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Annual Report of Operations for Flaming Gorge Dam Water Year 2017

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Introduction

This report details the operations of Flaming Gorge Dam during water year 2017 and is produced pursuant to the February 2006 Record of Decision for the Operation of Flaming Gorge Dam (ROD) (USBR, 2006), the Operation of Flaming Gorge Dam Final Environmental Impact Statement (FEIS) (USBR, 2005) and the 2005 Final Biological Opinion (BO) on the Operation of Flaming Gorge Dam (USFWS, 2005). This is the twelfth year of operations of Flaming Gorge Dam under the ROD. This report will entail that information as well as hydrologic conditions to support flow regimes.

The ROD directs Reclamation to operate to achieve, to the extent possible, the Flow Recommendations as described in the FEIS (USBR, 2005). 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).

As described in ROD (USBR, 2006): *“The administrative record referenced in Section 2.5.3 of the EIS and on page 4 above will include*

- *an annual report to document the technical working group’s [known as the Flaming Gorge Technical Working Group (FGTWG)] recommendations and discussions;*
- *Reclamation’s target flow regimes on a season by season basis;*
- *analysis of previous operations as related to recommendations and targets;*
- *a long term analysis of the frequency of achieving the flow thresholds described in the 2000 Flow and Temperature Recommendations (Muth et al., 2000).”*

and stated in the FEIS (USBR, 2005)

- *“An administrative record of the operational decisionmaking would be maintained and available to the public. This record would include analysis of previous operations and the effectiveness of achieving desired targets on a year-by-year basis.*
- *Technical Working Group [FGTWG] meetings would also provide an opportunity to discuss historic operations in terms of the accomplishments and shortcomings of meeting the 2000 Flow and Temperature Recommendations. Reclamation would maintain an administrative record of these meetings to document the planning process.”*

Finally, the USFWS 2005 BO (USFWS, 2005) has requirements for an annual report. It is as follows: *“Reclamation will provide to the Service and Recovery Program a concise annual operations report. A primary purpose of the annual report is to provide an assessment of how well operations at Flaming Gorge Dam contributed to meeting flow targets. In addition, the annual report will provide a record of operations as identified under the incidental take statement. Basic information that should be summarized includes the following:*

- *A review of the April-July unregulated inflow forecasts provided by the National Weather Service via the River Forecast Center that were used to classify Green River hydrology.*
- *Additional factors that were used to determine which flow recommendation hydrologic category was targeted (e.g. Flaming Gorge Reservoir elevation, Yampa hydrology, past operations, power needs, Technical Working Group conversations, etc.),*

- *An accounting of actual flows and operations: spring flows and baseflows (reference [United States Geological Survey (USGS)] gages at Yampa River at Deerlodge, Green River at Greendale, Utah Jensen, Ut, and near Green River, Ut),*
- *Results from Reclamation's spillway inspections,*
- *A summary of daily and seasonal fluctuations at Jensen, Utah,*
- *An overview of Reclamation's operations to meet thermal targets,*
- *An accounting of the actual thermal regime in upper and lower Lodore Canyon and the lower Yampa River based on available information.*
- *Recommendations to refine operations.*

Operational Plan Development and Process for Water Year 2017

In 2017, the operational process developed in 2006 was used to operate Flaming Gorge Dam. The operational plan development was based on the FEIS (Section 2.5.3) (USBR, 2005) and the commitments in the ROD (Sections VI, and VII) (USBR, 2006). The four-step process is described below.

Four-Step Process of developing and finalizing the Annual Operation Plan

The four-step process is a term used to discuss the ROD requested, proposed, development, comment/input and finalization of the Flaming Gorge Operation Plan. This process will concurrently fulfill informal consultation and Endangered Species Act coordination requirements for the action agencies. Below is a brief description of the four-step process,

1. The Upper Colorado River Endangered Fish Recovery Program (Recovery Program) may provide a request
2. A technical working group, known as FGTWG, consisting of biologists and hydrologists from Reclamation, Western Area Power Administration (WAPA) and the Fish and Wildlife Service (FWS), will annually propose an initial flow regime to the existing Flaming Gorge Working Group.
3. The Flaming Gorge Working Group will then provide comments and input on the proposed flows relative to all resource concerns.
4. Reclamation will then make a determination on how to incorporate the additional information into the annual operational plan.

Pertinent dates of Four Step Process 2017

The Recovery Program request was received on April 17, 2017. The key portion of the request is presented below. The Larval Trigger Study Plan (LTSP) refers to the final Study Plan to Examine the Effects of Using Larval Razorback Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam Peak Releases (ad hoc Committee, March 2012 (LTSP) (2012)).

THE RECOVERY PROGRAM'S 2017 GREEN RIVER FLOW REQUEST:

The Recovery Program's 2017 Green River Flow Request comprises two components: a Larval Trigger Study Plan (LTSP ad hoc committee 2012) spring peak and experimentation with alternative Reach 2 base flow target ranges that should be achieved coincident with the presence of drifting Colorado pikeminnow larvae and maintained through September 30. The Recovery Program believes all aspects of this request are supported by sound science and we understand that achieving both components may not

be possible based on water availability and operational considerations. The Recovery Program assumes that our 2017 flow requests will be refined in concert with the FGTWG using the best available flow forecast information. To assist Reclamation and the FGTWG, should such deliberations be necessary, the Recovery Program prioritizes these flow experiments as follows:

Priority 1 - LTSP spring peak (as per LTSP ad hoc committee 2012)

Priority 2 - New, proposed Reach 2 base flow ranges as per Bestgen and Hill (2016a) (as feasible within existing authority under the 2006 ROD).

The Flaming Gorge Technical Working Group (FGTWG) first met on March 8, 2017 and met 5 times through July 28, 2017. No FGTWG Proposal was created. The Recovery Request was both the FGTWG Proposal and Operation Plan.

Flaming Gorge Work Group Meetings were held on March 16, 2017 in Price, Utah; April 20, 2017 in Vernal, Utah; and on August 14, 2017 in Vernal, Utah.

Larvae were detected on June 3, 2017. Releases from Flaming Gorge were increased to full powerplant capacity and additional bypass on June 5, 2017. In combination, the peak release was approximately 8,600 for a total of 27 days, from June 5, 2017 to July 4, 2017.

