 Spring Flow Request referenced research regarding the magnitude and period of inundation at Stewart Lake, which typically inundates at relatively low flow elevations (*i.e.*, normally about 5,000 to 8,000 cfs). During summer 2012, UDWR excavated sediment deposited during 2011 from the inlet channel to restore connection conditions more consistent with those described for this site in the LTSP. However, as was the case in 2012, potential existed to fill Stewart Lake via its outflow channel, which typically connects to the Green River at lower flow elevations than the inflow. Also, personnel from Western Area Power Administration (Western), Argonne National Laboratories (funded by Western), and the Recovery Program surveyed Reach 2 levee breach elevations in Autumn 2012 to better assess connection flows for future LTSP experimentation. This information was shared with the FGTWG on May 2, 2013 and discussed during the May 3, 2013 FGTWG meeting.

The experimental timetable is to achieve 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. However, spring peak flow magnitudes will be driven by hydrologic conditions in the Upper Green and Yampa River Basins; therefore, it may not be possible to complete the experiment in six consecutive years.

On May 14, 2013, Reclamation received a spring and base flow request from the Service (Appendix F). The Service supported the Recovery Program research request dated February 26, 2013. 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 approving the Recovery Program's 2013 Spring Flow Request, and affirmed that doing so would meet Reclamation's responsibility to meet the ROD objectives in 2013.

The Service further requested that Reclamation augment the calculated Reach 1 base flow targets by as much as 40% above the average daily base flow for that reach of the Green

⁶ [Study Plan to Examine the Effects of Using Larval Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam \(Larval Trigger Study Plan *ad hoc* Committee 2012\).](#)

River during the summer period through September 30. The intent of the request was to improve backwater habitat conditions for young-of-year Colorado pikeminnow and negatively impact nonnative fish species. The Service acknowledged that higher summer flows in Reach 1 might require reduced Flaming Gorge Dam flows during winter releases. The Service supported Reclamation operating one hydrologic classification lower than the official hydrologic classification based on the CBRFC forecast, which for 2013 meant operating in the dry hydrologic classification.

Step 2: Development of Spring Proposal

The FGTWG met on March 6, 2013, to begin the development of a flow proposal for the spring of 2013. 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 2013 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. January through May, water year 2013 was characterized by moderately dry conditions in the Upper Green and dry conditions in the Yampa River Basin. The May forecast for the Yampa River Basin spring runoff volume increased into the moderately dry hydrologic classification and the official hydrologic classification was modified accordingly.

On June 5, 2013, the FGTWG met to discuss the spring and current base flow hydrology. The formal recommendation for targets at Jensen for the summer base flow season was a Reach 1 flow of 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.

Step 3: Solicitation of Comments

On April 24, 2013, Reclamation presented the 2013 FGTWG flow proposal (Appendix G) to the Working Group and solicited comments. 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 2013. Meeting minutes were recorded and written comments were solicited by Ed Vidmar, Chairperson of the Working Group.⁷ Reclamation received comments from the public during the 2013 decision-making process and these comments are available for review in Appendix H.

Step 4: Final Decision

The hydrologic classifications for the Upper Green and Yampa River basins were both in the moderately dry category. The ROD allows for flexibility to operate one classification lower or two classifications higher than indicated while being prepared to adjust if conditions warrant. Reclamation reviewed the FGTWG proposal and decided to implement the LTSP recommendations 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

⁷ 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.

(assuming land access was available) 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 to entrain larvae at the same time. Reclamation decided 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. Forecasts for Yampa River flows increased in May and Reclamation revised its initial recommendation to operate in the dry classification and instead recommended operating in the moderately dry hydrologic classification.

Unregulated inflow forecasts for Flaming Gorge Reservoir continued to decrease during May and June. Reclamation communicated with the FGTTWG regarding the July-September base flow releases and agreed to continue releasing 1,100 cfs through September 2013, Reclamation 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 further acknowledged that it would likely release steady 800 cfs beginning in water year 2014 and continuing through the months of October 2013 through April 2014.

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 2012 through April 2013). The Upper Green River Basin snowpack condition was near median on January 1, 2013, at 103 percent of median.⁸ On April 1, 2013, snowpack conditions in the Upper Green River Basin had decreased to 78 percent of median, but a series of April storms increased snowpack to 96 percent of median by May 1, 2013. The Yampa River Basin snowpack condition was below average on January 1, 2013, at 85 percent of median. On April 1, 2012, snowpack conditions in the Yampa River Basin had remained stable at 77 percent of median, and had increased to 94 percent of median by May 1, 2013. The Flaming Gorge Reservoir unregulated inflow 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 2013 water supply season are shown in Table 1.

⁸ In water year 2013, the Natural Resources Conservation Service (NRCS) implemented percent of median as the standard measure of snow water equivalent (SWE) based on the 1981-2010 period of record.

Table 1 – Progression of CBRFC Unregulated Inflow⁹ 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	745	76	665	71	220	64
February	640	65	590	63	185	54
March	550	56	565	60	175	51
April	490	50	495	53	140	41
May	480	49	605	65	173	50
June	440	45	620	66	150	43
July	345	35	---	---	---	---
Actual	361	37	573	61	131	39

Summary of Flaming Gorge Operations

Releases from Flaming Gorge were 810 cfs from October 6, 2012 through November 30, 2012, when releases increased at a rate of 50 cfs/day to 1,200 cfs according to a double-peak pattern implemented on December 9, 2012. Releases were maintained at the daily average release of 1,200 cfs according to a double-peak pattern through March 4, 2013. Releases were decreased over a two-day period to a steady release of 820 cfs on March 4 and 5, 2013. Releases remained at a steady 820 cfs through May 2013.

The Utah Division of Wildlife Resources (UDWR) requested a modification from normal operations on April 15 and 16, 2013, with a subsequent request to reschedule the April 16 releases to April 18, 2013, in order to conduct their spring fishery assessment (Appendix H). Releases were maintained at 820 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. Reclamation responded to the Recovery Program's request and agreed to support research under the LTSP and time releases from Flaming Gorge Dam to coincide with the presence of wild razorback sucker larvae in the Green River system.

May releases were maintained at the steady release of 800 cfs until larval detection occurred around May 27, 2013, and releases increased to full power plant capacity on May 29, 2013. Yampa River flows dropped below 4,000 cfs and Flaming Gorge Dam releases were

⁹ 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.

increased 1,000 cfs on June 4th above power plant capacity (~4,500 cfs) for a total release of 5,500 cfs to provide the highest flows possible to maintain flows in Reach 2 above 8,300 cfs. Releases returned to power plant capacity (~4,500 cfs) at 1800 MDT on June 5, 2013. The Green River measured at Jensen, Utah reached its peak of 10,700 cfs on June 6, 2013.

Flaming Gorge Dam releases began decreasing to base flow levels on June 7, 2013, at a rate of 350 cfs/day according to a single-peak hourly release pattern. Western Area Power Administration in cooperation with the Green River Outfitter Guides Association shifted the single-peak hourly release patterns back one hour beginning on June 9, 2013, and Flaming Gorge reached the summer base flow level of an average daily release of 1,100 cfs on June 16, 2013 according to a single-peak hourly pattern. The hourly pattern maintains a 0.1 meter stage change at Jensen, Utah attributable to hydropower fluctuation from Flaming Gorge Dam.

Yampa River flows peaked at 9,540 cfs on May 19, 2013, as Flaming Gorge Dam was releasing at the steady rate of 820 cfs prior to detection of wild razorback sucker larvae in the Green River system. The Green River at Jensen, Utah peak was 10,700 cfs on June 6, 2013, with total releases 5,500 cfs from Flaming Gorge Dam augmenting Yampa River flows. Flows at Jensen, Utah were above 8,300 cfs for 25 days total and above 8,300 cfs during larval presence for 18 consecutive days.

Flaming Gorge Reservoir elevation decreased a total of 6.14 feet (ft) from the maximum elevation of 6021.41 ft on October 1, 2012, to the annual minimum elevation of 6015.27 ft on September 25, 2013.

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

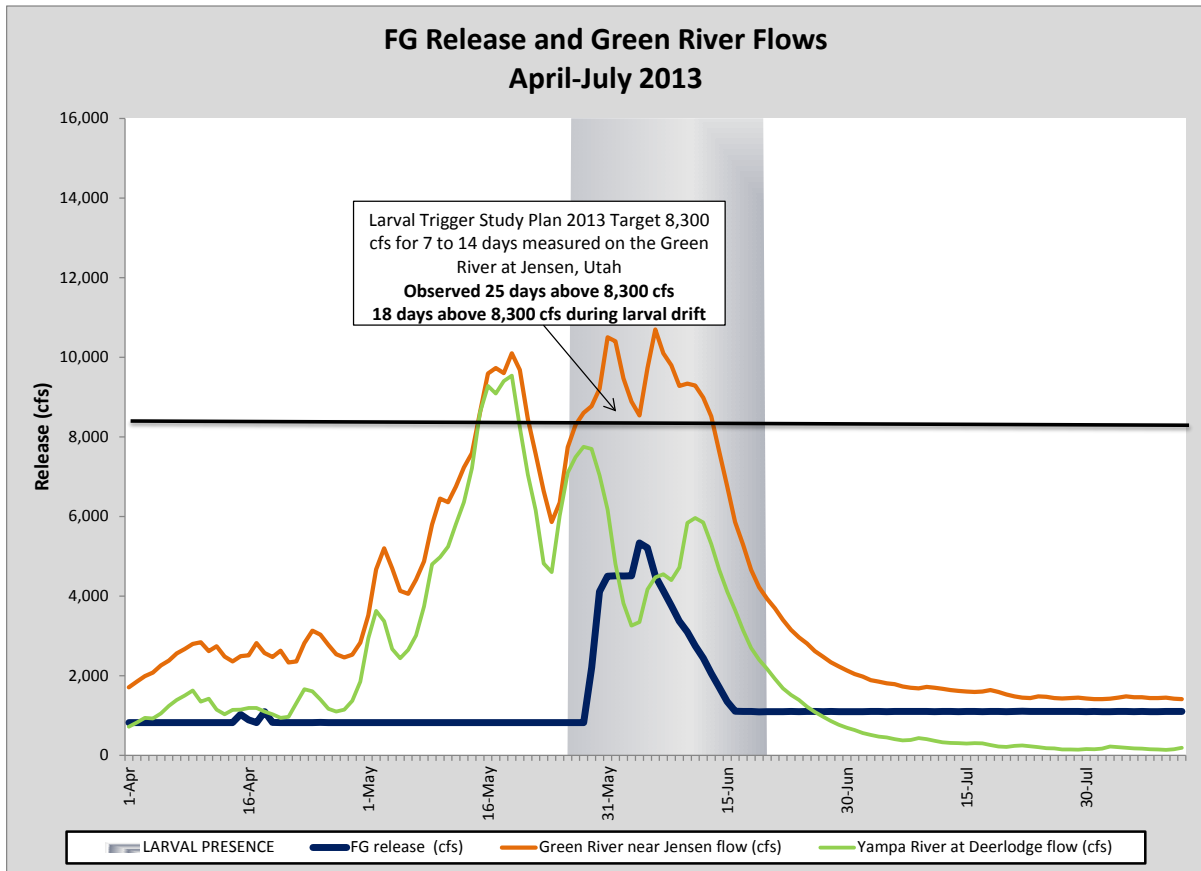


Figure 1 – Spring 2013 Flaming Gorge Spring Releases and Flows Measured at Yampa River at Deerlodge and Green River at Jensen.

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 it notes any unusual or excessive noise or vibration. The spillway inspection occurred on October 28, 2013, at reservoir elevation 6015.25 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 acre-foot.

Flow Objectives Achieved in Water Year 2013

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 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
2013	480	Moderately Dry	361	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 2013 was 480,000 acre-feet (AF) and resulting spring hydrologic classification was moderately dry.¹⁰ 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 2013 is the eighth year of operations under the ROD and is the eighth year for establishing the long-term frequencies of these spring flow objectives.

Table 3 – Reach 1 ROD Flow Objectives Achieved in 2013

Spring Peak Flow Objective [†]	Hydrologic Classification	Desired Frequency Percent of Achievement	Achieved in 2013	Observed Spring Class Frequency %*	Achievement Rate to Date (Cumulative Frequency %)*
Peak \geq 8,600 cfs for at least 1 day	Wet	10 %	No	13 %	13 %
Peak \geq power plant capacity for at least 1 day	Dry	100%	Yes	100 %	100 %

[†] Reach 1 release objectives are based on the flows needed to achieve recommended duration of bankfull and overbank flows in Reaches 2 and 3.

