San Juan River Basin Recovery Implementation Program
Environmental Flows Workgroup Meeting
Planning for Workshop #2
3-4 December 2015, Durango, Colorado

Meeting Summary

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Brian Westfall – Keller-Bliesner Engineering
Jason Davis – Fish and Wildlife Service
Mark McKinstry – Bureau of Reclamation
Benjamin Schleicher – Fish and Wildlife Service
Vincent Lamarra – Ecosystems Research Institute
Harry Crockett – State of Colorado
Mike Ruhl – State of New Mexico
Tom Wesche – HabiTech, Inc.
Dave Gori – The Nature Conservancy
Sharon Whitmore – Fish and Wildlife Service
Scott Durst – Fish and Wildlife Service
Brian Bledsoe – Colorado State University
Keith Gido – Kansas State University
Dave Propst – University of New Mexico
Steven Platania – ASIR
Susan Behery – Bureau of Reclamation
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Michael Farrington – ASIR
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Environmental Planning for Flow Workshop #2

At Flow Workshop #1 held on Feb. 12-13, 2015, attendees recommended that the Program Office take the lead on planning for and organizing the second workshop by convening a workgroup to deal with workshop details and logistics such as pulling together relevant documents and reports, identifying information needed prior to the workshop, and developing priority hypotheses.

On October 28, 2015, the Program Office sent out an email to the individuals who had indicated interest in being on the workshop planning workgroup. The date for a workgroup planning meeting was set for Dec. 3-4, 2015, immediately following a Biology Committee meeting on Dec. 1-2. Attached to the email was a draft outline that described the Program Office's thought process going into Workshop #2 and details of a path forward (https://www.fws.gov/southwest/sjrip/sjrippwd/documents/SJW2/Draft_Outline_for_SubGroup.pdf). The intent was to use the outline as a starting point for developing an agenda for the workgroup planning meeting. The workgroup was asked to provide comments and thoughts on the strategy. No comments were received.

On Nov. 12, a draft agenda for the 3-4 December planning meeting was sent to the workgroup. After receiving feedback, a slightly revised agenda was sent out on Nov. 18 along with a handout of reference materials for use during the workgroup meeting. Additional reference materials were also posted to the Program website's working documents link (https://www.fws.gov/southwest/sjrip/sjrippwd/PWD_SJW2.cfm). The following goals and objectives were included on the agenda as a path forward for the workgroup meeting recognizing that it might not be possible to complete them all during the two-day workgroup meeting.

1) Summarize existing information on flow-habitat-fish relationships and other relevant large-scale

patterns
2) Identify outstanding analyses
3) Review history of flows: why the flow recommendations have not been met
4) Devise means to better meet flow recommendations and determine what to do with available water (e.g., high spring targets, elevated base flows, fall spike flows)
5) Develop new decision tree or long-range plan for flow releases; logistically determine how we can meet flow recommendations
6) Develop research program to assess effects of flows

Environmental Flows Workshop #2 Workgroup Meeting 3-4 December 2015

Overview of pre-workshop history and goals (Scott Durst)
https://www.fws.gov/southwest/sjrip/sjrippwd/documents/SJW2/SJRIP_e-flows_workshop_2_workgrp_meeting_overview_(Durst).pptx

Prior to Flow Workshop #1, Reclamation proposed an alternate way to implement San Juan River flow recommendations which utilized an End of Water Year Storage Target (EWYST of 6,063 feet) for Navajo Dam (with option to lower the target to 6,050 feet in some years). The volume of water in excess of EWYST is deemed "available water" that can be released from Navajo Dam for environmental purposes (given the release constraints of the dam). Consensus was reached on using the EWYST method during Workshop #1; however, the process for using the available water into future (e.g., revised decision tree) still needed to be determined.* Outstanding tasks from Flow Workshop #1 included:

(1) Determining how to "use" available water
(2) Evaluating the effects of flows from the 1999 Flow Recommendations
(3) Revising the 1999 Flow Recommendations, as necessary

The 1999 Flow Recommendations decision tree resulted in frequent low-magnitude spring releases and limited releases occurred that met high flow targets. Miller (2006 Integration Report) found that the 2,500 cfs and 5,000 cfs flows did not appear to maintain habitat as expected in the absence of 8,000 and 10,000 cfs flows. The question in front of the committee was: how do we attain higher spring peaks on a more frequent basis? We are also limited in our ability to evaluate the effects of the 1999 Flow Recommendations because limited information is available on how the various flow targets (that may or may not have been meet since 1999) have affected the habitat and fish. The priority need is to develop the new process for implementing EWYST (per Behery's modeling in Workshop #1).

Durst explained that the path forward for the workgroup meeting was to review and reach agreement on flow relationships and flow history, identify outstanding analyses, prioritize flow releases based on available water, develop new decision tree or long range plan for flow releases, and identify what monitoring and research will be needed to assess the effect of flows. Other agenda items identified by the workgroup included a step-by-step review of the 1999 flow targets for future applicability and planning for Workshop #2.

* Workshop #1 notes are available on the SJRIP website (http://www.fws.gov/southwest/sjrip/SJREFW.cfm) but the document is not a BC consensus product.

SECTION: SUMMARY, REVIEW, AND AGREEMENT OF CURRENT STATE OF KNOWLEDGE

Presentation - Habitat responses to flow (Vince Lamarra)
https://www.fws.gov/southwest/sjrip/sjrippwd/documents/SJW2/Flow_Recs_Historical_Perspective_(Lamarra).ppt

Lamarra said he would not be talking about if or how the flow recommendations were met or not met.