Reclamation operated Flaming Gorge Dam to produce flows in Reach 2 to assist in the recovery of Colorado Pikeminnow during the summer of 2017. The 2017 April to July observed Flaming Gorge unregulated inflow was 2,214,000-acre feet, which was near a 1% exceedance value. The Yampa river inflow exceedance value was much lower near a 63% exceedance value. The base flow period hydrologic classification was wet as of August 2017. Daily base flows fluctuated during the summer to meet or exceed 2,400 cfs on the Green River at Jensen, Utah through September 30, 2017. This targeted flow range was not met during a dam inspection (dive inspection, August 27 to August 31).

Operation Decision

The Recovery Program request and intended FGTWG proposal had the same two elements concerning the flow regimes for the LTSP (2012) spring peak and alternative Reach 2 base flow target ranges for use with the ROD seasonal base flow variability.

The Recovery Program's 2017 Spring Flow Request established a release regime that facilitated further research under the LTSP. The LTSP's primary research objective was 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 second flow regime request was to use the seasonal base flow flexibility identified in the 2006 ROD to achieve revised range of summer base flows (Bestgen and Hill, 2016) intended to improve survival of age-0 Colorado pikeminnow (*Ptychocheilus lucius*). While this request from the Recovery Program did not have a valid study plan at the time of implementation, it was determined that the requested summer base flows could be achieved for all hydrologic conditions within the +/-40% flexibility allowed in the 2000 Flow and Temperature Recommendations (Muth et al., 2000). Therefore, to the maximum extent possible the objective flows in Reach 2 were attempted between the Request and 2000 Flow and Temperature Recommendations (Muth et al., 2000).

The summer-autumn and winter base flows periods followed the 2000 Flow and Temperature Recommendations (Muth et al., 2000).

Hydrology

Reservoir storage in Flaming Gorge increased during water year 2017. At the beginning of water year 2017, Flaming Gorge storage was 85 percent of live capacity at elevation 6,026.27 feet with 3,210,000-acre feet in storage. The unregulated inflow to Flaming Gorge during water year 2017 was 3,150,000-acre feet which is 217 percent of average. At the end of the water year, Flaming Gorge storage was at 94 percent of live capacity at elevation 6,033.63 feet with 3,490,000-acre feet resulting in a net increase during water year 2017 of 284,000-acre feet.

The hydrologic conditions during spring 2017 consisted of above average snow accumulation beginning in December 2016 and continuing through February 2017, although wet fall soil moisture conditions and much above average snowpack in higher elevations resulted in record forecasted inflows. Flaming Gorge unregulated inflows in March of 400,000-acre feet (392 percent of average). Snow water equivalent peaked on May 4, 2017 at 194 percent of average. The May final forecast for the April through July unregulated inflow volume into Flaming Gorge Reservoir was 2,260,000-acre feet which is 226 percent of average. Yampa River spring peak flows were significantly different than the Upper Green and fell into the average (below median) hydrologic condition. Yampa River conditions were average (below median), while the observed spring flows were average (below median) as well.

Table 1 –April – July Forecasts and Spring and Base Flow Hydrologic Classifications

Year	May 1st A-J Unregulated Inflow Forecast (1000 AF)	Spring Hydrologic Classification	Observed A-J Unregulated Inflow (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
2014	1,320	Average (Abv Median)	1,159	Average (Blw Median)
2015	570	Moderately Dry	1,035	Average (Blw Median)
2016	770	Moderately Dry	1,047	Average (Blw Median)
2017	2,260	Wet	2,214	Wet

Autumn and Winter Base Flow for Water Year 2017

Base Flow Calculation Autumn and Winter Water Year 2017 -- The autumn and winter base flow target were established using the June 2016 Most 24-Month Study. Autumn and winter base flow to achieves a 6,027 feet elevation by March 1, starting at a pool elevation of 6,031.03 feet, approximately 1670 cfs of dam releases achieved this condition. The average daily release during October – November is approximately 1,300 cfs, which is -22% of the calculated base flow at the Dam. Releases in December 2016, January 2017, and February 2017 started at 1,800 cfs which

was approximately +8% above this base flow target calculated in June. Due to the raising wetter conditions in late February operation were such to anticipate more volume of inflow that releases were increased to 2,400 cfs. As a result of this elevated base flow the pool elevation on March 1, 2017 was 6,023.03 feet.

Two base flow objectives were targeted during water year 2017.

3% Daily Flow Changes -- As described in the FEIS, flow changes no greater than 3% of the total river flow are to occur during the base flow period. During water year 2017, release changes during the base flow periods were limited to no more than 50 cfs per day and this largely achieved the daily flow change restriction throughout the base flow periods during water year 2017

Jensen 0.1- stage change -- As described in the 2000 Flow and Temperature Recommendations (Muth et al., 2000) “*Flow variation resulting from hydropower generation at Flaming Gorge Dam should be limited to produce no more than a 0.1-m stage change within a day at the USGS gage near Jensen, Utah.*”

In water year 2017, during the base flow periods Reclamation coordinated with WAPA to establish Flaming Gorge release patterns for power production. This is to meet the requirement that hydropower generation at Flaming Gorge dam should produce no more than 0.1-m stage change at the USGS Jensen Gage. To estimate the impact of proposed release patterns, a routing model called the SSARR model was used to predict stage changes under various steady flow conditions for the Yampa River. Based on results from the SSARR model, a release pattern was developed which optimized power production that also met the stage change requirement of the FEIS. As conditions changed, the release pattern was modified to attempt to maintain this daily stage change restriction.

The observed 24-hour stages during the months of October and November 2016 at the USGS Jensen gage were all below 0.165 meters. Nearly half of the 61 days has a breaking point between values above and below 0.134-meters and the average were 0.131-meters. During the months of December (2016), January (2017), and February (2017), observed 24-hour stage changes at the USGS gage were nearly all below 0.175-meters. Nearly half of the 90 days was a breaking point between values above and below 0.135-meters and the average were 0.145-meters.