*Based on eight years of operation under the ROD and spring hydrologic classification (2006-2013)

¹⁰ 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 2013

Spring Peak Flow Objective	Hydrologic Classification	Desired Frequency Percent of Achievement	Achieved in 2013	Observed Spring Class Frequency %*	Achievement Rate to Date (Cumulative Frequency %)*
Peak \geq 26,400 cfs for at least 1 day	Wet	10 %	No	0 %	13 %
Peak \geq 22,700 cfs for at least 2 weeks	Wet	10 %	No	0 %	13 %
Peak \geq 18,600 cfs for at least 4 weeks	Wet	10 %	No	0 %	13 %
Peak \geq 20,300 cfs for at least 1 day	Moderately Wet	30 %	No	13 %	25 %
Peak \geq 18,600 cfs for at least 2 weeks	Average (Wet)	40 %	No	25 %	25 %
Peak \geq 18,600 cfs for at least 1 day	Average (Wet)	50 %	No	50 %	63 %
Peak \geq 8,300 cfs for at least 1 day	Average (Dry)	100 %	Yes	100 %	100 %
Peak \geq 8,300 cfs for at least 1 week	Moderately Dry	90 %	Yes	100 %	88 %
Peak \geq 8,300 cfs for at least 2 days except in extreme dry years	Dry	98 %	Yes	100 %	100 %

*Based on eight years of operation under the ROD and spring hydrologic classification (2006-2013)

Table 5 – Reach 3 ROD Flow Objectives Achieved in 2013

Spring Peak Flow Objective	Hydrologic Classification	Desired Frequency Percent of Achievement	Achieved in 2013	Observed Spring Class Frequency %*	Achievement Rate to Date (Cumulative Frequency %)*
Peak \geq 39,000 cfs for at least 1 day	Wet	10 %	No	0 %	13 %
Peak \geq 24,000 cfs for at least 2 weeks	Wet	10 %	No	0 %	13 %
Peak \geq 22,000 cfs for at least 4 weeks	Wet	10 %	No	0 %	13 %
Peak \geq 24,000 cfs for at least 1 day	Moderately Wet	20 %	No	13 %	38 %
Peak \geq 22,000 cfs for at least 2 weeks	Average (Wet)	40 %	No	25 %	13 %
Peak \geq 22,000 cfs for at least 1 day	Average (Wet)	50 %	No	50 %	38 %
Peak \geq 8,300 cfs for at least 1 day	Moderately Dry	100 %	Yes	100 %	100 %
Peak \geq 8,300 cfs for at least 1 week	Moderately Dry	90 %	Yes	100 %	88 %
Peak \geq 8,300 cfs for at least 2 days except in extreme dry years	Dry	98 %	Yes	100 %	100 %

*Based on eight years of operation under the ROD and spring hydrologic classification (2006-2013)

Reclamation decided to operate in support of 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 Recovery Program’s 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 was not included in the study¹¹ and water year 2013 is included in the three years of flows 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 moderately dry hydrologic condition with flows between 8,300 cfs and 14,000 cfs targeted between 7 to 14 days. Flows at Jensen, Utah, were above 8,300 cfs for 18 days during larval drift and 25 days total, which met the objective for moderately dry years outlined in the LTSP and the ROD.

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.

¹¹ The LTSP was implemented in 2012. However, management of key floodplains required for research continuity was unavailable during larval drift.

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 361,000 AF and resulting base flow hydrologic classification was dry. Reach 1 flows were reduced to base flows of 1,100 cfs by June 16, 2013. The observed April-July unregulated inflow volume into Flaming Gorge Reservoir, August final forecast and average daily releases needed to achieve the May 1, 2014 elevation target of 6027 feet were used to calculate the Reach 1 daily average base flow of 800 cfs, which is within the base flow range for the dry classification as shown in Figure 2.

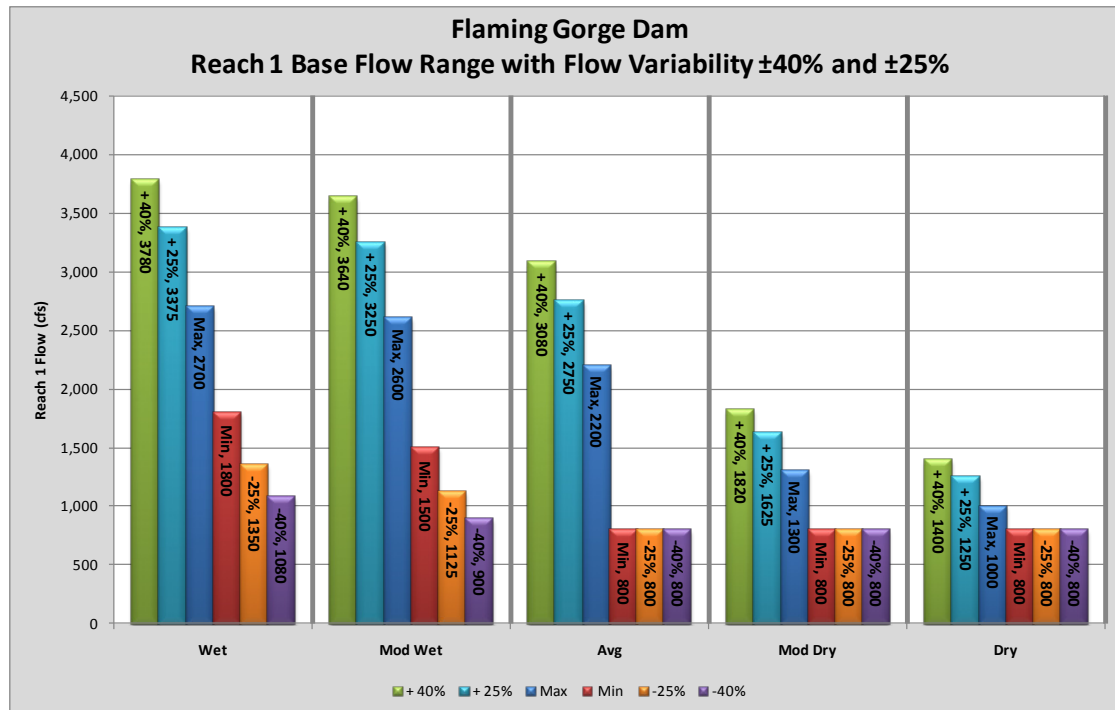


Figure 2 – Reach 1 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.

The FGTWG and the Service requested and the FGTWG proposed flows in Reach 2 for July through September at the maximum variability of +40 percent of the dry base flow classification. Reclamation decided to implement +40 percent for Reach 1 in the dry classification during July through September, and released 1,100 cfs in an effort to sustain flows in Reach 2 as requested. The request from the Service for increased releases during August-September increased the observed average daily base flow to 907 cfs for the August 2013-February 2014 base flow period. September and October unregulated inflow volume into Flaming Gorge Reservoir and Yampa River at Deerlodge Park flows were above average. This increased the hydrologic classification from dry to moderately dry for the remainder of the base flow season.

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). Observed December through February base flows for the dry classification in Reach 2 were within 25 percent of

the established moderately dry base flow classification (*i.e.* between 825 cfs to 1,850 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.

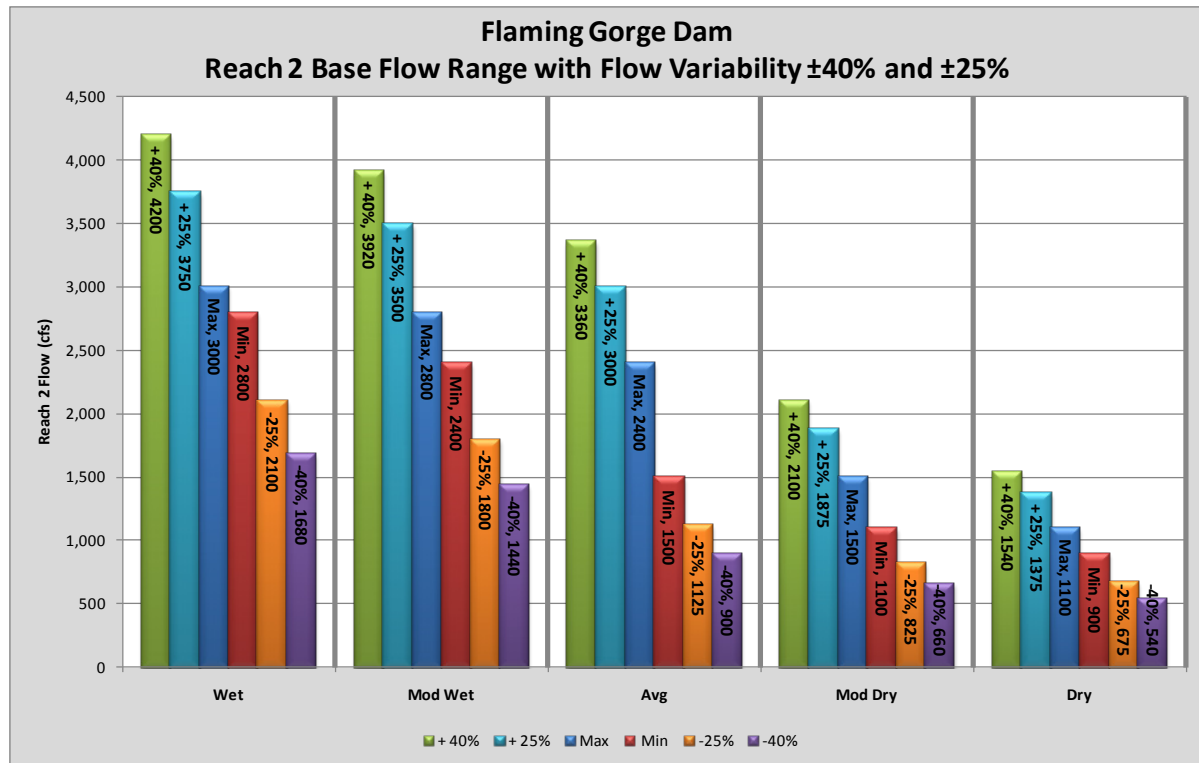


Figure 3 – Reach 2 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.

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 moderately dry base flow classification (*i.e.* between 1,125 cfs to 4,250 cfs). The USGS reports that December and January 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.

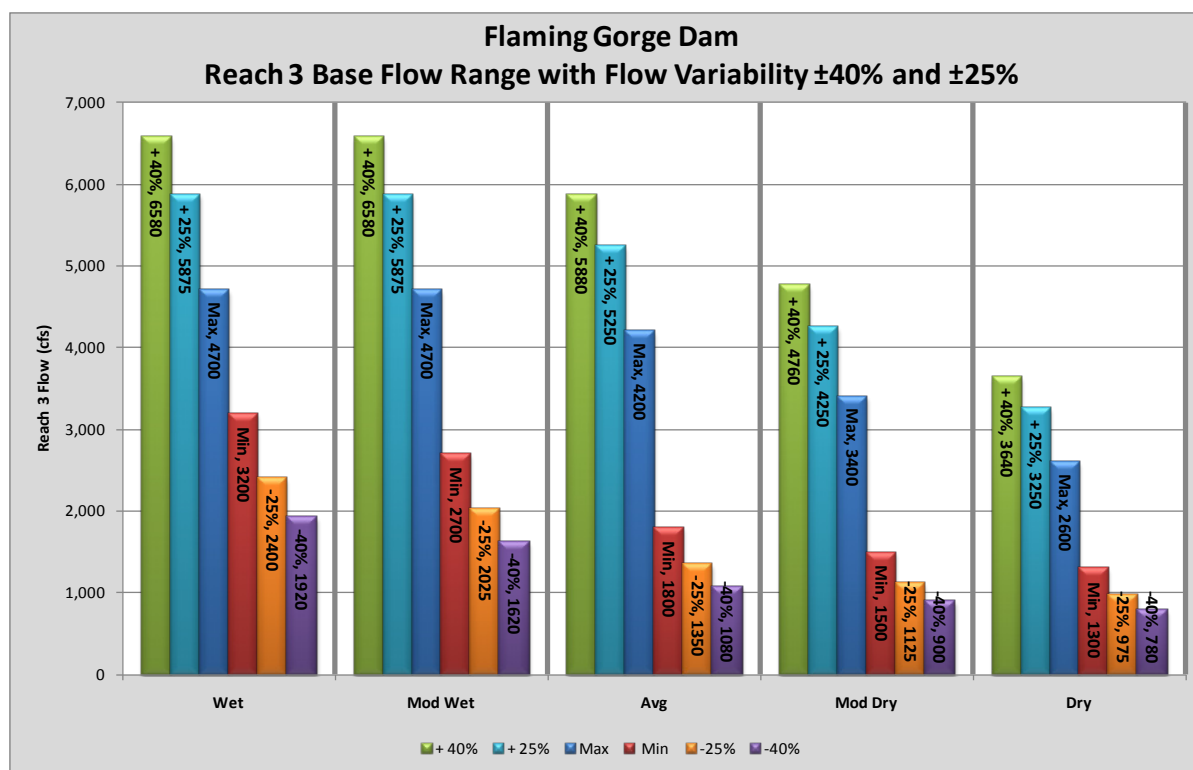


Figure 4 – Reach 3 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.