Lamarra gave an historical perspective of the 1999 Flow Recommendations. The intent was to provide a magnitude of flow (e.g., days greater than 10,000 cfs), a duration (e.g., 5 days between March 1 and July 31), and a frequency of occurrence (e.g., 20% of years, no longer than 10 consecutive years), and to mimic a natural hydrograph (timing). They were based on habitat and observed geomorphic changes during the research period and observations of fish community changes. A breakdown of the 1999 Flow Recommendations includes:

Flows > 10,000 cfs during runoff period, minimum of 5 days, 20% of years on average, no longer than 10 consecutive years without meeting 9,700 cfs – The flow recommendations were based on a 65-year period of hydrologic record, 1929-1993. Franssen asked why we were trying to attain a flow target based on 65 years when we only have an 18-year period of implementation and data. Lamarra said we were monitoring for the purpose not monitoring for response. The data shows that more islands formed after big flows but the number of islands has decreased over time.

Flows > 8,000 cfs, minimum of 10 days, 33% of years, no longer than 6 consecutive years without meeting 7,760 cfs – Lamarra evaluated a stated purpose that flows at >8,000 cfs would move cobble and build cobble bars for spawning but found the data cannot confirm if cobble habitats increased with 8,000 cfs flows. When the flow recommendations were developed, bank full was considered to be 8,000 cfs but has bank full changed? Bliesner said it did not change between 1997-2007. Lamarra said he thinks it may have changed now.

Flows > 5,000 cfs, minimum of 21 days or more, 50% of the years on average, no longer than 4 consecutive years without meeting 4,850 cfs – Data shows that 5,000 cfs for 70 days did clean backwaters but bigger flows would have also occurred during that time frame. The 5,000 cfs benefit, to clean and maintain backwaters, cannot occur without also having the bigger flows. Islands are also important for backwater formation and you get islands from high flows. Big volumes of water are needed.

Flows > 2,500 cfs, minimum 10 days or more, 80% of the years on average, no longer than 2 consecutive years without meeting 2,425 cfs – Westfall said the going theory when the flow recommendations were developed was that 2,500 cfs would provide clean cobble for spawning. The original focus of the flow targets was that spawning habitat was limited. Is spawning habitat limited? This may need to be re-visited. The flow recommendations operations should probably have been modified back in 2006 when Keller-Bliesner first pointed out that we should not be trying to attain the 2,500 flow target and should be focusing on trying to attain more frequent, high flows.

Lamarra said numerous factors make post-hoc analysis challenging including nature not providing a full spectrum of available water and flow recommendations criteria being interrelated. Also, monitoring was focused on recovery and response of the fish and not on evaluation of the flow recommendations and response of the habitat. As a result, specific parameters identified in the flow recommendations have not been monitored consistently. As a result, there are a lot of zeros in the data set especially in the higher flow categories which makes evaluating the effects of the 1999 Flow Recommendations on habitat and fish difficult.

There were few years where all flows targets were met or almost met. From 1992-2014, flows at >10,000 cfs for 5 days were met 13% of time; >8,000 cfs for 10 days met 22%; >5,000 cfs for 21 days met 48%; and, > 2,500 cfs for 10 days met 91%. All flows were met in 1995, 1997, and 2005 and almost met in 2008 (one day short at >10,000 cfs). The results are too many zeros in the data set. From 1992-

2014, 78% of the years in the data set are zeros at >10,000 cfs for 5 days; 52% are zeros at >8,000 cfs for 10 days; 26% are zeros at >5,000 cfs for 21 days; and, 9% are zeros at > 2,500 cfs for 10 days.

Habitat mapping was conducted from December 1992 to September 2014 (no mapping was conducted from 2008-2010). Mapping events had flows ranging from 479 to 9,453 cfs. A total of 670 channels have been defined in 26 mapping events. These may or may not exist today. These channels included 228 (34%) Secondary Channel Splits, 69 (10%) Main Channel Splits, 204 (31 %) Island Splits, and 169 (25%) Cobble/Sand Bar Splits. To better understand habitat-flow relationships, use of antecedent flow parameters was expanded. Lamarra pointed out that the current habitat mapping does not measure certain parameters such as river depth and sediment build-up in the lower canyon. Miller said the flow recommendations did not consider temperature but it should be factored in. McKinstry questioned whether temperature should be a factor considering Razorback Sucker are spawning at lower temperatures than the literature says in other parts of the Colorado River Basin such as the Grand Canyon.

Presentation - Larval fish response to flow (Mike Farrington)
https://www.fws.gov/southwest/sjrip/sjrippwd/documents/SJW2/Larval_fish_data_discharge_perspective_(Farrington).pdf

Farrington said ASIR switched from using CPUE to examine larval fish survey data to using mixture models in 2013. Mixture models are good for analyzing data with a lot of zeros. For this exercise, the covariates used in the models, in addition to year and reach for Razorback Sucker, were mean April flow and temperature, mean May flow and temperature, annual number of fish stocked, cumulative number of fish stocked and fall monitoring captures (1999-2014). For Colorado Pikeminnow, additional covariates included mean June flow and temperature, mean July flow and temperature, and captures of 450+ mm TL and 300-449 mm TL during Adult Monitoring (2003-2014).

Mixture model estimates for Razorback Sucker show that models with the covariate "cumulative number of fish stocked" for both delta and mu received the most support. Higher May flow resulted in lower larval Razorback Sucker captures. In the early years of sampling, Razorback Sucker spawned from mid-April to mid-May before spring peak at temperatures above 10° C but better at 13° C. The spawning period has been expanding. Using back calculated spawning dates, in 2014 spawning occurred from mid-March to end of June. For this reason, he does not think we want to dump a lot of cold water (correlated with high flows) into the river in spring.

Mixture model estimates for Colorado Pikeminnow show that models with the covariates "year" for delta and "monitoring 450+" for mu received the most support. The covariate "fall monitoring captures 450+" can be viewed as a surrogate for Colorado Pikeminnow augmentation. We do not have much data for Colorado Pikeminnow; however, so model results are not as good. Pikeminnow need 20° C mid-June to early July on the descending limb of the hydrograph.