USGS Gage – Greendale, UT – The autumn and winter base flow at Reach 1 targets per the 2000 Flow and Temperature Recommendations for the average condition is 800 – 2,200 cfs. The maximum and minimum at a +/- 25% is 600 – 2,750 cfs. Flows varied from October through February starting at 1,790 cfs in early October, then releases were sustained at 1,300 cfs for the autumn base flow period, then increased and was sustained at 1,800 cfs through most of the winter base flow period, ending near 2,400 late February which was measured at the USGS gage Greendale, UT.

USGS Gage – Yampa at Deerlodge Park, CO – The Yampa at Deerlodge Park (aka Yampa) gage supplements Reach 2 Targets. For the autumn and winter base flow the Yampa provided approximately 250 cfs to 550 cfs with an average near 410 cfs.

USGS Gage – Jensen, UT -- The autumn and winter base flow at Reach 2 targets per the 2000 Flow and Temperature Recommendations for the average condition is 1,500 – 2,400 cfs. The maximum and minimum at a +/- 25% is 1,125 – 3,000 cfs. Flows ranged from October through February to approximately 1,700 cfs to 2,400 cfs which was measured at the USGS gage Green River near Jensen, UT. Two distinct averages were observed first the autumn near 1,850 cfs and for the winter near 2,500 cfs. After February 10, flows increased from 3,000 cfs to near 4,500 cfs, which was due to both higher releases at the dam and inflow from tributary inflow resulting from weather events or early spring runoff.

USGS Gage – Green River, UT -- The autumn and winter base flow at Reach 3 targets per the 2000 Flow and Temperature Recommendations for the average condition is 1,800 – 4,200 cfs. The maximum and minimum at a +/- 25% is 1,350 – 5,250 cfs. Flows ranged from October through February to approximately 1,500 cfs to 8,200 cfs which was measured at the USGS gage Green River near Jensen, UT. Flows above 4,000 cfs in late February are the result of uncontrolled tributary inflow or early spring runoff. The bulk of the flows range from 2,800 to 3,600 cfs.

Spring Operations

The significant snow accumulation and record forecast volumes required Reclamation to focus on operations for wet hydrologic conditions. Larvae were detected on June 3, 2017. After public notification, releases from Flaming Gorge were increased to full powerplant capacity and additional bypass on June 5, 2017 (in combination, the peak release was approximately 8,600 cfs for a total of 27 days, from June 5, 2017 to July 4, 2017). Flaming Gorge Dam released powerplant capacity releases of 4,600 cfs for 122 days and above powerplant capacity for a total of 103 days during the April through July runoff period. Yampa River flows at the Deerlodge gage peaked twice during the spring runoff season, at 10,700 cfs on May 15, 2017 and at near 9,980 cfs on June 9, 2017. The first peak resulted from increased temperatures in the basin during May and the second from the remaining high elevation snowmelt. The peak release from Flaming Gorge occurred during the second Yampa River peak flows and supported larval entrainment and reservoir management during high spring inflows. Deerlodge flows were less than or equal to 9,980 cfs when Flaming Gorge releases were at powerplant capacity with additional bypass. Flows measured on the Green River at Jensen, Utah reached levels at or above 14,000 cfs for 14 days between June 3 and 16, 2017 with a peak of 17,900 cfs for one day on June 10, 2017. The peak flow at Jensen fell within the average (above median) hydrologic classification under the LTSP (2012).

The 2006 Flaming Gorge ROD (USBR, 2006) hydrologic classification for the Upper Green was characterized as wet. The flexibility in the ROD allows for a change in hydrology classification two higher and one lower than that designated by the unregulated inflow volume on May 1 depending upon Yampa River conditions. It was determined that, with the drier conditions in the Yampa River Basin, the hydrology classification was moderately wet and the LTSP hydrologic classification was moderately wet based on the May 1 forecast. Yampa River conditions were average (below median), while the observed spring flows were average (below median) as well.

Flows at Jensen did not meet or exceed 2006 Flaming Gorge ROD (USBR, 2006) flow targets in Reach 2 for the ROD Flow Recommendation of at least one day peak duration at 20,300 cfs and

18,600 cfs for two weeks in moderately wet years. The LTSP moderately wet flow target of between 20,300 cfs and 26,400 cfs for between one to fourteen days did not occur during larval drift.

Ramp down rates were consistent with 2000 Flow and Temperature Recommendations (Muth et al., 2000). Rates of decline for wet and moderately wet classification is 1000 cfs/day. A ramp down rate of 1,000 cfs/day was used the release rate from 8,600 to 2,600 cfs. The final ramp down for spring operation is 200 cfs to sustain flows at 2,400 cfs.

Base Flow Summer 2017

Base Flow Summer 2017 -- Hydrologic summer base flows for water year 2017 started in the first part of August 2017. From the 2000 Flow and Temperature Recommendations (Muth et al., 2000) for a wet condition the beginning of the base flow season is typically about mid-August and for a moderately wet condition the base flow season typically starts about August 1. The water year 2017 base flow was determined using both unregulated flow on the Green River and flow at Yampa River at Deerlodge. The Colorado Basin River Forecast Center (CBRFC) forecasted August 2017 unregulated inflow volume into the Flaming Gorge dam was about 145,000-acre feet which was approximately 164% of average. The average inflow for August month was 2,358 cfs calculated from the monthly CBRFC forecast. This inflow was not achieved until after August 2, 2017. The August 2, 2017 unregulated inflow into the Flaming Gorge Dam was the earliest the base flow season could be determined to have started based on this data. The August 2017 flow volume at the USGS Yampa Deerlodge gage was about 20,000-acre feet which was approximately 76% of average. The average flow for this August was 325 cfs. This flow was not achieved until August 5, 2017. The start of the base flow season was determined to start based on flows measured at the USGS Yampa Deerlodge gage when flows measured near 350 cfs. Using forecasted data on the unregulated Upper Green River and the Yampa River, estimate the summer base flow season starting in the early to middle August.