Temperature Objectives Achieved in Water Year 2013

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 meet the water temperature objectives below Flaming Gorge Dam described in the 2006 ROD and 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 WY2013, the elevation target was achieved on June 17.

On July 24, operating temperatures on one of the units exceeded equipment thresholds, a high temperature alarm sounded, and as a result SWS gates were lowered to 45 vertical feet below the surface of the reservoir. Temperature of water passing through the unit at the time of the alarm was 15.6° C (60.0 °F). On July 29, high water temperatures were once again recorded and SWS gates were lowered an additional 5 vertical feet. They remained at this elevation (5,967 feet msl) through November 25, at which point they were lowered to their winter operating elevation of 5,913 feet msl.

Average daily temperatures at Gates of Lodore (USGS 404417108524900) in 2013 intermittently equaled or exceeded Reach 1 objectives (18.0 °C or 64.4 °F; Figure 1) for 41 days between June 28 and August 28. The difference between daily water temperatures in the Yampa and Green rivers exceeded 5.0 °C (9.0 °F; Reach 2 objective) on June 6 but stayed below the 5.0 °C threshold for the duration of the SWS operational period (Figure 2). Releases of water from Flaming Gorge Dam averaged 13.5 °C (56.3 °F) from June through September 2013 and temperatures in excess of 16 °C (60.8 °F) occurred once on July 24.

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

Temperature Objectives	Reach*	Desired Frequency %	Achieved in 2013
Temperatures $\geq 64^{\circ}$ 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.

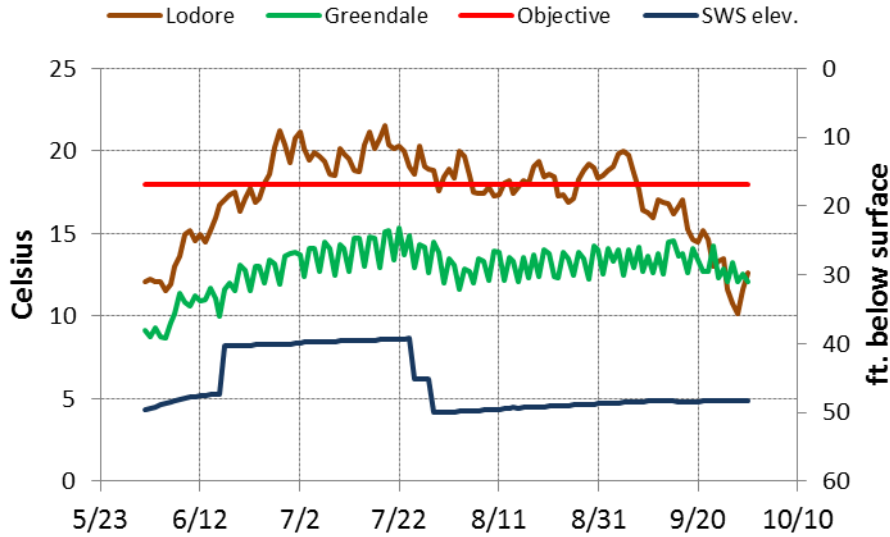


Figure 5 – Reach 1 Green River Average Daily Temperatures & SWS Elevation. Recorded temperatures at the Gates of Lodore gage (USGS 404417108524900) (brown series), Greendale gage (USGS 09234500) (green series), Reach 1 objective (red line), and SWS gate depth below reservoir surface (in blue, series correlates to the right hand axis), June-Sept 2013. SWS gate depths depicted are the average of 3 gates.

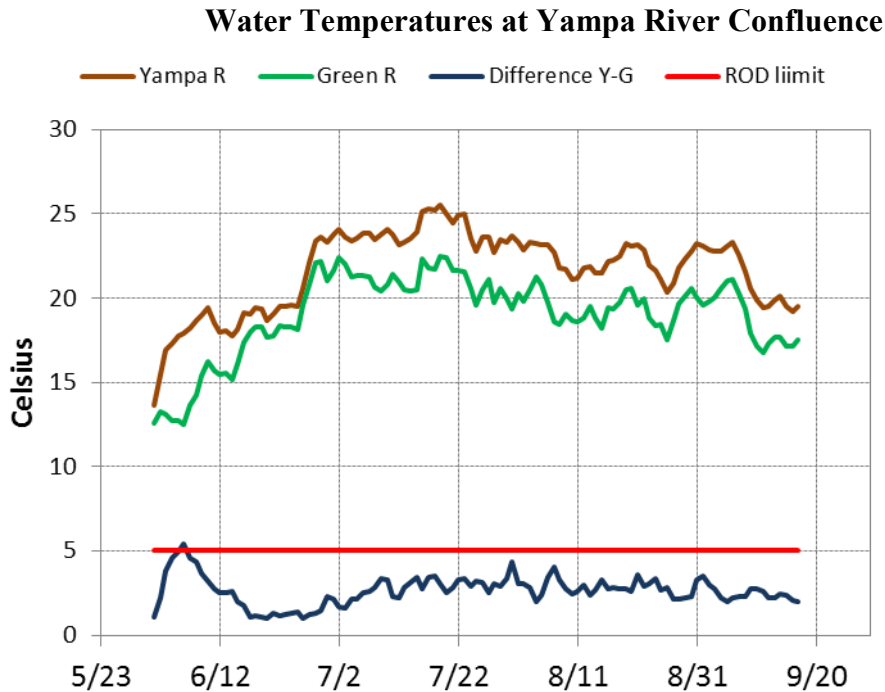


Figure 6. Green River Temperatures at the Yampa River Confluence. Temperatures are recorded at the Green River (USGS 404417108524900) (green series) and the Yampa River (USGS 09260050) (brown series), the difference between the two rivers (blue line), and the

maximum temperature difference specified in the 2006 ROD (red series line), June-Sept 2013.

Recommendations

In 2013, Reclamation operated Flaming Gorge Dam and Reservoir in compliance with the 2006 ROD and, to the extent possible, meet the goals and objectives of the Flow Recommendations and the LTSP. This was the third year implementing the LTSP, and the first year under moderately dry conditions. While Reclamation has normally increased Flaming Gorge Dam releases in the spring to match the peak and immediate post-peak of the Yampa River, in 2013 it increased releases after the Yampa River had peaked and was on the descending limb of the hydrograph. Reclamation met the moderately dry Reach 2 flow target of 8,300 cfs between 7 and 14 days at Jensen, Utah. Flows at Jensen, Utah in 2013 were above 8,300 cfs for a total of 25 days, 18 days of which was during larval drift, which conformed to the duration requirements for moderately dry years outlined in Table 2 of the LTSP (Table 6 in this document; 7-14 days between 8,300 and 14,000 cfs as measured at Jensen, Utah).

Coordination among Reclamation, the Recovery Program, the Service and UDWR occurred regularly and was used to determine the timing of the peak release in 2013 in support of the LTSP. Reclamation implemented an email and communication directory to make sure that updated data was 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. 2013. Flaming Gorge Technical Working Group Proposed Flow and Temperature Objective for 2013. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.
- 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. February 26, 2013. Memorandum to Larry Walkoviak and Heather Hermansen. Recovery Program Research Request for 2013 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 14, 2013. Memorandum to Director, Upper Colorado Region, Bureau of Reclamation and Chair, Flaming Gorge Technical Working Group, Bureau of Reclamation. 2013 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.

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.¹²

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

¹² Reclamation, 2006, Record of Decision on the Operation of Flaming Gorge Dam Final Environmental Impact Statement.

necessarily explicit in the flow recommendations, but is necessary to fulfill adaptive 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. Flaming Gorge Technical Working Group (FGTWG) - 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.

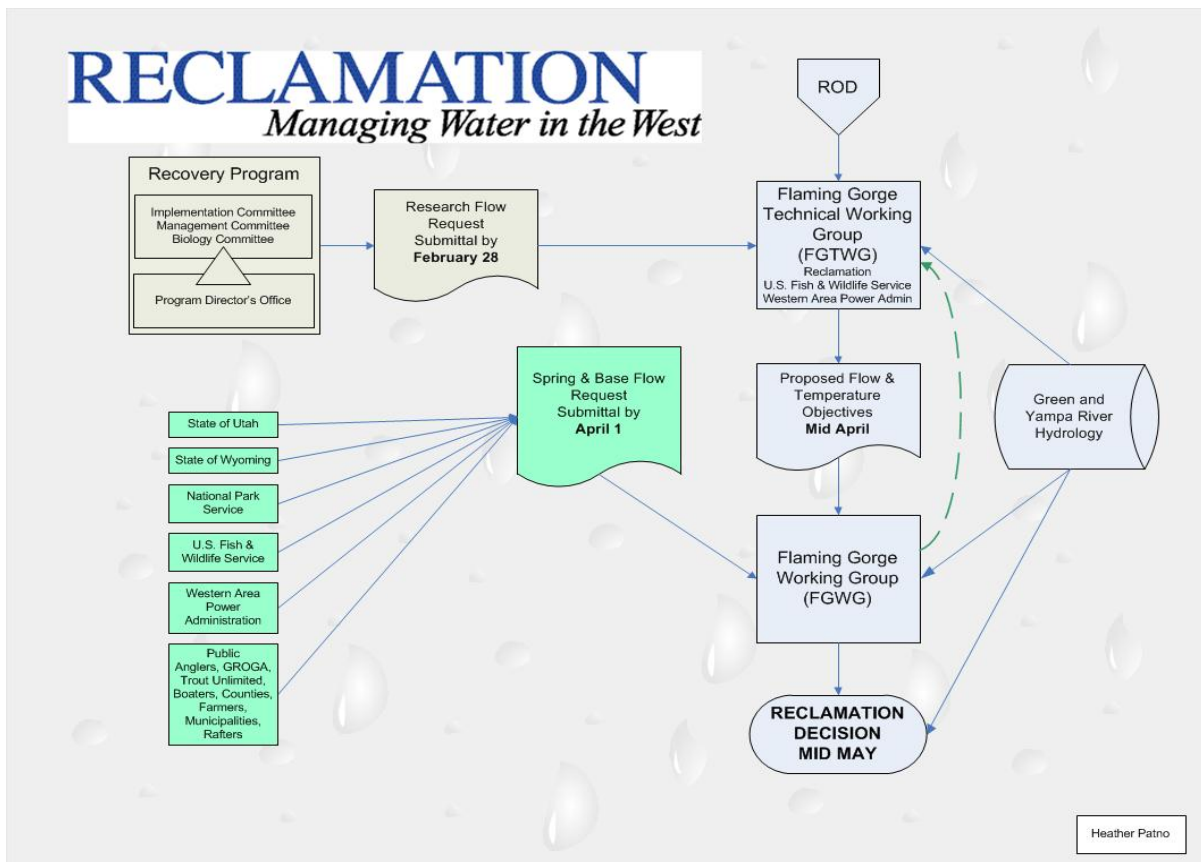
The FEIS specifically addresses and outlines the content of the Proposal. The Proposal describes the current hydrologic classification of the Green River and Yampa River Basins, including the most probable runoff patterns for the two basins. The Proposal also identifies the most likely Reach 2 flow magnitudes 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. Flaming Gorge Working Group – 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. Operational Plan - 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.



Appendix B

Week of October 1st

Forecasts continued to decrease and Flaming Gorge was in the dry hydrologic classification as outlined in the ROD. Flaming Gorge releases decreased at a rate of 50 cubic feet per second per day (cfs/day) from a daily average release of 1,100 cubic feet per second (cfs) to steady releases of 810 cfs. It was anticipated that releases during December through February would increase to an average daily release of 1,200 cfs.

Week of October 12th

Western Area Power Administration (Western) requested assistance with winter hydropower generation because of limitations among the other Colorado River Storage Project dams and reservoirs. Reclamation agreed to assist Western within the flexibility of the base flow ranges described in the ROD. Beginning December 1, 2012, Flaming Gorge Dam increased from an average daily release of 810 cfs to 1,200 cfs at a rate of 50 cfs/day. Releases were expected to remain at 1,200 cfs through the end of February. Hourly releases followed a double-peak pattern.

Week of January 28th

Generator maintenance and tested was completed on all three hydropower units. Flaming Gorge releases remained at an average daily release rate of 1,200 cfs with minor variations from the hourly release patterns throughout the week. The hourly release schedule followed a double-peak pattern.

