

The Lower Dolores River

**IMPLEMENTATION  
MONITORING  
AND EVALUATION PLAN**

For Native Fish



August 2012

LOWER DOLORES RIVER

## IMPLEMENTATION, MONITORING, AND EVALUATION PLAN

### FOR NATIVE FISH

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**In consultation with:**

Colorado Water Conservation Board  
U.S. Bureau of Land Management  
U.S. Bureau of Reclamation  
U.S. Forest Service

**Submitted for review and consideration by:**

The Colorado Water Conservation Board  
The Dolores River Dialogue  
The Lower Dolores River Working Group and its Legislative Subcommittee  
Participating Organizations and their Governing Structures

# LOWER DOLORES RIVER

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## IMPLEMENTATION, MONITORING AND EVALUATION PLAN

### I. INTRODUCTION and GOALS OF THE IMPLEMENTATION, MONITORING AND EVALUATION PLAN

In 1975, a joint Federal-State team consisting of the U.S. Forest Service, the Bureau of Outdoor Recreation, and the Colorado Department of Natural Resources (represented by the Colorado Water Conservation Board) recommended that the Dolores River from Section 2, T38N, R16W, NMPM below McPhee Dam to one mile above Highway 90 near Bedrock, CO, be designated a component of the National System of Wild and Scenic Rivers (Dolores River Wild and Scenic River Study Report, 1975). Nearly 40 years later, the San Juan Public Lands Center (SJPLC) began their work revising the San Juan National Forest and the San Juan Resource Area (now BLM's Tres Rios Field Office) Resource Management Plans. A requirement of the planning process was that all planning-area rivers be assessed (or reassessed) for their eligibility, classification, and suitability for inclusion in the National Wild and Scenic River System. The San Juan Public Lands Draft Land Management Plan (DLMP), released in December 2007, found the Dolores River from the outlet of McPhee Reservoir to Bedrock to be preliminarily suitable for inclusion in the National Wild and Scenic River System. Outstandingly Remarkable Values (ORVs) for the Dolores River between McPhee Reservoir and Bedrock include fish and wildlife resources, recreation, scenery, and other geological, ecological, and archeological values. Some of the specific ORVs are the roundtail chub, rafting, the New Mexico privet, the canyon treefrog and the Eastwood's monkeyflower.

Since the Dolores River Dialogue (DRD) had been engaging on the lower Dolores River<sup>1</sup> for several years, the DLMP acknowledged that there is potential for the DRD to find an alternative to suitability/designation that would “achieve similar protections for the stream and its ORVs” (San Juan Public Lands Draft Management Plan, 2007). The potential for the DRD to find an alternative to a suitability finding by the Federal land managers stemmed from the DRD’s previous work assisting the SJPLC in assessing Wild and Scenic River suitability, and in its ground-up, collaborative framework that was already attempting to address pressing ecological needs for the lower Dolores River, including some of the ORVs cited in the DLMP.

In December 2008, the SJPLC formally reached out to the DRD and asked for its assistance in identifying and securing needed protections of the ORVs, which could include alternatives to Wild and Scenic suitability. The DRD in conjunction with the Dolores Public Lands Office established the Lower Dolores River Working Group (LDRWG; Working Group) and began a multi-year process of understanding the human, ecological, and political dynamics at play on the lower Dolores River and what tools might best address the needs of the ORVs while simultaneously honoring local and regional concerns regarding a suitability designation.

In March 2010, the Working Group unanimously recommended that a National Conservation Area (NCA) designation be investigated as a means to protect the ORVs and to honor local and regional concerns that surround suitability. The creation of an NCA requires Congressional legislation, and the Working Group created a Legislative Subcommittee



to work through issues and bring ideas back to the full group. It is important to note that when the Working Group arrived at this point, it reached out to both Montrose County and the BLM Uncompahgre Field Office to include them in the discussion because it makes geographical sense for the NCA boundary to terminate just before the town of Bedrock, rather than at the Tres Rios FO boundary. Since the LDRWG embarked on this investigation and the development of a legislative outline for Congressional consideration, they have accomplished a great deal of consensus. Topics such as protection of certain ORVs, protection of existing water and private property rights, motorized vehicle use, grazing, mineral extraction, and lands with wilderness qualities are among those where the group has reached agreement.

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<sup>1</sup> The DRD, the Tres Rios BLM Field Office, and the Implementation Team all have slightly different definitions of 'the lower Dolores' River, based on jurisdiction or overall objectives. For the purposes of this document, the lower Dolores River refers to the reach from McPhee Dam to the confluence with the San Miguel River, where actions described in this document will most directly affect the fishery.

The Working Group was, however, unable to reach consensus on how legislation might specifically address the roundtail chub and the related topic of flow-dependent ORVs, including whitewater boating. As a result, in the fall of 2010 the Legislative Subcommittee created a process called ***A Way Forward***, designed as a transparent scientific inquiry using all available existing data to help stakeholders better understand the status of the roundtail chub as well as the bluehead sucker and the flannelmouth sucker in the Dolores River below McPhee Dam ('lower Dolores River') and to identify tools that could potentially help improve the status of each species. The three species, as opposed to just the roundtail chub, were chosen for study based on their recognition as 'species of concern' for most Colorado Basin states (including Colorado) and the BOR, USFS, and BLM. These species are the conservation targets for a multi-state, multi-agency conservation agreement – "Range-Wide Conservation Agreement and Strategy for Roundtail Chub *Gila Robusta*, Bluehead Sucker *Catostomus Discobolus*, and Flannelmouth Sucker *Catostomus Latipinnis*" (Sept. 2006) – to which Colorado, the United States Forest Service (USFS)/ Bureau of Land Management (BLM) and Bureau of Reclamation (BOR) are signatories. In addition, the range-wide declines described in the Conservation Agreement speak to their potential for listing by the U. S. Fish and Wildlife Service as threatened or endangered under the Endangered Species Act of 1973, as amended. The final report from ***A Way Forward*** was completed in August 2011.

The final report summarized the status and trends of the three species from McPhee Dam down to the confluence with the San Miguel River, discussed reasons for their decline, and presented opportunities for improvement of the native fish community. Reaches identified in **Table 1** were first stratified by the DRD in the Core Science Report (2005) and were based mainly on changes in geomorphic character (e.g., confined or unconfined), gradient, sinuosity, vegetative community composition, and instream habitat conditions. **Figure 1** identifies these reaches from McPhee Dam to the confluence with the Colorado River.

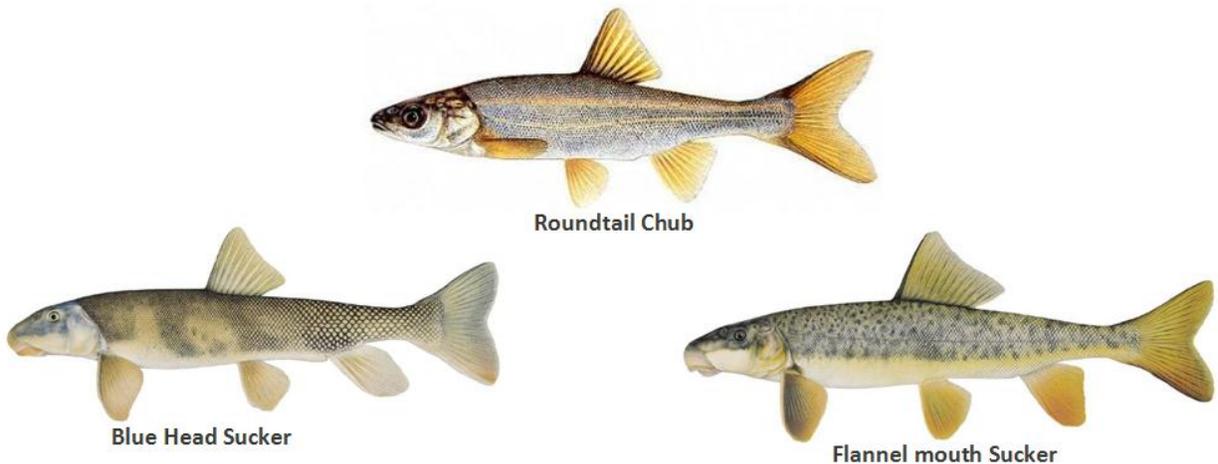


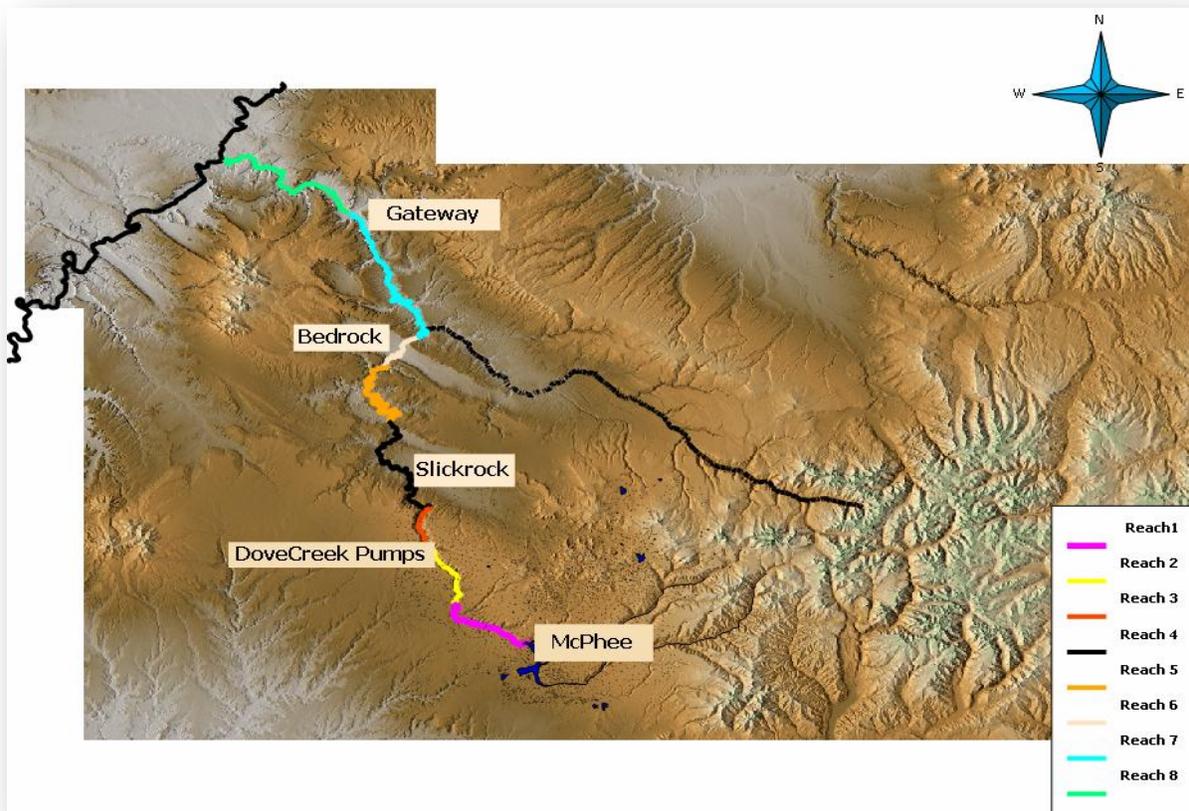
Table 1. Summary of Findings from *A Way Forward* Final Report\*

Species	Status	Trend
<b>Roundtail chub</b>	Rare in DRD reaches 1 and 2; relatively the most abundant of the three species in downstream reaches	Population declining or may be extirpated in reaches 1 and 2; populations small and either highly fluctuating or declining in downstream reaches
<b>Flannelmouth sucker</b>	Rare in upstream DRD reaches 1-3; present in variable abundance in downstream reaches	Population is declining in downstream reaches
<b>Bluehead sucker</b>	Rare in entire study area	Declining to the point of extirpation in most reaches

\* Bestgen, K.R., Budy, P., and Miller, W.J., Status and Trends of Flannelmouth Sucker *Catostomus latipinnis*, Bluehead Sucker *Catostomus discobolus*, and Roundtail Chub *Gila robusta*, in the Dolores River, Colorado, and Opportunities for Population Improvement: Phase II Report. August 2011.

## Native Fish





**Figure 1.** Reach classifications as determined by the Dolores River Dialogue Core Science Report (2005). *A Way Forward* study focused on Reaches 1-6, from McPhee Dam to the confluence with the San Miguel River.

The scientists concluded that the strength of status and trend conclusions was high while the strength of conclusions regarding the exact mechanisms underlying population decline was less certain. According to the *A Way Forward* final report, there is currently no single factor that is most responsible for native fish declines. The most likely combined causal factors for declines in the three species' populations are reduced frequency, magnitude and duration of peak flows (spills/managed releases) as well as reduced base flows compared to pre-diversion and impoundment times. Non-native fishes were also cited as having likely had negative effects on the native fishes mainly via predation on early life stages. The final report presented nine potential management opportunities that may assist with the improvement of the native fish community: spill management, baseflow management, sediment transport flows, habitat maintenance flows, thermal regime modification, reducing the effects of introduced coldwater species, reducing the effects of introduced warmwater species, and supplementing native fishes (See Section I.3).

In June 2011, the Legislative Subcommittee in cooperation with a Scientific Oversight Panel created specifically for the *A Way Forward* process ranked the nine opportunities based on urgency, necessity, and the complexity of implementation. All of the opportunities except discontinuing the stocking of coldwater fish were ranked by the group as items that “we can and should work on now” (Lower Dolores Working Group, ‘A Way Forward’ Researchers’ Presentations to the Oversight Panel and Legislative Committee, 2011 – See Appendix G). The group recognized the importance of improving base flows as a critical component of native fish sustainability, but also acknowledged the difficulty of finding a simple solution, so this ranking fell between ‘we can and should do this now’ and ‘we should do this but it will take education, consensus building, and time’. It was further decided that implementation of the opportunities identified by the AWF scientists could be addressed outside of the NCA legislation through a process that further described each opportunity identified, implementation, and effectiveness of monitoring. Subsequent corrective flow management actions may be required to move viability metrics in the correct direction. The formation of the Implementation Team and this Implementation, Monitoring and Evaluation Plan is the result of those efforts, and reflects a consensus amongst the parties involved that an adaptive management program with committed participants will complement the legislative efforts that are seeking to create the National Conservation Area.



Since the Implementation Team (IT) is an outgrowth of the NCA discussion, the *Implementation, Monitoring and Evaluation Plan* will be used in conjunction with proposed NCA legislation to meet the obligation to protect ORVs in the absence of Wild and Scenic suitability or designation. The commitment of the IT members to address opportunities to improve the native fish in the lower Dolores River needs to be made permanent in some way in order for suitability to be relinquished. While this topic has been discussed in the first phase of the IT’s work, agreement has not yet been reached on exactly how this will be accomplished. This will need to be determined in conjunction with NCA legislation moving forward (see Section 1.2, ‘Timeline’, for more discussion). The BLM’s preliminary finding of suitability for the lower Dolores in their Draft Land Management Plan should be carried forward into the Final Plan and maintained until the NCA proposal is passed into law and the work of the Implementation Team

is formalized. Additionally, while the link from the Implementation Team and Plan to NCA legislation is critical, it is also important to note that the ***A Way Forward*** process taught us that there is an imperative need to make substantial progress in improving the status of native fish. It is the intent of the IT members that the Team should continue to function and achieve stated goals independent of the outcome of the legislative process.

## 1. GOAL STATEMENT

The goal of the Implementation Team is to protect and enhance the long-term viability of native fish populations in the Dolores River below McPhee Dam. This *Implementation, Monitoring and Evaluation Plan* details the specific actions that Implementation Team partners will take to ensure the enduring protection of roundtail chub, flannelmouth sucker, and bluehead sucker in the Dolores River. This Plan provides the framework for a coordinated, long-term resource management strategy that will protect native fish and that can provide a partial basis for an alternative to a 'suitability' determination under the Wild and Scenic Rivers Act. The Implementation Team partnership is based on the premise of shared responsibility, and will proceed with respect for existing water rights and water allocations and the prior commitments imbedded in Dolores Project authorizations.

### A. IMPLEMENTATION TEAM

The Implementation Team emerged from the ***A Way Forward*** and Lower Dolores River Working Group ('Working Group') legislative processes, and is charged specifically with assessing, implementing, and evaluating the opportunities described by the scientists, and to adapt their management based on the success or failure of specific actions. This Implementation Plan describes the approach taken to achieve this, the actions under each of the opportunities, and specific fishery metrics that can be monitored and that quantify 'native fish viability' to the extent that this is possible (see Section 1.4). The partners who comprise this team were selected because of their critical roles relating to implementation of the opportunities, the commitments made in prior Dolores Project authorizations, or their representation of broad constituencies that may be critical toward achieving the objectives for native fish. The role of each participant is described more fully below.

- i. **U.S. Bureau of Reclamation (BOR)** - Owners of McPhee Dam. The Dolores Project is a federal project under the Colorado River Storage Project Act. Operations of McPhee are governed by contractual agreements with water users and the public via federal law and other permitting authorities and obligations (Reclamation Act, National Environmental Policy Act, Clean Water Act, Endangered Species Act, cooperative agreements (e.g., "Range-Wide Conservation Agreement and Strategy For Roundtail Chub *Gila Robusta*, Bluehead Sucker *Catostomus Discobolus*, and Flannelmouth Sucker *Catostomus*

*Latipinnis*"), etc. Other responsibilities include dam safety, forecasting, and power generation.

- ii. **U.S. Forest Service and Bureau of Land Management (USFS/BLM)** - Public land managers of the Dolores River corridor and surrounding landscapes. The Implementation Plan needs to conform to other management authorities and statutes that govern land management direction nation-wide, and should be referenced as a component of the Tres Rios Field Office's update to the Corridor Management Plan for the Dolores River. The Field Office's Wild and Scenic River Act finding that the corridor was 'preliminarily suitable' was the catalyst for the Working Group process and subsequent work on the native fish ORV (***A Way Forward***).
- iii. **Dolores Water Conservancy District (DWCD)** - Holder of water rights allocated to the Dolores Project. The DWCD is responsible, via multiple contracts with BOR and Dolores Project allocation holders, for distribution and accounting for water deliveries and for maximizing water yield for project users.
- iv. **Montezuma Valley Irrigation Company (MVIC)** - Private water company that is the original water-right holder on the Dolores River with senior direct-flow right of 795 cfs. Prior to the construction of McPhee, MVIC accepted contracts with BOR and DWCD that describe the delivery of MVIC water rights and allocations (non-Project and Project supplies) to their system. The MVIC Board and company managers also have a fiduciary responsibility to protect the value of company stock.
- v. **Colorado Parks and Wildlife (CPW)** - CPW has fisheries management responsibility for the Dolores River coldwater sport fishery and warmwater native aquatic community and provides the fishery monitoring component that is critical to assessing the status and trend of the fishery.
- vi. **Trout Unlimited (TU)** – TU is a national organization and the coldwater fishery proponent instrumental in the 'flow to pool' agreement, Environmental Assessment, and subsequent baseflow negotiations in the 1990s. TU continues to advocate for the 'quality coldwater fishery' mitigation commitment described in Project permitting documents.
- vii. **American Whitewater (AW)** – AW is a national organization representing conservation-minded whitewater boating enthusiasts. As whitewater boating is a flow-dependent ORV in the lower Dolores River, streamflows have a direct bearing on the quality of the recreational opportunities. AW has defined recreational streamflow needs, and continues to assess frequency, timing, and

duration of 'boatable flows' and commitments made in Project permitting documents as they relate to whitewater boating opportunities. AW has developed an approach for monitoring boater responses to annual reservoir operations and spill management alternatives provided in this Plan.

- viii. San Juan Citizens Alliance (SJCA)** – SJCA is a local grassroots conservation organization focused on both land and water in the lower Dolores Basin. SJCA provides the critical link between the flow-dependent ORVs described in the Wild and Scenic suitability assessment and the land component in the proposed Dolores River NCA. SJCA worked with the Dolores Water Conservancy District to start the Dolores River Dialogue.
- ix. The Nature Conservancy (TNC)** – TNC is a native-species conservation proponent with experience implementing complicated multiple use water management partnerships. TNC has made a large investment in the Dolores River corridor through TNC's water program (funding, staff, and direction for the Dolores River Restoration Partnership) and brings a comprehensive multi-faceted approach to solving difficult land and water use issues.

The Implementation Team was initially responsible for the drafting of this Implementation Plan, and as of June 30, 2012, had completed this endeavor. Additional tasks associated with this Plan are the drafting of an Executive Summary and an educational outreach pamphlet describing the issues surrounding the protection of native fish in the Dolores River. Given the responsibilities of each organization, the Implementation Team will continue working with their constituents to inform them of this process and will also continue to meet regularly to refine implementation strategies. It is anticipated that subsequent Implementation Team efforts will focus on the monitoring and evaluation of the opportunities, and particularly, making progress on the more complicated, multi-faceted issues such as spill management, warmwater invasive fish abatement and baseflow enhancement.

## B. INSTITUTIONAL CHALLENGES

Many of the participating entities described above have governance structures that do not necessarily blend with an adaptive management philosophy. In other words, there may be internal policy guidance or explicit contract language that could hinder an organization's ability to flexibly adapt to new management strategies in the time frames that the AWF science contractors envisioned. None of the opportunities presented can be implemented without addressing the institutional structures of these entities, their existing mandates, and their current mechanisms for adapting their management to meet evolving demands. Additional details regarding where institutional precedent, contracts, or guiding principles may conflict with the adaptive strategy this Plan envisions are described below in Section I.3.B, 'Implementation Issues'.

## 2. TIMELINE

It is important for the implementation program to proceed at a pace that is able to capitalize on any opportunity to manage for native fish downstream. The timeline laid out below will also be adapted to meet ongoing implementation issues, but the near-term, mid-term, and long-term will allow work on all opportunities concurrently. For example, thermal regime monitoring or spill management should be implemented immediately as the opportunity presents itself, whereas baseflow augmentation is an issue of equal importance but with a more complex dynamic amongst the stakeholders and their constituents.

Specific tasks for each of these three time frames are sketched out below. It is expected that as tasks are completed, this section will be re-drafted to reflect the new set of near-term tasks, those tasks that are further on the horizon (i.e., mid-term), and those which remain on a long-term planning horizon.

### A. NEAR TERM (FALL 2011 - SUMMER 2012)

- Implementation Team meetings every 3-4 weeks beginning July 28, 2011, through June 2012; continue collective investigation of opportunities presented by *A Way Forward* Scientists Phase II Final Report (August 2011);
- Draft *Implementation, Monitoring and Evaluation Plan* by end of June 2012;
- Develop 'Spill Guidelines' related to specific hydrologic scenarios dependent on Upper Colorado River Basin Forecast Center seasonal runoff forecasts for the Dolores Basin, reservoir elevations, and spring water demands. (**JUNE 30, 2012, NOTE:** McPhee Reservoir storage peaked May 9 at elevation 2916.25 feet, ~8 ft below fill, so there was no surplus and no opportunity to implement spill or thermal target flow guidelines as outlined in this document);
- Develop management indicators or biological metrics that can be used to assess the long-term viability of the warmwater native fish community (an initial draft of metrics is presented in Section 1.4);
- Test partners' ability to monitor specific physical and biological components related to native fish recruitment; assess whether specific flow-related actions helped meet short-term targets (e.g., did 150 cfs May 1 keep temp <15C?); evaluate activities undertaken to discern relative benefits; in other words, process annual monitoring data into management information;
- Determine structure and function of the Implementation Team and *Implementation, Monitoring and Evaluation Plan* and next steps for moving beyond this initial phase;
- Continue dialogue related to permanent protection of native fish ORV in the Dolores River that will provide a viable alternative to maintaining 'suitability' determination under the Wild and Scenic Rivers Act;

- Develop framework for addressing the important but long-term issue of protection and augmentation of baseflow to protect the fishery.