Presentation - Small-bodied fish response to flow (Keith Gido)
https://www.fws.gov/southwest/sjrip/sjrippwd/documents/SJW2/Flow_response_SJR_fishes_(Gido).pptx

Gido identified two papers that looked at relationships between San Juan River flow variation and small-bodied fish, Propst and Gido (2004) and Gido and Propst (2012). They looked at various flow attributes and their potential association with the recruitment of fish. Duration of low flows (less than 500 cfs) and magnitude of high flows are important. For catfish, there is a weak relationship with flow. He thinks they may be density dependent. Red shiners may come back if flows drop below 500 cfs. Results of the studies included:

Flow response of 2° channel fishes (1993 – 2001) – Propst and Gido (2004)

- Higher spring flows related to higher densities of native fishes
- Prolonged low flows during summer related to increased densities of some nonnative fishes

Flow response of 2° channel fishes (1993 – 2001) – Gido and Propst (2012)

- Relationship between native suckers and mean spring discharge present but weaker
- Strong association between nonnatives and prolonged summer low flow

Quantifying flow–ecology relationships with functional linear models - Stewart-Koster et al. (2014)

- Timing of high flows might influence fish response
- Functional linear analysis uses a "moving window" to assess flow-density relationships
- Similar results to Propst and Gido (2004) and Gido and Propst (2012)

Presentation - Temperature depression (Bill Miller)
https://www.fws.gov/southwest/sjrip/sjrippwd/documents/SJW2/SJRIP_e-flows_Water_Temp_(Miller_Dec_2015).pptx

Miller reported that initial work on water temperature monitoring started in 1992. Flow recommendations for a natural snow melt hydrograph with high spring/summer releases were formalized in 1999. Water temperature modeling in Navajo Reservoir and the San Juan River was conducted in late 1990s and early 2000s and has continued to present. River modeling looked at water temperature changes at Shiprock. Hydrology in the model was only for lower flows released from Navajo Dam. To look at flow and water temperature relationships, he assembled water temperature and discharge data for the Mexican Hat gage from 1945-2013 and segmented the analysis into pre-dam, post-dam, and post flow recommendation time periods.

Water temperatures have shifted down through time. Water temperature depression during release of peak flows is shown in the monitoring data downstream to Mexican Hat, Utah. Is this a result of low hydrology or flow recommendations operations? Water temperature did not show a depression during peak flows prior to construction of Navajo Dam. What are the potential implications for recovery? Temperature depression could delay or suppress spawning in Colorado Pikeminnow, reduce growth rates for larvae of both Razorback Sucker and Colorado Pikeminnow, and reduce reproductive success if spawning occurs prior to temperature drop. Between 1987-1997, Colorado Pikeminnow were captured in the San Juan River and recruitment was occurring. Water temperature needs to be considered in Navajo Dam release decisions. For example, you may not want to make high releases when Animas is low because cold water from the San Juan would exacerbate temperature depression downstream. If there was a temperature control device (TCD) at Navajo Dam, warmer water could be released from higher in reservoir to prevent temperature depression during spawning or cold water could be released from lower levels to disadvantage nonnative fish (e.g., Grand Canyon is cold and fish seem to do fine and they don't have catfish).

Miller said the next steps are to continue investigating the relationships between water temperature and timing, number and size of larvae; complete additional thermal modeling of Navajo Reservoir and San Juan River, develop a preferred water temperature regime as part of the flow recommendations; and develop a range of potential alternatives for ways to obtain water temperature modifications during Navajo Dam releases to moderate the water temperature depression. Considerations for a TCD on Navajo Dam include: cost and practicality of constructing a TCD, potential impact to trout water downstream of the dam, entrainment and release of non-native predators from Navajo Reservoir into the San Juan River, and establishment of those species in critical habitat.

SECTION: REVIEW HISTORY OF FLOWS

Presentation - Navajo Operations and Flow History and Decision Tree Options (Susan Behery)
https://www.fws.gov/southwest/sjrip/sjrippwd/documents/SJW2/SJRIP_e-flows_workshop_2_workgrp_meeting_(Behery_Dec2015).pptx

Behery reviewed operating procedures to meet flows targets, the history of flows including why we haven't met flow recommendations, and new processes for determining environmental releases as described in Reclamation's proposal and notes from E-flow Workshop #1.

There are a lot of operating limitations and guidance that must be followed to operate Navajo Dam. There are Dam limits, Flow Recommendations limits, and COE flood control limits. Guidance documents include SJRIP 1999 Flow Recommendations, Shortage Sharing Agreement (2013-2016), 2015 Interim Operations, and Corps of Engineers Water Control Manual (2011). Flow recommendations have only been officially followed since Reclamation adopted the Record of Decision (ROD) in 2006 but have been unofficially followed since the 1990's. Releases between 250 and 5,000 cfs are considered in compliance. Real time operations are based on forecasts and river flow forecasts are based on weather forecasts. The difference between minimum, most likely, and maximum forecast narrow through time. During spring operations (decision-making time), the May 1forecast spread is wide and actuals typically fall between predicted minimum and most lately. Forecasts have a lot of variability and error.