Week of February 26th

On February 26, 2013, Reclamation received a memorandum containing the Upper Colorado River Endangered Fish Recovery Program's (Recovery Program) Research Request for 2013 Green River Spring Flows. The 2013 Spring Flow Request was that the Flaming Gorge Technical Working Group (FGTWG) implement 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 *ad hoc* Committee 2012) (LTSP).

Week of March 4th

The January and February forecasts for unregulated inflow into Flaming Gorge Dam continued to decrease. Releases decreased in order to conserve water in anticipation of a dry hydrologic year. On March 4, 2013, releases were reduced to 998 cfs according to a double-peak pattern. On March 5, 2013, releases decreased to the minimum release of 800 cfs. It was anticipated that releases would remain at the minimum release of 800 cfs until spring runoff began.

The Colorado Basin River Forecast Center (RFC) issued the March final forecast for Flaming Gorge unregulated inflow volume of 550,000 acre-feet (af) (56 percent of average), decreasing 20 percent from the January final forecast of 745,000 af (76 percent of average). The Climate Prediction Center predicted continued warm and dry weather over the next three months and the RFC water supply forecast briefing predicted continued trends of decreasing forecasts.

The FGTWG met on March 6, 2013, 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 2013, 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.

Reclamation discussed the potential of bypass releases to augment Yampa River flows in order to achieve higher Reach 2 flow during larval presence because of the dry hydrologic year. The Reach 2 target of $\geq 8,300$ cfs for at least one week was the target under the March forecast.

(See Meeting Records: <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>)

Reclamation received a letter from the Utah Division of Wildlife Resources (UDWR) on March 6, 2013, requesting a modification from normal operations of Flaming Gorge Dam on April 15 and 16, 2013, so that they could conduct the spring fishery assessment.

Week of April 1st

The FGTWG met on April 5, 2013, and discussed the continued dry hydrology in the Upper Green and Yampa River Basins. The group then discussed the LTSP and targeted floodplains and management plans for 2013 research on the Green River below Flaming Gorge Dam. (See <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>)

Week of April 15th

Pursuant to the request from UDWR for a modification of releases to conduct their spring fishery assessment, releases were revised on April 15th during the early evening to early morning hours for the spring fishery assessment. UDWR requested that Reclamation reschedule releases on from April 16th to April 18th in order to complete their fishery assessment. Reclamation rescheduled releases to April 18th. Releases unassociated with the spring fishery assessment were steady 800 cfs releases during and after the assessment was finished.

Week of April 22nd

The Flaming Gorge Working Group meeting was held in Vernal, Utah, on April 24, 2013. (http://www.usbr.gov/uc/water/crsp/wg/fg/fg_20130424.html)

Week of April 29th

The FGTWG met on May 3, 2013, and discussed the current forecast and hydrology in the Green and Yampa River basins; larval sampling update; backwater survey results and the proposed spring flow operations. (See <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>)

Week of May 13th

On May 14, 2012, Reclamation received a memorandum from the U.S. Fish and Wildlife Service (Service) on the 2013 Green River Spring and Base Flows to Assist in Recovery of the Endangered Fishes. The Service supports the Recovery Program's 2013 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, 2013. The Service supports Reclamation following the Recovery Program's 2013 Research Request and LTSP, and considers that doing so will meeting Reclamation's responsibility to the ROD objectives in 2013.

The FGTWG met on May 17, 2013, and discussed the current hydrology, updated larval sampling results and floodplain management and availability. (See <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>)

Week of May 20th

The FGTWG met on May 22, 2013, and discussed the targeted flow regime in Reach 2 and updated the hydrologic classification from dry to moderately dry pursuant to an increased Yampa River forecast from the Colorado Basin River Forecast Center. (See <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>)

Week of May 27th

Larval detection occurred on May 27, 2013, and Reclamation increased Flaming Gorge Dam releases from 800 cfs to power plant capacity over two days beginning on May 29, 2013, in order to combine releases with the Yampa River and provide the highest flows possible to transport larval fish into nursery habitat along the Green River. Projections were for the Yampa River to reach at least 12,000 cfs.

The FGTWG met on May 28th, May 30th, and June 1st to coordinate Flaming Gorge Dam releases with Yampa River flows and floodplain management for optimal larval entrainment. (See <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>)

Week of June 3rd

Yampa River flows dropped below 4,000 cfs and Flaming Gorge Dam releases were increased 1,000 cfs on June 4th above power plant capacity (~4,500 cfs) for a total release of 5,500 cfs to provide the highest flows possible to maintain flows in Reach 2 above 8,300 cfs. Releases returned to power plant capacity (~4,500 cfs) at 1800 MDT on June 5, 2013. The Green River measured at Jensen, Utah reached its peak of 10,700 cfs on June 6, 2013.

The FGTWG met on June 4th and 5th to coordinate Flaming Gorge Dam base flows and floodplain management strategies. Flaming Gorge Dam unregulated inflow forecasts continued to decrease and the group recommended a base flow of 1,100 cfs from Reach 1 to support Colorado pikeminnow production in Reaches 2 and 3. (See <http://www.usbr.gov/uc/water/crsp/wg/fg/twg/twgSummaries.html>)

Flaming Gorge Dam releases began decreasing to base flow levels on June 7, 2013, at a rate of 350 cfs/day according to a single-peak hourly release pattern. Western Area Power Administration in cooperation with the Green River Outfitter Guides Association shifted the single-peak hourly release patterns one hour beginning on June 9, 2013, and Flaming Gorge reached the summer base flow level of an average daily release of 1,100 cfs on June 16, 2013 according to a single-peak hourly pattern. The hourly pattern maintains a 0.1 meter stage change at Jensen, Utah attributable to hydropower fluctuation from Flaming Gorge Dam.

Week of July 8th

The hourly release pattern of an average daily release of 1,100 cfs was shifted to comply with the 0.1-meter stage change at Jensen, Utah.

Week of August 12th

The hourly release pattern of an average daily release of 1,100 cfs was shifted to comply with the 0.1-meter stage change at Jensen, Utah.

Week of August 19th

The Flaming Gorge Working Group Meeting was held in Vernal, Utah, on August 21, 2013. (<http://www.usbr.gov/uc/water/crsp/wg/fg/fgcurrnt.html>)

Week of September 9th

UDWR requested a modification from normal operations of Flaming Gorge Dam on September 9 and 10, 2013, so that they might conduct the fall fishery assessment. In order to accommodate their request, Flaming Gorge releases were operated to assist the spring fishery assessment at 1,600 cfs. Releases returned to the average daily release rate of 1,100 cfs as close to the September 11th hourly schedule as possible.

Appendix C

Flaming Gorge Final Environmental Impact Statement

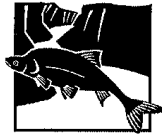
Table 2.1: Recommended Magnitudes and Durations Based on Flows and Temperatures for Endangered Fishes in the Green River Downstream from Flaming Gorge Dam as Identified in the 2000 Flow and Temperature Recommendations

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 March 1	• 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) • 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 flows 18,600 cfs (527 m ³ /s) for 4 weeks or more.	Flows greater than 18,600 cfs (527 m ³ /s) should be maintained for 2 weeks or more.	Flows greater than 18,600 cfs (527 m ³ /s) should be maintained for 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	• 89,000 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

February 26, 2013 Memorandum from the Recovery Program Director containing the Research Request for 2013 Green River Spring Flows



Upper Colorado River Endangered Fish Recovery Program

Noreen Walsh, Chairman
Implementation Committee


Thomas E. Chart
Program Director

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

Memorandum

February 26, 2013

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
Subject: Recovery Program's Research Request for 2013 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 2013 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 and 2012, 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 the river-floodplain connection with the presence of wild-produced razorback sucker larvae.

As was the case last year, this Recovery Program 2013 spring flow request is based on objectives outlined in our *Study Plan to Examine the Effects of Using Larval Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam* (LTSP) (Larval Trigger Study Plan Ad Hoc Committee 2012). 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

Colorado River Energy Distributors Association - Colorado Water Congress - National Park Service - State of Colorado
State of Utah - State of Wyoming - The Nature Conservancy - U.S. Bureau of Reclamation - U.S. Fish and Wildlife Service
Utah Water Users Association - Western Area Power Administration - Western Resource Advocates - Wyoming Water Association

Recovery Program requests three years with flows < 18,600 cfs and three years with flows \geq 18,600 cfs and with connecting flows in each of these years of at least seven days duration. However, spring peak flow magnitude requests will be driven by hydrologic conditions in the upper Green River Basin; therefore, it may not be possible to complete the experiment in six consecutive years.

In 2012, snowpack accumulation in the Yampa River drainage was categorized as 'dry' and 'moderately dry' in the Upper Green River drainage. The Recovery Program and the Flaming Gorge Technical Work Group (FGTWG) ultimately agreed to focus the 2012 spring flow request on the driest category of experimental conditions outlined in the LTSP. We applaud Reclamation's Flaming Gorge releases last May, which were timed coincident with the presence of larval razorback sucker (first larval detection – May 16, 2012; Bestgen et al. 2012a) and which proved integral in establishing a floodplain connection at Stewart Lake and Old Charley Wash. As per the LTSP, Utah Division of Wildlife Resources (UDWR) crews were able to document larval entrainment and describe physical conditions at that floodplain site (Breen and Skorupski 2012). Similarly, USFWS crews detected larval entrainment into the Old Charley site as well. During the spring and summer months of 2012, USFWS crews also (Webber and Jones 2012) sampled fish and monitored water quality at a variety of other floodplains that still held water from the extensive period of connection in 2011, but that did not connect in 2012. The Recovery Program is poised and properly funded to follow through on specific LTSP field investigations again in 2013 (e.g., Project Nos. 22F, 164 and 165; Scopes of Work available at: <http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/project-scopes-of-work.html>); sampling protocols and rationale are discussed further in Bestgen et al. (2012b).

As described in Breen and Skorupski 2012, the magnitude and period of inundation at the Stewart Lake site was limited last spring due to sedimentation in the inlet channel that occurred during the high flows of 2011. During summer 2012, UDWR excavated the inlet channel to restore connection conditions more consistent with those described for this site in the LTSP. Also, personnel from Western Area Power Administration (Western), Argonne National Laboratories (funded by Western), and the Recovery Program surveyed Reach 2 levee breach elevations in Autumn 2012 to better assess connection flows for future LTSP experimentation. We are hopeful the results of those surveys are available to the Recovery Program and the FGTWG this spring.

THE RECOVERY PROGRAM'S SPRING 2013 GREEN RIVER 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 razorback sucker 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. 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 2013 flow request.

In our request letter last year, the Recovery Program expressed reservations over Reclamation's potential use of the spillway (dam releases in excess of 8,600 cfs) in deference to the possible release of nonnative burbot from Flaming Gorge Reservoir. Accordingly, the Recovery Program, the National Park Service, UDWR, and Western committed to initiating a risk assessment of burbot entrainment associated with Flaming Gorge spring operations (also referenced in the LTSP). That risk assessment is nearly complete; a draft report will be submitted to the Recovery Program's Biology Committee by the end of February 2013. Preliminary results of that risk assessment were presented by Melissa Trammell, National Park Service, at the Recovery Program's Nonnative Fish Workshop held in Grand Junction, Colorado; December 5-6, 2012. Based on those preliminary results, the Recovery Program considers the risk of entraining burbot when dam releases exceed 8,600 cfs to be reasonably low at this time. That conclusion is based on the following:

- The incidence of adult burbot in the portion of Flaming Gorge Reservoir nearest the dam is currently very low.
- The risk of entraining adults and juveniles through the spillway will always be fairly low based on the species' behavior.
- The risk of entraining larvae is of moderate concern. According to the literature and known water temperatures in the reservoir in late May-June, Age-0 burbot would likely range in size from 10 to 40 mm (total length). Young burbot of 30-40 mm should be entering a "settlement period", i.e. transitioning from using the full water column in near shore habitats to a primarily benthic behavior, remaining near the shoreline but on the substrate. However, a portion of a larval cohort could still be limnetic during the spring runoff period. Therefore if Reclamation is considering using the spillway as part of the spring release the Recovery Program will sample for burbot larvae in the reservoir near the entrance to the spillway. This type of sampling could be accomplished quickly and on short notice.
 - If no larvae were captured, the Recovery Program would have no reservation with Reclamation's decision to use the spillway.

The Recovery Program assumes that a specific 2013 LTSP spring flow request will be developed in concert with the FGTWG using the best available flow forecast information.