Summer base flow target in Reach 2 began on August 8 and the proposed flow targets from the Colorado Pikeminnow proposed study for a wet condition is 2,400 - 3,000 cfs and for the 2000 Flow and Temperature Recommendations (Muth et al., 2000) is 2,800 - 3,000 cfs. Maximum flexibility allows a +/-40% of the calculated base flow at Reach 2, 1,680 cfs to 4,200 cfs. The upper range of Colorado Pikeminnow study proposed flow started on August 5, 2017. End of spring operations and the start of summer operation stayed the same at a 2,400 cfs release. During the summer base flow period flows range from near 1,940 cfs to 3,000 cfs at the USGS Jensen gage (Reach 2). Flow predominately range from near 2,700 cfs to 2,900 cfs.

The Reach 1 targets for 2000 Flow and Temperature Recommendations (Muth et al., 2000) is 1,800 cfs to 2,700 cfs for a wet hydrologic classification. Targeted average daily releases predominately ranged near 2,400 except during inspecting activities. Dam inspection activities occurred where daily average ramp down rates were 300 cfs/day and this decreased releases from 2,400 cfs to 1,500 cfs. The Reach 3 targets for 2000 Flow and Temperature Recommendations (Muth et al., 2000) is 3,200 cfs to 4,700 cfs. Flows measured at the USGS gage Green River, Utah varied from about 2,080 cfs to 3,510 cfs. Flow predominately observed in Reach 3 ranged from 2,600 cfs to 3,300 cfs.

Summer 2017 base flow calculation -- The April through July 2017 unregulated inflow was 2,214,000-acre feet (226 percent of average) which fell into a wet hydrologic condition. Using the August 2017 Most Probable 24 Month Study the average releases rate from Flaming Gorge Dam to achieve the March 1 upper level drawdown target pool elevation of 6,027 was 2,560 cfs. This release rate also achieved a base flow in Reach 2 that was within the desired base flow range for the average hydrological classification. The August and September 2017 average daily predominate release rate was near 2,400 cfs (-7% of base flow at the dam) and this was slightly lower than calculated release rate but still resulted in achieving a base flow rate in Reach 2 that was within the desired range.

3% changes – The spring ramp down tied into the summer base flow that resulted in a dam release at 2,400 cfs. Dam inspection activities including a dive inspection, required flows to be reduced rapidly. Also, during the State of Utah Department of Natural Resources Division of Wildlife Resources (DNR-DWR) tailwater fishery assessment flows were rapidly reduced. This resulted in a 300 cfs/day change that is near a 16% change. This occurred from August 27, 2017 to September 8, 2020. No other flow changes occurred in the summer base flow period.

Jensen 0.1-stage change – In water year 2017, during the base flow periods Reclamation coordinated with WAPA to establish Flaming Gorge release patterns for power production. This is to meet the requirement that hydropower generation at Flaming Gorge dam should produce no more than 0.1-m stage change at the USGS Jensen Gage. Observed stage changes during this summer base flow season were at or below 0.144-meters except from the inspection period and DNR-DWR tailwater fishery assessment (August 27, 2017 to September 8, 2017). Nearly half of the 61 days had a breaking point between values above and below 0.122-meters and the average were 0.129-meters, including the inspection observed period.

Spillway Inspection

The use of the spillway will only be used for extreme dam safety situation. Inspections of the structure would be made after each spill event. The spillway was not used in water year 2017. The Service expects Reclamation to report the results of their post-spill spillway inspections in their annual operations report. The spillway was inspected on August 22-23, 2017. The spillway components including gates, inlet, chute, walls, pier, floor, tunnel / aeration slot, flip bucket area were inspected. These components of the spillway were noted as Satisfactory (will fulfill the intended purpose, (No comment required). For the 2017 inspection there are no operation and maintenance recommendations, per the Flaming Gorge Dam - Annual Site Inspection (ASI) FY 2017 Colorado River Storage Project report, concerning the spillway structure was made.

Long Term Analysis of the Frequency of Achieving the Flow Thresholds

Spring Peak Targets -- Per the ROD (USBR, 2006) long term thresholds described in the 2000 Flow and Temperature Recommendations (Muth et al., 2000) are described below. The 2017 April through July May 1st forecasted and August observed hydrologic condition during spring runoff stayed as a wet hydrologic classification. The May 2017 CBRFC forecasted April through July had a volume of 2,260,000-acre feet which was a wet condition as described by the 2012 LTSP. The August 2017 observed April through July volume was 2,214,000-acre feet which was a wet hydrologic condition as described by the 2012 LTSP. The flexibility in the

ROD allows for a change in hydrology classification two higher and one lower than that designated by the unregulated inflow volume on May 1 depending upon Yampa River conditions. Due to the implementation of the LTSP (2012), two additional hydrologic conditions were evaluated, Average below median and Average above median. It was determined that, with the drier conditions in the Yampa River Basin, the hydrology classification was moderately wet and the LTSP hydrologic classification was moderately wet based on the May 1 forecast. Yampa River conditions were average (below median), while the observed spring flows were average (below median) as well.

According to the 2012 LTSP, for a moderately wet hydrological condition, flows in Reach 2 are recommended to be between 20,300 cfs and 26,400 cfs for different durations, that is 1 to 7 days, 7 to 14 days, and greater than 14 days. According to the 2000 Flow and Temperature Recommendations, for this moderately wet condition peak flows magnitude equal and/or greater than 20,300 cfs. For the peak-flow duration recommendations, 18,600 cfs should be maintained for 2 weeks or more. The LTSP moderately wet flow target of between 20,300 cfs and 26,400 cfs for between one to fourteen days did not occur during larval drift. Also, the 2000 Flow and Temperature Recommendations duration of greater than 18,600 cfs did not occur for any days.

Flows measured on the Green River at Jensen, Utah reached levels at or above 14,000 cfs for 12 days with a peak of 17,900 cfs for one day. Reach 2 Spring Peak targets that was achieved is an Average hydrologic condition concerning 2000 Flow and Temperature Recommendations (greater and/or equal to 8,300 cfs in other average years). The LTSP target that was achieved is an Average (below median) condition (greater and/or equal to 14,000 cfs and less than 18,600 cfs).