ORIGINAL 1999 FLOW RECS DECISION TREE IMPLEMENTATION: We have tried to achieve flow recommendation statistics based on a 65 year period of hydrologic record. Difficulties in implementing flow recommendation include: using imperfect forecasts, timing Navajo releases with Animas peak, and dealing with erratic runoff. Reclamation followed the original decision tree that was developed to meet the flow targets. Were the flow recommendations met? Yes and no. Over the past 15 years, we've experienced a dry spell rivaling the 1950's. The minimum flow targets have been met with a few exceptions. However, the 65-year flow distribution has not been replicated during the period of flow recommendation implementation. Why have we not been successful meeting the higher flow targets? This was mostly due to not timing releases with the Animas peak, trying to deal with multiple Animas peaks, lack of adequate water for a peak (Navajo Dam is only half of the equation; need the Animas to contribute), and/or the peak being too short in duration. Other reasons could be forecast error, gage shifts causing reduced releases, the decision tree's prioritization of frequency of any size releases over frequency of Type 3-4 releases, looking at only 10-15 (mainly drought) years rather than a 65 year period of implementation that flow statistics are based on. We did our best with what we had but the water just hasn't been there. Could our success have been improved with better hydrology, better forecasts, timing, decisions, etc.? Yes, but also the original decision tree limited our ability to achieve flow targets.

2015 INTERIM OPERATIONS AND DECISION TREE – Back in early 2014, Reclamation first proposed an alternate method to implement San Juan River flow recommendations. The proposed method uses an End of Water Year Storage Target process for Navajo Dam (EWYST of 6,063 feet with option to lower the target to 6,050 feet in some years). The volume of water in excess of EWYST is deemed "available water" that can be released from Navajo Dam for environmental purposes (given the release constraints of the Dam). Based on the EWYST method, Westfall developed a decision tree, based on Reclamations operation model, for making release decisions that do not include "look backs" (Figure 1). During E-flows Workshop #1 in February 2015, the EWYST method and this decision tree was adopted as an interim method until the BC could further develop the new process for implementing EWYST.

Under the EWYST method, available water for a spring peak release is calculated using an EWYST of 6,063 feet (with an option to use 6,050 feet). The method minimizes the risks of both shortage and spill

in the reservoir. Navajo Dam will be operated to meet EWYST by the end of each water year (with all contracts and target base flows met). Any volume over the EWYST is available for Spring Peak Releases or other adaptive management deemed useful by the SJRIP. Available water will be released by the rules set in any revised Flow Recommendations. In dry years, the reservoir may come short of EWYST (i.e., contracts and target base flows will be met, but no water available for spring peak release).

Behery showed the four types of hydrographs and volume of water available for each peak flow, Type 4 (344,000 af), Type 3 (236,000 af), Type 2 (166,000); and Type 1 (114,000 af). The Type 4 hydrograph includes a ramp up and down as per the flow recommendations. The release volumes can be classified as follows:

- Base Release: The volume required to maintain the target base flow minimum.
- Spring Peak Release: Release volume on top of the base release that is designed to mimic a natural runoff hydrograph.
- Operational Spill: Release volume on top of spring peak release and base release designed to make room in the reservoir. Examples of possible releases include shaping the nose of the spring peak release, increasing the target base flow, and doing a fall spike release.

Behery showed several model runs comparing releases under the Original 1999 Flow Recommendations Decision Tree and the 2015 Interim Operations Decision Tree. She pointed out she used the operations model for runs that are based on actual conditions not the SJRB hydrology model.

Miller asked about effects on geomorphology and said he would like more detail. Lamarra suggested doing away with the nose and increasing days @ 5,000 cfs. Behery said they may have to start making releases earlier to get rid of water. She emphasized that everything is trumped by flood control rules. Bliesner voiced concern about baseline depletions because the 1999 Flow Recommendations were based on baseline depletions for determining frequency.

NEW FLEXIBLE EWYST AND DECISION TREE – For this workgroup meeting, Behery said she worked with Durst and Franssen to see what happens if Type 1 and 2 releases were eliminated in favor of only making Type 3 and 4 releases. They came up with a decision tree that uses the two EWYSTs at the same time. Available Water is calculated using the 6,050 feet EWYST. If this results in sufficient available water for a Type 3 or Type 4 release, that release is made. If there is not available water for a Type 3 or 4 release at EWYST at 6050, then an EWYST of 6,063 is used and any water available at that target is released via Operational Spill. This is nearly what we have with the Interim Operations, i.e., 6,063 feet EWYST with the option to go to 6,050 feet EWYST, but the 6,050 feet part had not been modeled previously because it would be a real-time decision. This method puts rules on the 6,050 feet option. She pointed out that she made some changes to the decision tree since first working on this with Durst and Franssen so the tree in her presentation (Figure 2) is different than Figure 6 in the workshop handout. Model runs of the three decision trees show that the Flexible EWYST method allows for eight more Type 4 releases (2 per decade on average) compared to the 6,063 feet EWYST alone.

The possible downsides of the Flexible EWYST method are that no Type 1 and Type 2 releases are made and an increased risk of shortage at EWYST of 6,050 feet (though the risk is still fairly low).

SECTION: STEP-BY-STEP REVIEW OF THE 1999 FLOW RECOMMENDATIONS FOR THE SAN JUAN RIVER (Holden 1999)

A. Category: Flow > 10,000 cfs during runoff period (March 1 to July 31).

Duration: **A minimum of 5 days between March 1 and July 31**.

Frequency: **Flows > 10,000 cfs for 5 days or more need to occur in 20% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 9,700 cfs (97% of 10,000 cfs) within the 65-year period of record is 10 years.

Purpose: Flows above 10,000 cfs provide significant out-of-bank flow, generate new cobble sources, change channel configuration providing for channel diversity, and provide nutrient loading to the system, thus improving habitat productivity. Such flows provide material to develop spawning habitat and maintain channel diversity and habitat complexity necessary for all life stages of the endangered fishes. The frequency and duration are based on mimicry of the natural hydrograph, which is important for Colorado pikeminnow reproductive success and maintenance of channel complexity, as evidenced by the increase in the number of islands following high flow conditions. Channel complexity is important to both Colorado pikeminnow and razorback sucker.