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 2013 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. U. S. Fish and Wildlife Service, Denver, CO. Larval Fish Laboratory Contribution 163. Final Report available at: <http://www.coloradoriverrecovery.org/documents-publications/technical-reports/hab/Bestgenetal.2011FloodPlainSynthesisFinalReport.pdf>
- Bestgen, K.R., A. Webber, and T. Jones. 2012a. Project 22f - Interagency standardized monitoring program (ISMP) assessment of endangered fish reproduction in relation to Flaming Gorge operations in the middle Green and lower Yampa rivers-Yampa and middle Green River assessment of Colorado pikeminnow and razorback sucker larvae. FY2012 Annual Report available at: <http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2012/rsch/22f.pdf>
- Bestgen, K. R., K. A. Zelasko, and G. C. White. 2012b. Monitoring reproduction, recruitment, and population status of razorback suckers in the Upper Colorado River Basin. Final Report to the Upper Colorado River Endangered Fish Recovery Program, U. S. Fish and Wildlife Service, Denver. Larval Fish Laboratory Contribution 170. Available at: <http://www.coloradoriverrecovery.org/documents-publications/technical-reports/rsch/BestgenetalProject159RZBMonitoringOctober2012Final.pdf>
- Breen, M.J. and J.A. Skorupski. 2012. Project 165 - Use of the Stewart Lake floodplain by larval and adult endangered fishes. FY2012 Annual Report available at: <http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2012/hab/FR165.pdf>

- Larval Trigger Study Plan Ad Hoc Committee. 2012. Study Plan to Examine the Effects of Using Larval Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam. Available at: <http://www.coloradoriverrecovery.org/documents-publications/technical-reports/isf/larvaltriggerstudyplan.pdf>
- 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 FG-53 to the Upper Colorado River Endangered Fish Recovery Program. U. S. Fish and Wildlife Service, Denver, CO.
- 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. 2012. Project 164 - Middle Green River floodplain sampling. FY2012 Annual Report available at: <http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2012/hab/FR164.pdf>
- Cc: Malcolm Wilson, Chief, Water Resources Group, USBR, Salt Lake City, Utah
 Beverley Heffernan, Manager, Environmental Resources Division, USBR, Salt Lake City, Utah
 Bridget Fahey, Endangered Species Branch Chief, Ecological Services, USFWS
 John Shields, Chairman, UCREFRP - Management Committee, Wyoming State Engineers Office, Cheyenne, Wyoming
 Jerry Wilhite, Chairman, UCREFRP - Biology Committee, Western Area Power Administration, Lakewood, Colorado
 Larry Crist, Field Supervisor, Ecological Service, USFWS, Utah Field Office, Salt Lake City, Utah

Appendix E

March 26, 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

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 iii

INTRODUCTION 1

PROPOSED MONITORING AND RESEARCH..... 4

 Topic 1: Entrainment and Retention of Razorback Sucker Larvae in Floodplain Wetlands..... 9

 Topic 2: Survival and Escapement of Entrained Razorback Suckers..... 11

 Topic 3: Availability of Colorado Pikeminnow Habitat..... 13

 Topic 4: Sediment Mobilization and Channel Maintenance..... 14

 Topic 5: Fish Community Response..... 15

RESEARCH PRIORITIES AND IMPLEMENTATION..... 17

REFERENCES 20

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 $\geq 18,600$ 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, *Ptychocheilus 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	≥ 748 m ³ /s (26,400 cfs)	≥ 575 m ³ /s (20,300 cfs)	≥ 527 m ³ /s (18,600 cfs) in 1 of 2 average years; ≥ 235 m ³ /s (8,300 cfs) in other average years	≥ 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 (≥ 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 $\geq 18,600$ 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: 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 H ₁ plus: 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 H ₁ plus: 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.

Hypotheses² to be tested under Topic 1 include:

H₁: Entrainment and retention of larvae in floodplain wetlands are not related to the timing of connecting flows relative to the timing of larval drift.

H₂: Entrainment and retention of larvae in floodplain wetlands are not related to the magnitude of connecting flows when larvae are present.

H₃: Entrainment and retention of larvae in floodplain wetlands are not related to the duration of connecting flows when larvae are present.

H₄: 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:

H₁: 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).

H₂: 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.

H₃: Number of razorback suckers that are able to escape floodplain wetland habitats to the main channel is not related to floodplain wetland characteristics.

H₄: Floodplain wetlands are not different in terms of surface area, depth, and cover at peak, post-peak, autumn, and end of winter.

H₅: 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:

H₁: Base flow magnitude is not affected by the use of a larval trigger.

H₂: The amount of backwater habitat available for Colorado pikeminnow during the base flow period is not affected by the use of a larval trigger.

H₃: 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:

H₁: The amount of suspended sediment transport is not affected by the use of a larval trigger.

H₂: Bedload transport is not affected by the use of a larval trigger.

H₃: 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:

H₁: The diversity and abundance of nonnative fish established in floodplain wetlands is not affected by the use of a larval trigger.

H₂: 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 $\geq 18,600$ 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.

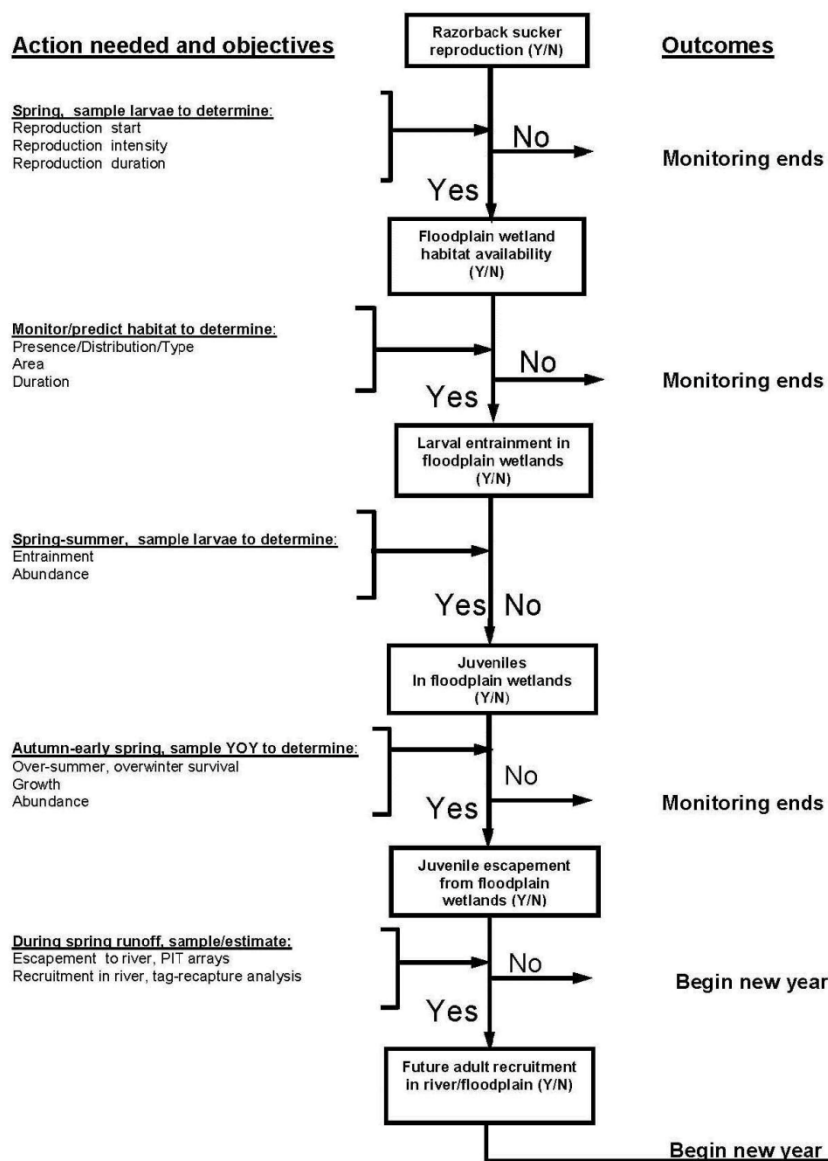


FIGURE 1. Monitoring Decision Tree to Be Used in Evaluating the Larval Trigger

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#1>. Completed studies are available at: <http://www.coloradoriverrecovery.org/documents-publications/technical-reports/habitat-restoration.html>.

Appendix F

May 14, 2013 Memorandum from the U.S. Fish and Wildlife Service for the 2013 Green River Spring and Base Flows to Assist in Recovery of Endangered Fishes



ORIGINAL
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 14, 2013

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

RECEIVED BOR SLCU ORIGINAL FILE COPY		
MAY 20 '13		
Class ENV-4.00		
Pri FG		
Contr # 00052013-03		
Fidr # 10000094		
Date	Initial	To
5/22/13	BCT	FOU
		732

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 *L. Gist*

Subject: 2013 Green River Spring and Base Flows to Assist in Recovery of the Endangered Fishes

This letter describes our recommendations for 2013 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 recommend 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-peak Research Flow

We support the Upper Colorado River Endangered Fish Recovery Program's (Recovery Program) 2013 Spring Flow Request, as explained in their February 26, 2013 letter. The primary objective as presented in their letter is to time Flaming Gorge releases and resultant floodplain connection with the presence of wild produced razorback sucker larvae. The Recovery Program's objective 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, and uses the best available science to guide Flaming Gorge operations and recovery actions in an adaptive management framework. Timing Flaming Gorge r

releases concurrently with wild produced larvae is a major step in re-establishing a stable population of razorback sucker in the Green River basin.

The Recovery Program, in an effort to scientifically evaluate the results of operating Flaming Gorge Dam 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*¹ (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 one set of flow conditions of that matrix could be accomplished in a single year. Because the LTSP describes a systematic analysis for evaluating the success of operating Flaming Gorge concurrently with wild produced razorback sucker larvae, we conclude it is very important to follow its recommendations whenever possible.

The Bureau of Reclamation (Reclamation) proposes to operate peak releases conservatively and exercise the flexibility in the ROD by operating one classification lower than indicated in the forecasts. As a result, Reclamation will operate under a dry classification for the spring peak, despite both the Upper Green and Yampa River Basins being in the moderately dry classification as of the April mid-month forecast. We understand that a dry 2012 and a moderately dry 2013 have reduced much of the flexibility Reclamation has for reservoir operations.

Under this operation proposal, the LTSP advises providing flows between 8,300 and 14,000 cubic feet per second (cfs) for one to six days in order to connect floodplain habitats such as Stewart Lake, Old Charley Wash, and Above Brennan. Last year these same operational criteria were targeted and achieved (5 days above 8,300 cfs). Sampling indicated that razorback suckers were entrained into Stewart Lake, demonstrating success. However, because of operational constraints those larval fish were not returned to the river as planned, as Stewart Lake desiccated during a very dry year.

We support Reclamation targeting one to six days above 8,300 cfs under the LTSP. We believe that 2012 conditions did not fulfill the intent of the LTSP because of the desiccation of Stewart Lake, and therefore a repeat of the efforts in 2012 is warranted. In 2013, Program partners believe that Stewart Lake will remain wetted before being drained in late summer to support selenium remediation. This selenium remediation effort is consistent with endangered fish recovery. As a result of these coordinated management actions, we believe we can provide a meaningful data point for the LTSP this year.

We request that Reclamation attempts to provide connection at targeted floodplain habitats for six consecutive days (or as many as possible). Because hydrologic conditions are in the moderately dry category, but Reclamation is operating one classification drier, we believe that operating towards a longer duration of connection is warranted. Also, we request that Reclamation work the FGTWG to determine if floodplain habitats besides Stewart Lake and Old Charley Wash can be connected during larval drift. We understand

¹ Can be found online at: <http://www.coloradoriverrecovery.org/documents-publications/technical-reports/isf/larvaltriggerstudyplan.pdf>

flows to connect these floodplain habitats will largely be based on Yampa flows coincident with Flaming Gorge releases.

Justification for the LTSP under the Flaming Gorge BO and ROD

The LTSP is an important document that is assisting in the consistent evaluation of 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 2013 Spring Flow Request and implementation of the LTSP are supported by the 2005 BO and we support Reclamation’s 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 Reclamation’s future LTSP-related spring operations. We recognize that Reclamation’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 2013 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 2013 Spring Flow Request and LTSP, and consider that doing so will meet Reclamation's responsibility to the ROD objectives in 2013.

Operations of Stewart Lake

As previously mentioned, we believe water management for selenium remediation at Stewart Lake is consistent with endangered fish recovery. Past operations of Stewart Lake (independent of endangered fish considerations) have focused on a 'fill and drain' operation. This operation followed the general procedure of an initial intake of water into Stewart Lake with Green River spring peak flows, a complete fill of the lake with Red Fleet water, and a draining of the lake after months of inundation. This operational plan has been utilized consistently² and successfully over the majority of the past decade and has improved the selenium levels in Stewart Lake.