**June 30, 2012 note:** This increment concluded with the completion of this draft *Implementation, Monitoring, and Evaluation Plan*. In addition, the Implementation Team has continued to meet and is in the process of assessing the following year's 'near-term' activities. The Implementation Team has also installed a satellite-linked real-time temperature gage just upstream of Disappointment Creek, and has plans for FY 2012-13 to install a PIT ('passive integrated transponder') tag array, mark eligible native fish, and continue with low-flow fish monitoring activities. Cooperative agreements have been reached among IT members to improve boater response survey capacity, and to determine how composite hydrographs designed to optimize amongst competing needs will affect riparian resources. **NO SPILL OCCURRED IN 2012.**

#### B. MID-TERM (1-3 YEARS)

- The Implementation Team will continue to meet on a regular basis to continue discussions on the complex, long-term issues, and to ensure that the monitoring and evaluation information derived from the actions described in this plan will help direct water management below the dam;
- Implement details of *Implementation, Monitoring and Evaluation Plan*;
- As forecasted surplus water is realized, implement specifics of the spill guidelines developed over the initial term of the Implementation Team; use AW boater monitoring protocols developed in early 2012 to assess the success of the spill;
- Continue annual iterations of spill guidelines and the seasonal monitoring program based on prior years' evaluations;
- Re-evaluate long-term 'viability targets' (management indicators) in light of overall monitoring during the mid-term period;
- Evaluate the overall implementation process against the requirement that it will provide part of an alternative to maintaining Wild and Scenic suitability determination under the Wild and Scenic Rivers Act;
- Deliberately work with the Lower Dolores River Working Group's Legislative Subcommittee to reach agreement on a mechanism for permanent protection of the native fish ORV.

### C. PERPETUAL PROTECTION OF ORV

- Set in motion mechanisms for permanent protection of the native fish ORV. Solutions could include but are not limited to:
  - NEPA action;
  - language in NCA legislation;
  - linking the *Implementation, Monitoring, and Evaluation Plan* to existing documents that address native fish species (e.g., Range-Wide Conservation Agreement, BOR 1996 EA) and potentially the NCA RMP;
  - and/or official actions by partners that ensure permanent commitment to the native fish ORV in the Dolores, (e.g., MOA, MOU, or other binding commitments).
- Actively support NCA legislation.

### 3. Overview of Opportunities Identified by *A Way Forward*

The AWF scientists itemized nine opportunities they felt should be pursued or at the least, thoroughly discussed to assess the feasibility of implementation. This *Implementation, Monitoring, and Evaluation Plan* is constructed to specifically address these opportunities as they were presented in the AWF scientists' final report. Sections on geomorphic processes and coldwater non-native fish have been consolidated in this plan, but the entire list of opportunities presented by the scientists is included below:



- Spill Management
- Baseflow Management
- Geomorphic Processes - Sediment Flushing Flows
- Geomorphic Processes - Habitat Maintenance Flows
- Thermal Regime Modification
- Reduce Coldwater Invasive Effects - Discontinue Stocking
- Reduce Coldwater Invasive Effects - Reduce Brown Trout Reproductive Success
- Reduce Warmwater Invasive Effects - Disadvantage Smallmouth Bass Reproductive Success
- Supplement Adult Native Fish

## A. SYNERGIES AND DIFFERENCES

This section describes the connectivity between the different opportunities presented in the AWF Report, most notably how spill management is likely to provide the most significant, direct effect on downstream temperature and habitats, and an indirect effect on availability of baseflow.

- Spill management is the opportunity that has direct bearing on geomorphic processes, thermal regime modification, and baseflow management.
- These synergies need to be accounted for as flow targets are described for different forecasted surplus flow scenarios.
- Redundancy of opportunities - Sediment transport flows incorporate a spectrum from easily mobile fine sediments to mobilization of large clasts entering the channel through hillslope (as opposed to fluvial) processes. The two sediment transport opportunities presented are generally: (1) those flows necessary to flush fine sediments from spawning gravels and cobbles used by native fish; and (2) those flows necessary to move particles from the mid- to upper spectrum of available materials (e.g.,  $D_{50}$ ,  $D_{84}$ ) that create and maintain the variety of instream habitats necessary to meet the life-stage needs of native fish. Flows that move the larger particle sizes will necessarily also be effective at mobilizing the fine sediments necessary for spawning success.
- Inter-annual considerations - The Implementation Team flow management efforts need to account for likely benefits of flow recommendations for a given runoff season in recognition of both the physical circumstances of prior years (monitoring and evaluation feedback) and social needs (e.g., lack of boatable flows in prior years). Thus flow guidelines for similar spills may not appear consistent from year to year, as they may be adjusted to reflect prior years' targets or altered objectives based on the evaluation of monitoring data.

## B. IMPLEMENTATION ISSUES

This section is similar to Section 1.1.B, entitled 'Institutional Challenges', in that much of the history of the Dolores Project and in general, water development in the West has proceeded under the premise of the protection of one's usufructuary rights. Under Colorado water law, a water right is considered a private property right if it is used according to the Colorado Revised Statutes, which codifies the constitutional right of appropriation. Because the Dolores Project proceeded under the federal environmental statutes of the 1960s and 1970s, mitigation under NEPA also featured prominently in the authorizing documents for the Project. (See Dolores Project Definite Plan Report, Environmental Impact Statement, Supplements, and 1996 Environmental Assessment.) In addition, the Dolores Project users have an obligation to repay the Bureau of Reclamation for construction of McPhee Dam, and numerous additional

contracts have been written to govern Project operations and water accounting for Project and non-Project allocations.

This Implementation Process is designed to exploit areas within the governing documents and authorizations where water management flexibility exists in order to meet common objectives for the Implementation Team participants; that is, to ensure the long-term viability of the native fish below McPhee Dam. If this is to occur, participants must be able to find the flexibility to take advantage of opportunities that may present themselves which may run counter to the protection of one's 'rights' or elimination of risk. All participants have something to gain from success, something to lose from failure, and potentially, must all compromise on one matter or another in order to achieve the downstream objective. Some of these issues are itemized briefly below.

**i. Project Purposes -**

- "Baseflow is for the Trout; the Spill is for the Rafters." These are common words for Dolores Project 'historians', in that the Project operational targets stratified these two components of the downstream flow. The 1996 Environmental Assessment formally charged the Dolores River Biology Team - consisting primarily of an interagency team of fishery biologists - with managing the fishery pool (and ancillary



components) for the benefit of the downstream fishery. 'Spill water' is the water that in some years is in excess of McPhee storage capacity, and results in 'free river' conditions below McPhee. These flows have been managed mainly for the benefit of the rafting community, targeting minimal 'boatable flows' so that commercial watercraft could navigate Snaggletooth rapid, a Class IV rapid near the bottom of Reach 3. The stratification of the baseflow and spill components of the downstream water supply was noted by the AWF science contractors, who recommended better integration of these resources.

- Though much of the 'fishery' language in the Project documents (DPR and 1996 EA) includes native fish, the notation that one of the Project purposes was to create a 'quality trout fishery' has been problematic for the Biology Team, as the perception was that management for coldwater and warmwater species was mutually exclusive. CPW has a mandate to manage for both sport and native

fisheries, and stratifies the habitat designations for each at the Bradfield Bridge based primarily on water temperature. Due to the use of the lowest of the three dam outlets (excluding the bypass gates at the bottom of the dam), the first 12 miles will necessarily be coldwater habitat and not supportive of native warmwater fish species. However, there remains the perception that the Biology Team has managed for coldwater species to the detriment of native fish, whereas in fact, the baseflow releases for both guilds of fish are similar.

- As the implementation process proceeds, especially as draft NCA legislation matures, official recognition of the trade-off between Wild and Scenic Rivers Act suitability for the Dolores below McPhee, the NCA, and perpetual protection of the native fish ORV may need to be solidified. Such official recognition by the federal agencies involved in the Implementation Team process may re-initiate NEPA environmental review to address any new federal action, which could include explicit recognition of native fish as a Project purpose. This would ensure that management for native fish receives a management priority equivalent to the trout fishery and recreational boating.

## ii. Institutional Challenges

- **BOR** – The Dolores Project was authorized by the Colorado River Basin Act of September 30, 1968 (Public Law 90-537), as a participating project under the Colorado River Storage Project Act of April 11, 1956 (Public Law 84-485). Guidance documents under the Colorado River Storage Project Act trump locals' ability to alter legislative mandates without complying with other federal regulations, notably those written under the National Environmental Policy Act and the Endangered Species Act. In addition to the authority for the Project, existing BOR contracts with DWCD and MVIC have established current water uses and operations; and this increases the complexity of altering current water management practices.
- **DWCD and MVIC** - Current management for the Project and for non-Project water is to maximize Project water yield and to minimize risk to water supplies. Both entities have occasion to interact with the BOR or other federal agencies (e.g., U.S. Army Corps of Engineers) during the course of operations. DWCD is obligated by contract to protect Dolores Project water allocations to Full Service Irrigators, the fishery below McPhee Dam, the Ute Mountain Tribe Farm and Ranch Enterprise, supplemental Project water to MVIC, and Municipal and Industrial (M&I) water for Towaoc, Dove Creek, Cortez and rural M&I use contracts as well as the release of excess 'spill' water to provide boatable days. In order to protect these water supplies, both entities must assess the risk of a potential listing under the Endangered Species Act of any of the three native fish species occupying the Dolores River below McPhee, which could result in imposed adjustments in the operation of McPhee Reservoir. As such, both entities have an interest in efforts that improve the status of the three native

fish species without jeopardizing the water rights and Dolores Project allocations that are fundamental to meeting water supply obligations.

- **CPW** - Sport fish management was a mitigation commitment of the project, with CPW as cooperator (then as the Colorado Division of Wildlife and the Department of Natural Resources). However, brown trout utilization of transition habitats may be in conflict with management for warmwater conservation species. The smallmouth bass invasion is especially challenging given limited management options and physical constraints. The State and CPW in particular have a strong desire to maintain jurisdiction/ management of Colorado's native species and not cede management authority to the Fish and Wildlife Service (i.e., no new federal listing of species under the ESA). The United States Fish & Wildlife Service (USFWS) relies on the multi-state/agency/NGO Range-Wide Conservation Agreement in the interim to protect and conserve the three native warmwater species.

### iii. Non-Governmental Organizational Challenges

- **American Whitewater** represents the general interests of a wide array of boating communities that utilize managed spills from McPhee Reservoir for a variety of whitewater recreational experiences. While there is an explicit Project goal to regulate streamflows for boating use in anticipation of spills, due to the inherent diversity of boating interests it has historically been difficult to identify and effectively manage for the full range of whitewater flow needs.
- **Trout Unlimited** has explicitly recognized the value of preserving coldwater angling opportunities for the public, and works nation-wide to maintain coldwater trout fisheries for both native and non-native salmonid species. However, similar to CPW's 'bifurcated' mandate to manage for all fisheries, the perception may be that managing for native fish may be to the detriment of coldwater species.
- The **San Juan Citizens Alliance** has been an active supporter of flow management to protect river ecology and native fish species, and also was instrumental in garnering support for the National Conservation Area proposal through their efforts with the Lower Dolores Working Group and Legislative Subcommittee. In working through both processes and directly with the communities potentially affected by changes in land and water management in the region, the challenge will be to find an appropriate solution that protects both native fish and the surrounding watershed, while also meeting water demands.
- **The Nature Conservancy** has broad conservation interests, but also has certain processes or resources at their disposal that typically result in efficiently achieving conservation goals. The long-term prospects of an adaptive management process may not fit well into their regional conservation strategy.

In addition, investments without certainty of success make their Dolores River work particularly challenging.

**iv. Federal Land Management**

The federal land managers - **BLM** and **USFS** - adhere to land management processes governed by federal land management statutes (Federal Land Planning Management Act; National Forest Management Act) by which land management plans are revised to meet the evolving demands of multi-faceted constituents. Adaptive processes for federal managers are atypical relative to the more linear crafting of management plans followed by subsequent environmental review of the plan alternatives under consideration.

**v. Range-Wide Conservation Agreement and Strategy For Roundtail Chub *Gila robusta*, Bluehead Sucker *Catostomus discobolus*, and Flannelmouth Sucker *Catostomus latipinnis*" (Sept. 2006).**

This Agreement was signed by multiple parties and six states. Amongst Implementation Team participants, signatories included the State of Colorado, the U.S. Forest Service, Bureau of Land Management, and Bureau of Reclamation. Specific conservation actions itemized in this agreement include:

- Status assessment of native warmwater fish;
- Establish and maintain range-wide database, including current occupied habitats and potential habitats; life history requirements, habitat requirements, and conservation needs;
- Genetic and phenological characterizations of native species populations;
- Implement range-wide habitat conservation measures;
- Control of non-native predators, competitors, and white sucker (genetic threat);
- Expansion of native fish population distributions through transplant or reintroduction;
- Implement sub-regional or basin-specific conservation efforts, including long-term population and habitat monitoring programs;
- Implement education and outreach programs promoting the need for native warmwater fish species conservation.

None of these actions are inconsistent with the recommendations of the AWF science contractors, and all are being considered either directly by the Implementation Team through this planning process or by CPW as part of its own state-wide conservation strategy for these three native species. This document serves to reinforce the efforts of the Implementation Team and affirm other partners' commitment to the process.

**vi. Hydrologic Variability**

The basic theme within the Dolores River basin as a whole is inter-annual variability. The most current source of information on climate variability in Colorado is the Colorado River Water Availability Study, Phase I<sup>2</sup>. Hydrologic data from this region of Colorado typically shows greater variance from the mean regarding total runoff, streamflow, snow-water equivalent, and other hydrologic indicators. In addition, there is general uncertainty regarding the effects of global climate change on precipitation. The U.S. Southwest is notable in that all models indicate that warming temperatures may be accompanied by decreases in precipitation and increases in evapotranspiration in this region. The combination of warming temperatures, longer growing seasons, and highly variable precipitation would lead one to believe that water managers in the Dolores basin will need to be increasingly vigilant in order to balance competing demands for the resource.

**vii. Linkage to Dolores River NCA and Lower Dolores Corridor Management**

As noted in the Introduction, the Implementation Plan is an outgrowth of, and thus linked to, the Lower Dolores River Working Group's exploration of a National Conservation Area designation in lieu of suitability or designation under the Wild and Scenic Rivers Act. The circumstances that led to the linkage are detailed in that section, so will not be repeated here (see Section I, 'Introduction and Goals of the *Implementation, Monitoring and Evaluation Plan*'). Below is a discussion of a range of potential tools considered by the Implementation Team which could create the linkage, as well as how the Implementation Team and Legislative Subcommittee will work together moving forward.

The exact link back to the legislation has not yet been determined, but importantly, the Implementation Team *process* itself is not deemed to be an acceptable surrogate to a finding of suitability (and protection of the native fish ORV). The *successful implementation* of this plan certainly will be a critical part of the solution, however. The main question that remains is how to make the implementation of the process more permanent in order to create the assurance that the native fish ORV will be protected in the absence of suitability.

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<sup>2</sup> CWCB: see <http://cwcb.state.co.us/technical-resources/colorado-river-water-availability-study/Pages/main.aspx>

While agreement has not been reached on how the link will be made, the Implementation Team has discussed this necessary step and the following possibilities were identified. This list represents a wide range of possibilities, some of which would remain within the current authorizations and contracts of the Dolores Project, while others could potentially require some level of formal modification. Potential solutions could include but are not limited to:

- NEPA action, triggered by a multi-party proposal to change existing management priorities and still remain within the Project authorization and contracts;
- language in NCA legislation that could prescribe how water would be managed to meet a flow-dependent ORV and still remain within the Project authorization and contracts;
- linking the *Implementation, Monitoring, and Evaluation Plan* to existing documents that address native fish species (e.g., Range-Wide Conservation Agreement, BOR 1996 EA) and potentially the NCA Resource Management Plan;
- official actions by partners that ensure permanent commitment to the native fish ORV in the Dolores (e.g., MOA, MOU, or other binding commitments).

Lengthy, difficult Legislative Subcommittee and Implementation Team discussions indicate that there is no easy or perfect solution immediately accepted by all stakeholders to formally link the *Implementation, Monitoring and Evaluation Plan* to the NCA to achieve the needed assurance that the native fish ORV will be protected if the Wild and Scenic suitability determination is gone. However, the IT will work closely with the Legislative Subcommittee of the Working Group over the next 6 to 12 months to solidify the link between these efforts. Apart from the native fish ORV addressed here, the Lower Dolores River Working Group, specifically the Legislative Subcommittee, has several other topics yet to be addressed before the effort can move into a more formal legislative process. At the same time those topics are being addressed, the IT will implement this Plan. The two efforts will move forward concurrently and remain in close communication so that both groups track toward clear objectives for native fish and land protection. As this Plan is implemented, stakeholders involved in both processes will likely feel more comfortable with how the Implementation Team will function moving forward and how well the *Implementation, Monitoring and Evaluation Plan* is executed.

Additionally, while the link from the Implementation Team and Plan to NCA legislation is critical, it is also important to note that the ***A Way Forward*** process taught us that there is an imperative need to make substantial progress in improving the status of native fish. It is the intent of the IT members that the Team should continue to function and achieve stated goals independent of the outcome of the legislative process.

Further, the Implementation Team understands that an explicit, periodic evaluation of the AWF and Implementation *process* is appropriate, and that the process itself is not deemed a

surrogate to suitability but is currently deemed the best means of protecting the native fish ORV. While the IT and Legislative Subcommittee work to identify and implement the link, this review will ensure that the process remains productive and partners are committed, and other permitting or legislative activities may be affected if the process is not deemed effective.

### C. MONITORING AND EVALUATION OF OPPORTUNITIES

Monitoring and evaluation of the opportunities and most importantly, the fishery response to these activities is critical in order to learn and adapt management actions; subsequent monitoring will allow refinement of flow guidelines that favor native fish without unduly harming the coldwater trout fishery below the dam, commitments to boaters, downstream riparian communities, and Project and non-Project water users. However, though monitoring is often referenced as a means to learn and adapt, in practice monitoring biological communities is particularly challenging.

Some specific challenges of monitoring the Dolores River and biological response of the native fish community include:

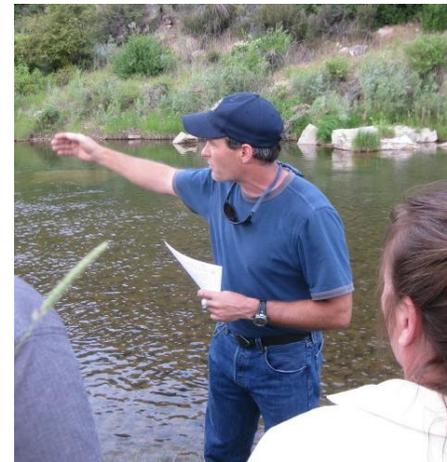
- i. Understanding the expected response of the physical components that water management is targeting, i.e., we have some ideas of what flows mobilize what sediment size for a particular reach, but at this point, most of the 'flow response monitoring' must be framed as testable hypotheses that will be refined over subsequent flow events.
- ii. The complexity of biological response to input parameters. Flow in the Dolores River below McPhee is undoubtedly a primary driver of the biota that live there; however, the AWF scientists were quick to point to other variables that determine biological community composition, such as presence/absence of appropriate habitats; presence of competitors and predators; water temperatures; food resources; and whether or not there is a minimal threshold of adult-sized fish existing to achieve successful spawn. Changing flow may affect one factor for the benefit of native fish, but there may be other factors limiting the ability of monitoring to see the expected benefits.



- iii. The process whereby the assessment of 'year  $n$ ' activities and monitoring become inputs for the following year's ('year  $n+1$ ') flow targets and subsequent monitoring activities. This is the notion that this process is nimble and flexible enough to change management within a given water year based on evidence collected following the spring or summer monitoring period the prior year.
- iv. The physical limitations posed by a scarce water supply and remote canyons where it is believed the best native fish habitat in the lower Dolores exists. For example, the reach from the Pyramid to the James Ranch near Slickrock is best sampled over a 2-day period with flows near 500 cfs. Slickrock Canyon is best sampled over a 3-day period with flows held near 800 cfs. It has proven difficult over the last 5-7 years to schedule these monitoring surveys due to the need to plan logistics in advance, mobilize crews, and in general try to replicate flow conditions so that future surveys are comparable. This problem is exacerbated in small-spill years (less than 50,000 AF), where water supply forecasts and runoff timing uncertainty is high. In addition, these canyons cannot be effectively sampled for adult fish in a non-spill, baseflow-only year (e.g., 2012) so information about the fishery is necessarily constrained by flow conditions.

#### 4. ASSESSING AND ENSURING NATIVE FISH VIABILITY

The Colorado Department of Natural Resources (DNR) drafted a 'white paper' outlining the Dolores River native fish issues and made recommendations for how to proceed basin-wide to achieve native warmwater fishery objectives for the basin (Appendix E). In addition, DNR and the State of Colorado are signatory to the Three-Species Conservation Agreement (see I.3.B.v., summary of this agreement) and are near Final Draft of a Conservation Strategy for Colorado that details the work state-wide to protect, preserve, and recover these native species to Western Slope rivers. Generally, the goal is the same as that desired by the Implementation Team participants; that is, to preserve the viability of warmwater native fish populations in the basin so that any potential for federal listing of these fish under the Endangered Species Act can be pre-empted by evidence supporting the contrary. Specifically, the goals are to more often meet the minimum instream flow of 78 cfs between McPhee Dam and the San Miguel River appropriated by the CWCB; to maintain and protect existing habitats below the San Miguel River confluence; and to avoid extirpation of these native species from the reach above the San Miguel confluence through baseflow protection and coordinated spill



releases. The five recommendations made to the Project operators and water users were as follows:

- i. a guaranteed annual increase to the fish pool to at least 36,500 acre-feet as identified in the 1996 EA;
- ii. improvement of reservoir operation to benefit native fish populations, including lengthening of the spill whenever possible and coordinating releases to minimize thermal shock in order to mimic the timing and patterns of native inflows above the dam;
- iii. adaptive spill management oversight by the Dolores Biological Team;
- iv. establishment of instream flow protection for existing native fish populations and stream flows on the San Miguel River, the Dolores River downstream of the San Miguel confluence, and important tributaries;
- v. although it is considered temporary and relatively costly, acquisition of additional water for the Fish Pool through a lease via the CWCB.

Further discussion on these recommendations is imbedded in numerous sections below, including baseflow management (Section IV). The AWF scientists also gave supporting evidence for improvements in thermal regime (Section III) and spill management (Section II) to improve the overall chance for native fish to persist in the lower Dolores basin.

## A. NATIVE FISH GOALS

The purpose of these goals is to outline how the Implementation Team intends to maintain, protect, and enhance the native fish ORV in the Dolores Canyon as an alternative to the BLM's Wild and Scenic River suitability determination. Although there are several segments under consideration for suitability, these goals apply to the Dolores River under consideration by the Tres Rios (formerly Dolores) Field Office and the Uncompahgre Field Office in the reach of river from Bradfield Bridge to Bedrock, CO (above the San Miguel River confluence). The principles and goals outlined here also will assist with achieving native fish sustainability goals downstream of the San Miguel confluence and throughout the lower Dolores River basin. Current activities being implemented region-wide for the three native warmwater species are listed in Section I.3.B.v, drawn from the Range-Wide Conservation Agreement for these species. The Implementation Team will work to continue to use these actions to direct their activities within the McPhee-to-Bedrock reach of the Dolores River.

There are a few points of clarification. First, the Implementation Team recognizes that achieving native fish populations analogous to pre-water development times is not a realistic

goal. Specific fish population metrics (e.g., fish per mile) are based on the best information about what the river is capable of producing in the reaches above Bedrock, CO, and may not apply to reaches below the San Miguel confluence. Because sampling methodologies vary widely between sites, no one fishery metric will be applicable to the entire reach under consideration. Success will be considered when multiple indicators (e.g., species composition, density, distribution, population structure, and habitat) all trend towards the metrics representing a viable native fishery.