B. Category: Flow > 8,000 cfs during runoff period.

Duration: **A minimum of 10 days between March 1 and July 31.**

Frequency: **Flows > 8,000 cfs for 10 days or more need to occur in 33% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 7,760 cfs (97% of 8,000 cfs) within the 65-year period of record is 6 years.

Purpose: Bankfull discharge is generally between 7,000 and 10,500 cfs in the San Juan River below Farmington, New Mexico, with 8,000 cfs being representative of the bulk of the river. Bankfull discharge approximately 1 year in 3 on average is necessary to maintain channel cross-section. Flows at this level provide sufficient stream energy to move cobble and build cobble bars necessary for spawning Colorado pikeminnow. Duration of 8 days at this frequency is adequate for channel and spawning bar maintenance. However, research shows a positive response of bluehead sucker and speckled dace abundance with increasing duration of flows above 8,000 cfs from 0 to 19 days. Therefore, the minimum duration was increased from 8 to 10 days to account for this measured response. Flows above 8,000 cfs may be important for providing habitat for larval razorback sucker if flooded vegetation and other habitats formed during peak and receding flows are used by the species. This flow level also maintains mimicry of the natural hydrograph during higher flow years, an important feature for Colorado pikeminnow reproductive success.

Discussion – 10,000 and 8,000 flow targets and their purposes remain a high priority. We have not achieved these targets and need to develop decision trees to increase the magnitude, frequency, and duration of flows in the San Juan River, i.e., flows >8,000 cfs to achieve the purposes stated in the original flow recommendations. The hypotheses that >10,000 cfs provides out-of-bank flows and flows >8,000 cfs provide bank-full flows are still valid. Additional purposes not in the original purposes that need to be added include delaying and/or suppressing the establishment of non-native vegetation and promoting cottonwood recruitment/regeneration. To determine at what point wetted area is maximized, discharge and amount of area that gets inundated needs to be plotted. A new estimate is needed on the

degree of nonnative vegetation encroachment. Hypotheses identified that should be developed and tested include: what is needed for improving fish recruitment and productivity, are high flows detrimental to nonnative fish, will flows >10,000 cfs cause out-of bank flooding and promote cottonwood establishment, and is there enough flow to create new, long secondary channels or to increase complexity.

C. Category: Flow > 5,000 cfs during runoff period.

Duration: **A minimum of 21 days between March 1 and July 31.**

Frequency: **Flows > 5,000 cfs for 21 days or more need to occur in 50% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 4,850 cfs (97% of 5,000 cfs) within the 65-year period of record is 4 years.

Purpose: Flows of 5,000 cfs or greater for 21 days are necessary to clean backwaters and maintain low-velocity habitat in secondary channels in Reach 3, thereby maximizing nursery habitat for the system. The required frequency of these flows is dependent upon perturbating storm events in the previous period, requiring flushing in about 50% of the years on average. Backwaters in the upper portion of the nursery habitat range clean with less flow but may be too close to spawning sites for full utilization. Maintenance of Reach 3 is deemed critical at this time because of its location relative to the Colorado pikeminnow spawning area (RM 132) and its backwater habitat abundance.

Discussion – If we don't have mid-range flows (Category C flows) as often, are there negative effects? The group agreed that relaxing mid-range flow requirements would do no harm. These flows will increase if you optimize getting >8,000 cfs. Mid-range flows (5,000 cfs) work better in association with high flows that include a tail. If you do mid-range flows by themselves, they don't do much. These flows are still important when in combination with higher flows but should not be targeted with operations. Should the Animas peak be in the operational model?

D. Category: Flow >2,500 cfs during runoff period.

Duration: **A minimum of 10 days between March 1 and July 31.**

Frequency: **Flows > 2,500 cfs for 10 days or more need to occur in 80% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 2,425 cfs (97% of 2,500 cfs) within the 65-year period of record is 2 years.

Purpose: Flows above 2,500 cfs cause cobble movement in higher gradient areas on spawning bars. Flows above 2,500 cfs for 10 days provide sufficient movement to produce clean cobble for spawning. These conditions also provide sufficient peak flow to trigger spawning in Colorado pikeminnow. The frequency specified represents a need for frequent spawning conditions but recognizes that it is better to provide water for larger flow events than to force a release of this magnitude each year. The specified frequency represents these tradeoffs.

Discussion – Targeting Category D flows, > 2,500 cfs, did not do what they were expected to do, i.e., trigger spawning. The original purposes also said flows > 2,500 cfs for 10 days provide sufficient movement to produce clean cobble for spawning. Spring peak flows are important for this. This category is no longer needed.

E. Category: Timing of the peak flows noted in A through D above must be similar to historical conditions, and the variability in timing of the peak flows that occurred historically must also be mimicked.

Timing: Mean date of peak flow in the habitat range (RM180 and below) for any future level of development when modeled for the period of 1929 to 1993 must be within 5 days ± of historical mean date of May 31 for the same period.

Variability: Standard deviation of date of peak to be 12 to 25 days from the mean date of May 31.

Purpose: Maintaining similar peak timing will provide ascending and descending hydrograph limbs timed similarly to the historical conditions that are suspected important for spawning of the endangered fishes.

Discussion – Category E, timing of the peak, is important but it is also important to keep in mind that we are trying to mimic a natural hydrograph with the flow recommendations not replicate it. We have observed a shift in the peak so rather than setting peak releases around a specified day; releases should match the Animas River peak. Trying to match the Animas peak is difficult because of limitations in forecasting. Reclamation has to give a one week notice to basin residents of increased Navajo Dam releases (ramp-up). Is there a time or flow requirement to ramp up to peak releases?

F. Category: Target Base Flow (mean weekly non-spring runoff flow).

Level: 500 cfs from Farmington to Lake Powell, with 250 cfs minimum from Navajo Dam.