Recent work demonstrated that the most effective operation for selenium remediation would be a single fill and drain operation³ with a total duration of inundation of about 90 days. To be consistent with past operations and to follow the most effective remediation process, UDWR's proposed 2013 operations are to allow Green River connection flows to first enter the lake, use Red Fleet water to completely fill the lake, and tentatively drain the lake on August 15 (Stewart Lake Working Group 2013). We support this proposal.

Our office believes that operating Stewart Lake for selenium remediation under this consistent operation plan will benefit endangered fish without affecting the selenium remediation efforts that have been underway for many years. We find no reason to adjust selenium remediation operations from past procedures and support the UDWR's plan to drain the lake near the end of the summer. In fact, we believe that the LTSP request to consistently connect Stewart Lake in all years will continue to provide selenium remediation benefits by providing a consistent supply of water for initial filling.

Recently, some concern has been raised about the legal and biological ramifications for entraining larval fish into Stewart Lake before selenium levels are completely remediated. However, we believe that any larval fish entrained into Stewart Lake are

² This plan has been used each year between 2003 and 2010. Historically high flows in 2011 altered operations in 2011 (no Red Fleet water needed because of large input of Green River water) and 2012 (no Red Fleet water used in order to dry the lake bed sufficiently from the 2011 flows) (Stewart Lake Working Group 2013)

³ rather than fill and drain twice a year

more likely to survive in Stewart Lake than in the main channel habitats. We base this on continued improvement of selenium levels in Stewart Lake and years of unsuccessful recruitment of the species in main channel habitats that contain non-native predators. Although Stewart Lake selenium levels have not been completely remediated, Stewart Lake offers larval fish better habitat than the main channel because larval fish can grow more quickly and in a predator free environment⁴. While some impacts to endangered fish from selenium exposure may still occur (reduced survival, physiological abnormalities, etc.), these impacts are much less than the likely predation effects in the main channel.

As a result, we believe that entraining larval razorback sucker into Stewart Lake (via Flaming Gorge operations) and harboring them over the summer (via Stewart Lake remediation efforts) offer a net benefit to the species. While there may be some level of incidental take⁵ from selenium levels in the lake, this take is covered in the 2005 BO for operation of Flaming Gorge. We would like to compliment Reclamation, the UDWR, and other partners for improving conditions of Stewart Lake and are confident complete remediation will occur in the near future.

Base Flow Request

Because of projected drier than average year conditions, we believe that base flow augmentation is a very important consideration for 2013. Base flows are important for a variety of ecological reasons, such as increased resource and habitat availability. We propose the following approach to base flow operations in 2013, which mirrors our recommended approach in 2010 and 2012. The 2010 and 2012 proposals relied on the most up-to-date research available. Biological data collected those years indicated that numbers of Colorado pikeminnow continue to improve.

Our understanding is that Reclamation will identify a Reach 1 base flow target commensurate with the April - July hydrologic condition in accordance with the ROD and the BO. The Reach 1 target will create 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 Reclamation does not operate under a classification drier than the official base flow classification and also releases higher flows than the scheduled base flow target through September 30, 2012. We understand that Reclamation 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 Reclamation augment the Reach 1 calculated base flow target by as much as 40%. For example, if Reclamation 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

⁴ UDWR is operating a weir to prevent large bodied fish from entering Stewart Lake in 2013

⁵ As defined under the Endangered Species Act

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 requests in 2008, 2009, 2010, 2011, and 2012, 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 138⁶ – Interagency Standardized Monitoring Program (Table 2). 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 years, 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 2). We understand that there are many variables that could have contributed 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 by providing consistent high-quality backwater habitat throughout the summer growing season.

In response to our 2012 request, Reclamation augmented flows in Reach 2 before September 30th, as much as water supply allowed (Table 1). At the Jensen gauge (Reach 2) average flows decreased from approximately 1700 cfs on July 15th to 1280 on

⁶ Can be found online at : <http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2012/rsch/138.pdf>

September 30th. Augmented flows were highest in early summer, with releases from Flaming Gorge being approximately 1300 cfs until September 7th. From September 10th until September 30th, releases averaged approximately 1120 cfs as the water supply outlook worsened. Overall, the summer base flow period had an average flow of approximately 1443 cfs at the Jensen Gauge.

Table 1. 2012 Flows in Reach 2 of the Green River.

	Base flow period	Comparison of augmented flow throughout season	
	July 15 th to Sept. 30 th	July 20 th to Sept. 6 th	Sept. 10 th to Sept. 30 th
Typical Flaming Gorge releases (Reach 1)	n/a	1330 cfs	1120 cfs
Average flow at Jensen Gauge (Reach 2)	1443 cfs	1490 cfs	1280 cfs

September sampling⁷ in the middle Green River, when flows were close to 1300 cfs at Jensen, demonstrated that backwater habitats were reduced in area and depth – likely due to decreased base flows (Skorupski et al. 2012, p. 3). UDWR captured 2 age-0 Colorado pikeminnow and 0 juvenile pikeminnow in backwater habitats, representing the second lowest catch rates since 1990 (Skorupski et al. 2012, p. 3 & p. 9). Contrastingly, sampling in the Yampa River in June through August of 2012 indicated that it was a relatively strong year for reproduction for Colorado pikeminnow as many larvae were captured and the spawning season was very long (Bestgen et al. 2012, p. 6). These results likely indicate that Colorado pikeminnow spawning was strong throughout the Green River basin in early summer (June and July) but as backwater habitat dried throughout the summer, young fish were forced to main channel habitats.

Predicted 2013 conditions are again drier than average, indicating that this year the FGTVG should 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. Results from 2012 suggest that low base flows in September prematurely reduced backwater habitat quality and likely forced any juvenile or age-0 Colorado pikeminnow into the mainstem channel before the growing season ended. Maintaining consistent base flows throughout September allows young fish to reach adequate size before entering the main channel habitat.

Most above-average Colorado pikeminnow recruitment events in the middle and lower Green River occurred when summer flows ranged from about 1,800 to 2,700 cfs (Bestgen 1997; in Muth et al. 2000). Similarly, most below-average Colorado pikeminnow recruitment events occurred when flows were below 1350 cfs. 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

⁷ Annual monitoring for YOY Colorado pikeminnow began 17 September 2012 and was completed on 27 September 2012.

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.”

Table 2. Age-0 Colorado pikeminnow (CPM) standardized catch and corresponding flow conditions in Reach 2 as measured by the USGS at their Jensen, Utah gage. Green rows indicate successful Colorado pikeminnow reproduction, blue rows indicate flows exceeding the Colorado pikeminnow ecological threshold, red lines indicate years where flows were below 1000 cfs.

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 ⁸	8660	
2012	2	1443	

Goal 2: Hinder smallmouth bass reproduction

Smallmouth bass have become a problematic nonnative species in the Upper Colorado River Basin, preying on native species & competing for resources. Understanding smallmouth bass spawning periodicity and adjusting flow releases from Flaming Gorge Dam accordingly will likely help with disruption of the species’ reproduction and lead to a reduction in the overall population. Smallmouth bass spawning and recruitment is often favored by lower flows and associated warmer water temperatures (Graham and Orth 1986, Swenson et al. 2002), thus higher flows coupled with lower water temperatures may prove detrimental to smallmouth bass reproduction. Studies in other parts of the range of smallmouth bass have shown that weather-related water temperature reductions or increased flow events reduce their spawning success and number of offspring. Specifically, high flows can be associated with year-class failures (Smith et al. 2005) and may sweep eggs or fry from nursery areas (Mason et al. 1991). Reduced water temperatures often result in abandonment of spawning

⁸ 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. 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).

nests by the guarding male bass, after which developing eggs and just-hatched young are susceptible to predation and other mortality factors. Smallmouth bass may also be susceptible to increased turbidity or siltation which can disrupt spawning or feeding (Berkman and Rabeni 1987; Sweka and Hartman 2003). Further, smallmouth bass often inhabit regulated rivers where static, stable flow regimes provide favorable habitat and managing flows to provide a more variable flow regime may make it more difficult for this species to persist (Mims and Olden 2012).

Information from the Upper Colorado River Basin continues to indicate that higher and cooler base flows delay smallmouth bass spawning and reduce growth of the age-0 smallmouth bass cohort. 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). Smallmouth bass in the Green River-Lodore Canyon study area first hatch

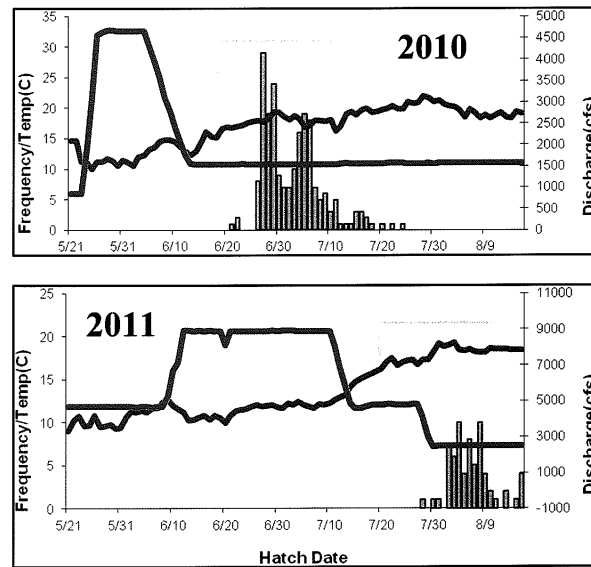


Figure 1. Comparison of flow (green), water temperature (purple), and onset of 16° C water temperature (gray arrow) in Lodore Canyon (Green River - Reach 1), 2010 & 2011. Distributions of hatching dates of, including first hatching in 2010 and 2011 and hatch duration in 2010. Bass were collected from the Green River in Lodore Canyon. Left vertical axis is the frequency of fish in histograms or water temperature; right vertical axis is Green River discharge (in cubic feet per second).

well after spring peak releases decline and just slightly after (usually within one week) mean daily water temperatures regularly exceed 16°C. During years with relatively wet or cool springtime periods (2011), smallmouth bass spawning occurred nearly three weeks later than during a year with drier, warmer conditions (2010). The same relationship has been

observed on the Yampa River. Hatching date and the extent of the reproductive season was much shorter in 2011 when high flows were relatively cool. The 2012 water temperatures suggest a relatively late initiation of hatching as well, and that is supported by capture of very few and relatively small bass in Lodore Canyon in late-July. High flows and associated cool temperatures appear to not only delay spawning but also slow the growth rates of age-0 smallmouth bass which decreases their likelihood for overwinter survival (Shuter et al. 1980; Lawrence et al. 2012).

Conclusion

In summary, we request that Reclamation:

- Time spring flow releases from Flaming Gorge to correspond with the presence of wild produced razorback sucker larvae according to the LTSP in order to improve entrainment success;
- Attempt to meet connection at Stewart Lake for 6 consecutive days and target wetlands with higher connecting flows if Yampa River flows allow;
- Work with the UDWR to operate Stewart Lake water supplies for selenium remediation efforts equivalent to the past, by filling the lake following a Green River connection and draining later in the summer; and
- Enhance summer base flows in Reach 2 of the Green River 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 2013 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. Furthermore, we believe that these operations are consistent with the existing BOs for Flaming Gorge and Stewart Lake and the Flaming Gorge ROD.

We thank Reclamation 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 at 801-975-3330 ext. 143.

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.
- Berkman, H.E. and C.F. Rabeni. 1987. Effect of siltation on stream fish communities. *Environmental Biology of Fishes* 18:285-294.
- 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 temperature, and floodplain wetland availability. Final Report to the Upper Colorado River Endangered Fish Recovery Program. Larval Fish Laboratory Contribution 163.
- Bestgen, K.R., A. Weber, and T. Jones. 2012. Interagency Standardized Monitoring Program Assessment of Endangered Fish Reproduction in Relation to Flaming Gorge Operations in the Middle Green and Lower Yampa Rivers-Yampa and Middle Green River Assessment of Colorado Pikeminnow and Razorback Sucker Larvae. FY 2012 Annual Project Report, Colorado River Recovery Program Project Number 22f.
- Graham, R.J., and D.J. Orth. 1986. Effects of temperature and streamflow on time and duration of spawning by smallmouth bass. *Transactions of the American Fisheries Society* 115:693-702.
- 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.
- Lawrence, D. J., J. D. Olden, and C. E. Torgersen. Spatiotemporal patterns and habitat associations of smallmouth bass (*Micropterus dolomieu*) invading salmon-rearing habitat. *Freshwater Biology* 57:1929-1946.
- Mason, J. W., D. J. Graczyk, and R. A. Kerr, 1991. Effects of runoff on smallmouth bass populations in four southwestern Wisconsin streams. Pages 28-38 in D. C. Jackson, editor. First International Smallmouth Bass Symposium. Mississippi State University, Mississippi State.
- Mims, M. C., and J. D. Olden. 2012. Life history theory predicts fish assemblage response to hydrologic regimes. *Ecology* 93:35-45.
- Montgomery, J. C., D. H. Fickeisen, and C. D. Becker. 1980. Factors influencing smallmouth bass production in the Hanford area, Columbia River. *Northwest Science* 54:296-305.