Native fish populations below McPhee Dam are in decline and have been so for many years. Therefore, the goals emphasize protection and enhancement measures rather than maintenance given the current status of the fisheries. The guiding principles outlined below provide a backdrop to formulating goals and objectives.

**Guiding Principles:**

- Fish and habitat goals should be based on empirical science.
- In the absence of better information, the restoration of natural flow and water temperature patterns is the best course of action for native fishes.
- There are multiple causes for the decline in native fish species. No single management action is likely to produce the desired effect of native fish restoration.
- Not all reaches of the river are suitable for native fish restoration and/or expected population densities.
- Keep small problems small: coldwater releases have a 20+ year record of keeping non-natives like smallmouth bass, white sucker, and walleye in the reservoir and out of the river below McPhee, so the current release strategy is not adding non-natives to the downstream environment.
- To the extent possible, avoid prolonged low baseflows that mimic extreme drought conditions of 2002. Extreme low-flow conditions will likely wipe out any biological gains to the native fishery and exacerbate the non-native smallmouth bass problem.
- Monitoring fish populations and habitat provides critical information needed for management decisions.
- Additional monitoring should be identified and conducted as necessary to ensure that sufficient knowledge exists to adequately determine the efficacy of management actions.
- Detectable changes to fish density, distribution, population, or population structure will likely take some time (perhaps several years) post implementation of an identified action(s).

**Goals:**

1. At a **MINIMUM** restore the density, distribution, and population structure of native fishes in the Dolores River to early 1990's levels, which include the following benchmarks:
  - a. 75% native fish species composition<sup>3</sup> for large-bodied fish sampled (7% bluehead sucker<sup>4</sup>)<sup>5</sup>
  - b. 3-species fish densities (juvenile and adult) goals are listed in **Table 2** for 1-pass longitudinal raft and 2-pass walk shock fish sampling stations.
  - c. Presence of young of the year 3-species on a consistent<sup>6</sup> basis.
  - d. Maintain and/or expand 3-species distribution<sup>7</sup>

**Table 2. Fish density goals (fish per mile) for the Dolores River relative to current conditions. Raft electrofishing goals are based on average fish per mile estimates (1 pass) through Bradfield-Dove Creek pump station (19 mi), Pyramid-Disappointment Creek (13 mi), Big Gypsum (5 mi), and Slickrock Canyon (33 mi).**

Species	Bradfield - Bedrock (Current)	San Miguel (Current)	Goal 1 pass raft (fish/mi)	DC Pumps (1989-1992 - early post-dam period)	DC Pumps (2000- Present- reflects current conditions)	Goal 2 pass removal DC Pumps (fish/mi)
FMS	12.3	26.1	18	30.6	1.3	20
BHS	2.0	26.3	4	76.5	2.8	30
RTC	8.9	11.4	10	413	391	400
% BHS	6%	33%	10%			5%

<sup>3</sup> Existing native fish species composition (3-species only) varies from 22% at Pyramid, 76% at Big Gyp, to 91% through Slickrock Canyon. 75% is a reasonable and attainable goal over the entire reach (average of three sites listed above is currently 63% native) and comparable to 1990s levels

<sup>4</sup> Bluehead sucker are widely viewed as an "indicator species" of habitat conditions. A 7% bluehead sucker component is low relative to other Colorado Basin streams (Table 1)

<sup>5</sup> Species composition means 3-species and larger-bodied non-natives excluding small-bodied native (speckled dace, mottled sculpin) and innocuous non-natives such as fathead minnows. This does not apply to seine haul data where the purpose of fish sampling is to collect small-bodied fishes

<sup>6</sup> Consistent basis means goals are reached one out of every third year of measurement – the point is to find a metric representation for 'age class structure' or 'age distribution'. 'Size distribution' is a decent surrogate, but with few fish and some very small fish showing adult phenology, the 'age class metric' will continue to be assessed.

<sup>7</sup> The Dove Creek pump station is close to the upper limits of flannelmouth and bluehead sucker distribution. Increasing BHS and FMS densities at the DC Pumps and/or to Bradfield Bridge indicates a range expansion over existing conditions.

2. Reverse trend in density, distribution, and population structure for non-natives (e.g., smallmouth bass, brown trout, green sunfish, crayfish, bullhead).
  - a. Reduce non-native species average composition to less than 25% of large-bodied fish captured
  - b. Reduce adult smallmouth bass densities to less than 8 fish/mile (1 pass; Pyramid-Disappointment Creek)
  - c. Reduce brown trout densities (Bradfield – Disappointment) to less than 3 fish/mile (1 pass) or 30 fish/mi (2 pass)
  - d. Keep smallmouth bass distribution between Dove Creek pump station and Disappointment Creek from expanding
  - e. Reduce average size of smallmouth bass captured from 8 to 6 inches or less<sup>8</sup>
  
3. Maintain suitable spawning conditions for bluehead and flannelmouth sucker during April and May.
  - a. Keep average daily water temperatures below 15°C (59°F) by combining real-time temperature readings (Dove Creek pumps, Disappointment Creek) with discharges from McPhee Dam. Minimize extreme fluctuations in water temperature during spawning season ( $\leq 0.5^{\circ}\text{C}/\text{d}$  - hypothesis based on temperature data from prior spill years - see 2009 temp rates of change - too fast!).
  - b. Mimic, to the extent possible, incremental increases in spring flow (i.e., discharges from McPhee) during April/May proportional to the Dolores River above McPhee Reservoir<sup>9</sup>.
  - c. Use 25-50K AF spills to prepare spawning substrates by allowing enough flow to mobilize fines from spawning substrate (~400-500 cfs).
  - d. Use 100+KAF spills to mobilize riffle substrates (large gravel to cobble sizes) to maintain interstitial space and maximize invertebrate productivity.

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<sup>8</sup> Review Yampa River literature for target size.

<sup>9</sup> This idea is to link flows below the dam in 'native fish habitats' to the actual real-time flow at the Dolores gage. It is dependent on the forecasted surplus, but the link to 'native flow' in a managed environment gets directly at the cues that native fish need to spawn successfully.

**B. MONITORING AND EVALUATION OF NATIVE FISH VIABILITY**

Water and mineral development in the Dolores River has impacted the distribution and abundance of warmwater native fish species for well over 100 years. The earliest fish surveys were conducted in the mid-1950s using a variety of techniques and in locations relatively easy to reach. The first longitudinal ichthyofaunal surveys were done by Holden and Stalnaker (1971) and Valdez (1981, 1992). The purpose



of these early longitudinal surveys was to determine the presence/absence, distribution, and abundance of rare and endangered fishes in the Dolores River, not roundtail chub, flannelmouth and bluehead sucker. Three-species fishes were not ignored but sometimes their abundance was described qualitatively (i.e., rare or abundant) not quantitatively (fish per mile or hour), making comparisons today somewhat difficult. Since the late 1980s several long-term monitoring locations (primarily in Reaches 1 and 3) are surveyed annually with a number of other rigorous data sets developed by Nehring and Anderson in Reaches 2 and 4, respectively. Combined, these data sets (periodic, longitudinal, and annual baseline) are sufficient to clearly show a declining trend in native fish populations below McPhee Dam (Bestgen et al., 2011).

The goal of this monitoring plan is to detect changes in the abundance, distribution, and population structure of roundtail chub, flannelmouth and bluehead sucker associated with altered flow regimes designed to mimic a more natural spring and summer hydrograph in the Dolores River. Changes in fish populations will be assessed against the baseline data sets mentioned above. In addition, Colorado Parks and Wildlife (CPW) will develop a fish sampling protocol to assess early life stages of 3-species.

Monitoring fish populations in the Dolores River is a difficult prospect given the unpredictability of suitable fish sampling flows below the dam and the remote and inaccessible nature of the canyons during low water conditions. Logistics is not the only consideration. Although there may be multiple monitoring opportunities, CPW has finite resources with respect to time, personnel, equipment, and dollars. The fish monitoring surveys presented hereafter can reasonably be done by CPW staff and are sufficient to detect any significant changes in fish populations due to altered flow and habitat conditions.

## Fish Monitoring

Fish sampling stations are noted in **Figure 2**. In general, they consist of: five annually sampled walk shocking stations between McPhee Dam and the Dove Creek pumps; one annually sampled site in the Big Gypsum Valley sampled by raft shocking at low flow; one opportunistically sampled 14-mile reach named 'Pyramid to the James Ranch' (upper end of Reach 4) named for landmarks at either end of the reach; and the 35-mile Slickrock Canyon reach, which can only be sampled during the low end of 'boating flows' (~800 cfs).



**Figure 2.** Detailed map including sampling reaches.

1. **Dolores River #3b (Reach 1 - McPhee Dam to Bradfield Bridge):** Annual walk shock survey of 4 historic sites by 2-pass removal electrofishing (1,000-ft stations). Purpose of survey will be to assess the trout population, detect non-native fish escapement from the reservoir, and detect any range expansions of 3-species. Survey will be done during mid-September at 40 cfs flows. Historic baseline shows increased biomass of fishes with successive years of higher than minimal baseflows

over a 5-year timeframe. Increased biomass of trout in this reach may indicate improving habitat conditions for native fishes downstream.

2. Dolores River #3a (**Reach 2 - Bradfield Bridge to the Dove Creek Pumps - Ponderosa Gorge**): Periodic survey conditions permitting. Raft mark and recapture electrofishing survey of all 19 miles (2 passes). Raft shocking must occur during the managed release, preferably at flows between 400 and 800 cfs. Purpose of survey will be to assess expansion of native fish abundance, to assess (and potentially to suppress) brown trout numbers, and detect the presence/absence of fish escapement from the reservoir in this transitional cold to warmwater reach of the Dolores River. Baseline data collected by Nehring in 1993, 2005, and 2007 show declining abundance and distribution of both native and non-native fishes. Flannelmouth and bluehead suckers have been essentially extirpated from Reach 2, which may contain limited suitable habitat but not optimal habitat in some years due to coldwater releases from McPhee Dam. Because of the transitional nature of this reach, this survey will be low priority relative to the other surveys, and one pass catch-per-unit effort (CPUE) would be more realistic than the 2-pass mark-recapture surveys of Nehring.
3. Dolores River #3a (**Reach 3 - Dove Creek pump site**): Annual fall walk shock survey of 1 historic site by 2-pass removal electrofishing (1,000-ft station). Survey will be done the 2nd or 3rd week of September at 40 cfs. Purpose of survey will be to monitor the abundance and distribution of native and non-native fish populations, expansion of both native and non-native ranges, and population structure of both. Large-bodied non-native fish will be removed.
4. Dolores River #3a (**Reach 4 - Pyramid to Disappointment Creek**): Periodic survey conditions permitting. One pass raft electrofishing 14-mile Pyramid station. Survey depends on 400-600 cfs release from the reservoir anytime from mid-May to mid-June. Purpose of survey is to monitor the abundance and distribution of native and non-native fishes (smallmouth bass), document active spawning areas and reproductive times, remove non-native fish, and detect the presence or absence of other invasive fish species.
5. Dolores River #2a (**Reach 4 - Big Gypsum rec site**): Annual survey by raft electrofishing in a 5-mile reach of the Dolores River in Big Gypsum Valley. One pass survey effort at flows above 50 cfs typically done post runoff in June. Purpose of survey is to monitor the abundance and distribution of native and non-native fish populations, expansion of non-native ranges, and population structure of both. Non-native fishes will be removed. Anderson (2007) documented the dramatic decline in native fish populations after the 2002 drought at this site; thus, we expect

- to see improvements in native fish density and population structure with improved flow conditions.
6. Dolores River #2a (**Reach 5 - Slickrock Canyon**): Periodic survey conditions permitting. One pass raft electrofishing in the 32-mile-long Slickrock Canyon section of the Dolores. Survey depends on 400-800 cfs flows during a managed release from McPhee Dam (May to June). Purpose of survey is to monitor the abundance and distribution of native and non-native fish populations, expansion of non-native ranges, and population structure of both. Non-native fish will be removed. A 2007 survey suggests the abundance of all fishes is low in this section but the native species composition is high.
  7. Dolores River #3a-2a (**Reaches 3-5**): Annual early life history survey. Beach seining and backpack shocking backwaters, embayments, side channels, slackwater, and isolated pools. Purpose of survey is to assess successful spawning of 3-species, rearing habitat, and removal of non-native fish species. Survey will be conducted in mid-late August under existing baseflows. Reference photos and data on habitat characteristics will be collected.
  8. Periodic Aquatic Surveys in Tributaries. Currently, CPW is assessing the distribution of 3-species throughout their historic range by randomly selecting stream segments where little information exists. This includes a number of tributaries to the Dolores River Basin, including the reaches between McPhee Dam and Bedrock. Surveys may provide information about occupation or seasonal use by native fish species. Some notable tributaries that will be assessed at more frequent intervals (every 5 years) are Disappointment and La Sal creeks.
  9. Additional Assessments of Native Fishes and Life History Needs:
    - (i) Aquatic research – Aging native fishes was difficult, if not impossible, without removing the otolith, which is lethal to the fish. However, recent investigations show aging live fish with fin rays is as accurate as lethal methodologies. Native fishes and bass will be aged to see what hydrologic, temperature, and habitat conditions makes good and bad cohort years. Careful aging analysis may be used to determine when to disadvantage non-native smallmouth bass.
    - (ii) Larval fish sampling may document the conditions necessary for embryo development and emergence. It does not determine whether habitat conditions are suitable for growth and subsequent recruitment into the adult population. CPW does not routinely conduct larval fish sampling but Colorado State University can assist in collections and analysis on a contract basis.

(iii) The basic role of habitats as a 'source' of native fish or a 'sink' in the Dolores River and tributaries may be determined by assessing the movement of juvenile and adult fish in the Dolores and San Miguel rivers. Movement studies may prove instructive relative to flow release patterns. Although there are several techniques to assess adult fish movement, with the remoteness of the Dolores River, a stationary Passive Integrated Transponder (PIT) tag array can detect upstream or downstream movement of previously tagged fishes. The DWCD and Implementation Team are pursuing funding for a PIT tag array in the Dolores River. CPW would be responsible for maintenance, data collection, storage, and analysis.



(iv) It should be ensured that geomorphic/ sediment monitoring also addresses 'general fish habitat characteristics' in those sampling efforts. Habitat variables may be assessed using a variety of methodologies. Habitat variables for native fishes should be compared to the Weighted Usable Area metrics developed by Anderson and Stewart (2007) to assess current conditions.

### **Water Quality Monitoring**

Real-time monitoring of air, water temperature and relative humidity above Disappointment Creek (middle of Reach 4) has been implemented during the initial year the Implementation Team has been active, and CPW has supplemented USGS data at the Bedrock gage with sub-daily thermograph data from a number of other sites below McPhee. The purpose of real-time monitoring of water temperature is to adjust flows in the Dolores River to suppress premature

warming of the water in early spring prior to a managed release. Early warming due to artificially low flows in the spring may spur gonad maturation in fishes and result in premature spawning, subjecting the embryos and larval fish to a dramatic downward drop in temperature when the managed spill is released. Real-time data will be available to aquatic, facility, and water managers. CPW will house the long-term dataset. A more complete description of management for thermal regime is included in Section III, 'Thermal Regime Modification'.

## II. SPILL MANAGEMENT

The 1975 recommendation to designate the Dolores River a component of the National System of Wild and Scenic Rivers was based on the assumption that the proposed Dolores Project, including McPhee Dam, would enhance the River's Wild & Scenic "qualities". The Dolores Project by design stores much of the annual spring runoff in McPhee Reservoir, reducing the amount of streamflow available to downstream values, including fish and recreation. In their 1977 Definite Plan Report (DPR) for the Dolores Project, the BOR discusses the intent to manage releases from McPhee Dam to maintain and improve the aesthetics and



Wild and Scenic qualities of the downstream segments. Specifically, under Project conditions outlined in the DPR, available streamflows would be regulated by release of snowmelt runoff in anticipation of spills.

Spill management is the most critical component of mitigating adverse impacts on the whitewater boating ORV, in addition to providing improvements to the Dolores River fishery. The Definite Plan Report outlines specific objectives for spill management below McPhee Dam of surplus snowmelt runoff that could be spilled or released in anticipation of spills. Spill water averaged 76,100 AF over the period of record considered in the Definite Plan Report, whichd as an example described managing 66,000 AF of the 76,100 AF to provide whitewater boating opportunities from mid-April to the end of June.

As per the 1977 Final Environmental Impact Statement (FEIS) for the Dolores Project, downstream releases of surplus runoff are to be scheduled in five or more consecutive days of

500 cfs or greater, and announced in advance in order to mitigate operations of the reservoir and to make most efficient use of the river. Current operations of McPhee Reservoir adhere to additional criteria developed by the BOR for spill management and downstream releases. In years when surplus snowmelt runoff is forecasted to be less than 50,000 acre-feet, management actions first fill the reservoir prior to providing releases below McPhee Dam. Historically, spill management has been highly erratic in these low-surplus years, and timing, duration and magnitude of downstream releases have not met the conditions set forth in the FEIS.

Since the Implementation Plan will be used to meet the obligation to protect ORVs in the absence of Wild and Scenic suitability or designation, the commitment of the IT members to address opportunities to improve spill management needs to be made permanent. Efforts to document the effects of Dolores Project operations on the whitewater boating ORV are currently being implemented by IT members, and will be used to inform adaptations to annual operations in the future.

## 1. OBJECTIVES

Spill management was identified by all AWF scientists as a core opportunity that could provide multiple benefits to the downstream native fishery (specifically, geomorphic functions of flushing and habitat maintenance flows; maintenance of a native thermal regime; and conservation of the base pool). As spill volumes increase, the opportunity to affect multiple factors that may benefit the native fishery and improve whitewater boating opportunities also increases. The challenge is to find ways to ensure fishery benefits for spills of all sizes, including smaller spills traditionally managed using 'fill then spill' operational practices, whereby the reservoir fills before any releases above the base pool release are made.

The objectives for spill management under all hydrologic scenarios are to make releases that support and encourage native fish reproduction and survival while minimizing the risk of non-fill of McPhee and any adverse impacts to whitewater boating. Because every year's hydrologic scenario is different, the Implementation Team has outlined spill volumes of different magnitudes (25K AF, 50K AF, 100K AF, and 200K AF); the objectives, release volumes and timelines for decision-making for each hypothetical scenario are outlined such that decision makers can use the BOR's forecasts to create the best opportunity for native fish spawning success while minimizing risks to other water users in the Dolores.

## 2. EFFECTS SPILL MANAGEMENT HAS ON OTHER AWF OPPORTUNITIES

### A. THERMAL REGIME MODIFICATION

More detail on this opportunity will be presented below in Section III, 'Thermal Regime Modification', but by way of summary, 'fill and spill' operational strategies have de-synchronized native fishes' ability to use water temperature as an appropriate spawning cue. Native fish, especially flannelmouth and bluehead suckers, typically spawn in spring and early summer in response to changes in photo-period and water temperature, most often on the descending limb of a snowmelt runoff hydrograph. Temperature data from various sites below McPhee Dam show that prior to the beginning of a managed spill in spring, the water temperatures of baseflow-only releases elevate to the point that native suckers may initiate spawning activity prior to large, coldwater releases (especially flannelmouth sucker, which may spawn between 10-18°C; 50-64°F); this has been observed on multiple occasions since 2006. Spawning prior to the release of spill water makes incubating eggs or hatched fry particularly susceptible to abrupt temperature depression when spill releases are made. The intent of using spill management to mitigate thermal shock to developing fish embryos or recently hatched larval fish was seized on by all AWF scientists.

During spring runoff, the temperature of the water at downstream sites is inversely correlated with the volume of water being released; thus the opportunity identified by AWF scientists was early release of some quantity of forecasted spill water during the spring (April-May) that would more closely mimic natural runoff patterns and depress water temperatures enough to delay spawning until after peak runoff. The challenges are threefold:

1. It is not known precisely how much water would be needed to suppress water temperatures such that 'spawn delay' is successful. A coarse water temperature model (SSTEMP) indicated that flow volumes of 125 - 200 cfs May 1 may be necessary to keep temperatures below 15°C at the Dove Creek pumps, and more water may be necessary further downstream to keep temperatures low enough to delay spawning activity.
2. Any release of the 'managed spill' water prior to filling the reservoir increases the risk that the reservoir may not fill.
3. Water released above the base pool allocation is by Project commitment 'boatable flow water' historically operated to make the most effective use of surplus runoff for recreational boating.

The hydrographs developed by the Implementation Team are supported by a decision-making framework that provides the best opportunity for a successful spawn while also minimizing the

risk that the reservoir will not fill. In addition, real-time temperature and flow data from downstream reaches will minimize the release of projected surplus water in order to minimize the potential loss of recreational boating opportunities.

## B. BASEFLOW MANAGEMENT

Specific opportunities related to baseflow management are further described in Section IV, 'Baseflow Management', but the length of the managed spill has a direct effect on the amount of water available for downstream release after the managed spill is curtailed. Baseflow components include the following: 29,300 AF of Dolores Project water, with another 524 AF of Dolores Project water allocated under an interim agreement (collectively these are the Dolores Project Fishery Pool); 700 AF of augmentation water made available from Project supplies used to replace depletions occurring due to the BOR's salinity control unit in Paradox; and 1,274 AF of non-Project 'senior water' for meeting downstream senior water right demands. The base pool is not used for the duration of a managed spill. The result is a base pool of 31,798 AF distributed over 365 days less the number of days that a managed spill occurred. When Project water shortages occur, portions of the base pool are equally shorted.

In practice, a water budget for the entire base pool is developed by the Dolores River Biology Team at their annual meeting in early to mid-March, when runoff forecasts are becoming more accurate. During managed spills, there is no debit to the fish pool allocation, so the length of the managed spill has a direct effect on the availability of water - and instream habitat - when baseflow-only releases are made. The opportunity identified by AWF scientists under 'Spill Management' was that altering spill management to more closely mimic natural inflow and elongate the managed spill would conserve the base pool by delaying fish pool releases.

The challenge presented by this opportunity is a function of the de-synchronization of the different accounting 'water years' used by the fishery pool and other Project water users; specifically unless a managed spill begins April 1, some base pool water is used *prior* to the reservoir filling. Any water conserved through altered spill management by having a longer spill period (relative to 'fill and spill' practices) would be used *after* the reservoir is filled and managed spill releases have ended. The result is that more water would be released downstream from the reservoir from summer-early spring than under current conditions, resulting in a corresponding deficit in carryover storage in the reservoir. For example, if the spill is lengthened by 30 days under a new operation scenario, carryover storage in the reservoir might be ~3000 AF less (30 days x 50 cfs x 2 AF/cfs-d). If the reservoir fills the following year, there is no impact to Project water supplies, but if the reservoir doesn't spill, this 3000 AF deficit may potentially impact Project supplies the following year, including the fishery allocation. Implementation Team partners have disagreed on the viability of lengthening the managed spill under given spill scenarios, with water users and the BOR citing unacceptable risk to Project water supplies. The IT may investigate means of 'insuring' against this risk, or potentially altering the way the fishery 'water year account' is managed so that

early releases that benefit native fish and extend the base pool water can be attained without injury to water users.

## C. SEDIMENT TRANSPORT

AWF scientists noted that improved coordination of spill releases to meet specific sediment transport objectives would be beneficial to sediment transport and habitat maintenance. Generally, they suggested that increases in the magnitude and frequency of spill events downstream of McPhee that restored pre-dam stream power would benefit transport capacity and habitats downstream, but they also realized the inherent uncertainty of the frequency and magnitude of spill events. More detail on sediment transport opportunities is presented in Section V, 'Sediment Transport', but it is recognized that any sediment transport capacity in the river below McPhee is dependent on the size, frequency, and duration of the managed spill.