Purpose: Maintaining low, stable base flows enhances nursery habitat conditions. Flows between 500 and 1,000 cfs optimize backwater habitat. Selecting flows at the low end of the range increases the availability of water for development and spring releases. It also provides capacity for storm flows to increase flows and still maintain optimum backwater area. This level of flow balances provision of near-maximum low-velocity habitat and near- optimum flows in secondary channels, while allowing water availability to maintain the required frequency, magnitude, and duration of peak flows important for Colorado pikeminnow reproductive success.

Discussion – Category F base flows, 500-1,000 cfs, should be potentially increased to 1,200 cfs to increase the amount of low velocity habitat. Specific base flows based on desired outcomes need to be identified (e.g., X amount of low velocity habitat will be provided at X flows). Time frames for flows need to be set (e.g., runoff - August 15 for low velocity habitats, August 15 – September for higher flows to disadvantage nonnative fish). These are hypotheses that need to be tested (e.g., targeting consistently higher base flows at 1,200 cfs will trigger more spawning and/or provide more nursery habitat). Farrington said this could not be tested under the current larval monitoring design because larval habitat can always be found at various base flows. If you increase backwater habitat or lose wetted

habitat at the lower base flows, the benefit cannot be measured. Lamarra said he has data but would need to look at it in a different way. Farrington said he has monitoring site data but it will not answer the question. Backwaters have the highest numbers of larval suckers but they shift to other habitats as juveniles (around fall). Propst said red shiners have moved out of backwaters by early August. Purposes identified for base flows were favoring backwaters after the descending limb and disadvantaging nonnative fish. The group agreed that the current purposes are still valid but that they need to be testable.

G. Category: Flood Control Releases (incorporated in operating rule).

Control: Handle flood control releases as a spike (high magnitude, short duration) and release when flood control rules require, except that the release shall not occur earlier than September 1. If an earlier release is required, extend the duration of the peak of the release hydrograph. A ramp up and ramp down of 1,000 cfs per day should be used to a maximum release of 5,000 cfs. If the volume of water to release is less than that required to reach 5,000 cfs, adjust the magnitude of the peak accordingly, maintaining the ramp rates. Multiple releases may be made each year. These spike releases shall be used in place of adjustments to base flow.

Purpose: Historically, flood control releases were made by increasing fall and winter base flows. This elevates flows above the optimum range for nursery habitat. Periodic clean-water spike flows improve low-velocity habitat quality by flushing sediment and may suppress red shiner and fathead minnow abundance.

Discussion – Category G, flood control releases are Operational Spill. We will need to work with Behery to determine how operational spill can be used to best benefit the fish and habitat. The original flow recommendations say that spike releases shall be used in place of adjustments to base flows to above the target range (great than 1,000 cfs). Past options for Operational Spill included increasing the nose of the peak release and fall spikes. New options discussed include shaping the peak by adding additional days at peak, decreasing the nose or adding a tail to the peak release, and increasing base flows.

SECTION: MODIFY/DEVELOP DECISION TREE AND REACH AGREEMENT TO MOVE FORWARD

Summary/General Agreements:

- The 1999 flow recommendations still provide the fundamental basis for the flow release categories. After 18 years of flow recommendations, the BC determined that the methodology to reach flow targets needed to change. A new method for implementing the flow recommendations needs to allow for more flexible decision-making based on hydrologic and other conditions. The modified flow recommendations are still based on mimicking a natural hydrograph (not replicating it) and species and habitat needs but how they are implemented needs to be more flexible and testable under the current hydrology and system limitations and constraints.
- Purposes, hypotheses, level of supporting data, and questions we want to answer need to be identified and part of the modified flow recommendations.
- Targeting mid-range flows at the expense of high flows is not good. The BC agreed to eliminate Type 1 and 2 releases as operational targets because those lower flow categories are met when Type 3 and 4 releases are made.

- Attaining the frequency of high flows as described in the flow recommendations is still dependent on Animas flows; therefore, trying to time the Animas peak needs to be an integral part of the operational target.
- The group decided to further develop Flexible EWYST Method prioritizing Type 3 and Type 4 releases, their associated ramp-downs and increased base flows. Details of each will need to be worked out (e.g., shape of peak flows, higher base flow targets)
- All flow recommendation parameters identified during discussions need to be part of the target(s) and should have hypotheses developed to clarify expected responses. The accompanying hypotheses need to answer priority questions of what magnitude, timing, and duration is needed to benefit fish and habitat (e.g., what flows are needed to best disadvantage Russian olive establishment, when do high flows cause temperature depression that negatively affects spawning).
- Implementation of specific monitoring to measure effects of the targeted releases and flows on fish and habitat must be an integral part of the flow recommendations. Fish need to be well represented in the hypotheses. A scientifically-sound research program is needed that can assess the effects of releases and flows on fish and habitat. For example, monitoring needs to occur before and after high flows to determine channel changes that occur from major flow events.

<u>Outstanding Issues/Questions:</u>

- How should the peak releases be shaped? Adding a nose on Type 3 and Type 4 (both 3 weeks) is a way to get rid of water. Extending peak releases to 4 weeks causes operational insecurity. Is "available days at peak" a priority over having a nose? The original nose was based on sediment transport not biology. We could start at a Type 3 release, go to 30 days then start adding to the nose, if needed. At 30 days, Reclamation will need to have a shutdown period for safety purposes.
- Does temperature need to be part of the flow target(s)? To measure, a flow test could be implemented that targets temperature to improve spawning success. Can something be done right now to test this? We could look at big release years and see what the temperatures were and what the next year's larval results were. Coordinating spring releases with high Animas flows should minimize the effects of temperature depression. In the future, spring peak releases should not be made when there are not corresponding high flows from the Animas.
- Is spawning habitat limiting in the San Juan River?
- Should base flow targets be higher than they were (e.g., 1,500 cfs for 3 weeks would provide more wetted surface area possibly disadvantaging nonnative fish and vegetation)?
- Is a connection to Lake Powell needed for recovery?
- Are there releases (temporally, duration, etc.) that could negatively affect fish (e.g., would making releases in early spring before Razorback Sucker spawning negatively affect spawning)?