- 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.
- Skorupski, J.A., M.J. Breen, B.J. Kiefer, and K. Creighton. 2012. Young-of-the-year Colorado pikeminnow monitoring. FY 2012 Annual Project Report, Colorado River Recovery Program Project Number 138.
- Smith, S. M., J. S. Odenkirk, and S. J. Reeser. 2005. Smallmouth bass recruitment variability and its relation to stream discharge in three Virginia Rivers. North American Journal of Fisheries Management 25:1112-1121.
- Sweka, J.A., and K.J. Hartman. 2003. Reduction of reactive distance and foraging success in smallmouth bass, *Micropterus dolomieu*, exposed to elevated turbidity levels. Environmental Biology of Fishes 67:341-347.
- Swensen, W. A., B. J. Shuter, D. J. Orr, and G. D. Heberling. 2002. The effects of stream temperature and velocity on first-year growth and year-class abundance of smallmouth bass in the upper Mississippi River. American Fisheries Society Symposium 31:101-113.
- Stewart Lake Working Group. 2013. Stewart Lake Annual Meeting Minutes (Draft).
- 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 2013



Flaming Gorge Technical Working Group

Proposed Flow and Temperature Objectives for 2013



U.S. Department of the Interior
Bureau of Reclamation

May 2013

Table of Contents

Introduction.....	3
Proposed Flow and Temperature Objectives for 2013	3
Proposed 2013 Spring Flow Objectives.....	3
Proposed Base Flow and Temperature Objectives for Base Flows 2013.....	4
Basin Hydrology.....	6
Green River Basin Hydrology	6
Yampa River Basin Hydrology.....	7
Probabilities of Flow Events for Spring 2013	7
Recovery Program Research Request.....	9
Record of Decision Spring Flow Objectives	10
Moderately Dry Classification	11
Dry Classification	11
Average (Below Median) Classification	12
Average (Above Median) Classification	12



U.S. Department of the Interior
Bureau of Reclamation

May 2013

Proposed Flow and Temperature Objectives

Water Year 2013

Introduction

This proposal details the Flaming Gorge Dam 2013 operational plan and is produced pursuant to the February 2006 Record of Decision for the Operation of Flaming Gorge Dam (ROD; Reclamation 2006), the Operation of Flaming Gorge Dam Final Environmental Impact Statement (FEIS; Reclamation 2006), and 2005 Final Biological Opinion on the Operation of Flaming Gorge Dam (2005 BO; Service 2005).

The Flaming Gorge Technical Working Group (FGTWG) was established pursuant to the FEIS and ROD. 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 Upper Colorado Endangered Fish Recovery Program (Recovery Program) into the flow proposal so that Recovery Program research could also be facilitated. Members of the FGTWG include biologists and hydrologists from the Bureau of Reclamation (Reclamation), the U.S. Fish and Wildlife Service (Service), and Western Area Power Administration (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.

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., 2000), (Flow Recommendations). The Flow Recommendations provide the basis for the proposed action outlined 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).

Proposed Flow and Temperature Objectives for 2013

Proposed 2013 Spring Flow Objectives

For the purposes of implementing the ROD in 2013, an evaluation has been made of the current hydrologic conditions in the Upper Green River (*i.e.* above Flaming Gorge Dam) and Yampa River Basins. The evaluation centered on the historical unregulated inflow statistics for Flaming Gorge Dam during the period from 1963 through 2012. Based on these statistics and the May 1, 2013 final forecast of 480,000 acre-feet for Flaming Gorge, the hydrologic classification will be moderately dry (70% to 90% exceedance) for spring 2013. The combined April through July forecast of the Yampa River at

Maybell and Little Snake at Lily is 778,000 acre-feet. This forecast would fall into the moderately dry hydrologic classification of the ROD.¹

Reclamation received and provided to the FGTWG a memorandum dated February 26, 2013, from the Director of the Recovery Program providing the Research Request for 2013 Green River Spring Flows (2013 Spring Flow Request). The 2013 Spring Flow Request is that the FGTWG implement 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 *ad hoc* Committee 2012) (LTSP) and is described in further detail in the Recovery Program Research Request section of this document.

The May final forecasts for both the Upper Green and Yampa River Basin are in the moderately dry hydrologic classification. The Upper Green and Yampa River Basins are anticipated to continue to receive smaller amounts of precipitation through mid-May. Reclamation recommends operating within the official moderately dry hydrologic classification. The LTSP outlines peak flows under the moderately dry classification measured at Jensen, Utah above 8,300 cfs for a period between 7 to 14 days during larval drift. According to the LTSP, these flows will provide connection at the Stewart Lake, Above Brennan and Old Charley Wash floodplains. Reclamation recommends shortening the moderately dry duration during larval drift and decreasing Flaming Gorge Dam releases to base flow levels if peak flows resulting from the combination of Yampa River flows and Flaming Gorge releases no longer provide connection or benefit to razorback sucker and the targeted floodplain gates are closed.

Proposed Base Flow and Temperature Objectives for Base Flows 2013

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 July 1, 2013. 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 (Figures 1 and 2). Pursuant to the Flow Recommendations, during the August through November base-flow period, the daily flows should be within $\pm 40\%$ of mean base flow. During the December through February base-flow period, the daily flows should be within $\pm 25\%$ 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 2013 (June through August).

¹ Appendix A illustrates the May 1, 2013, final forecast for Flaming Gorge Reservoir and the Yampa River Basin in relation to the hydrologic categories described in the Flow Recommendations.

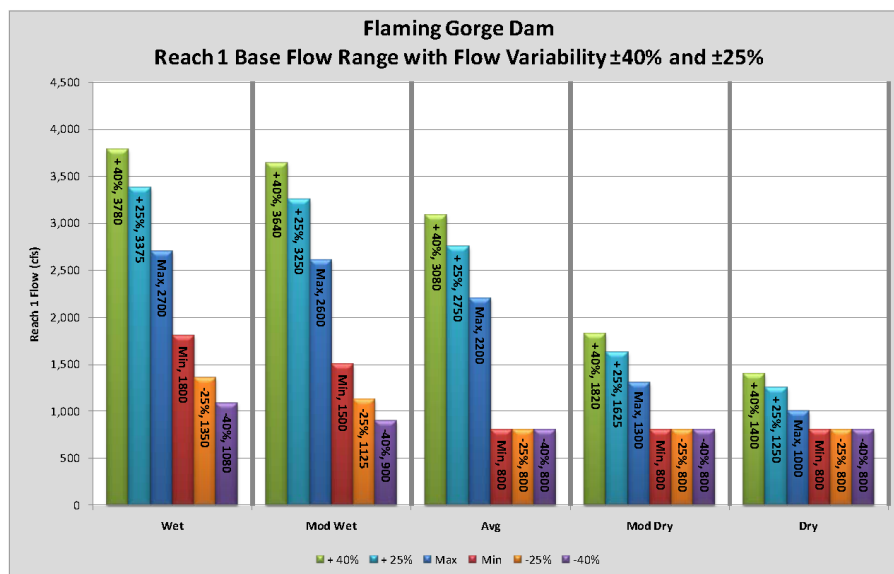


Figure 1 – Reach 1 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.

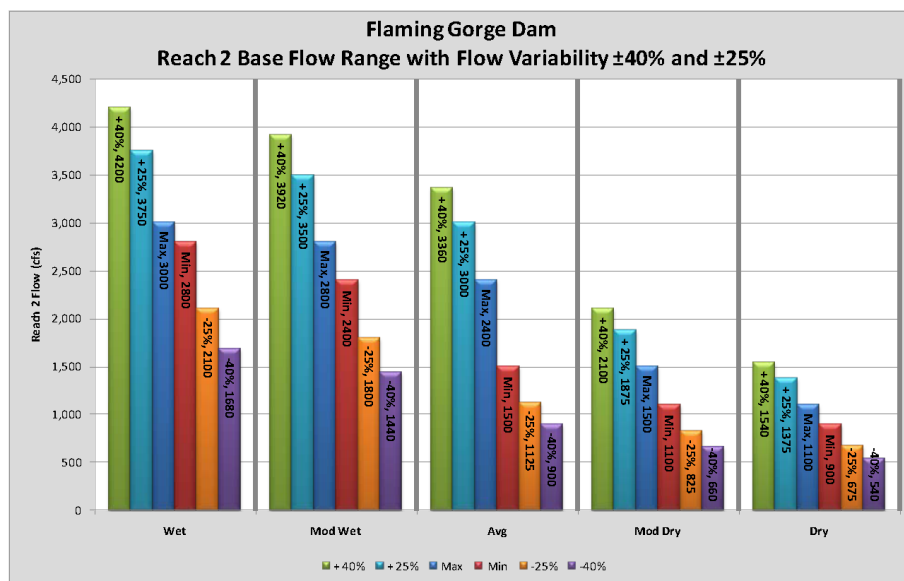


Figure 2 – Reach 2 Base Flow Ranges for each Hydrologic Classification as Outlined in the ROD.

Basin Hydrology

Green River Basin Hydrology

The May 1, 2013, final forecast of April through July unregulated inflow (current forecast) for Flaming Gorge Reservoir is 480,000 acre-feet (AF) (49% of 30-year average). This forecast falls at approximately 87% exceedance based on the historic unregulated inflow record (1963-2012). Figure 3 shows the current forecast in relation to the historic unregulated inflow volumes.

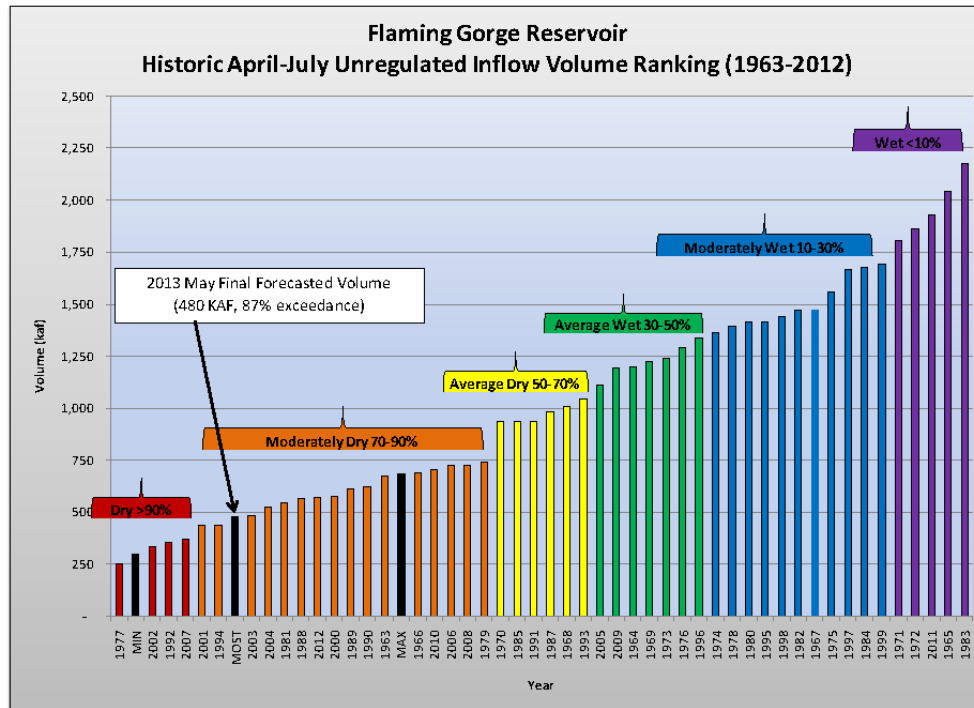


Figure 3 – Flaming Gorge Reservoir May final forecast and ranked historic unregulated April through July inflow volume for years 1963-2012.

As of May 1, 2013, Flaming Gorge Reservoir had a water surface elevation of approximately 6020.5 feet above sea level. There is approximately 3.000 million acre-feet of live storage (79% storage capacity) in Flaming Gorge and approximately 0.75 million acre-feet of space.

Yampa River Basin Hydrology

The combined current forecast for the Little Snake at Lily plus Yampa River at Maybell is 778,000 AF (61% of 30-year average). This forecast falls at approximately 84% exceedance based on a ranking of the historic record (1922-2012). Figure 4 below shows the current forecast in relation to historic flow volumes.