Concerning base flow during the summer period (water year 2017) for a wet condition this year's observed base flow for August and September averaged 2,760 cfs at the USGS Jensen gage in Reach 2. This is consistent with both the 2000 Flow and Temperature Recommendations (Muth et al., 2000) base flow as well as the Colorado Pikeminnow study proposed base flows for a wet condition. Since the signing of the ROD 2006 and including this year and years where inflows were increased due to weather events 9 of 12 years were within the +/-40% of the 2000 Flow and Temperature Recommendations (Muth et al., 2000) summer base flow ranges. This is based on the April-July observed classification condition for August and September. The water years 2008, 2010, 2011, 2013, and 2014 had flows outside the Reach 2 +/-40% targets. In water years 2008 and 2014 this is due to short-term increases in tributary inflow resulting from weather events. In the 2010 and 2011 base flow seen on the Yampa River did not occur until later in August. Also, in 2010, Reach 2 targets were larger than +40% of maximum range but only varied near average at +46% of the base flow. In 2013 seasonal lag at the Yampa river occurred that resulted in elevated flow in late September at Reach 2.

Concerning base flow during the autumn period (water year 2017) for an average condition (based on 2016 April-July observed unregulated inflow) this year's observed base flow for August and September averaged 1,915 cfs at the USGS Jensen gage in Reach 2. This is consistent with the 2000 Flow and Temperature Recommendations (Muth et al, 2000) base flow for an average condition (1,500 cfs to 2,400 cfs). Since the signing of the ROD 2006 and including this year and including years where inflows were increased due to weather events 9 of 11 years were within the +/-40% of the 2000 Flow and Temperature Recommendations (Muth et al., 2000) autumn base flow ranges. The years 2007, 2008, 2011, 2014, and 2015 had flows

outside the Reach 2 +/-40% targets. This is based on the previous water year April-July observed classification condition. In years 2007, 2011, and 2015 this is due to short-term increases in tributary inflow resulting from weather events. In years 2008 and 2014, both Dry Hydrologic classifications, flows in Reach 2 were above the +40% base flow ranges and this is due to dam minimum release constraints and the Yampa providing larger flows.

Concerning base flow during the winter period (water year 2017) for an average condition (based on 2016 April-July observed unregulated inflow) this year's observed base flow for December, January, and February predominately averaged 2,400 cfs at the USGS Jensen gage in Reach 2. The lower observed flows in Reach 2 is near 1,800 cfs and the upper range is near 4,000 cfs. The observed flows near 4,000 is a result of increase dam release operations due to increase forecasted unregulated inflows in February. The predominate 2,400 cfs observed flows in Reach 2 is consistent with the 2000 Flow and Temperature Recommendations (Muth et al., 2000) base flow for an average condition (1,500 cfs to 2,400 cfs). Since the signing of the ROD 2006 and including this year and including years where inflows were increased due to weather events 9 of 11 years were within the +/-25% of the 2000 Flow and Temperature Recommendations (Muth et al., 2000) winter base flow ranges. The years 2007, 2008, 2009, 2011, 2012, 2013, 2014, 2015, 2016, and 2017 had flows outside the Reach 2 +/-25% targets. For the years 2007, 2008, 2009, 2011, 2013, 2015, 2016, and 2017, this is due to short-term increases in tributary inflow resulting from weather events. The 2011 and 2017 both April through July observed unregulated inflow was either a moderately wet or wet and resulted in wet observed hydrologic conditions. Operations were such that releases were increased for the anticipated wet years, thus were operated above the flow recommendation. In 2012, flows in Reach decreased below -25% of base flow target and this occurred during transitioning the early period of the winter base flow periods and only lasted for three days. In 2014, a Dry Hydrologic classification, flows in Reach 2 were above the +25% base flow ranges and this is due to dam releases not being able to be below minimum releases and the Yampa providing larger flows.

The Reaches 1, 2 and 3, ROD Flow Recommendation spring objectives and the desired frequency of achievement are described in Tables 2, 3 and 4. Water year 2017 is the 12th year of operations under the ROD.

Table 2 – Reach 1 ROD Flow Objectives Achievements in 2017

Spring Peak Flow Objective	Hydrologic Classification	Desired Frequency Percent of Achievement	Achieved in 2017	Achievement Rate to Date (Cumulative Frequency %)*
Peak \geq 8,600 cfs, \geq 1 day	Wet	10 %	Yes	36 %
Peak \geq power plant capacity \geq 1 day	Moderately Wet - Dry	100%	Yes	100 %

*Based on 12 years of operation under the ROD and spring hydrologic classification (2006-2017)

Table 3 – Reach 2 ROD Flow Objectives Achievements in 2017

Spring Peak Flow Objective	Hydrologic Classification	Desired Frequency Percent of Achievement	Achieved in 2017	Achievement Rate to Date (Cumulative Frequency %)*
Peak \geq 26,400, cfs \geq 1 day	Wet	10 %	No	7 %
Peak \geq 22,700, cfs \geq 2 weeks	Wet	10 %	No	7 %
Peak \geq 18,600, cfs \geq 4 weeks	Wet	10 %	No	7 %
Peak \geq 20,300, cfs \geq 1 day	Moderately Wet	30 %	Yes	29 %
Peak \geq 18,600, cfs \geq 2 weeks	Average	40 %	No	14 %
Peak \geq 18,600, cfs \geq 1 day	Average	50 %	Yes	43 %
Peak \geq 8,300, cfs \geq 1 day	Average	100 %	Yes	100 %
Peak \geq 8,300, cfs \geq 1 week	Moderately Dry	90 %	Yes	93 %
Peak \geq 8,300, cfs \geq 2 days except in extreme dry years	Dry	98 %	Yes	100 %

*Based on 12 years of operation under the ROD and spring hydrologic classification (2006-2017)

Table 4 – Reach 3 ROD Flow Objectives Achievements in 2017

Spring Peak Flow Objective	Hydrologic Classification	Desired Frequency Percent of Achievement	Achieved in 2017	Achievement Rate to Date (Cumulative Frequency %)*
Peak \geq 39,000, cfs \geq 1 day	Wet	10 %	No	7 %
Peak \geq 24,000, cfs \geq 2 weeks	Wet	10 %	Yes	14 %
Peak \geq 22,000, cfs \geq 4 weeks	Wet	10 %	No	7 %
Peak \geq 24,000, cfs \geq 1 day	Moderately Wet	20 %	Yes	36 %
Peak \geq 22,000, cfs \geq 2 weeks	Average	40 %	Yes	14 %
Peak \geq 22,000, cfs \geq 1 day	Average	50 %	Yes	36 %
Peak \geq 8,300, cfs \geq 1 day	Moderately Dry	100 %	Yes	100 %
Peak \geq 8,300, cfs \geq 1 week	Moderately Dry	90 %	Yes	93 %
Peak \geq 8,300, cfs \geq 2 days except in extreme dry years	Dry	98 %	Yes	100 %