Two specific sediment transport targets have been identified by AWF scientists: (i) those flows necessary to scour algae or mobilize finer particles that tend to adhere to spawning gravels and cobbles, fill interstitial spaces between these particles, and settle in pools and that may begin to mobilize median particles in riffles ('flushing flows'); and (ii) flows large enough to mobilize significant quantities of riffle materials themselves at the D<sub>50</sub> or D<sub>84</sub><sup>10</sup> size classes ('habitat maintenance flows'), and that occasionally re-set channel geometry by lateral erosion, floodplain inundation, and nutrient exchange with floodplains. Flushing flows are important to prepare spawning areas and improve oxygenated flow environments around deposited eggs; habitat maintenance flows are critical to provide the diversity of instream habitats necessary to meet the needs of various life stages of native fish. Flushing flows and habitat maintenance flows have been estimated for different reaches of the Dolores River, and range from 400-800 cfs for flushing needs to between 2000 and 3400 cfs for habitat maintenance flows. Larger flows provide proportionately more opportunities to perform work on the channel and more extensive floodplain exchange.

Neither flushing flows nor habitat maintenance flows are possible without a spill; thus there is a nexus between spill opportunities and sediment transport opportunities and it is clear that whenever a spill occurs, there will be incidental benefits for sediment transport. However, significant challenges persist when managing spills specifically to meet sediment transport targets. In general, it is difficult to target managed spill releases for specific flow rates because the reservoir is full at the time of a managed spill so the release reflects the inflow less

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<sup>10</sup> D<sub>50</sub> and D<sub>84</sub> refer to the particle size classes observed in the active stream channel or more specifically for habitat maintenance flows, in riffles. D<sub>50</sub> indicates the median particle size in the sample (50% of the particles are smaller); D<sub>84</sub> is a larger clast size indicating that 84% - approximately two standard deviations above the median in a normally distributed sample - are smaller.

diversions to the out-of-basin canals and laterals. Specifically, managing for flushing flows requires the release of large amounts of water from storage, but may not meet minimal whitewater boating flow targets (minimal flows are ~700 - 900 cfs), so 'boatable flow days' may be reduced. There also is limited information about the sediment transport dynamics below the dam, and the geomorphic template differs widely between the different reaches occupied by native fish; thus a large release is not warranted until sediment transport flow information to meet specified transport objectives is more clearly defined.

At this time, the Implementation Team recognizes that sediment flushing targets - the smaller end of the sediment transport regime - may be an important objective whenever a spill opportunity is presented, since spawning success of native fish is a pre-requisite if native fish are to persist below the dam. It is also worth mentioning that flushing flow targets of 400-800 cfs also present the best opportunity for monitoring native fish in remote sites (Pyramid to Disappointment ~ 500 cfs; Slickrock Canyon ~ 800 cfs) that cannot be shocked using wade-shocking techniques, and also meet some of the non-whitewater goals of other river boaters. It is desirable to find a balance between meeting flushing flow needs with releases at a minimal boating experience (700-900 cfs) while not losing sight of the need to monitor the fishery through the Pyramid - Disappointment Creek reach.



Colorado Pikeminnow

### 3. RANGE OF VARIABILITY - OPPORTUNITIES AND CONSTRAINTS

Ironically, extreme variability within the Dolores River drainage is perhaps the most predictable hydrologic variable. Elevations of over 14,000 feet in the southwestern San Juan Mountains create a snowmelt-driven runoff pattern, but its southerly latitude also brings with it a unique blend of hydrologic effects from ENSO (El Niño - Southern Oscillation) and monsoonal-driven storm events. As a result, the Dolores River experiences some of the greatest natural variability amongst Colorado rivers. Warmwater native fish in the basin evolved and adapted to hydrologic variability characteristic of desert rivers in the American Southwest through reproductive strategies, general longevity, and phenology.

The hydrologic changes brought about by Montezuma Valley Irrigation Company (MVIC) canal diversions (beginning in 1886) and McPhee Dam (completed in 1986) have been well documented and were summarized by AWF scientists, but both water projects have stressed native fish populations by altering native flow conditions and fragmenting native fish habitat. These projects have created a new hydrologic template that frames the possibility for native fish recovery in the basin, and the Implementation Team has focused on what is feasible given the hydrologic reality driven by water development overlaid on unique climatic factors.

As noted in the 'Objectives' section for 'Spill Management' (Section II.1, above), spill management opportunities were stratified by spill magnitude: 25K AF, 50K AF, 100K AF, 200K AF. Early Implementation Team meetings focused on developing hydrographs for native fish for each spill size based on specific ecological or physical parameters that were both science-based and deemed feasible given a specific 'spill budget'. Native fish assumptions for all spill sizes were as follows:

- Priority objective was to improve ascending spring flows beginning April 1 that ramp sufficiently to minimize pre-spill water warm-up and subsequent pre-spill spawn.
- Secondary focus was on elongating spill relative to current conditions to improve baseflow condition over current management.
- Provide flushing flows to prepare spawning bed (~400 cfs).
- Attempt to index releases to flows at the Dolores gage above McPhee, most critical at/ near peak and on recession.
- Recession limb target < 200 cfs over 2 days and/or 3-day 500 cfs monitoring flow depending on native flows and data priorities.
- Omitted 400 cfs 12-hour trout stocking flow and shifted as much water as was available toward improving baseflows.
- Maintain 10-20 day period at 40 cfs mid-September to maintain consistency at long-term electro-fishing sampling locations.

In addition, specific flow targets and hypothetical hydrographs for native fish were developed for each of the four spill magnitudes, and are included in Appendix A.

Subsequent to the development of native fish hydrographs, American Whitewater (AW) presented a report entitled 'Defining Recreational Flow Needs in the Lower Dolores River: Stream Flow Evaluations for Whitewater Boating' (Appendix B) in which direct surveys of boaters (including different craft types) indicated boating preferences for different reaches of the Dolores below McPhee. From these surveys, AW developed 'acceptability curves' that graphically illustrate boater preference and detailed by reach and by craft type 'minimum acceptable' and 'optimal' flows (as well as other recreational user definitions) that collectively provide an excellent picture of current recreational user flow preferences on the Dolores River. They then presented hydrographs for the same four hypothetical spill scenarios (also included in Appendix A).

As noted, the objective for the Implementation Team for the 'Spill Management' opportunity is to develop specific flow targets that provide the best conditions for successful spawning and recruitment for native fish, while minimizing disruption to other users of the Dolores River. Of critical importance was the input of the Bureau of Reclamation, which owns the Project facilities and develops an annual operating plan, and the Dolores Water Conservancy District, which owns the bulk of the water rights stored in the reservoir and directly manages the Dolores Project operations and accounting. The BOR also provided a set of release hydrographs which attempted to factor in native fish objectives while still meeting the fill-and-release criteria and mandates for the Project (see Appendix A).

A hydrologic subcommittee of the Implementation Team met Oct. 18, 2011, to reconcile the various hydrographs that had been presented to the larger group. Below are the assumptions used to develop a composite hydrograph for each of the four spill levels and the hypothetical hydrographs that collectively illustrate flow targets for spills of each magnitude over the March 1 - June 30 runoff period. These targets first address the needs of native fish, then attempt to reconcile the objectives of the whitewater boating community and the requirements of Dolores Project operations. These hydrographs will be iteratively combined with the Upper Colorado Basin Forecast Center coordinated forecasts to develop operations plans that will evolve as snowpack and runoff conditions in the watershed change, but provide a template for how to optimize Project operations to meet competing demands.

The most contentious issue emerging from the development of these flow targets remains the risk that releases to meet temperature suppression goals during April and early May present to Project users, particularly at the 25K AF and 50K AF projected surplus volumes. This issue has yet to be addressed directly, but a decision-making framework is being developed that will allow for multiple decision points during the runoff season, coinciding with the coordinated runoff forecasts, that will allow operators to minimize the risk to Project water supplies. The

second issue that has yet to gain much traction with Project water users is the positive effect that elongating the duration of the managed spill can have on base pool supplies and instream habitat availability. Because baseflow was cited as a critical limiting factor to native fish productivity and survival, this issue may subsequently be addressed through a potential lease option, credible risk assessment, some means of 'insuring' against future risk, or re-assessment of base pool accounting. As agreed to in the principles of AWF and the Dolores River Dialogue processes, none of these options should result in injuries to Project water supplies.

**A. 25K AF**

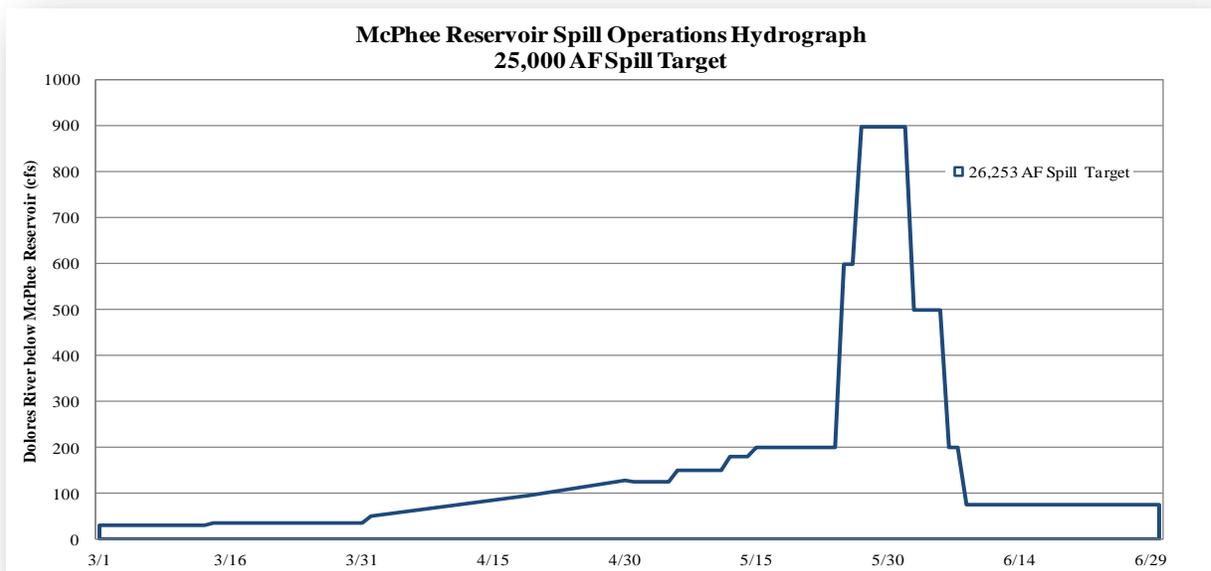
**SPECIFIC GOALS:**

**CPW:** Mobilize small gravel and fine sediment (200-400 cfs), spawning suppression (200 cfs by May 15 ), optimal monitoring flow of 500 cfs (on receding limb of hydrograph), mimic native flow, increase baseflow (elongate managed spill, meet 78 cfs ISF).

**AW:** Boatable flows (900 cfs) provided immediately before Memorial Day, through the 1st weekend of June. Mimic a natural hydrograph. Provide *acceptable* boatable flows (900-1900 cfs) for a minimum of five consecutive days. Provide advance notice.

**BOR/DWCD:** Consideration of reservoir elevations, downstream ramping criteria, determination of the start of the managed spill, communications of operations to the public, and public safety.

**Figure 3**



**B. 50K AF**

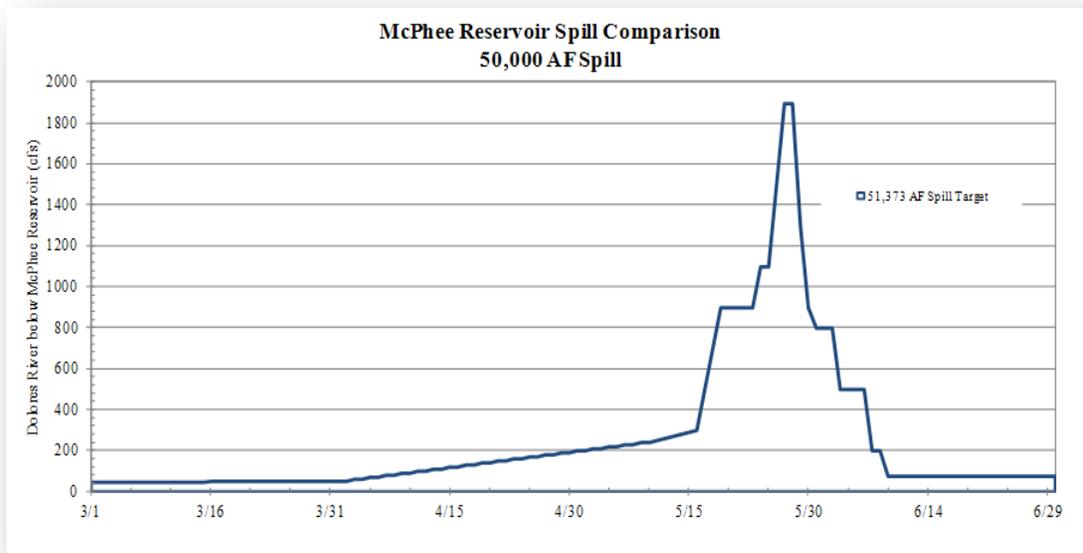
**SPECIFIC GOALS:**

**CPW:** Mobilize small gravel and fine sediment (200-400 cfs), spawning suppression (200 cfs or greater by May 15 ), optimal monitoring flow of 500 cfs (on receding limb of hydrograph), mimic native flow, increase baseflow (elongate managed spill, meet 78 cfs ISF).

**AW:** Boatable flows provided immediately before Memorial Day, through the 1st weekend of June. Mimic a natural hydrograph. Provide *optimal* boatable flows (1900-2100 cfs) at peak. Provide advance notice.

**BOR/DWCD:** Consideration of reservoir elevations, downstream ramping criteria, determination of the start of the managed spill, communications of operations to the public, and public safety.

**Figure 4**



**C. 100K AF**

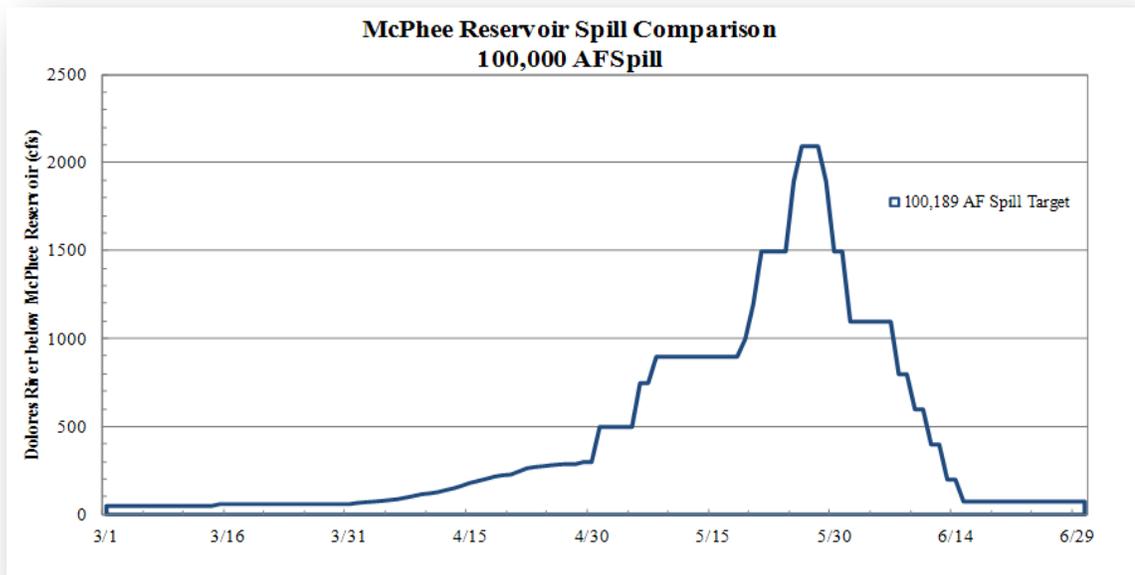
**SPECIFIC GOALS:**

**CPW:** Achieve minimal bankfull flows (>2,000 cfs), optimal monitoring flow of 500 cfs (on ascending limb of the hydrograph), mimic native flow, increase baseflow (elongate managed spill, meet 78 cfs ISF).

**AW:** Boatable flows provided before Memorial Day, through the 1st week of June. Mimic a natural hydrograph. Provide *acceptable* boatable flows (900-1900 cfs) for a minimum of five consecutive days. Provide *optimal* flows (1900-2100 cfs) for three consecutive days at peak. Provide advance notice.

**BOR/DWCD:** Consideration of reservoir elevations, downstream ramping criteria, determination of the start of the managed spill, communications of operations to the public, and public safety.

**Figure 5**



**D. 200K AF**

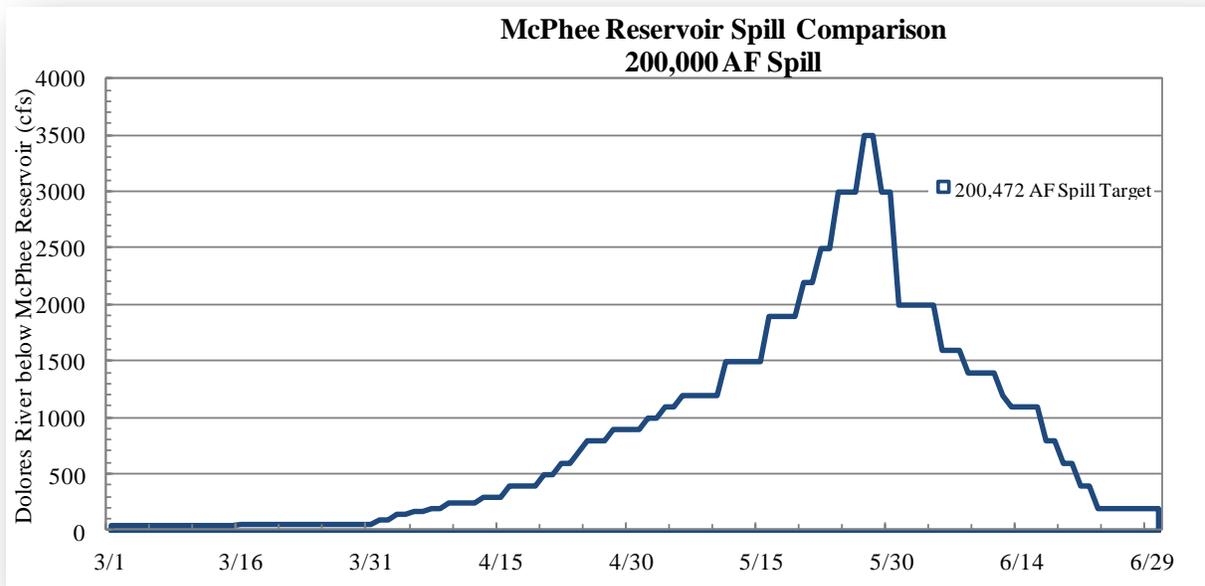
**SPECIFIC GOALS:**

**CPW:** Achieve bankfull flows (>2,000 cfs) and channel maintenance flows (>2,600 cfs) for 7 days, achieve channel scouring flows of 3,400 cfs, optimal monitoring flow of 500 cfs (on ascending limb of the hydrograph), mimic native flow, increase baseflow (elongate managed spill, meet 78 cfs ISF).

**AW:** Boatable flows provided before May 1, through the 2nd week of June. Mimic a natural hydrograph. Provide *acceptable* boatable flows (900-1900 cfs) for a minimum of five consecutive days on the receding limb of the spill. Maximize *optimal* boatable flows (1900-2100 cfs) during managed release. Provide *high acceptable* boatable flows (>2100 cfs) for 10 days at peak. Provide advance notice.

**BOR/DWCD:** Consideration of reservoir elevations, downstream ramping criteria, determination of the start of the managed spill, communications of operations to the public, and public safety.

**Figure 6**



## 4. MONITORING AND EVALUATION: EFFECTIVENESS OF SPILL MANAGEMENT

Comprehensive spill management that integrates real-time supply data with downstream flow and temperature data will provide the best opportunity for release scenarios that benefit the needs of native fish. In summary, these needs are:

- appropriate spawning cues (combination of water temperature, photoperiod, and potentially water chemistry) such that egg laying, incubation, and fry emergence are timed to maximize the chances for larval survival;
- relatively clean spawning sites (gravel and cobble) cleansed by removal of fines prior to spawn;
- instream habitat diversity that meets the needs of larval fish, fry, juveniles, and adults (backwaters and eddy habitats; cover; pool volume; productive riffles);
- adequate flow of water during baseflow periods to allow movement between habitat types and longitudinally up- and downstream.

Return frequency of flow events is an important concept in riparian and geomorphic literature that is not addressed in detail in this Plan. However, the DRD Correlation Report (2006) presented the results of an updated, post-Project re-run of the original Definite Plan Report flow modeling done for the Dolores Project (1977), which consisted of 77 years of modeled flow with all Dolores River depletions considered. These findings suggested that:

- (1) Approximately 45 percent of years are ‘no-spill’ years, with only one year of modeled shortage;
- (2) Of the spill years (55 percent of total years), the average spill magnitude is approximately 187,000 AF, with 2/3 of those spills falling between 64,000 AF and 310,000 AF.

These modeled hydrologies provide the best available predictions of future hydrologic expectations for flows below McPhee. It will be important to re-visit these predictions against actual data sets, since the importance of spill management for other ecological and recreational factors cannot be overstated.

Early releases to meet thermal targets use water that may otherwise have been used to provide boatable days, so an assessment of whether boating flow targets were met should also be included as part of the annual review of a year's spill. The boating community has said that increasing flow certainty and meeting certain optimized targets for different craft types are important objectives. American Whitewater has developed boater user surveys and has constructed survey boxes to be installed at commonly used access points along the river (e.g.,

Bradfield Bridge, Dove Creek pumps, Big Gyp recreation site; Bedrock). The written surveys will be complemented by person-to-person interviews as resources are made available in order to acquire the best information from boaters regarding their trip planning process and river experience.

Proper spill management can positively affect all these factors, so the success of spill management for a given water year will depend on an evaluation of how well operators were able to meet targeted objectives for spills of a given size. These objectives are presented below in **Table 3** in a simplified 'checklist' format to determine whether the specific objectives for spills of a given magnitude were met. It is also anticipated that an annual 'retrospective' spill management meeting would provide an opportunity to evaluate and articulate both the process of spill management for the year and the ecological benefits.

**Table 3.** Sample table indicating whether specific spill management targets were met during a given water year.

	Thermal Target* (<15°C prior to peak release)	Flushing Flow Target (~400+ cfs to flush fines from cobbles)	Habitat Targets (complexity, diversity encouraged by 2000+ cfs)	Baseflow Target (MAX reserve of base pool during spill to maximize growth opportunity)	Boating Flow Targets (certainty of user days; optimized flows, etc.)
25,000 AF	✓	✓	NA	✓	✓
50,000 AF	✓	✓	NA	✓	✓
100,000 AF	✓	✓	✓	✓	✓
200,000 AF	✓	✓	✓	✓	✓
WY 2012	NA	NA	NA	NA	NA
WY ?					

\* May include also target that minimizes rate of change of temp to keep daily change less than 0.3-0.5 °C/d during pre-spill period.

### III. THERMAL REGIME MODIFICATION

#### 1. OBJECTIVES AND NEED FOR THERMAL REGIME MODIFICATION

*A Way Forward* scientists all pointed out the benefits of trying to create a thermal regime below McPhee Dam that more closely reflected a natural pattern of water temperature

warming during the spring. The two most dominant variables controlling water temperatures below the dam during this period are air temperature and discharge volume. The scientists presented thermal plots from 2005 and 2009 that contrasted the inverse relation between discharge and water temperature during spring (**Figures 7 and 8**). The plots show the variability between a large spill year (191,578 AF in 2005 - a 'spill and fill' year) and a modest spill year (51,113 AF in 2009 - a 'fill and spill' year); the 2005 plot also shows the inflow data from the Dolores gage, illustrating that in a large spill year, release patterns closely reflect inflows, especially during the critical spawning months for suckers of April through June.