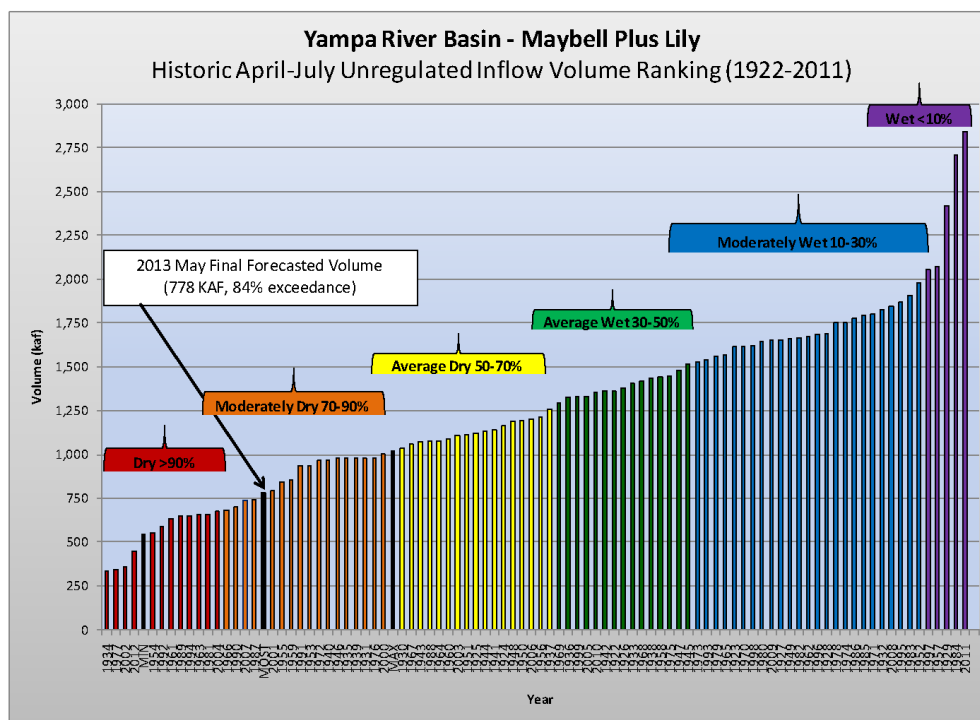


Figure 4 – Yampa River Basin (Maybell plus Lily) current forecast and ranked historic unregulated April through July inflow volume for years 1922-2012.

Hydrologic conditions in the Yampa River Basin are moderately dry and spring runoff conditions will likely have a significant effect on the efficiency of the 2013 spring peak.

Probabilities of Flow Events for Spring 2013

The Flaming Gorge unregulated inflow and Yampa River forecasts are moderately dry and trending solidly toward dry. Conditions this year are uncannily similar to 2012, except with drier antecedent soil conditions and lower reservoir storage. An analysis was completed to assist in the determination of appropriate flow objectives for spring and summer 2013. 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.

The Yampa most probable flow volume of 778,000 AF is close to 2001. 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, 2013 Final Forecast
Thousand Acre-Feet (KAF)

Year	April-July Unreg Inflow Volume (KAF)
MIN	546
2004	678
1966	679
1990	703
2007	736
1987	746
MOST	778
2001	790
1955	845
1959	852
1991	934
1953	938
MAX	1,020

Table 2
Spring 2013 – Days above Specific Flow Thresholds in the Yampa River (Maybell plus Lily)
Based on the May 1, 2013, Final Forecast
Percent Exceedance (%)

May Final Forecast	% Exceed	Days above 4,000 cfs	Days above 5,000 cfs	Days above 6,000 cfs	Days above 7,000 cfs	Days above 8,000 cfs	Days above 9,000 cfs	Days above 10,000 cfs
YAMPA	25%	44	35	24	15	8	5	2
	50%	40	31	19	12	3	0	0
	75%	33	17	11	5	1	0	0
	90%	30	14	8	3	0	0	0

Recovery Program Research Request

Reclamation received and provided to the Flaming Gorge Technical Working Group (FGTWG) a memorandum dated February 26, 2013, from the Director of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) providing the Recovery Program's Research Request for 2013 Green River Spring Flows (2013 Spring Flow Request).

The Recovery Program requests that the FGTWG implement the LTSP by matching 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 LTSP describes a range of floodplain scenarios that they would like to study and how they would evaluate the results. Additionally, the 2013 Spring Flow Request's primary objective is to build on past research to benefit the razorback sucker population throughout the Green River by timing the river-floodplain connection with the presence of wild-produced razorback sucker larvae. (2013 Spring Flow Request) The 2013 Spring Flow Request supports operations consistent with the 2005 BO and ROD.

The 2013 Spring Flow Request references research regarding the magnitude and period of inundation at the Stewart Lake site. Stewart Lake was limited last spring due to sedimentation in the inlet channel that occurred during the high flows of 2011. During summer 2012, UDWR excavated the inlet channel to restore connection conditions more consistent with those described for this site in the LTSP. Also, personnel from Western Area Power Administration (Western), Argonne National Laboratories (funded by Western), and the Recovery Program surveyed Reach 2 levee breach elevations in Autumn 2012 to better assess connection flows for future LTSP experimentation. The Recovery Program is hopeful the results of those surveys are available to the Recovery Program and the FGTWG this spring. (2013 Spring Flow Request)

The experimental timetable is to achieve 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. However, spring peak flow magnitudes will be driven by hydrologic conditions in the Upper Green River Basin; therefore, it may not be possible to complete the experiment in six consecutive years. (2013 Spring Flow Request)

Table 3 is a copy of the matrix found in Table 2 of the LTSP. It describes the flow conditions and corresponding wetlands.

Table 3 – 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
f = flow-through wetland, s = single-breath wetland Up to eight wetlands would be sampled in a given year with the three in the lowest flow category being sampled in all years. Refer to Table [4] 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.				

Record of Decision Spring Flow Objectives

The 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 2013 are as follows:

Moderately Dry Classification

If the April through July unregulated inflow into Flaming Gorge Reservoir remains in the range from 428,000 AF to 779,000 AF the hydrological classification would be moderately dry. The ROD spring flow objectives for moderately dry years are:

The peak flow as measured at Jensen, Utah this year would correspond with the moderately dry hydrologic condition. The LTSP outlines moderately dry flows between 8,300 cfs and 14,000 cfs at Jensen for a period between 7 to 14 days, and minimum seven-day duration. These flows provide connection at the Stewart Lake, Above Brennan and Old Charley Wash floodplains.

The ROD spring flow objectives for moderately dry years are:

Table 4 – 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

Dry Classification

Hydrologic conditions are similar to those in the spring of 2012. It is likely that hydrologic conditions into Flaming Gorge Reservoir will change before implementation of the proposed 2013 flow objectives. In the event conditions become drier and the Flaming Gorge Reservoir unregulated inflow forecast for April through July falls below 428,000 AF, the hydrological classification would be dry.

The peak flow as measured at Jensen, Utah, would correspond with the dry hydrologic condition with flows greater than 8,300 cfs for a period between 1 to 7 days, with an attempt to meet the minimum seven-day duration. These flows provide connection at the Stewart Lake, Above Brennan and Old Charley Wash floodplains.

ROD spring flow objectives for dry years are:

Table 53 – 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

Average (Below Median) Classification

If conditions become wetter than the current forecast at Flaming Gorge Reservoir and the April through July forecast increases above 779,000 AF, the hydrological classification would be average (below median). ROD spring flow objectives for average (below median) years are:

Table 6 – Average (Below Median) 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 in 50% of average years	One week (i.e. 7 days) in 50% of average years

Flow Recommendations and FEIS

Average (Above Median) Classification

If conditions become wetter than the current forecast at Flaming Gorge Reservoir and the April through July forecast increases above 1,045,000 AF, the hydrological classification would be average (above median). ROD spring flow objectives for average (above median) years are:

Table 7 – Average (Above Median) 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

Flow Recommendations and FEIS

Literature Cited

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

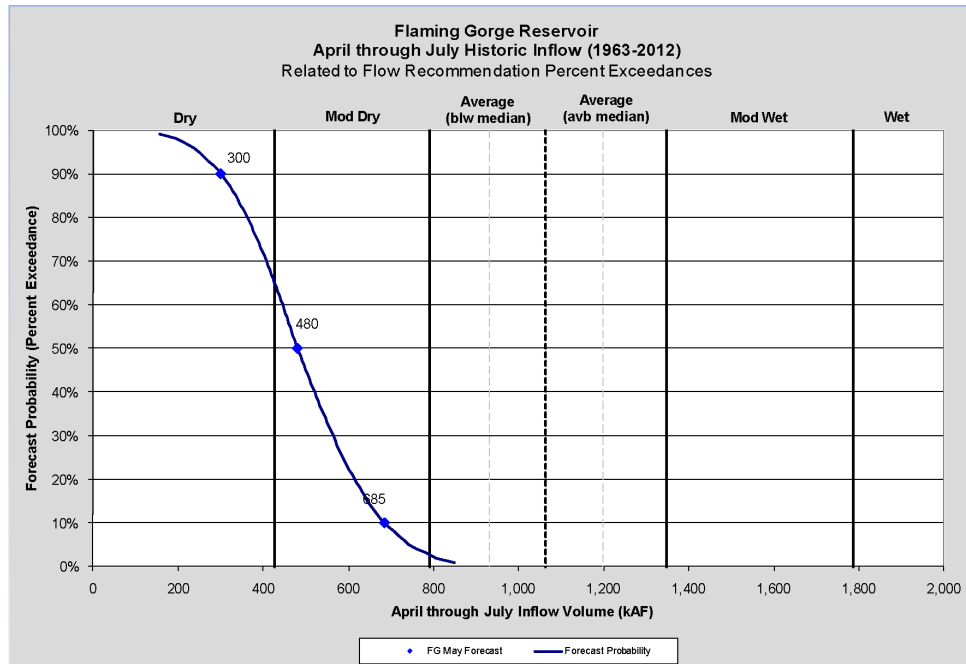
Larval Trigger Study Plan ad hoc Committee. 2012. Study Plan to Examine the Effects of Using Larval Razorback Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam Peak Releases. U.S. Fish and Wildlife Service, Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

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. February 26, 2013. Memorandum to Larry Walkoviak and Heather Hermansen. Recovery Program Research Request for 2013 Green River Spring Flows. U.S. Fish and Wildlife Service, Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

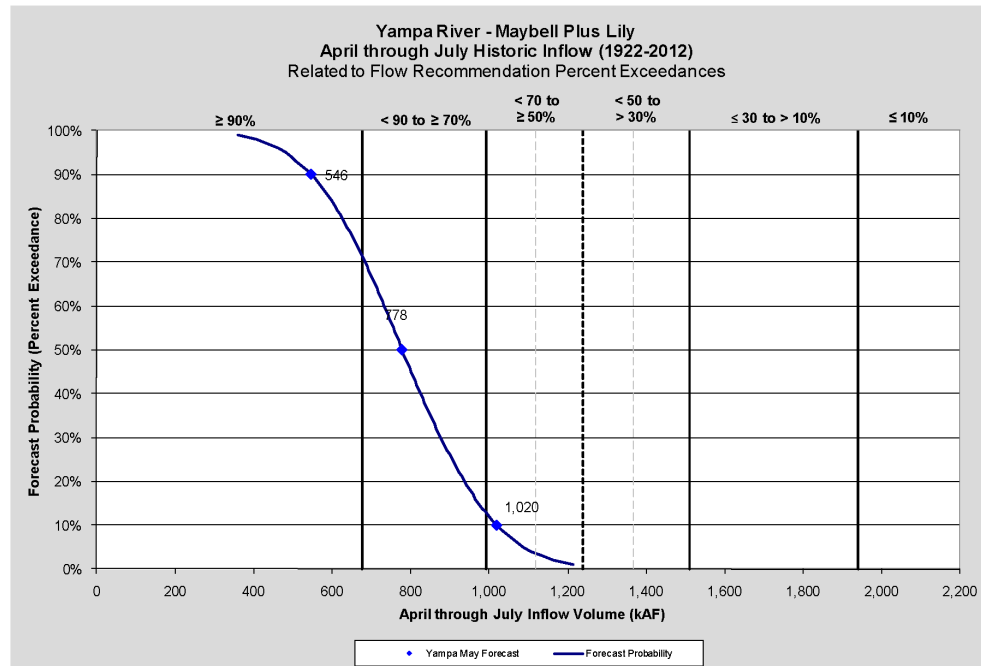
APPENDIX A

March 4, 2013 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

March 4, 2013 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

Comment Letters Received through the Flaming Gorge Working Group Process



GARY R. HERBERT
Governor

GREGORY S. BILL
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-cading. 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





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

ON FILE SUBJECT:

UC-436

WTR-1.10

AUG 09 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

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

WBR:Hermansen:abaker:8/8/2012:801-524-3883

TAWRG\Heather\Response_UDWR_FallElectrofishing.docx