*Based on 12 years of operation under the ROD and spring hydrologic classification (2006-2017)

Temperature Objectives Achieved in Water Year 2017

An operational plan for the selective withdrawal system (SWS) on Flaming Gorge Dam was completed by a subset of the FGTWG in June 2007 and revised in June 2012. The operational plan provides guidelines for implementation of the 2006 ROD temperature objectives below Flaming Gorge Dam (Table 1). Operational guidelines direct operators to achieve maximum gate elevation (40 feet below reservoir surface) by June 15 of each year in order to deliver target outflow temperatures of 15-16 °C (59 - 61 °F) during the summer months.

On June 15 of water year 2017, SWS gates were elevated to 41 feet below the reservoir surface, however target dam release temperatures (15 °C or 59 °F at the Greendale gauge, USGS 09234500) were not fully achieved until about mid-July (Figure 1). On June 27, high temperature stator alarms on the dam's generators prompted operators to lower SWS gates to 46 feet below the reservoir surface in an attempt to release cooler water. Two similar 5 feet

downward adjustments were made on July 3 and Aug 1, and SWS gates had to be lowered 15 feet to 73 feet below the surface on Sept 1 (Figure 1).

Table 5 – Temperature objectives for the Green River below Flaming Gorge Dam pursuant to the 2005 EIS and 2006 ROD. Reach 1 is from the dam to the Yampa River confluence; Reach 2 is from the Yampa River to Sand Wash, UT.

Temperature Objectives	Reach	Desired Frequency %	Achieved in 2017
Temperatures $\geq 18^{\circ}\text{C}$ (64.4°F) for 3-5 weeks ¹ starting in June (dry-average years) or August (moderately wet-wet years)	1	100%	Yes (27 days or about 4 weeks at or above 18°C)
Green River should be no more than 5°C (41°F) colder than the Yampa River during the base flow period in order to minimize thermal shock to drifting Colorado pikeminnow larvae	2	100%	No (18 days in excess of 5°C difference during the Colorado pikeminnow larval drift)

Average daily temperatures at Gates of Lodore (USGS 404417108524900) in late water year 2017 intermittently equaled or exceeded Reach 1 objectives (18°C or 64°F ; Figure 1) for 27 days between July 10 and August 6. This fulfills the minimum duration of such temperatures specified in the 2006 ROD (21 days at 18°C ¹) but did not coincide entirely with observations of Colorado pikeminnow larval drift, which began on July 1 and lasted through August 9. This discrepancy was due to the vastly different hydrology of the Upper Green River (near record-setting wet levels) in comparison with the much drier Yampa River. As a result, Flaming Gorge Dam releases averaged 8,293 cfs (full bypass and powerplant capacity) levels from June 1 through July 4, at which time the Yampa River was about 2,000 cfs and declining to base flow levels. Although down ramping operations began after July 4, the Green River did not warm to within 5°C (41°F) of the Yampa River temperature during the first two weeks of the Colorado pikeminnow drift period. On July 1, the Yampa River was 7°C warmer than the Green River at its confluence and remained from 5 to as much as 9°C warmer than the Green River through July 18; thus, Colorado pikeminnow larvae drifting down the Yampa River during the first half of July may have experienced some degree of thermal shock as they entered the Green River. After July 18 temperature differences between the Yampa and Green rivers were within the 5°C objective. Per Muth et al. (2000), it is acknowledged that it may not be feasible to achieve target water temperatures in wetter years, as illustrated by water year 2017.

Temperature differences between the Yampa and Green rivers in July 2017 were often well above the 5°C maximum objective, although in the strictest sense of the temperature

¹ The U.S. Fish and Wildlife Service (K. McAbee, personal communication, 2012) has advised Reclamation to observe the target duration of the Lodore temperature objective specified in the 2005 Biological Opinion, which is 3-5 weeks at or above 18°C .

recommendations these objectives would not be expected to be met until August 1 or August 15, the beginning of the base flow period in a wet year such as 2017. This illustrates a disconnect between the intent of the temperature recommendations (i.e., to minimize thermal shock during periods of larval drift) and the recommended implementation timeframe which coincides and varies according with hydrologic categories set forth for the Green River basin. For example, if the Colorado pikeminnow spawning chronology is governed by conditions in the Yampa River, operations in the Green River to provide warm water may be temporally out of synchronization with the Yampa River if hydrologies in the two basins are radically different as they were in 2017. Therefore, the criteria for the optimal timeframe for minimal differences between the Yampa and Green rivers would logically be dictated by conditions in the Yampa River and the subsequent larval drift chronology, not hydrology of the Green River.

It should be further noted, also, that SWS gates would in most circumstances already be at their maximum elevation at the onset of larval pikeminnow drift, and that flow volumes in the Green River may be the only other means to modify temperatures near the Green/Yampa River confluence. Operation of Flaming Gorge Dam to assist in recovery of endangered fish is currently under review by the Green River Evaluation and Assessment Team (GREAT) who are exploring options to minimize temperature differences between the Green and Yampa rivers and create more favorable conditions for larval Colorado pikeminnow as soon as possible following conclusion of spring peak flows. This option may necessitate adoption of faster down ramp rates than are currently allowed (10 m³/s [350 cfs] per day to 28 m³/s [1000 cfs] per day depending on hydrologic conditions) so that favorable base flows and temperatures can be attained quickly following the spring peak flows.