<u>Action Items/Tasks to be completed prior to Flow Workshop #3:</u>

- Develop a draft modified flow recommendations table based on the workgroup meeting comments/input – Program Office (see **Table 1)**
- Develop a detailed description of EWYST Operating Rules for inclusion in the new flow recommendations including operational spill. Model runs are needed to see what targets are met under various options for operational spill water including options for shaping peak releases and flexible duration peaks – Behery and Program Office

- Compare SJRB Hydrology Model Gen 2 to Gen 4 depletions. Reclamation and Service will meet in Jan/Feb to discuss baseline depletions in the model – Reclamation/Service
- Include a parameter for previous year/following year in mixture models – Farrington
- Describe the basis for changes to the flow recommendations and provide justification – Program Office and P.I.'s.
- Revisit safety operations required at the Dam when maximum amounts of water are being released – Behery
- Do model runs of various days at peak flow – Behery
- Schedule Workshop #2 in March/April to include both BC and CC – Program Office
- Develop agenda for Flow Workshop #2 – Program Office

  Agenda items identified during the workgroup meeting included:

  - Summarize progress that has been made (e-flow workshop #1 and workgroup meeting). Describe changes and recommendations.
  - Review results of model runs to see effects of various release options (e.g., elevated base flows at 750 and 1,000 cfs).
  - Formalize the new decision tree and revised flow recommendations.
  - Identify structure of end product for revised flow recommendations and operations
  - Identify flow recommendations for 2016.
  - Get input/comments.

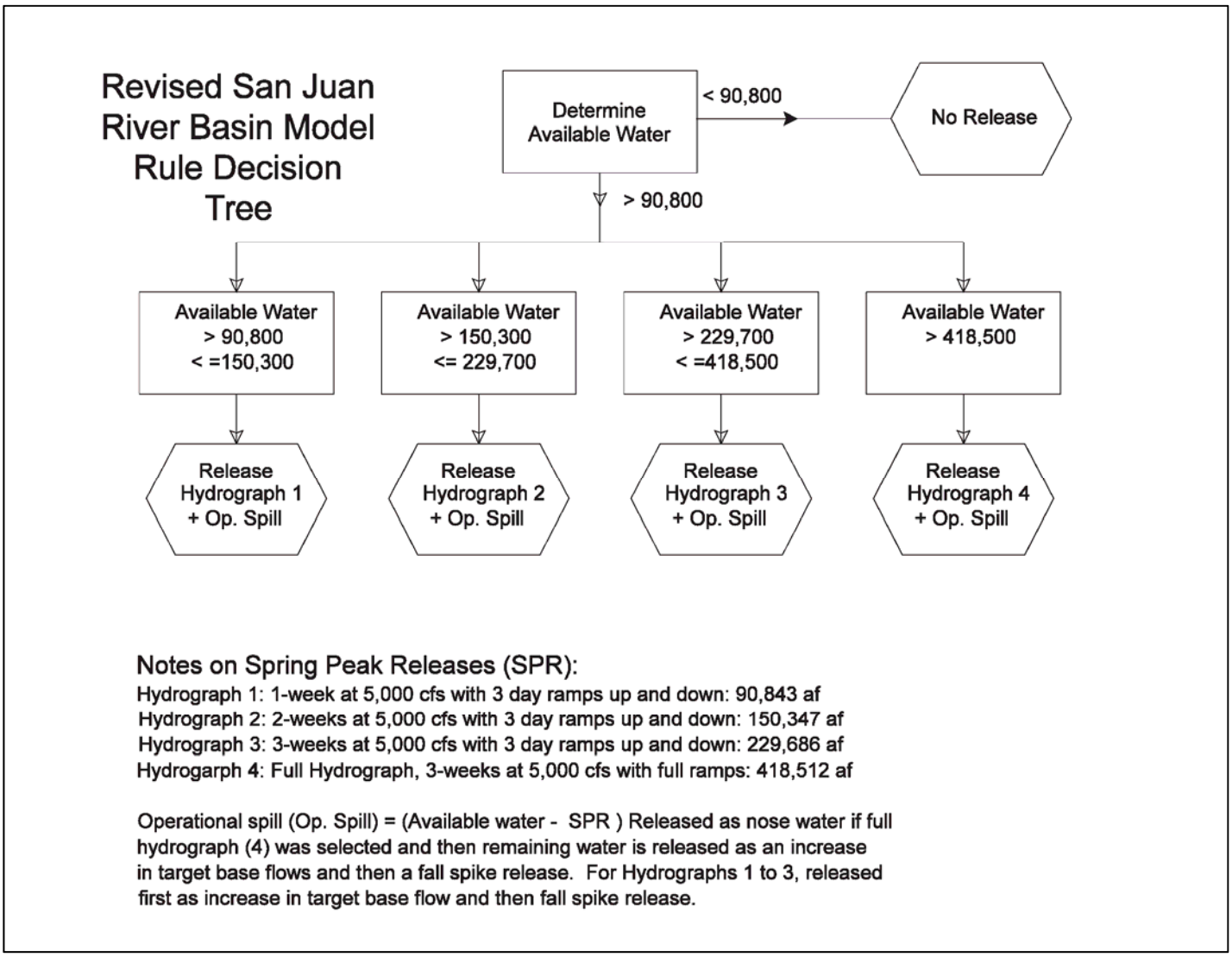

Figure 1. 2015 Interim Operations (EWYST 6,063 feet)

Calculate Available Water (AW) under EWYST 6050. Is Available Water < 229,700?	--YES-->	No release. EWYST changes to 6063 ft.
| NO | V		
229,700 af <Available Water <418,500 af	--YES-->	Release Type 3. EWYST changes to 6063 ft after release.
| NO | V		
Available Water > 418,500 af	--YES-->	Release Type 4. EWYST changes to 6063 ft after release.