Figure 7.

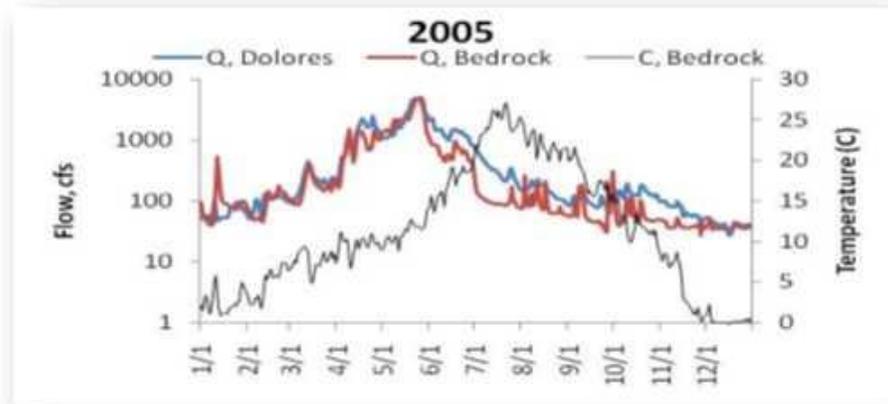
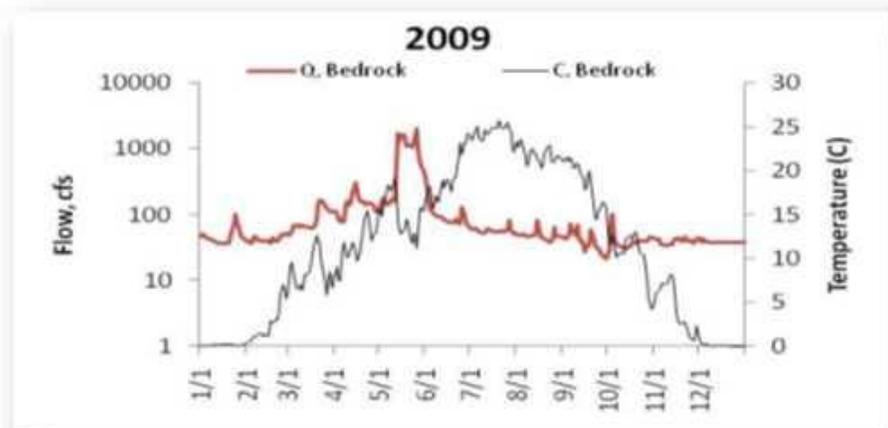


Figure 8.



**Figures 7 and 8.** Thermographs and flows from contrasting spill years in 2005 and 2009. Ample flows in 2005 allowed for a gently tapered thermal response; in 2009 uncertainty regarding the volume and timing of runoff created thermal spikes and dips, which create poor spawning conditions for native fish.

Based upon their analysis of data such as these thermograph-hydrograph overlays, they emphasized the need to manage the thermal regime to provide the correct thermal cues at times appropriate for natural life stage functions (e.g. spawning, growth). They also state that a thermal regime with a more natural pattern could also return a more natural diversity and productivity to the invertebrate community.

In 2009 the Dolores River Dialogue contracted a study to determine how the Selective Level Outlet Works (SLOWS) built into McPhee Dam could be used to affect downstream water temperatures (Anderson, 2011). Anderson used both the SELECT water quality model developed by the U.S. Army Corps of Engineers Research and Development Center and the SSTEMP model developed cooperatively by USDA Soil Conservation Service (now NRCS) and the U.S. Fish and Wildlife Service. Anderson was also asked to run these models using only the lowest outlet level (SLOW3) and incremental releases to provide a coarse estimate of the flow needed during April and May to keep temperatures below 15°C to suppress spring spawning of native fish. Output data from these temperature models suggested that discharges of between 100-150 cfs in late April, and 200-300 cfs in late May, would be necessary to keep temperatures below spawning temperature thresholds at sites from 32 miles (Dove Creek pumps) to 54 miles (James Ranch, just upstream of the Disappointment Creek confluence) below the dam. Thus preliminary release targets were set at 125 cfs for April 30 and 200 cfs May 15 for the lowest projected surplus level (25K AF). As shown in the hydrographs presented in Section II.3 under 'Spill Management', these targets increase to 200 cfs and 300 cfs respectively for a 50K AF spill. Projected surpluses of 100K AF or more have a high likelihood of initiating the managed spill by April 30, and temperature suppression is not an issue.

#### **Real-Time Temperature and Streamflow Information**

The Dolores River watershed encompasses tremendously variable topography from headwaters above 14,000 feet elevation to its confluence with the Colorado River at about 4000 feet elevation. As a result, historic data from the Bedrock gage (~5000 ft elevation) shows a distinct bimodal trace in response to snowmelt runoff as low-elevation snowpack first drains areas below McPhee Reservoir (Dolores Rim to west and 'Glade' to east) then snowmelt from high elevations reaches the reservoir and, during spill years, is passed through. The 'low snow' runoff in many years provides peaks upwards of 1000 cfs in early to mid-April, while the main peak usually arrives about May 20 in the town of Dolores. However, neither magnitude nor timing of these sources of runoff in the basin is easily predicted, and all combinations of contributions from each source to flows near Slickrock have been realized, including essentially zero runoff and no surplus water (e.g., 2000-2004).

The Slickrock gage is located approximately 70 miles below McPhee, and during baseflow releases from McPhee, provides data that reflects the contributions of low-elevation runoff below the dam. In addition, the Colorado Parks and Wildlife (through the CWCB 'AWF Implementation' grant) installed a real-time satellite-linked temperature gage that provides relative humidity, stream and air temperature just above the Disappointment Creek confluence

([www.DataGarrison.com](http://www.DataGarrison.com)). Though the hydrographs presented in Section II assign a definite release schedule for each of the hypothetical spill projections, it is the intent of the Implementation Team and dam operators to utilize both the Slickrock gage information and the real-time temperature data to fine-tune releases to the extent feasible, since any water released prior to a managed spill is not considered 'boatable water' and diminishes the number of boatable days that would otherwise come from the spill. In addition, optimizing dam operations will also necessitate continued integration of runoff forecast information provided to the BOR bi-weekly from the Upper Colorado River Basin Forecast Center and the 5- or 10-day weather forecasts from the National Weather Service. As noted above, the specific objectives are to balance the need to keep water in the river below an average daily temperature of 15°C prior to the release of a managed spill, while recognizing the commitment to provide boatable flows with surplus snowmelt runoff and minimizing the risk that pre-spill releases have a material effect on Dolores Project water supplies.

## 2. MONITORING AND EVALUATION OF RELEASE FOR TEMPERATURE MODIFICATION

As described in the preceding section, two assumptions are built into the release scenarios for spill management that meets the needs of native fish:

- that average daily stream temperatures should be less than 15°C to keep native fish from spawning prior to the spill; and
- that a minimum streamflow of 125 cfs April 30 and 200 cfs as of May 15 will provide the thermal mass necessary to keep streamflow below this threshold.

A third assumption is implicit; that is, that meeting the temperature objective will allow the fish to spawn in a more appropriate manner after the main spill has come, either on the receding side of the hydrograph, or post-spill during late spring or early summer. All of these assumptions should be considered 'testable hypotheses', and monitoring should directly address whether these hypotheses are valid or whether alternative hypotheses should be considered.

Addressing the two assumptions enumerated above can be as simple as plotting temperature from the real-time sensor against both release data from the dam and data from the Slickrock gage to assess how closely the assumptions hold. Evaluation of the data will be complicated by the nature of the water year (i.e., was there low runoff available? How do releases from McPhee compare to the Slickrock gage? Should we consider creating a rating curve for a site on Disappointment Creek near the mouth so that we are accounting for these flows at Slickrock?); however, it will also allow the Implementation Team to gain a better understanding of the variability of the low-snow contribution to flow and temperatures in the river.

Assessing the effectiveness of temperature suppression in inhibiting native fish spawn prior to the spill will require a fairly extensive monitoring effort within spawning habitat, and carried further, to assess whether native fish spawned successfully after the spill. Sampling or monitoring success of embryo development and larval fish emergence is addressed in Section I.4, 'Assessing Native Fish Viability', and CPW or contractors to the Implementation Team may be able to carry out specific surveys to answer this important question. In the near term, however, 'successful spawn' may be assessed most cost-efficiently through annual surveys at the long-term sampling sites that pick up predominantly the native fish community (Dove Creek pump site; Big Gypsum site) or through the opportunistic longitudinal surveys carried out when flow conditions permit (Pyramid to Disappointment Creek; Slickrock Canyon). Successful spawn should result in finding a higher abundance of young-of-year, juvenile fish, and eventually, higher biomass of native fish recruited into the population.

## IV. BASEFLOW MANAGEMENT

### 1. History of Baseflow Management Since Dolores Project Implementation

Improvements in base pool size and management have been cited in prior studies of the fishery downstream of McPhee as necessary steps toward maintaining viable native fish populations, and the *A Way Forward* scientific panel affirmed this basic need by highlighting it as the option most likely to achieve benefits to the native fishery. Habitat quality and quantity is a limiting factor for native fish survival in the reach of the Dolores between the dam and the San Miguel confluence, and the current base pool size limits the flexibility of natural resource managers to do much other than provide minimal flows for existing fish to survive. Though many factors contribute to the downward trends of native fish in the Dolores, the lack of adequate baseflow diminishes the carrying capacity within the reach, and limits the resiliency of native fish to respond to other stressors like drought, predation, competition, sedimentation, and reduced peak flows. Improving the size and management of the base pool is a critical component of improving native fish viability below McPhee Dam.

During project inception, year-round flows below McPhee were to be dictated based on an annual March 1 assessment of projected runoff and reservoir storage, with flows of 20, 50, or 78 cfs determined by a 'dry', 'normal', or 'wet' year, respectively. In March 1990 the first 'dry' index was realized, and quickly thereafter fishery advocates realized that 20 cfs was not enough water to sustain the fishery that had developed below the dam in the early years of operation. Subsequently, DWCD agreed to provide 6000 AF of water, and flows in late June were improved to 50 cfs. However, it was acknowledged that a different means of addressing base flows needed to be developed. Between 1990 and 1996, negotiations and fishery studies were conducted, and in 1996 an Environmental Assessment (Final EA) and Record of Decision

('Finding of No Significant Impact' or FONSI) were released that changed the indexed flow regime to a 'managed pool' scenario. The purpose of the 'flow to pool' EA was "to establish the size of, and management parameters for, the fish and wildlife pool". In the FONSI the following approach to acquiring the necessary baseflow was adopted using a three-increment process:

**Increment I (3,900 AF)** - The BOR purchased 3,900 AF of water from DWCD to increase the pool of water reserved for fish and wildlife purposes to 29,300 AF. This water was added to the 'up to' 3,900 AF of water for senior downstream water rights for a total managed pool of up to 33,200 AF. The acquisition of this water resolved the discrepancy in the original Project operation study regarding the average annual volume of Project water required from storage to fulfill the 1977 DPR/FEIS downstream water release criteria ('mistake water'). This phase has been completed.

**Increment II (3,300 AF)** - With funding provided by BOR, the Ute Mountain Ute Tribe agreed to provide 3,300 AF of water on a lease basis for up to 5 years, to increase the fishery pool from 29,300 AF to 32,600 AF. This water was additive to senior downstream water rights (up to 3,900 AF) for a total managed pool of up to 36,500 AF. Permanent acquisition of Increment II water was contemplated, but it would require cost-sharing participation by others (DOW, USFWS, BLM, USFS, TU). BOR provided \$371,000 to establish a trust account for the future acquisition of water, and other entities wishing to participate in water acquisition would make deposits to this account. This account has an approximate balance of \$400,000, but no water has been leased or acquired using these funds.

**Increment III (water in excess of 7,200 AF)** - The trust account described above would remain open and the acquisition process would continue. This increment may include acquisition of water which could be managed for purposes other than fish and wildlife.

The approach outlined in the FONSI initiated the formation of the Dolores River Instream Flow Partnership (DRIP), an inter-agency partnership (with stakeholders) with the purpose of acquiring additional baseflows for the downstream fishery. This partnership failed to execute any leases or acquisitions beyond the initial 5-year lease of 3,300 AF of Ute water. By 1999 the Ute lease was terminated and in 2002 a Dolores River call by MVIC resulted in a re-quantification of the senior downstream demands from 3900 AF to 1,274 AF. The total base pool now stands at 31,798 AF, over 4,700 AF short of the Increment II goal.

Specifically, the base pool is made up from the following sources:

- (i) 29,300 AF of Dolores Project water allocated to the fishery pool ('Project fish pool'). This water shares any allocation shortages shared by other Project water users.
- (ii) 524 AF of Project water allocated under an interim agreement to the fishery pool. This was originally part of the 3900 AF of 'senior, non-Project water' that was re-quantified following the drought in 2002-2003. A proportional amount of

the difference between the re-quantified need and the 'up to 3900 AF senior water rights' was re-allocated to Project users (full service farmers; Ute Mountain Farm and Ranch; the fish pool).

- (iii) 1274 AF of 'downstream senior water rights', necessary to meet the headgate demands of downstream water rights senior to the Dolores Project;
- (iv) 700 AF of augmentation water required to offset depletions due to deep brine injection of intercepted groundwater at the BOR's Paradox salinity control plant.

## 2. Importance of Baseflow to Native Fish

Baseflow is defined as non-snowmelt-derived river flow. The melting of snow in the spring and early summer creates high streamflows that scour accumulated fine to coarse sediments out of habitats used by fish. The high runoff cleans and sorts cobbles which native fish use for spawning. Higher streamflows also provide deeper water for fish passage (movement) and cover from predators. The disturbance of substrate caused by high spring flows is also beneficial for the invertebrate community, resulting in higher species richness and densities of aquatic insects.

In contrast, baseflows provide the minimum habitat for other basic life functions like nursery areas for young fishes in slow-velocity habitats, food production areas (riffles), feeding lanes and runs for fishes, and resting habitats for summer and winter use, as well as cover from predators. Summer baseflow periods result in relatively warm water; maximum food production in the stream creates conditions conducive to maximum growth for fishes. Growth is important for survival. Bigger fish can escape predators more easily, move larger distances to find food or cover, develop and hold more eggs; thus their reproductive potential is higher.

A river channel is formed by commonly reoccurring spring floods – flows that occur on average about once every couple of years. Baseflows occupy this larger channel for most of the calendar year. If there is a large disconnect between channel-forming flows and baseflow, this may disrupt areas for food production and feeding, passageways for movement, pool size and area, and increase the potential to interact negatively with other native species as well as non-native species through competition and/or predation.

Before the Dolores Project, the Dolores River regularly experienced natural high-flow flooding events. Baseflows during this time were extremely low and minimized growth potential for fish, but residual flows from flooding events persisted just long enough to allow sufficient drift of young fishes and movement of juvenile adults to summer and winter refuge and feeding areas. Thus, the native fish community existed but at very low numbers compared to other Colorado River Basin streams. After the Dolores Project, spring floods below the dam were reduced in both magnitude and frequency.

Natural baseflows in the Dolores should be around 11% of the bankfull flows (channel-forming flow). Current baseflows are at about 2-3% (from Richard and Anderson's work). Unfortunately, the magnitude of baseflow that has been restored post-McPhee Dam has not resulted in an anticipated increase in the abundance and distribution of native fishes, and as noted in other sections, complications from predation, thermal regime, and sediment mobility suppress native fish populations.

Baseflow objectives developed by the Dolores River Biology Committee (see below for an explanation of this interagency team) for native and non-native fishes over the years are virtually identical. Warmwater native fishes (suckers and chubs) and coldwater sport fishes (trout) mostly occupy different reaches of the river, with some overlap where water temperatures are transitioning between optimal cold and warm preferences for fishes but their habitat needs (e.g., flows) are quite similar. This line of reasoning is fairly simple in concept. For example, since water temperature is directly related to water volume, then delivering sufficient amounts of water downstream to keep trout cool is also beneficial to warmwater natives because the volume of water also determines the percent wetted channel width. Increases in the amount of water released increase the wetted cross section of the stream. The percent wetted channel establishes the abundance and availability of food, foraging, resting, and hiding cover for multiple life stages of fish, irrespective of whether they are native or not.

The question of how much water to deliver is limited by the base pool allocation. Various baseflow studies and scenarios were developed over the years by the CPW and BLM. In general, optimal (not minimal) baseflows for trout and/or native fishes range between 150 and 300 cfs. Recognizing these flows were not possible with the Dolores Project, Stewart and Anderson (2007) recommended a minimum flow of 80 cfs at the Big Gypsum study area to protect native fishes, and 60 cfs in years when the reservoir spilled. Note that the BLM's Instream Flow Study (1992) indicated that approximately 25 percent of flow was lost during summer releases of 78 cfs between the dam and Big Gypsum site. Thus, to achieve a recommended flow of 80 cfs at the Big Gypsum site, flows released out of the dam would need to be closer to 100 cfs.

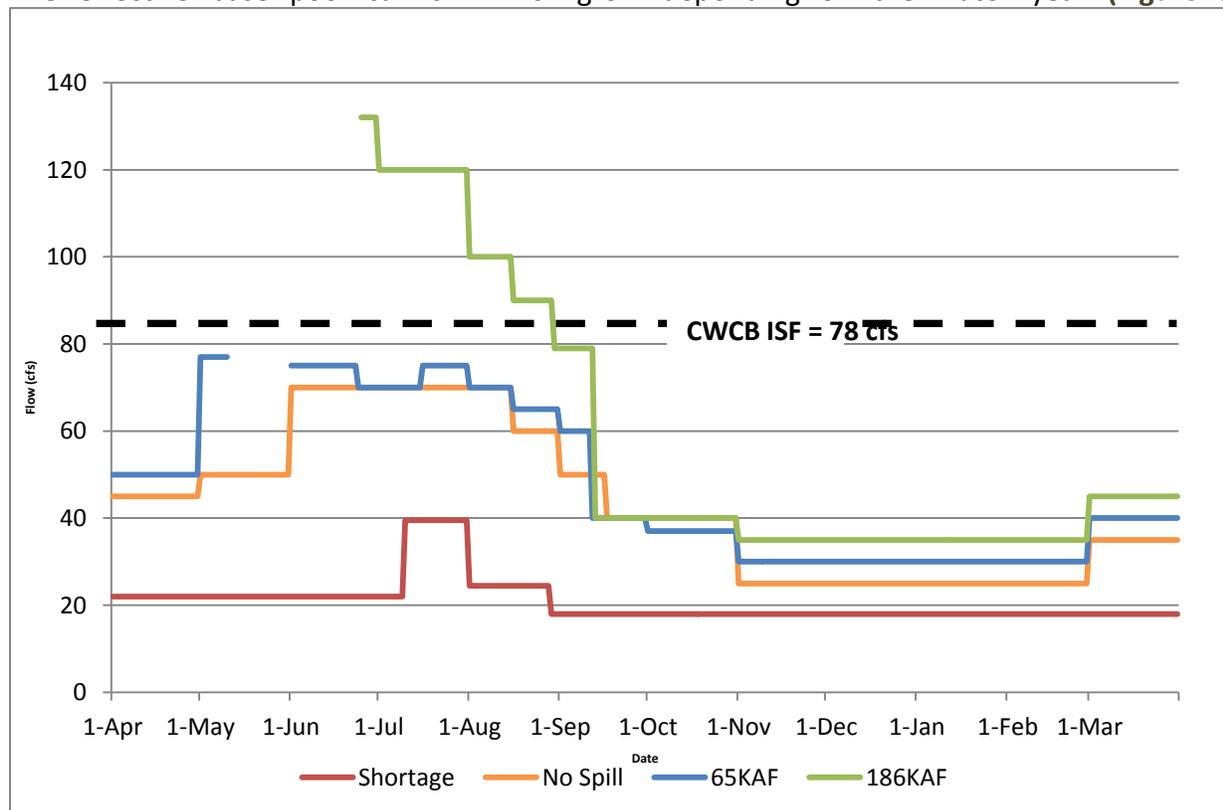
### 3. Current Management of Baseflow Pool (31,798 AF)

As noted above, a total of 36,500 AF of water was the minimum pool goal that biologists familiar with the river recommended, as detailed in the 1996 EA and Decision Record. This amount of water was considered a biological minimum for adequate management of aquatic resources. Despite some early success through the Ute Mountain Ute lease and an over-subscribed 'senior downstream water' allocation, the additional 3,300 AF was never permanently acquired and the downstream senior allocation shrank to 1,274 AF. With the addition of the Paradox salinity augmentation water and the re-allocated difference between senior reserved and actual pools (which added 524 AF to the Project fishery pool but resulted in

2,102 AF less water in the total base pool), the total downstream release for the Dolores River is now 31,798 AF. The Project pool for fish and wildlife resources is 29,824 AF, which is subject to the same allocation shortage faced by irrigators. The augmentation water and senior water releases are not subject to Project shortage allocations, but the senior rights passed downstream through McPhee Reservoir depend on administration of water rights within the Dolores River basin.

Recommendations for base pool management are provided by an interagency team called the Dolores River Biology Committee. The Biology Committee consists of members from the Colorado Parks and Wildlife (CPW), U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), Bureau of Reclamation (BOR), and Trout Unlimited (TU). The purpose of the interagency team is to use the best scientific information available on fishes, both native and non-native, to make flow recommendations in the river below McPhee Reservoir. Recommendations for the base pool are generally accepted, but the BOR will ask that if possible, baseflows be designed to also maximize power generation from the turbines below the dam (operating at 25 cfs increments, up to 75 cfs).

The effective base pool can shrink or grow depending on the water year (**Figure 9**).



Water from the fish pool is not used when a ‘managed release’ is declared by the BOR. Wet years with extended managed releases to the Dolores River downstream of McPhee Dam

conserve water in the fish pool. This 'conserved water' is typically used to enhance baseflows during the summer months (growing season) and to provide better-than-average overwintering flows for both native fish and non-native salmonid species.

**Figure 9.** Baseflow hydrographs depicting scenarios ranging from shortage years (48%, e.g., 2002-'03), full allocation without spill years (e.g., 2006), and spill years showing 65K AF and 186K AF (e.g., 2007, 2008). Gaps in the hydrographs for spill years show where the base pool is not assessed a release volume, allowing for greater flows during critical summer months and better winter flow conditions. Note also that the 'water year' for base pool management begins April 1.

Dry years affect the base pool in two ways. First, a dry year may result in enough water to declare a full allocation to Project water users, but not enough to create a managed spill. Water from the base pool is then delivered for the 365-day year according to a water budget developed by the Biology Committee. If drought persists (e.g., 2002 and 2003) and there is not enough water to meet everybody's needs, the Dolores Project component - 29,824 AF - shares the shortage of water at the same percentage as Project full service and Ute Mountain Farm and Ranch agricultural users.

Maximum baseflows from the existing fish pool typically reached over the summer growing months are 60-120 cfs, depending on the water year. So, the question the Biology Committee considers when formulating a water budget for the year is not so much how much water but when to deliver the water to maximize the well-being of fishes within the confines of the fish pool.