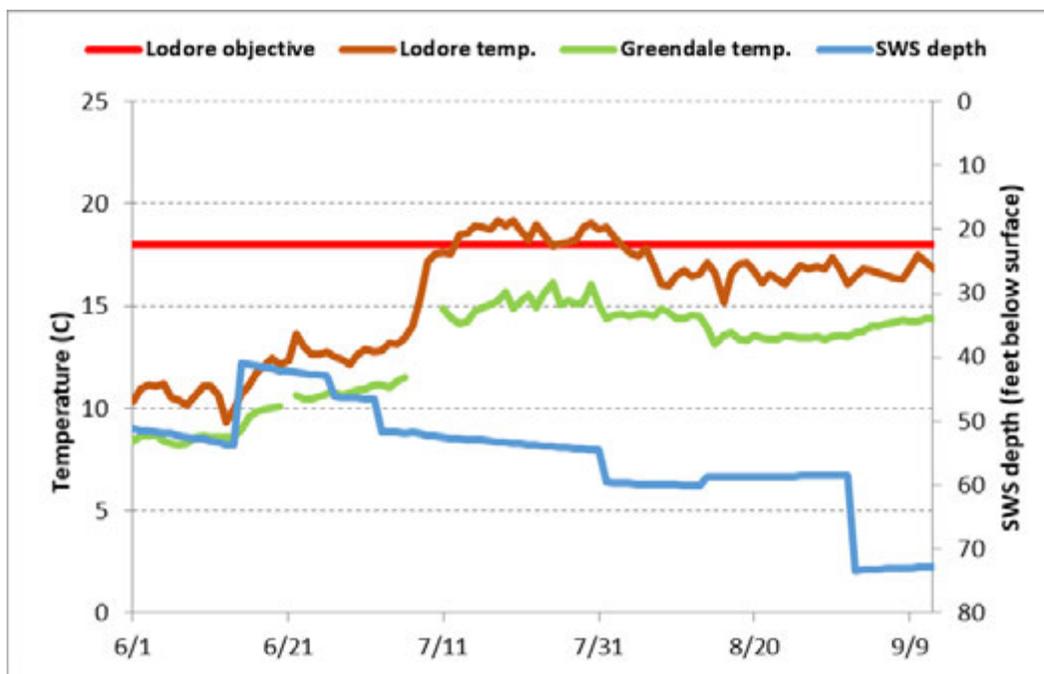


Figure 1 - Average daily temperatures recorded at the Gates of Lodore gage (brown series), Greendale gage (green series; USGS 09234500), Reach 1 (Gates of Lodore) objective (red line), and SWS gate depth below reservoir surface (blue series, second axis), June-September 2017. SWS gate depths are the average of three units

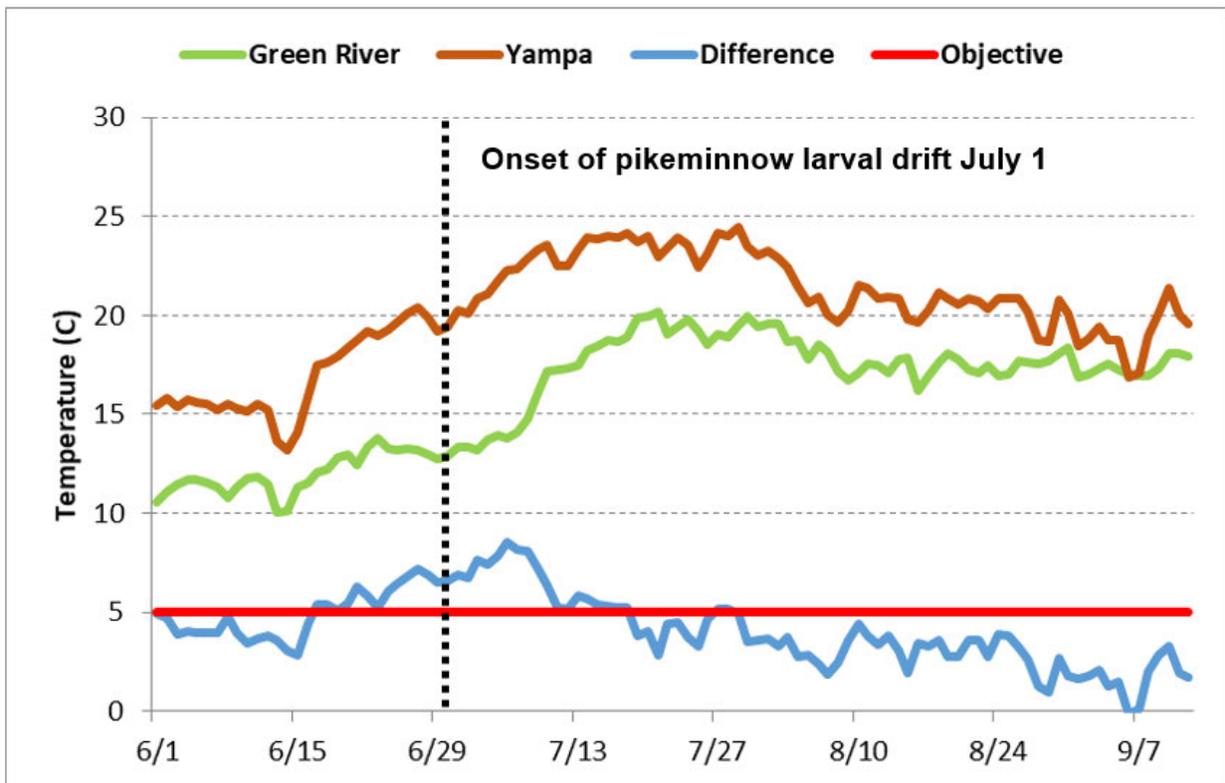


Figure 2 - Temperature of the Green River (green series) at the Yampa River confluence and of the Yampa River (brown series), the difference between the two rivers (blue line), and the maximum temperature difference (5 °C) specified in the 2006 ROD (red line), June-September, 2017.

Recommendations to Refine Operations

Recommendations are to have a formal FGTWG Proposal and Operation Plan as outlined in the four-step process. Clarification in the Operation Plan should state that in wetter situations during DWR-DNR tail water fish assessments a larger ramp down/up, greater than 50 cfs, will be required. Base flow calculations in the future should be calculated at a minimum before and/or during the respective base flow period (summer, autumn, and winter).

Flaming Gorge Technical Working Group recommendations and discussions to document planning process

Included in the Appendix is a summary of events and meeting minutes from the FGTWG meetings.