Figure 2. Flexible EWYST Method (uses same AW calculation as the Interim 2015 Method)

Table 1. Draft Modified Flow Recommendations and Predicted Responses

This table summarizes the hypothesized abiotic and biotic effects of flow recommendation metrics and targets along with evidence and assumptions supporting those hypotheses. Highlighted hypotheses were not included in the original flow recommendations document. The BC should add relevant hypotheses and provide evidence and assumption behind those and existing hypotheses.

10,000 cfs Flow Metric

Duration: **A minimum of 5 days between March 1 and July 31.**

Frequency: **Flows >10,000 for 5 days or more need to occur in 20% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 9,700 cfs (97% of 10,000 cfs) within the 65-year period of record is 10 years.

Hypothesized effects ≥10,000 cfs:	
Abiotic	**Evidence and assumptions**
1. Out of bank flow	
2. Generates new cobble sources	
3. Changes channel morphology and maintains channel complexity	Increased number of islands after high flows (Lamarra ####)
4. Increases nutrient loading and productivity	
5. Suppress nonnative vegetation in the bank full channel	
Biotic	
1. Colorado Pikeminnow reproductive success	
2. Important to Colorado Pikeminnow and Razorback Sucker	
3. Promote native fish abundance	Gido and Propst (2012)

8,000 cfs Flow Metric

Duration: **A minimum of 10 days between March 1 and July 31.**

Frequency: **Flows of > 8,000 cfs for 10 days or more need to occur in 33% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 7,760 cfs (97% of 8,000 cfs) within the 65-year period of record is 6 years.

Hypothesized effects ≥8,000 cfs:	
Abiotic	**Evidence and assumptions**
1. Maintenance of channel cross section	Bankfull discharge is between 7,000 and 10,500 cfs below Farmington, with 8,000 cfs being representative of the bulk of the river.
2. Moves cobble and builds cobble bars	
3. Create larval Razorback Sucker habitat during peak and receding flows	
4. Suppress nonnative vegetation in the bank full channel	

Biotic	
1. Increase abundance of native fish	Bluehead Sucker and Speckled Dace showed a positive response to flows above 8,000 cfs for 0-19 days. Gido and Propst (2012)
2. Colorado Pikeminnow reproductive success	

5,000 cfs Flow Metric

Duration: **A minimum of 21 days between March 1 and July 31.**

Frequency: **Flows of > 5,000 cfs for 21 days or more need to occur in 50% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 4,850 cfs (97% of 5,000 cfs) within the 65-year period of record is 4 years.

Hypothesized effects ≥5,000 cfs:	
Abiotic	**Evidence and assumptions**
1. Clean backwaters and maintain low velocity habitat in Reach 3	Increases nursery habitat
Biotic	

2,500 cfs Flow Metric

Duration: **A minimum of 10 days between March 1 and July 31.**

Frequency: **Flows of > 2,500 cfs for 10 days or more need to occur in 80% of the years on average for the period of record 1929-1993.** Maximum number of consecutive years without meeting at least a flow of 2,425 cfs (97% of 2,500 cfs) within the 65-year period of record is 2 years.

Hypothesized effects ≥2,500 cfs:	
Abiotic	**Evidence and assumptions**
1. Moves cobble in high gradient areas	
2. Cleans cobble for spawning	
Biotic	
1. Triggers spawning by Colorado Pikeminnow	

Timing of the peak flows noted above must be similar to historical conditions, and the variability in timing of the peak flows that occur historically must also be mimicked.

Timing: Mean date of peak flow in the habitat range (RM 180 and below) for any future level of development when modeled for the period of 1929-1993 must be within 5 days +/- of historical mean date of May 31 for the same period.

Hypothesized effects timing of peak flow:	
Abiotic	**Evidence and assumptions**
Biotic	
1. Important for endangered fish spawning	

Target base flow (mean weekly non-spring runoff flow)

Level: 500 cfs from Farmington to Lake Powell, with 250 cfs minimum from Navajo Dam.

Hypothesized effects target base flow:	
Abiotic	**Evidence and assumptions**
1. Enhances nursery habitats	
2. 500-1000 cfs optimizes backwater habitat	
3. Target base flows need to be higher to achieve desired effects.	Long-term decline in total channel area (Lamarra)
Biotic	
1. Important for endangered fish spawning	
2. Suppress nonnative fish abundance (red shiner, fathead minnow and mosquitofish).	Gido and Propst (2012)

Operational Spill, formerly flood control releases (incorporated into operating rule)

Control: Handle flood control release as a spike (high magnitude, short duration) and release when flood control rules require, except that the release shall not occur earlier than September 1. If an earlier release is required, extend the duration of the peak of the release hydrograph. A ramp up and ramp down of 1,000 cfs per day should be used to a maximum release of 5,000 cfs. If the volume of water to release is less than that required to reach 5,000 cfs, adjust the magnitude of the peak accordingly, maintaining the ramp rates. Multiple releases may be made each year. These spike release shall be used in place of adjustment to base flow.

Hypothesized effects of flood control releases:	
Abiotic	**Evidence and assumptions**
1. Improve low velocity habitat quality by flushing sediment	
Biotic	
1. Suppress Red Shiner and Flathead Minnow abundance	