Timing of water deliveries to fishes in the Dolores River downstream of McPhee Dam is important. Timing is based on the following criteria:

**Winter Flows** Fishes need adequate water depth and cover from harsh freezing conditions (e.g., anchor and frazzle ice formation in the water). Flows need to be stable and consistent; otherwise fish can move into sub-optimal habitats that either dry or freeze. Nehring (1993) recommended winter flows between 25 and 35 cfs. Once a flow is determined by water availability, the main consideration is to not deviate from it. These flows are minimal. They don't allow for fish movement between overwintering habitats (pools) because riffle depths are too shallow. Once a fish chooses a place to winter in, it is stuck in that location. Higher overwintering flows would allow fish to move from sub- to more optimal habitats, plus an increase in the volume of water helps protect fishes from wide temperature swings and freezing.

**Spring Flows** Flow recommendations for March/April are generally in the 50 cfs range. Flows need to be a little higher than winter flows to allow better connectivity between habitats for reproductive needs and to help 'dampen' the effects of large springtime ambient air

fluctuations. Spring spawning fish (both native and non-native) use cues like rising stream discharges associated with the onset of spring melt, increasing photoperiods and water temperatures, and increasing turbidity associated with scouring of fine sediments for maturation of gonads, reproductive site selection, and gamete release. In the absence of a managed release from McPhee Dam, it is not possible to mimic these processes with the existing fish pool. Managed releases are a critical component of spring water management for fishes (see hydrograph discussion in Section II.3).

**Summer Flows** As with any temperate animal, summer is a time of growth and prosperity for fishes. Growth determines their ability to escape predators, move to and effectively compete with other fishes in productive feeding and breeding habitats, and to increase their reproductive potential (e.g., number of eggs per female). Food production and optimal temperatures are the two key factors determining growth. These factors are tied to flow (more wetted channel, more bugs and algae production). Depending on the water year, Biology Committee-recommended flows are maximized during the summer to provide the conditions above. Recommended flows range between 60 and 120 cfs from June-August. During shared shortage years, flows have ranged between 22 and 39 cfs. Flow-temperature studies done by Nehring suggest minimum flows between the dam and Bradfield Bridge during the warmest months should be 70 cfs or greater to avoid acute and chronic high water temperatures for trout and allow sufficient depth in riffles for fishes to move to cooler habitats. Anderson (2007) suggested minimum summer flows for native fishes at 80 cfs.

**Fall Flows** Fall brings cooler temperatures and flows need to be sufficient to avoid extreme temperature fluctuations and to allow fish passage to overwintering sites. Flows are generally delivered from the fish pool between 60 cfs down to 40 cfs and finally 35-25 cfs for overwintering. The Biology Committee recommends about a 12-hour 'stocking' flow to evenly distribute fingerling rainbow trout from the dam to Bradfield. This is a best management practice for stocking fingerling trout. Flows are gradually increased starting at midnight before stocking occurs, peak at about 350-400 cfs, then are gradually reduced back to baseflows of 40 cfs in early October.

It is important to remember the flows cited above consume the existing fish pool. On dry years with no managed release, maximum summer discharges that protect minimal fish habitat are 70 cfs for a few months. Flows within the existing fish pool are considered sub-optimal and minimal for native and non-native fishes in the Dolores River. Both trout and native fish biomasses are far below what would be considered healthy compared to other less-impacted streams. Shared shortages are particularly devastating to the native and trout fish populations and may actually encourage the proliferation of invasive species such as crayfish and smallmouth bass.

## 4. Baseflow Pool Fishery Needs - Summary of AWF Findings

- There is a strong positive correlation between summer baseflow conditions and native fish populations;
- Current baseflows are held constant for long periods of time and are far below recommended flows for improved native fish populations;
- Higher baseflows would provide more habitat for native fish and invertebrates;
- Higher baseflows would provide more escape cover and more diverse habitat, decreasing competition and predation between native and non-native fish;
- Higher baseflows have the potential to improve water quality, including thermal buffering against extreme day-time temperatures.

## 5. Opportunities to Address Baseflow Needs

Both the 1996 EA and *A Way Forward* scientific findings called out the need for additional water in the base pool for downstream releases to sustain ecological values, including native fish. Both the EA and the scientific review refer to a lease of additional water as a means to benefit the native fishery, which may also provide financial resources to benefit irrigators. The lease of water, these documents point out, may provide for irrigators' capital needs and add to the long-term local control of water resources. The 1996 EA specifically called for acquisitions to grow the McPhee fishery pool allocation to a minimum pool of 36,500 AF. A lease or acquisition would occur under a 'willing seller' premise to improve baseflow operational flexibility, and to improve habitat availability and diversity for native fish.

- (i) Existing baseflow management for native fish
- (ii) Addressing baseflow shortage
- (iii) Baseflow augmentation

Limited water supplies within the basin have made the acquisition of additional water to augment base flows extremely challenging. To provide a factual and transparent base of information to address this challenge, water managers from DWCD and MVIC agreed to put together a table that inventories all known water rights and allocations, including quantities, approvals and concurrences required for any change, and related issues. Identified water supplies are presented comprehensively without passing judgment as to their potential use for baseflow augmentation. This 'Compilation of Physical Water Supplies and Water Rights' is presented in the following section with context concerning acquisition efforts as well as an overview of potential opportunities for Policy, Basin Efficiency, and Capital Projects to play a role in meeting this challenge. While the table itself is a factual rendering of sources, quantities and necessary approvals, the column on issues is subject to discussion and refinement, as are the sections on Policies, Efficiencies and Capital Investment Potentials. The evaluation prepared by the water managers is presented below.

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**DWCD and MVIC Compilation of Physical Water Supplies and Water Rights With Regard to Sources for Baseflow Enhancement****Acquisition of Water for the Fishery: A 22-Year Effort**

The discussion about how to add water to base flows below McPhee has been going on since the 1990 dry year 20 cfs release culminating in the 1996 “Flow to Pool” EA. The ‘Finding of No Significant Impact for the Proposal to Modify Operation of McPhee Reservoir and Acquire Additional Water for Fish and Wildlife Purposes’ states under Proposed Action that:

“Reclamation proposes to acquire 7,200 AF of water to establish a pool of storage in McPhee of up to 36,500 AF for downstream release from McPhee Reservoir to the Dolores River. This volume has been recommended as a suitable goal by several resource management agencies and Trout Unlimited. The 7,200 AF would be added to the 25,400 AF of Project water reserved by the United States for fish and wildlife purposes and up to 3,900 AF of water required to satisfy senior downstream water rights”.

This search for “Increment II” water for the fish pool includes \$371,000, plus accrued interest, appropriated as cost-share to support permanent acquisition of water:

“Permanent acquisition of Increment II water will require cost sharing participation by others. Reclamation will appropriate \$371,000 to establish an account for the acquisition of water. Entities wishing to participate in water acquisition would make deposits to this account. A coalition of entities and interested individuals would be organized to administer the account and purchase water.”

As discussed above and presented in the “Water Sources in and Through McPhee” table below (Table 4), the “fish pool” currently stands at 31,798 AF, which is 4,702 AF below the Increment II target of up to 36,500 AF. It should also be noted that 524 AF of the current 31,798 AF pool is an interim allocation, which has not yet become permanent.

**Why Has Increment II Water Acquisition Been So Difficult to Complete?**

With the up-to-36,500 AF target and \$371,000 in place since 1996, why has it been so difficult to find and acquire Phase II water? The reality is that the hydrology within the Dolores Basin is limited, fully allocated and over-appropriated. Given this reality, there are four known ways to provide additional water downstream:

1. **Increased Storage Dedicated to the Fishery:** DWCD holds a storage right for the fishery on Plateau Creek that is tributary to McPhee Reservoir. This reservoir could only be filled during a spill and would impact boating flows. Permitting would be lengthy, with construction cost estimates approaching \$30 million.
2. **Increased Efficiencies that Could Free Up Available MVIC Water:** Permanent exercise of this option presents a variety of water administration and legal

issues, and would hinge on the confidence of MVIC shareholders that this could be done while meeting obligations to shareholders.

3. **Acquisition & Transfer of Private Water Rights in the Dolores Basin:** This option would involve “buy and dry” of water rights in the Dolores River Valley above McPhee Reservoir. This option would diminish the productivity and beauty of a valley that has agricultural and aesthetic values enjoyed by local residents and visitors that travel the Highway 145 corridor.
4. **Dolores Project Water:** The Dolores Project is fully allocated. Any additional water provided to the fishery would need to come from the holders of existing Dolores Project allocations, and/or changes in intended use established by Dolores Project contracts involving the Bureau of Reclamation.

The limitations described above have led to an interest in examining any “potential” water sources that could be used to accomplish Increment II water acquisitions. To respond to this interest with the utmost transparency, DWCD and MVIC water managers decided to present a table reflecting all known physical water sources and quantities. The ‘potentials’ of any of these sources are constrained by the approvals and concurrences involved in any change as well as a wide variety of issues including, but not limited to, the policy positions of the governing boards of the water-providing entities, the values and rights of shareholders and allocation holders, the magnitude of costs involved and an extensive array of contractual commitments involving multiple parties.

#### **Physical Sources, Policy Issues, and Basin Efficiency and Capital Projects:**

What follows is a “Table of Water Sources In and Through McPhee” with explanatory notes. In constructing this table, no value judgment was placed by water managers on the viability or desirability of tapping any of these sources for the downstream fishery. The purpose of the table is transparency. Accordingly, each known source by ‘Water Rights & Allocations’ is presented in Column 1, followed by a ‘Quantity’ (AF) in Column 2, required ‘Approvals’ in Column 3, required ‘Concurrences’ in Column 4, and known ‘Issues’ in Column 5.

This table does not assume or imply any level of willingness by any source to provide, approve or concur with water from these sources for downstream use. The ‘Issues’ column calls out issues known by the water managers who constructed the table. It is assumed that other issues will be added as the table is more widely discussed. While a draft of the *Implementation, Monitoring and Evaluation Plan* will be completed in June 2012, it is assumed that the discussion of these sources by all interested parties will take place in the months and years after the issue of this draft. Any use of these sources for the fish pool can only happen if necessary agreements, approvals, and concurrences are in place, and critical issues can be addressed.

Following the ‘Table of Water Sources’ is a discussion about considerations involving ‘Policy’ and considerations about ‘Basin Efficiency and Capital Projects’ to reflect discussions occurring

within the Implementation Team and elsewhere. These considerations are very much a work in progress and will undoubtedly be shaped as discussions within the Implementation Team and participating institutions continue.

**Table 4.** Physical Water Sources in and Through McPhee Reservoir

Water Rights & Allocations (1)	Quantity AF (2)	Approvals (3)	Concurrence (4)	Issues (5)
DP-DWCD M&I (4)	5,400	DWCD, BOR	DWR	Temporal as saved for future community growth. Competition for short term leasing. DWCD Board priority is to use for irrigation needs. Leased in recent years to Ute Mountain Tribe Farm and Ranch Enterprise.
DP-DWCD / Full Service Irrigation	56,267	DWCD, BOR	DWR	Subject to shortage, fully allocated & utilized, changes with crop mix over time. 100% pressurized delivery and multiple diverse ownership. High delivery and irrigation efficiency
DP-UMUT SJ F&W	800	UMUT, BOR	DWCD, DWR	Has obligations to wildlife on UMU Reservation
DP-UMUT Irrigation	23,717	UMUT, BOR	DWCD, DWR	Fully utilized, subject to shortage, changes with crop mix. 100% pressurized delivery with single ownership. High delivery and irrigation efficiency
DP- Cortez M&I (4)	2,300	Cortez, BOR	DWCD, DWR	Saved for future, not fully utilized
DP-Dove Creek M&I (4)	280	Dove Creek, BOR	DWCD, DWR	Saved for future, not fully utilized
DP- UMUT M&I (4)	1,000	UMUT, BOR	DWCD, DWR	Fully utilized, but could see efficiency improvements
DP-BOR SJ F&W	800	BOR	DWCD, DWR	Has obligation to wetlands mitigation, salinity & wildlife. On wet years, large spill or wet monsoons, when Totten is flushed, may not need full quantities. Would come available as conditions unfold April to July.
DP - Fish Pool	31,798	CPW, BOR	DWCD, DWR	29,300 fish pool & 524 interim allocation (subject to shortage), 1,274 downstream senior rights, 700 salinity augmentation. EA references both trout and native fisheries.

Water Rights & Allocations (1)	Quantity AF (2)	Approvals (3)	Concurrence (4)	Issues (5)
DWCD Plateau Reservoir (6) Fishery, M&I	+/- 20,000	DWCD, CPW, USFS, BOR	DWR	Expensive to build, but decreed to store water for fishery & M&I (from spill, junior to McPhee). Filled only in spill years which impacts the spill, but could be released even in no-spill and shortage years. Yield +/- 3,000 per year for 5 years of no spill. \$27,300,000 capital cost (2011) plus O&M required. Yield could be flexible based on downstream needs and CPW Lone Mesa State Park requirements.
Totten Exchange  Irrigation, Domestic, Exchange / Augmentation	3,000	DWCD, BOR	MVIC, UMUT, DWR	Through exchange with willing receivers, requires capital improvement, but existing storage is less expensive than new, fills during spill with resulting impacts. Fills with irrigation return flows from Ritter Draw and potentially Simon Draw. Similar to Plateau as “renewed” storage, but an existing reservoir that is recycled is substantially cheaper in cost and impacts than a new one. Fills on McPhee spill +/- 50% of years and yield depends on certainty required. Can be used by exchange.
DP-MVIC Irrigation Project Water	0-60,000	MVIC, BOR	DWCD, DWR	Supplemental to MVIC non-Project water rights, fully allocated, inversely proportional to MVIC non-Project supplies. Used primarily in current year needs as no carryover and subject to weather: snowpack, temperature and monsoons and timing of all three.
MVIC Direct Flow  Irrigation	150,400	MVIC, DWR	BOR, DWCD	Pre-1922 water rights, fully utilized particularly post-June, inversely proportional to Project water. Runs April 1 – Oct. 31. River drops below needs +/- July 1, except for monsoons. Subject to decreed uses by DWR.
Cortez Direct Flow	4.2 CFS	Cortez, DWR	BOR, DWCD	Primary source to Cortez, supplemented by DP M&I
Montezuma Water Company	13.2 CFS	MWC, DWR	BOR, DWCD	Operated through McPhee via Carriage Contract

Water Rights & Allocations (1)	Quantity AF (2)	Approvals (3)	Concurrence (4)	Issues (5)
Other private upstream water rights	Unknown	Private Party, DWR		Based on known upstream users, quantities are relatively small, a few thousand acre-feet. A small few are senior to MVIC, most are junior to MVIC, but senior to McPhee. Those junior to McPhee are M&I.

**Notes to Physical Allocation Table**

All additional draws on McPhee storage, i.e., diversions post-July 1, diminish carryover and subsequent managed releases (spills) while simultaneously utilizing (increasing) the full yield of the reservoir. The diminished carryover comes with increased shortage impacts and possibly recurrence.

(1) DWCD owns the water rights to direct flow to and storage in McPhee Reservoir. Dolores Project recipients hold allocations based on contracts. MVIC DP allocations are calculated based on their available non-Project water rights. DWCD is contracted to run the complete BOR Dolores Project with the full yield of the reservoir; particularly important is the carryover. Other than M&I for future community development, all allocations are currently committed.

(2) Irrigation supplies and fish pool are subject to shortage.

(3) All storage from McPhee can be flexible, but requires very specific approvals and all parties' concurrence. These are not precise, but indicate the interconnected parties via contracts, water rights, water law and potential mutual cooperation and possible injury. BOR must determine and approve all contracts after evaluating impacts to the Dolores Project, while DWCD must appropriately account for diversions and releases. DWR likewise must account for all uses under Colorado water law.

(4) All DP M&I has first call on McPhee yield; there can be no shortage for domestic / M&I use.

(5) Part of MVIC supplies, may overlap with other sources and/or quantities.

(6) DWCD owns water rights on several new storage reservoirs, including Plateau Creek, Beaver Creek, Bear Creek and Plateau pump-back power generation storage. Yield would depend on reservoir management, how you use the supply.

- BOR Bureau of Reclamation
- CPW Colorado Parks and Wildlife
- DP Dolores Project
- DWCD Dolores Water Conservancy District
- DWR Division of Water Resources
- MVIC Montezuma Valley Irrigation Company
- UMUT Ute Mountain Ute Tribe
- M&I Municipal & Industrial
- SJ F&W San Juan Fish & Wildlife

**Policy**

These issues bring up Colorado water law, Reclamation law, NEPA, economics, Dolores Project operations, local community sentiments and a host of interested stakeholders concerned with the Dolores River. Therefore, proposed plans would likely require a diverse set of professional resources to fully explore potential opportunities.

Any new sources impact the managed release (spill) and recreational boaters for whom it is managed per the Dolores Project EIS. Based on an average spill, impacts are relatively small (5 - 20%) on a downstream flow much truncated from the historic natural regime. Likewise, irrigators have risk from additional diversions from storage (i.e., any use of McPhee storage post-spill lessens the carryover), which probably exacerbates shortage impacts and incrementally increases recurrence. M&I is largely protected and must continue to have priority on DP supplies. Therefore, any increased base flow comes at a cost and/or risk to the spill and boaters and/or the Dolores Project community irrigators (UMUT, MVIC, & DWCD) in Montezuma and Dolores counties or must displace an existing use.

The target in the 1996 Flow to Pool EA was up to 36,500 AF. Currently 31,798 AF is released in conjunction with the fish pool, which is 4,702 AF below target. Any policy goal to increase the baseflow should calculate potential needs with this target in mind.

The many constraints indicate a need for flexibility, as it is impossible to get a new permanent and (relatively) firm supply for the purpose of augmenting baseflows without also either increasing costs and/or risks to current uses or taking water away from one or more current uses.

A truly flexible and willing system requires a viable water market: flexible, temporally sensitive, efficient transactions that also involve individuals in decisions, risks and rewards, while protecting the community and irrigation organizations. Many likely planning horizons would encompass approximately 20 years, much like the Colorado River Interim Operating Guidelines for Coordinated Operation of Lake Powell and Lake Mead, 2007-2026. This provides operating experience for all parties for future planning horizons. It also allows parties to understand their risks during the interim period with an expectation that they are not permanent.

Wet water is most available when McPhee is full, i.e., in a spill year, and a later spill, peaking past May 20, is better for McPhee carryover & Project supplies, though MVIC total supply impacts are reversed due to their Project water calculations. Any increased draw lowers the carryover and shifts risk to subsequent years.

Drought periods are tough times. Dry-year leasing could be a potential option. It may be a different type of transaction, like a water bank or interruptible supply plan (ISP). The supply and price/cost of water drives conservation and availability. Drought shrinks the supply of water

and drives the price. The highest and best use of water is affirmed by the willingness of society to pay for the supply. That value is most vividly demonstrated in drought.

Potential candidates requiring policy work could include various physical supplies listed above, but they all have unique conditions and interests.

### **Basin Efficiency, Capital Projects**

There is limited ability to conserve on M&I supplies due to the small quantities, the existing system efficiencies and the need to preserve these supplies for the future, even though these uses are not subject to shortage reduction. This generally holds for all small allocations, e.g., Fish and Wildlife (F&W) water.

Efficiency gains would include largely capital projects that create intentional savings and provide an incentive to the current user. Potential efficiency savings yield the most saved water from large, traditional irrigation suppliers.

### **SUMMARY**

There is no unallocated / unspoken for / “free” water in the Dolores River watershed. New usable wet water either comes from a spill (managed release), in the form of new storage and/or lower McPhee carryover, or it comes from someone else’s water supply (private property right, legal allocation, court-decreed settlement quantity for subjugated Winters Doctrine rights). In any given year, there may be unused water supply that generally ends up in McPhee, Groundhog or Narraguinnep as carryover storage, which insures next year’s supply (including spills), provides for the full yield of the reservoir, protects subsequent years’ supply and reduces the severity and frequency of shortages. There may also be water that ends up in McElmo Creek (possibly Navajo Wash) that results from inefficiencies in farm applications or within the delivery systems. The desire to move supplies from their current use to a different use is driven by the willingness of society to support change.

## **6. Implementation Strategy: Addressing Baseflow Needs**

This Implementation Plan addresses the majority of the nine opportunities identified by the **A Way Forward** native fish scientists through specific implementation, monitoring and evaluation actions. While baseflow enhancement was clearly identified by the scientists as one of the primary opportunities that needs to be pursued in conjunction with opportunities such as spill, thermal, and predator management strategies, it also is relatively more complex. The goal of increasing the baseflow management pool to 36,500 AF per year by adding water to currently deficient baseflow pool supplies is well documented. But the strategies, tradeoffs, and actual costs related to securing this additional water are, as yet, not fully analyzed and understood. Therefore, implementation strategies for meeting this goal have yet to be defined and are not included in this inaugural iteration of the Implementation Plan.

The conservation community is committed to finding an approach to baseflow enhancement that is beneficial to the ecological health of the basin and the economic vitality of basin water users as a whole. Based on the DWCD-MVIC compilation of physical water resources, summarized in the table above, and the potential economic and ecological value that can be derived from improved and flexible water management, capital investments in basin infrastructure and efficiency, the conservation community is prepared to invest in solutions identified by basin water users that will result in broad-based human, economic, and ecological benefits. The conservation community further understands that finding the best set of solutions for all interests will require working together on an open and factual basis.

To move the baseflow enhancement need and opportunity towards an implementation strategy, the conservation community seeks discussions with the basin's water-providing entities aimed at finding flexible and mutually acceptable approaches to improving water availability and a fair distribution of the resulting benefits. The conservation community recognizes that any viable approach will need to be evaluated in detail to insure the benefits sought by all interests can be achieved and to determine those action steps and investments that will be required to successfully develop any alternative under consideration.

As long as it has confidence that its interests in improving the condition of native fish and addressing the basin's overall ecological health will be served by doing so, the conservation community is prepared to invest in what emerges as the best solution, as well as in the evaluation process that will be essential to identify and validate options leading to a preferred solution. The Nature Conservancy, Trout Unlimited and San Juan Citizens Alliance are prepared to take the lead on behalf of the conservation community, and will seek a venue for working with the water-providing entities to craft a solution to the fishery pool need with broad-based benefits to the water community as a whole.

## 7. Monitoring and Evaluation of the Effectiveness of Baseflow Opportunity

Baseflow augmentation to improve the instream habitat conditions for native fish may be best monitored by re-examining habitat suitability curves developed by Anderson (2007) for bluehead suckers through the Big Gypsum study reach. Bluehead suckers are the most imperiled of the three species within the reach from the dam to the San Miguel River confluence and are considered the most obligate to riffle habitats. Thus improvement to their primary habitat will also improve habitat conditions for the flannelmouth sucker and roundtail chub. Although a minimum habitat condition of 12% available habitat for bluehead sucker measured at the Big Gypsum site<sup>11</sup> would be considered the minimum to sustain blueheads in

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<sup>11</sup> Current Habitat Suitability Curves (Anderson 2007) suggest bluehead sucker habitat is at about 5%. Bluehead sucker are our indicator species; take care of them and you will take care of other native fish habitats.

this reach, this goal may also be assessed based on progress made toward the goal on an annual or bi-annual basis. Monitoring will also focus on the roundtail chub, which is the native fish that is the ORV associated with Wild and Scenic eligibility and suitability.

The simplest means of assessing progress toward meeting the short-term baseflow objectives of either more frequently meeting the 78 cfs instream flow appropriation or acquiring the 4,702 AF of water needed to meet the 36,500 AF goal is to simply examine the release hydrographs and summarize these metrics in terms of 'days 78 cfs met or exceeded' or a simple calculation to determine how much water was accounted to the baseflow pool.

## V. SEDIMENT TRANSPORT

### 1. Definition and Targets for Flushing and Habitat Maintenance Flows

The AWF scientists independently validated earlier conclusions that the reduction in overall stream power<sup>12</sup> following dam construction has had significant implications for native fish habitat in the river. The scientists also agreed that spill management designed to achieve multiple purposes would be the most beneficial use of projected surplus water, but their report suggests that managing spills to meet specific flushing or habitat maintenance targets may be subordinate to meeting other native fish opportunities (e.g., thermal regime modification). Monitoring the effects of spill management against flushing and habitat maintenance objectives will allow refinement of flow targets that achieve multiple purposes or when specific sediment management goals are a priority. As monitoring of instream habitats and floodplains continues, the Implementation Team may consider more detailed studies of how sediment flux affects these habitats, including sediment transport modeling and calibration.