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Appendix -- Summary of events and meeting minutes from the FGTWG meetings.

Meeting Notes -- Tuesday, March 28, 2017

In attendance: Heather Patno, Jerry Wilhite, Matt Breen, George Weekley, Kevin McAbee, Ashley Nielson, Dave Speas, Peter Crookston, Tildon Jones, Steve Hulet, Don Anderson, Dale Hamilton, Paul Abate, Leslie Bennett

- It has been a very interesting March. The Upper Green has stayed wet and the Yampa has dried out.
- Hydrology Summary was reviewed
 - The streamflow on March 21st has already passed record by almost double.
 - This does not include March inflows.
 - The Yampa is a different story. There has been significant melt except at the highest elevations.
- The ROD allows flexibility for the May 1st classification. We have not seen such a difference between Flaming Gorge and Yampa hydrology. There is flexibility to move timing of water. We will be operating this year for dam safety.
- Question as to when the Razorback sucker will spawn, because in the last wet year (2011) spawn was June 24th. The increased flows out of Flaming Gorge will lower the water temperature. The peak of Yampa may happen before the Razorback sucker spawn.
- 2011 had the highest volume out of Yampa. This year the volume is much lower and will affect the water temperature.
- George Weekley shared that this year will be very hard to forecast as the conditions are unprecedented. He proposes the Pikeminnow spawn will be later than normal.
- As Kevin Bestgen was unable to be on the call, members would like to propose questions to him for additional information prior to the next meeting:
 - To what extent do the water temperatures in the Green River display a que for spawning into the warmer Yampa River.
 - What is the chronology of razorback sucker in the Green River
 - Is there an advantage to bypass earlier prior to June
 - If bypass is utilized in April and forward what affect to razorback sucker
 - How does the different hydrology and snowpack in the two basins affect spawning chronology
- The ROD requires elevations lower in a wet year. Will need to utilize bypass similar to 2011. Stakeholders in Price do not want a repeat of 2011. The fishing guides do not like the water to fluctuate due to bypass releases. Elevations are required below 6023 by May 1st.

Meeting Notes -- Wednesday, May 10, 2017

In attendance: Heather Patno, Jed Parker, Jerry Wilhite, Kevin McAbee, Ashley Nielson, Randy Staffeldt, Daryl Magnuson, Peter Crookston, Tildon Jones, Tom Chart, Dan Schaad, Kevin Bestgen, Steve Hulet, John Morton, Leslie Bennett

- Jerry reported on the Anglers meeting.
- Temperatures from the selective withdrawal structure were discussed.

- Hydrology Summary was reviewed
 - This year has been an anomaly.
 - Ashley pointed out her figures are from yesterday and with today's precipitation and warmer temperatures we could now see a peak in the Yampa in the next 10 days. Flows expected to reach 9,600 cfs in the next ten days.
 - The ROD has Flaming Gorge as wet and the Yampa at Average-Below Median. Utilizing the flexibility outlined in the ROD and shifting one classification down, the hydrology classification will be moderately wet. It is unlikely we will meet moderately wet targets at Jensen of 20,300 cfs peak magnitude and 18,600 cfs for 14-day duration. Green River at Jensen may not reach 18,600 this year.
 - Heather has not included information relative to the ten-day deterministic and long-term Yampa River forecast due to the wet conditions in which operating procedures are for hydrology. Ashley has this if needed and the link is public on their website here:
https://www.cbrfc.noaa.gov/product/hydrofcst/csv2table.php?fname=yampa_peak/ydlc2_dly.csv
 - There is still a lot of SWE at Tower. Uncertainty exists as to how this will melt off and whether there will be a second peak later in the season. It is likely the Yampa will increase again, but whether the increase is sustained over the next few weeks or a second peak occurs in late-May is still uncertain.
 - Kevin and Tildon reported the water is still really cold and pushing spawning until the end of May. There are no ripe or tuberculate fish in the razorback sampling.
- Flaming Gorge Operations were discussed. The current elevation is 6022. There is some flexibility to decrease to 6600 cfs. Two options were discussed: 1) Decrease releases now potentially increasing the temperature of the water to assist with spawning. Would need to increase to 8600 cfs at a later date. 2) Maintain flows now and be able to decrease releases earlier for pikeminnow base flows. It was agreed upon to decrease releases now. Heather will do so in the next few days and will hold that level until larvae emergence.
- Stewart Lake operations were waiting for this discussion to determine action.

Meeting Notes -- Friday, July 28, 2017

In attendance: Heather Patno, Kevin McAbee, Jerry Wilhite, Crystal Dean, Ashley Nielson, Kevin Bestgen, Tom Chart, Don Anderson, Steve Hulet, Peter Crookston, Dave Speas, Larry Crist, Leslie Bennett

- Discussions were held regarding the scheduled dive requirements.
 - Steve provided historical reference. In September 2014 a dive team originally discovered a cave that had formed 11 feet deep by 23 feet long where the hollow jets hit the surface. Not able to determine if this was natural or caused by erosion. Markers were placed and a dive scheduled for March 2017 to determine changes. This had to be rescheduled again to the week of 8/28/17.
 - The dive team needs 800 cfs flow or lower to conduct inspection
 - Maintenance issues are not covered under the ROD, only emergencies
 - Normal procedure would require 32 days down and 32 days back up.

- Discussion of postponing the dive to next Spring 2018. The dive team has a very full schedule and will potentially face the same problems.
- Discussions of lowering cfs to just for the required 2-3 hours divers need.
- 2400 cfs is currently scheduled for Spring 2018
- Jerry, Chrystal and Heather will create a plan and send out to the group for approval. Steve will double check with the dive master regarding the total number of dive hours necessary.
- Not expecting to do another dive again for 5 years. Based on the results, may need to do one sooner. Prior to rescheduling any future dives the FGTWG will be consulted.
- A discussion of the current fish situation was held.
 - As of July 2nd pike minnow were present
 - Reproductive season is usually 4 weeks
 - Drawing down now would cause dam safety issues as well as extend high flows into Winter season.
 - Planning now for risk management and forecast uncertainty.
 - Regarding dam safety we are still in a 'wet' year.
 - This may end up the 2nd wettest year in the Upper Green.