As noted in Section II, 'Spill Management', sediment flux in rivers is dependent on high flows. The scientists broke the analysis of sediment transport opportunities into 'flushing flows' and 'habitat maintenance flows', with emphasis on refining the flows needed to meet all life-stage habitat objectives for native fish. It should be recognized also that the effects of larger sediment transport flows on Dolores River habitats will be most readily observed in unconfined, alluvial reaches, where channel morphology is not constrained by bedrock or dominated by hillslope processes, as in canyon reaches. Thus for native fish, these goals most notably apply to lower portions of Reach 3 and Reach 4, where alluvial processes dominate the instream and riparian habitats.

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<sup>12</sup> 'Stream power' is a function of flow; specifically stream power is directly proportional to the square of the velocity of moving water (i.e.,  $\text{Power} \sim V^2$ ). In general, flow velocities increase as stream discharge increases.

However, the AWF scientists also warned that in alluvial reaches that are confined by channel incision, increasing streamflow may further degrade the bed, resulting in further isolation of the active channel from its floodplain. This process may result in eventual abandonment of the floodplain, concentration of larger flows within the entrenched reach, and further downcutting. They presented some evidence of this through review of the Bedrock gage rating data available through the USGS. The habitat implications noted by the scientists suggest that these reaches may exhibit relatively monotypic, low-productivity areas, minimizing their value for production or growth for native fish.

This section further refines two elements of each of these coarse stratifications, based on the habitat benefits to native fish that can accrue from meeting these sediment flux objectives. These are defined as follows:

### Flushing Flows

- **Flow Hypothesis is 400-800 cfs:** Mobilize fine tributary sediments (<2mm particle sizes) accumulated in both pools and riffles from monsoon runoff. This is important to minimize substrate embeddedness, improve primary productivity within riffles, and prepare cobbles prior to spawning to maximize opportunities for successful spawn. The overall effect on pool fill and scour is unknown, as some mobilized fines will settle in downstream pools.
- **Flow Hypothesis is 800-2000 cfs:** Mobilize the median particle size ( $D_{50}$ ) in half the riffles. This function begins the process of bedload transport, whereby riffle substrate mobilizes and re-settles, and pools begin to scour. This phase of sediment transport begins the process of re-building vertical relief (and habitat diversity) between riffles (depositional areas) and pools (scour areas), and also provides all the aeration/productivity benefits described for the fine flushing flows.

### Habitat Maintenance Flows

- **Flow Hypothesis is 2000-3400 cfs; (2600 cfs as targeted bankfull flow in Big Gypsum Valley):** Mobilize larger riffle particle sizes ( $D_{50}$  -  $D_{84}$ ) for majority of riffles and enable sediment exchange between riffles and in-channel bars. At the lower end, these flows should initiate inundation of floodplains within a reach and at the higher end they should inundate the majority of floodplain surfaces in alluvial reaches except for reaches affected by entrenchment. Pool scour and evacuation of sediments from pool storage is a significant benefit for instream habitats; initiation of nutrient exchange between the river and floodplains also has significant benefit to native fish.
- **Flow hypothesis is > 3400 cfs in Big Gypsum Valley:** Significant overbank flooding, with sustained events exceeding bankfull stage for the majority of reaches. This flow should initiate significant movement of riffle  $D_{84}$  and result in observable lateral migration processes, floodplain inundation and exchange of coarse material between in-channel

and floodplain environments. Large flood events of 3400 cfs and greater will enable the overall channel and adjacent riparian areas to create and maintain the diversity of niche types that encourage biological diversity to persist.

## 2. Monitoring of Flushing and Habitat Maintenance Flows

This monitoring plan has not been developed to precisely identify the flow that mobilizes fine sediments or bedload, but rather to determine or verify if the managed hydrology is adequately maintaining desired habitat conditions. However, monitoring should provide a better estimate of fine sediment and bed transport as a function of flow. Annual, routine monitoring (e.g., cross-section transects and longitudinal profiles) will allow the Implementation Team to identify gross changes to channel morphology driven by flow regime. Time-series aerial photo analysis or infrequent channel floodplain bathymetry will provide information about long-term morphologic response to flows. Specific snowpack information prior to a runoff will allow for targeted monitoring to more narrowly define the effectiveness of specific flows to meet sediment transport objectives.

The following goals are intended to summarize how habitat features necessary to sustain a native fishery are related to sediment transport flows, and what can be measured to determine whether habitat objectives are being sustained by a given flow regime. If monitoring determines that habitat objectives are not being met, changes in flow regime should be considered, including re-assessing sediment transport flow hypotheses. There is also a short-term need to compile available summary or site-specific information from the Dolores River that could provide the context for additional monitoring of sediment transport, and also help to frame specific questions for future monitoring.

**Table 5.** Flow hypotheses, native fish habitat objectives, and measurable indicators that will assist the Implementation Team in determining whether proposed flows to meet native fish objectives will support sediment transport objectives.

Flow Hypothesis	Habitat Objective	Measurable Benchmark
<b>Flushing flow</b> 400-800 cfs to scour fine sediment	Maintain quality spawning habitat at times appropriate for spawning to occur	Quantify percentage of fines (<2mm) in spawning beds (cobble) pre- and post- flow event; percentage of fines measured should be reduced, with specific attention paid to aligning flushing flows relative to the timing of native fish spawning.
<b>Flushing flow</b> 800-2000 cfs to initiate mobilization of the median-size particle	Maintenance of riffle and pool vertical relief	$D_{50}$ should coarsen in riffles; annual accumulation of fine sediment should be scoured from pools. Pool-riffle profile should be maintained.
	Maintain benthic macro-invertebrate productivity	Taxa measurements for benthic macro-invertebrate species in riffles (quantitative/ qualitative measures?) should reflect productive instream environment.

Flow Hypothesis	Habitat Objective	Measurable Benchmark
<b>Habitat Maintenance Flow</b> 2000 - 3400 cfs for 7+ days (bankfull flows)	Maintain pattern and profile appropriate for the reach	Monitor changes in cross-section and profile dimensions; aggradation or degradation should be assessed; over a reach, over time, gradient and pool-riffle spacing should be consistent. Assess plan-view changes, such as stabilization of mid-channel bars or bar extension; vegetative encroachment on point bars; medial bar expansion.
	Scour pools	Maintenance of pool depth (see above re: pool depths).
	Mobilize majority of riffle materials	Monitor mobile fraction of channel bed in riffle; tracers or direct bedload transport measurements; hydraulic modeling.
	Initiation of significant interaction with floodplains in alluvial reaches.	Cottonwood recruitment (or at least some indication of seed-bed preparation and germination); maintenance of other riparian indicators (e.g., minimize encroachment of xeric/mesic species onto floodplains). Validate $Q_{bkf}$ hypotheses by reach.
<b>Habitat maintenance Flow</b> Peak flows of >3400 cfs at a frequency of ~7-10 years	Mobilize and re-set riffle habitats; create and maintain instream habitat diversity (pool scour; backwaters; secondary channels)	Document movement of $D_{84}$ in riffles; assess instream habitat complexity.
	Maintain floodplain exchange and robust riparian vegetative community	Monitor riparian vegetation diversity and density; cottonwood germination and recruitment (NOTE - Riparian monitoring will be an important indicator of whether large flows are providing the exchange benefits to instream resources).
	Energy and nutrient exchange between channel and floodplains	Validate $Q_{bkf}$ hypotheses by reach. Floodplain inundation depths; measure exchange of material between channel and floodplain (e.g., painted patches; floodplain transect monitoring).
	Maintenance of alluvial aquifer	Groundwater monitoring in floodplain.

### FLUSHING FLOW GOAL 1. Maintenance of spawning habitat and benthic macro-invertebrate productivity

#### Assumptions:

1. Native fish use riffles in the Dolores for spawning, adhering eggs to riffle substrates.
2. To improve spawning success, fines should be removed from riffles prior to spawning, maximizing the chance for successful adherence to substrate.

3. The flow that mobilizes fine sediment is ~ 400 cfs.
4. Benthic macro-invertebrates are an important food source for native fish and provide the basis of the aquatic food chain.
5. Productivity of riffle fauna is enhanced by well-oxygenated water flowing through interstitial spaces in substrate matrix.
6. Flows that initiate movement of median riffle particle size, which maximize invertebrate productivity, range from 800 to 2000 cfs, and are highly reach-dependent.

### **Possible Monitoring Protocols:**

#### **1. Sampling frame and template pebble count**

A 0.6 X 0.6 meter aluminum sampling frame is gridded using thin elastic bands. The grid is set on the stream bed at preset intervals along a tape. Particles are sampled under the grid intersection and measured using a template. The protocol was developed to minimize operator bias and variability in particle selection.

#### **2. Embeddedness measurement of cobbles/gravels in riffles.**

Embeddedness describes the phenomenon of fine sediments filling the interstices between coarser sediments on the streambed (Sylte and Fischenich, 2002). It is usually measured by sampling a 30-60 cm hoop several times across transects until the desired sample size is collected. There are also several visual methods including using a 'viewing bucket' with a measuring grid.

#### **3. Core samples**

The vertical profile of a stream channel can be used to obtain information on the amount of sediment supplied to the stream, the sediment particles sizes, and the manner in which the sediment was transported and deposited. An analysis may show if an increase in the fine sediment supply over time has occurred. McNeil Samplers can be used, although there are different ways of collecting samples and we might have to experiment to figure out what works best. Core sampling would require some post processing of samples to segregate particles into size classes. This could be a good research project rather than a monitoring item.

#### **4. Fine sediment traps**

Bury a series of infiltration bags or containers in the stream bed to be collected at a later date. The samples (once found) would require post processing to segregate into particle size classes.

### **5. Wolman pebble count**

This protocol provides information on changes in overall particle size distributions over time. Emphasis should be made to count the fine sediment layered on top of the large substrate since studies have shown that smaller particles (<8mm) are under-represented using this protocol.

### **6. Collection of fine sediment within riffles**

Sediment embedded on and around gravel and cobble is stirred up within an open-bottomed bucket secured to the stream substrate. Suspended sediment is then drawn off using a portable bilge pump (hand-operated). The sediment sample is then settled and analyzed for weight, maybe particle size. It might be possible to use a Hess sampler (macro-invertebrate sampler) for collection.

### **7. Qualitative observations of sediment in riffles prior to the spill and/or after the spill when waters clear.**

Using a 'viewing bucket' might allow photos of the stream substrate. Success of this would be dependent on the same observer going back to the same areas over time and collecting similar information. The advantages include being able to survey a larger area and observing features that are difficult to quantify. This method could be considered an instream analog to traditional photo point monitoring.

### **8. Benthic macro-invertebrate sampling**

Several of the above sampling methods could be designed to be complementary with collecting a macro sample. Funds would need to be included to process a sample if it was collected.

## **FLUSHING AND HABITAT MAINTENANCE GOAL 2. Maintenance of the riffle and pool habitat**

### **Assumptions:**

1. Channel maintenance flows are required to scour pools and to deposit fresh riffle material.
2. Maintenance of the riffle/pool sequence is necessary to provide habitat for all life stages of native fishes.
3. Flows encompass the low end of incipient motion of riffle bed materials (~800 cfs) up to bankfull flows that transport median riffle material and initiate movement of larger substrate (~2600 cfs).

### **Possible Monitoring Protocols:**

1. Repeat cross sections and longitudinal profiles

A series of permanent cross sections and a corresponding longitudinal profile of the streambed surveyed over either a distance of 10 channel widths or representative pool/riffle sequences. Survey should be repeated at regular time intervals, more frequently when the reservoir spills. Cross sections would be installed in alluvial reaches where pattern and profile is flow-dependent. HEC-RAS could be used to determine one dimensional habitat at differing flow levels (tier off existing Reach 4 data from Big Gypsum Valley, Richard and Anderson, 2007). Monitoring channel dimensions pre- and post- spill would give us some information regarding sediment mobilization. Longitudinal profiles would give us some information on changes in pool depth and allow evaluation of the vertical relief within the reach.

**2. Wolman pebble count**

This protocol provides information on changes in overall particle size distributions over time. Emphasis should be made to count the fine sediment layered on top of the large substrate since studies have shown that smaller particles (<8mm) are under-represented using this protocol.

**3. Low-level aerial photography repeated at same flow levels**

This would give us reach-wide information on some channel metrics such as width of active channel, point and mid-channel bar patterns, riffle length, and changes in channel location. This data wouldn't be as precise as LiDAR or as the cross sections but would be more affordable than LiDAR (green or near infrared). Collecting stereo aerial photography presents difficulties for funding and logistics. New imagery could be compared to digitally scanned, rectified and geo-referenced aerial photography from 1981, 2005, 2009, and 2011 to map channel features sensitive to change. This is one of the few ways we can obtain information on some channel characteristics pre-McPhee Dam. NOTE: An analysis of pre-dam, early-mid 1990s, and late-2000s data may indicate current trajectories of channel response to dam closure. More specific analysis of pre- and post-drought aerals (e.g., 1995 and 2005) may allow inference for how drought from 2000-2005 affected channel morphology.

**4. Repeat photo points**

Ground-based photographs need to be done at the same time of year, same time of day, and using a similar camera from the same location. This can provide a qualitative assessment of change. Photos could be taken at low water to capture features such as mid-channel bars with something to provide perspective (e.g., a person, survey pole, etc.).

**5. Sampling frame template pebble counts at cross sections**

The SFT method appears to be more accurate and precise than the Wolman protocol. This method would provide an overview of substrate at a cross section

and can measure if a shift in the D50 is occurring over time. We need to determine sampling locations/strategy.

#### 6. Pool monitoring – $V^*$

The parameter  $V^*$  quantifies the ratio of the fine sediment volume in pools  $V_{\text{fines}}$  to pool volume  $V_{\text{pool}}$ . To compute  $V^*$ , the water depth and the thickness of the fine sediment deposit is measured along a grid system spanned over the pool. The thickness of the fine sediment deposit is measured by probing with a steel rod that has a cm gradation.

#### 7. Re-survey of Rick Anderson's study reach (by foot and boat) combined with habitat modeling at different flow levels.

This effort requires intensive field surveys to re-create bathymetric dataset for Big Gypsum Valley study reach.

#### 8. Green or terrestrial LiDAR

The flight integrates collection of data:

- Bare earth mapping of floodplain
- Channel bathymetric survey (Green LiDAR only)
- Color infrared photography of vegetation

For monitoring purposes: the channel mapping could provide excellent information on changes in channel structure (pool depth changes, riffle length, scour); it is NOT so good at providing precise data on lateral bank migration. It would be useful for geomorphic and vegetation monitoring/research. LiDAR channel mapping could be compared to mapping done by Rick Anderson - i.e., mapping is just as accurate as the ground-based method. The data collected could also give information on the vertical structure of the vegetation canopy.

Green LiDAR won't work on turbid waters and it is logistically difficult and expensive. Terrestrial LiDAR won't penetrate the water column to provide instream habitat information critical to assessing native fish habitat response to flows. The Implementation Team would need a research-level inquiry in order to pursue this technology.

**HABITAT MAINTENANCE GOAL 3: Maintain instream - floodplain energy exchange and robust riparian vegetative community**

#### Assumptions:

1. In downstream alluvial reaches (e.g., Reach 4), cottonwood abundance and recruitment is an important indicator that alluvial processes are being maintained.

2. Disturbance of the floodplain by inundation is necessary to:
  - a. maintain broadleaf cottonwood community;
  - b. keep invasive non-native plant species and upland species from dominating floodplain habitats;
  - c. maintain structure and diversity of riparian community.
3. Inundation of the floodplain recharges shallow groundwater aquifer and aids in maintaining width of riparian area and vegetative diversity of the riparian area.
4. Inundation of floodplain areas induces greater connectivity between in-channel and riparian habitats, allows both organic and inorganic matter exchange, induces instream productivity, and diversifies habitat niche availability for native fish.
5. The range of flows required to support nutrient exchange and create or maintain backwater and overbank habitats for native fish are initiated at ~2600 cfs (50% of reach), and are realized at a significant level at the Big Gypsum Valley site at 3400 cfs (90% of reach).
6. Large-scale movement of riffle materials at or above the  $D_{84}$  clast size ensures riffle productivity, building of point bars, and downstream meander migration typical of properly functioning alluvial river systems.

**Possible Monitoring Protocols:**

**Note re: riparian monitoring:** The Dolores River Restoration Partnership (DRRP) is developing long-term Dolores River treatment and monitoring protocols for their work on the entire corridor (McPhee Dam to the confluence with the Colorado River). The Implementation Team will coordinate efforts with the DRRP to leverage available resources and information. In addition, the Implementation Team is contracting with a riparian ecologist to summarize existing riparian information for the Dolores, and specifically to assess whether the composite hydrographs for native fish (see 'Spill Management', Section II.3) will support or disrupt management objectives for riparian species. If riparian objectives are not supported by the hydrographs, the ecologist has been asked to suggest how the hydrographs could be modified to support the objectives.

**1. Riparian vegetation monitoring at cross section locations**

Cross section/riparian vegetation monitoring has been initiated at several locations in Big Gypsum and several locations upstream by Mike Jensen (USFS).

- a. Transect or quadrat placements along geomorphic cross sections monitoring species composition or an indication of general type (e.g., riparian/upland; grass/sedge, forb, shrub, tree, etc.).

- b. Specific monitoring for recruitment and abundance of cottonwood at potential floodplain recruitment sites.

## 2. Aerial photographs or other remote sensing technology

Retrospective and long-term use of aerial imagery may be important to develop a better understanding of how overbank and backwater habitats are responding to flow regime. In addition, certain remote sensing technology can be used to determine general structure of riparian community. (Is the resolution of NAIP imagery adequate for monitoring vegetation? Cottonwood loss? Width? Structure?)

## 3. Groundwater monitoring

Researchers at Fort Lewis College have one field season of piezometer data in Big Gyp (Suckla property) indicating that it is a losing reach. Therefore, recharge to the alluvial aquifer by flooding or high water is important to maintain the riparian area width. Continued piezometer studies would help to track recharge of the alluvial aquifer over time and would help determine if riparian areas are shrinking due to lack of recharge.

## 4. Installation of crest gages at cross section locations

Crest gage (or some type of gaging) would provide us with information on floodplain inundation depth level post-spill, or high-water event. This information could be coordinated with vegetation/floodplain monitoring documenting scour/ deposition/ seedlings. It is believed that Fort Lewis researchers will be installing some this coming field season at their study sites; it is hoped that these studies can continue long enough to capture some of the variability in groundwater dynamics.

## 5. Painted patch, sediment traps, or tracer particles studies

These consist of specific indicators of sediment transport that can reflect transport capacity at a variety of elevations relative to stream stage (i.e., within the active channel; intermediate benches; floodplain surfaces). It is relatively simple to design studies; it can be difficult to relocate tracer particles. Sediment traps may introduce hydraulic 'bias' relative to placement of traps within the streambed;  $\frac{1}{2}$  m<sup>2</sup> painted patches are relatively simple to establish and monitor but data can be difficult to quantify.

**Table 6.** Sediment transport monitoring plan indicating targeted process and flow levels, recommended monitoring tools, applicable reach, and timing or frequency of monitoring required. As indicated in this table, many of the sediment transport monitoring strategies are dependent on a particular flow regime and will by nature be adaptive and responsive to a given flow opportunity in a particular water year. Others are more routine in nature and should be

incorporated as is feasible into annual monitoring of the Dolores River for the benefit of the native fishery.

RIVER PROCESS	DESIRED FREQUENCY	MONITORING TOOLS	REACH	FREQUENCY
<b>Flushing Flow: fines. Scour accumulated fine sediment to maintain bed porosity and prepare cobbles for spawning (~400-800 cfs)</b>	Flows of $\geq 400$ cfs for 1 day in fall or spring almost every year. May be coincident w/ trout stocking Reach 1 or built into spring suppression or fish monitoring flows.	% fines in bed sample through core samples or sampling grid; pebble counts; 'viewing bucket' ocular surveys; sediment traps; or suspended load samples at flows to 400 cfs; photo points; scour probes; benthic sampling.	Spatially varied (riffles, pools, reaches 2-4); focus on potential spawning reaches and Reach 4 below Disappointment or Big Gypsum Valley site.	Frequency as needed, affected by prior monsoons, spawning conditions, or data needs. Consider annually as spawning sites identified.
<b>Flushing Flow: incipient motion for <math>D_{50}</math> and pool scour; refresh spawning cobbles; enhance instream productivity; maintain pattern and profile (800-2000 cfs)</b>	Flows of 800-2000 cfs for 7+ days every 1-2 years.	Cross section and longitudinal surveys; % fines in bed sample; pebble counts; photo points; in-channel sampling frame, 'painted patch' or sediment traps; scour monitoring of pools; long-term aerial photo analyses.	Spatially varied (reaches 2-4); shift some focus to alluvial reaches but maintain attention on spawning areas.	Pre- and post-spill monitoring when opportunities are available. Cross section/longitudinal surveys as needed. ~5-yr intervals for aerial reach analyses.
<b>Habitat maintenance flow: <math>D_{50}</math> - <math>D_{84}</math>. Maintain vertical relief between riffles and pools; course sediment movement; initiate overbank flooding (2000-3400 cfs).</b>	Flows of $\geq 2000$ cfs for 7-14 days, with a spike $> 3000$ cfs every 2-4 years. 2600 cfs and 3400 cfs are applicable bankfull targets in Big Gypsum reach.	Cross section and longitudinal surveys; pebble counts and bucket/sieve analyses from bars; 'painted patch' or sediment traps. Scour monitoring of pools; floodplain groundwater monitoring; vegetative monitoring of cross sections.	Spatially varied (reaches 2-4). Focus on representative alluvial reaches.	Pre- and post-spill monitoring when opportunities are available. ~5-yr intervals for aerial reach analyses.

RIVER PROCESS	DESIRED FREQUENCY	MONITORING TOOLS	REACH	FREQUENCY
<b>Habitat maintenance flow: Infrequent channel resetting flow; encourage dynamic river processes; instream and riparian habitat diversity (3400 cfs+)</b>	Peak flows of $\geq 3400$ cfs at a frequency of 7-10 years; more frequently if possible.	Physical and vegetative monitoring of cross sections; longitudinal profiles through pool-riffle sequences. Pebble counts or other sampling grid methodology; photo points. Groundwater monitoring and crest gages; aerial photography, LiDAR or other remote sensing techniques to assess physical and ecological responses (assess channel and floodplain complexity).	Spatially varied (reaches 2-4). Focus on representative alluvial reaches and where data already exist (Reach 4).	Pre- and post-spill monitoring when opportunities are available. ~5-yr intervals for aerial reach analyses. Near-term update to 2007 bathymetric data.

## VI. WARMWATER INVASIVE FISH

### 1. Introduction and Background

Non-native fishes have been a part of the Dolores River ichthyofauna for over 100 years. High spring runoff and turbidity, extremely low baseflows, and poor water quality associated with mining influenced the entire fish assemblage. These early conditions may explain in part why white sucker, and other invasive fish species, never established themselves in the Dolores River in appreciable numbers. However, with the creation of McPhee Dam and the Dolores Project, the opportunity for non-native fish establishment grew.

The reservoir created a large lake environment suitable for non-native fishes like smallmouth bass, sunfish, walleye, and white sucker but not suitable for native suckers and roundtail chub. Hypolimnetic releases created a coldwater “tailrace” fishery below McPhee Dam suitable for trout where 3-species habitat once existed. Although the length of coldwater habitat varies from year to year based on water deliveries and ambient air temperature, an estimated 20 miles of habitat was lost to coldwater releases. If McPhee Reservoir is included, the total loss of physical native fish habitat is approximately 30 miles of the Dolores River. Perennial tributaries in this reach below McPhee Dam (Narraguinnep Canyon) may have been dislocated from downstream native populations. Perennial tributaries to McPhee Reservoir are now occupied by white sucker, and the genetic purity of native suckers has been compromised (e.g., Plateau Creek).

In 1993, a managed release via the spillway was made necessary because the gates through which a managed release would normally occur were under repair. Numerous fishes including kokanee salmon, trout, smallmouth bass, green sunfish and yellow perch emigrated from the reservoir and were subsequently removed by electrofishing large reaches of the river over the next 7 years. It was thought after a number of years without a detection of smallmouth bass that the effort was successful. In 2006, the first smallmouth bass was captured about 37 miles downstream of the dam. A subsequent survey done below this point discovered a thriving and reproducing population of smallmouth bass above Disappointment Creek.

Smallmouth bass (**Figure 7**) are a threat to the 3-species. In the Yampa River, cumulative smallmouth bass piscivory of small-bodied fishes could be 10 times higher than northern pike and channel catfish combined (Johnson et al., 2008). The small size or “miniaturization” of all of the 3-species in the Dolores makes them particularly vulnerable to predation by smallmouth bass.

Smallmouth bass populations appear to thrive under drought conditions when pool habitats in Southwest rivers begin to resemble warmwater lake environments more suitable to bass than native fishes. Non-native crayfish do well during low flows as well. This combination of drought, non-native predators and prey can create the conditions for a population explosion of smallmouth bass which undoubtedly happened in the Dolores River in 2002-2003 and was also observed on the Yampa River during the same timeframe (Martinez, 2011).

Currently, the smallmouth bass population appears to be relatively confined in the Dolores River to the reach below the Dover Creek pumps but above Disappointment Creek, ~ 30 miles of river. Significant sedimentation below Disappointment Creek may keep this population from expanding downstream and, while limiting native fish habitat, the tailwater release of coldwater from the lowest of the three Selective Level Outlet Works also contributes to their narrow distribution in Reaches 3 and 4, with dense, dominant populations sampled in the last 14 miles above Disappointment Creek.

**Figure 10.** Multiple age classes of smallmouth bass on the lower Dolores River, May 2011.



This plan addresses the need to diminish the impacts of non-native predatory fishes in the Dolores River. Diminish is the optimal word because as a goal, elimination of non-native predators is not practical or realistic. Most of the management activities described below are either in place now or will be implemented during fish monitoring efforts. Special targeted actions will require some initial data-gathering (e.g., the interaction between flushing flows and smallmouth bass spawning and nest protection) and assessment on the impacts to the native fishery and water supply before proceeding.

A combination of management actions and recommendations by CPW and the Dolores Project Biology Committee are currently employed to limit the escapement of non-native warmwater fishes from McPhee Reservoir and to limit the effects of these fish downstream. These are:

- Avoid using the spillway at McPhee Dam to the greatest extent possible. Surface spills result in non-native escapement. Removal efforts done by the CDOW for several years after the surface spill in 1993 documented escaped smallmouth bass not seen prior to surface spills.
- Use the lowest reservoir outlet (jet valve and/or 3<sup>rd</sup> SLOW) during managed releases to avoid entraining non-native fishes such as white sucker, smallmouth bass, and walleye. This strategy has been in effect for the life of the Project. While absence of evidence is not evidence of absence, annual monitoring of fish populations suggest this strategy has been successful at preventing fish from escaping into the Dolores River below McPhee Reservoir. There is some limited evidence through a small entrainment study done by Dr. Bill Miller that bottom releases prevent escapement of non-natives. However, CPW has documented the escapement of yellow perch and kokanee salmon from bottom outlet releases. In the Dolores below McPhee Dam, lack of appropriate habitat in the upper 30 miles of river also may contribute to non-establishment of any fish that survive entrainment.
- Prevent the illegal introduction of nuisance non-native fish species in McPhee Reservoir. Walleye were illegally introduced sometime in the early 1990s. CPW does not manage for walleye (or any other illegally stocked fish) in McPhee. There is no bag limit for walleye in the reservoir by regulation.
- Prevent establishment of non-natives within the drainage below McPhee. All warmwater fish stocking must be approved through a permitting process on private land. All non-native, warmwater stocking done by the State is regulated by a Non-Native Stocking Procedures Protocol – an agreement between the States and the USFWS.
- Encourage physical removal of non-native fishes during fish monitoring surveys and when exceptional conditions permit. As a matter of practice, warmwater non-native fishes are routinely removed during fish inventories on the Dolores River.
- Prevent the introduction of potential upstream threats such as invasive species and new diseases. Boat inspection stations are now in place to prevent the introduction of zebra

and quagga mussel and other aquatic nuisance species and diseases such as rusty crayfish, nuisance fish species, viral hemorrhagic septicemia (VHS) disease, and nuisance plants.

## 2. Implementation Actions, Monitoring and Evaluation of Warmwater Invasive Species

Colorado Parks and Wildlife is primarily responsible for implementing strategies to diminish the impact of non-native warmwater fishes on native fishes. Primary non-native species targets are smallmouth bass, green sunfish, channel catfish, black bullhead, and common carp. Strategies for preventing other warmwater fishes from escaping and occupying the Dolores River are described in the previous section.

Reducing the abundance and distribution of warmwater non-native fish species is a critical strategy. Management actions that have been used in other Western Slope rivers including the Dolores include:

- Removal of non-native fishes during electrofishing surveys (see **Table 7** for a list of sites, frequency, and evaluation). Adult fish are most susceptible to mechanical removal by electrofishing.
- Manipulate water temperatures by early water releases to delay the onset of non-native fish spawning (see III. Thermal Regime Modification). Research suggests delaying the onset of smallmouth bass spawning may increase the mortality of young fish during the winter months.
- Disrupt spawning and recruitment success of smallmouth bass with targeted flow releases. Bass and sunfish are nest spawners. Newly hatched fish are weak swimmers and a well-timed flow spike could result in high mortality of eggs and larval bass and sunfish.
- Promote angler harvest of warmwater non-native fishes. Currently, there is no bag limit on non-native warmwater fishes below Bradfield Bridge.
- Increase baseflows to promote growth of native fishes. Larger native fishes will be less susceptible to predation by non-native fishes. Higher baseflows limit the quality of pool and near-bank habitat smallmouth bass occupy.

The relative success of these management actions varies, as does the feasibility of implementation. Removal of adult fish during electrofishing operations is unlikely to exert significant reductions in the number of smallmouth bass or other targeted warmwater non-native species. Large-scale removal efforts of smallmouth bass on the Yampa River in Northwest Colorado, and similar efforts aimed at channel catfish on the San Juan River, have been largely ineffective at reducing overall numbers of targeted fishes but do show some

promise with reducing the overall size and age of fish in the population. Smaller fish are younger fish and this strategy may help reduce the number of reproductive individuals in the population. Adult native fishes may be less vulnerable to predation by smaller bass; however, young native fishes would still be quite vulnerable.

Large-scale removal efforts are also hampered by the remote location and short boating season on the Dolores River. Electrofishing during high runoff is largely ineffective due to the steep nature of the Dolores River channel. During baseflow periods, pools are typically too deep to wade and electrofish<sup>13</sup>. Riffles are too shallow to pass a heavy electrofishing boat during most of the year and roadside access is poor to non-existent.

Manipulating water temperatures and flows may offer the best approach to reducing the abundance and distribution of non-native warmwater fishes in the Dolores River. The first step will be to identify when critical spawning and early life stages of smallmouth bass occur. The second will be to identify the amount, duration, and source of water to disrupt the breeding success of smallmouth bass. Finally, implementing experimental flows and monitoring and evaluating the results will provide the information needed to negatively influence smallmouth bass numbers in the Dolores River.

Angler harvest shows little promise of reducing overall numbers of smallmouth bass. Although bass are quite susceptible to capture, the Dolores River is remote, hard to access, and difficult to fish from the shoreline. Angler tournaments could be promoted but the possible disruption of other sensitive wildlife such as bighorn sheep and lambs is not something CPW would be very supportive of. In addition, the unintended consequence may be that the angling public begins to *value* the smallmouth bass fishery and seek protective measures. Regulatory measures protecting the harvest of smallmouth bass are not something CPW would pursue and it is best not to create an angler issue that does not currently exist. However, education on the effects of non-native fishes and thoughtful harvest of bass are things CPW will promote.

Evaluating and assessing strategies aimed at diminishing the threats of non-native warmwater predators will be primarily conducted during annual monitoring trips (**Table 7**). The scope of these trips will largely depend on the water year with larger spills creating the opportunity to expand monitoring efforts. Since warmwater non-native fishes occupy the same habitats as young native fishes, this provides the opportunity to evaluate flow and temperature manipulations on bass when assessing early life stages of native fishes. Abundance, distribution,

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<sup>13</sup> Wade EF - wade electrofishing; 500-1000 foot reach must be wadeable at low water; Raft EF - electrofishing from rafts. Flow requirements are a minimum of ~800 cfs in Ponderosa Gorge; 400 cfs 'Pyramid to Disappointment'; 800 cfs through Slickrock Canyon. PIT tag - passive integrated transponder implanted in adult native fish. Combined with PIT tag array (cross-channel receiver / transmitter), allows individual fish to be electronically monitored passing upstream or downstream through the array. DCPS - Dove Creek Pump Station; SE - seine netting; GN - gill netting; RBT - rainbow trout; SMB - smallmouth bass; FMS - flannelmouth sucker; BHS - bluehead sucker; RTC - roundtail chub.

and size trends will be evaluated during electrofishing surveys. Marking and assessing the movement of fishes may help evaluate the risk of expanding bass populations downstream.



**Small Mouth Bass**



**Channel Catfish**

**Table 7.** Monitoring location, type, frequency and evaluation of non-native fishes in the Dolores River below McPhee Reservoir. Table includes management actions that may be undertaken concurrent with monitoring.

Goal	Objective(s)	Location	Type of Monitoring	Frequency	Evaluation
Prevent non-native fish escapement	Monitor presence or absence of escaped non-native fishes. Increase in RBT abundance indicates better habitat conditions for natives.	McPhee-Bradfield Bridge	Wade EF, PIT tag	Annual	No detection of reservoir fishes is good; increasing RBT abundance suggests improving spill/baseflows which are good for native fishes
Reduce brown trout densities	Reduce potential predation pressure on native fishes by decreasing the % of brown trout in the catch.	Bradfield Bridge - Dove Creek Pump station	Raft EF, PIT tag	Periodic/Spill/Med Priority	Trout densities trending below 50 f/mi suggest progress. Diet and movement analysis provides information for above Bradfield management of trout
Expand native fish distribution upstream of the DCPS	Increase % of native fish in the catch. Increase number of young natives in catch.	Bradfield Bridge - Dove Creek Pump station (DCPS)	Raft EF, PIT tag	Periodic/Spill/Med Priority	Presence of FMS adults and BHS may indicate improvement. Presence of native fishes from downstream areas suggests temporal habitat use and possible range expansion.

Goal	Objective(s)	Location	Type of Monitoring	Frequency	Evaluation
Expand abundance of young, juvenile, and adult native fishes	Physically remove non-natives. Monitor increases in adult and early life stages of native fishes. Contrast with 25-year database.	Dove Creek Pump station	Wade EF, PIT tag	Annual	Increasing numbers of FMS and BHS adults, juveniles, and young of the year suggest improvements. Presence of SMB suggest upstream expansion (bad). RTC populations abundance should show steady to increasing trend.
Reduce smallmouth bass densities and size structure	Physically remove non-natives. Monitor increases in adult and early life stages of native fishes. Monitor presence/absence of spawning native and non-native fishes. Assess changes in SMB population structure associated with targeted releases to limit reproduction and/or recruitment.	Pyramid Mtn. to Disappointment Creek	Raft EF, Seine, GN, PIT tag	Periodic/Spill/High Priority	Decreasing abundance and size structure of SMB indicates progress towards goal. Consistent/increasing presence of early life history stages suggests improvements in native fish community. Presence of adult native fishes during reproductive times suggests suitable spawning habitat conditions provided by spill management.
Reduce predators and increase % native fishes	Monitor abundance and distribution of native fishes and remove non-natives. Assess expansion of SMB.	Slickrock to Big Gypsum Valley	Raft EF, Seine, GN, PIT tag	Periodic/Spill/Low Priority	No baseline survey data in reach. Assess presence/absence of native and non-native fishes or other non-native threats. Presence of native fishes from up- or downstream areas suggests adequate habitat connectivity.
Expand abundance of young, juvenile, and adult native fishes	Physically remove non-natives. Monitor increases in adult and early life stages of native fishes. Contrast with 10+ year database.	Big Gypsum Valley	Raft EF, Seine, GN, PIT tag	Annual	Low to no expansion of SMB in this reach suggests upstream management efforts are effective. Trending increases in native fishes of all size/age categories suggest improved conditions. No detection of additional non-natives a positive.

Goal	Objective(s)	Location	Type of Monitoring	Frequency	Evaluation
Expand abundance of young, juvenile, and adult native fishes	Physically remove non-natives. Monitor increases in adult and early life stages of native fishes.	Slickrock Canyon to Bedrock	Raft EF, Seine, GN, PIT tag	Periodic/Spill/Low Priority	Low to no expansion of SMB in this reach suggests upstream management efforts are effective. Trending increases in native fishes of all size/age categories suggest improved conditions. No detection of additional non-natives a positive.

## VII. COLDWATER INVASIVE FISH MANAGEMENT

### 1. Introduction and Background

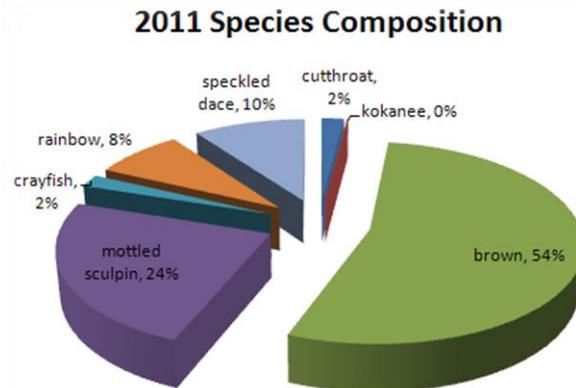
The Dolores Project mitigation for loss of the coldwater fishery inundated by the reservoir was the creation of a “quality trout fishery” below McPhee, likely modeled on other high-quality tailwater fisheries in Western rivers (e.g., Gunnison Gorge, Fryingpan, Navajo, Flaming Gorge, etc.). To avoid escapement of unwanted non-native fish into the Dolores River from McPhee, water is released out of the lowest of the outlets. Due to the coldwater release, coldwater habitat will persist below the dam, while the non-native warmwater species remain in the reservoir, which as discussed briefly in Section VI, also creates a coldwater habitat barrier. This creation of a coldwater fishery below McPhee Dam is considered mitigation of impacts to coldwater fisheries from the construction of the Dolores Project, but it may also be an effective means of stratifying the non-native warmwater species in the dam from native warmwater species occupying habitat beginning about 30 miles below the dam.

Colorado Parks and Wildlife (CPW) manages for trout from McPhee Dam to Bradfield Bridge. Because the biomass of trout (weight of combined trout in fishery samples) is so low, CPW placed a no harvest regulation on this reach of stream to preserve a “quality” trout fishery. Below Bradfield Bridge the water generally becomes transitional between cold- and warmwater fish habitat, thus native fish are the primary management focus from the bridge to the Colorado River confluence.

CPW has been surveying 3-4 sites above Bradfield Bridge (see **Figure 11** example from 2011 survey) and the Dove Creek pump site annually since the late 1980s, compiling what the AWF scientists considered an extremely robust dataset for these sites. Longitudinal surveys through Ponderosa Gorge (Bradfield to the Dove Creek pumps) and those targeted for native species

from the Pyramid to Disappointment Creek give CPW the information it needs to assess current management. The AWF scientists suggested that trout may be inhibiting native fish survival in some reaches, so CPW should continue to address this issue as management for native fish evolves, and potentially becomes more actively oriented toward managing against trout.

**Figure 11.** Fish species captured at 3 combined electrofishing stations between McPhee Dam and Bradfield Bridge, September 2011.



Itemized below are some observations from CPW's data and experience managing the fishery below McPhee, as well as some potential issues that emerge should CPW adopt a more aggressive suppression strategy for the coldwater fishery below McPhee:

### Brown Trout



- Brown trout are the most abundant trout between McPhee Dam and Bradfield Bridge (**Figure 11**). Brown trout prefer quiet, low velocity pools with cover, while rainbow trout prefer pools with deeper riffle/pocket water habitat nearby.
- Brown trout are more tolerant of warm water than rainbow trout, but are also considered to be more piscivorous than rainbows (Yard et al., 2011).
- Increasing baseflows benefit rainbow trout by adding deeper riffles, increasing pocket water, and minimizing still water pool habitats. Under the current baseflow regime, the habitat is more suitable for brown trout than rainbow trout.
- Brown trout density is low in reaches occupied predominantly by native fish.
- The prey base for trout is most likely mottled sculpin, a common coldwater species in the Dolores.

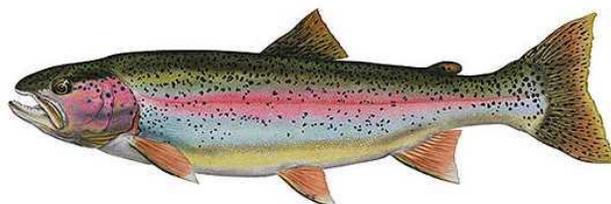
- Brown trout are relatively abundant in the first 10 miles of the Dolores River, but their density diminishes greatly over the next 20 miles of river (i.e., from 400 to less than 50 fish per mile).
- Brown trout movement into areas below Bradfield Bridge is minimal. Tagging studies of brown trout done in the early 1990s suggests minimal downstream movement (K. Thompson, CPW researcher, personal communication).

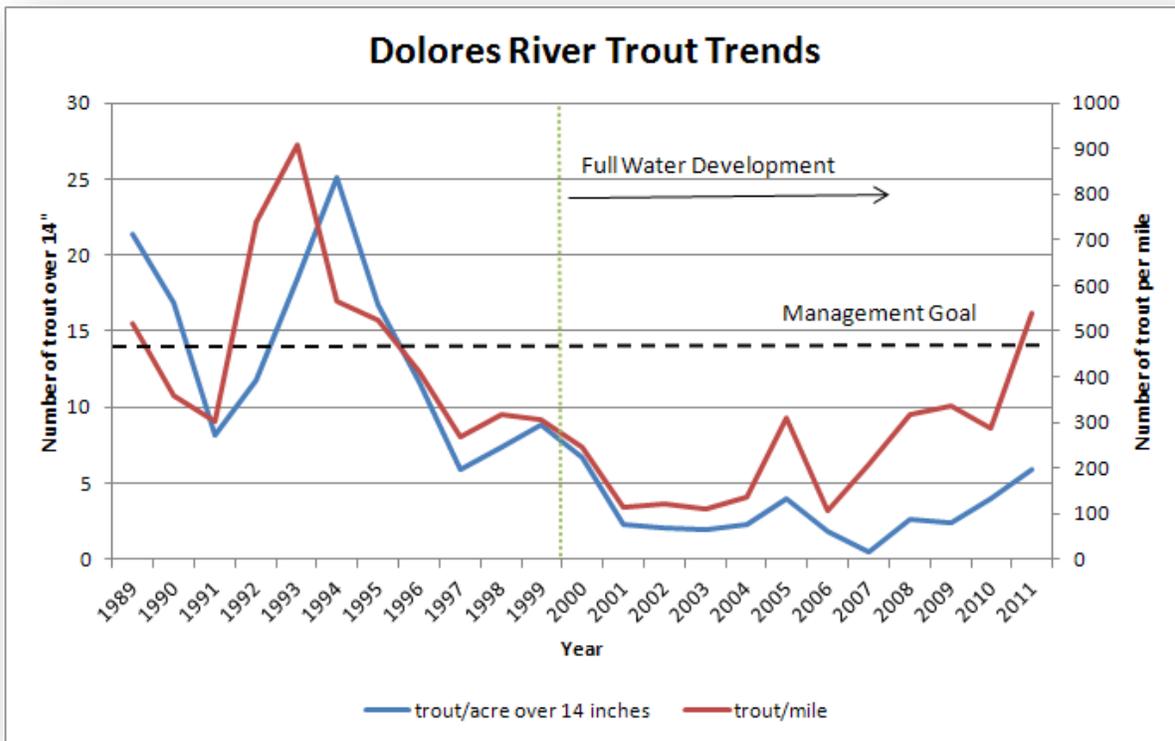
Should aggressive abatement of coldwater sport fish be seriously considered, CPW would need to engage their constituents (the fishing public) in further discussion and also address potential internal management conflicts that could arise relative to CPW's Strategic Wildlife Plan and the State's mitigation commitment to establish a coldwater fishery below the dam. The following issues would have to be overcome:

- Angler acceptance of an aggressive abatement of coldwater fish species from below the dam is low.
- The perceived risk to the native warmwater fishery from trout predation is low.
- There may be real economic consequences to guide services and local coldwater angling suppliers from trout abatement.
- Current management for coldwater species, which breaks management between coldwater sport fish and warmwater native species at Bradfield Bridge, is compatible with management for native warmwater species, based on habitats that are naturally stratified by coldwater releases. Encouraging a rainbow trout fishery to thrive below the dam should begin to displace the more predatory brown trout from the upper reach.

The limiting factor for trout in the Dolores River below McPhee Reservoir is primarily low flow periods. The combination of drought and full development of water infrastructure and deliveries since 2000 has reduced the water supply to the lower Dolores, and the average abundance of trout per mile fell by 46% above Bradfield Bridge (**Figure 12**). With a series of better water years (i.e., spill years) the Dolores River has moved closer to management objectives since 2005.

### Rainbow Trout





**Figure 12.** Composite of trout sampling trends in the McPhee Dam to Bradfield Bridge reach of the Dolores. The impacts of drought years 2000-2004 are evident for both total number of fish and quality of fish over this period, with both metrics trending positively during the 2005-2011 period.

Drought is hard on brown trout but not on smallmouth bass. Below Bradfield Bridge, brown trout densities (fish per mile) declined by over 82% after the drought of 2002/03 to less than 50 fish per mile. In contrast, extremely low flow periods were favorable for smallmouth reproduction and growth as the river warmed and habitats were more reminiscent of small, in-stream lakes while riffle habitats all but disappeared. After the drought smallmouth bass comprise 55-57% of fish captured during surveys.

The threat brown trout pose to native fishes is difficult to assess but considered relatively low. While true that brown trout are considered highly piscivorous, a favorite prey item that occupies coldwater habitats are mottled sculpin. The overall impact of brown trout on native suckers and roundtail chub remains unclear and may be reason for additional research as this process continues. As the AWF panel points out, the population of native fishes (3-species) is so low that any predation by brown trout increases the threat of extirpation. Thus, while the reasons to actively manage against brown trout are far less clear than for smallmouth bass,

there is also no reason to protect brown trout with restrictive regulations below Bradfield Bridge.

## 2. Management Options For Coldwater Fish

As noted in other sections, management by CPW is for coldwater fish above Bradfield Bridge, and for native fish below the dam. In general, the tools used by CPW to select for certain targeted populations of aquatic species are regulations, stocking, and in extreme cases, selective removal of undesirable species (e.g., smallmouth bass and northern pike in the Yampa River) or certain age classes of species (juvenile lake trout in Blue Mesa Reservoir). Management for coldwater species currently consists of restrictive regulations (flies and lures only; two-fish bag limits) and stocking of fingerling rainbow trout and cutthroat trout. These are addressed below.

### A. Cease Stocking

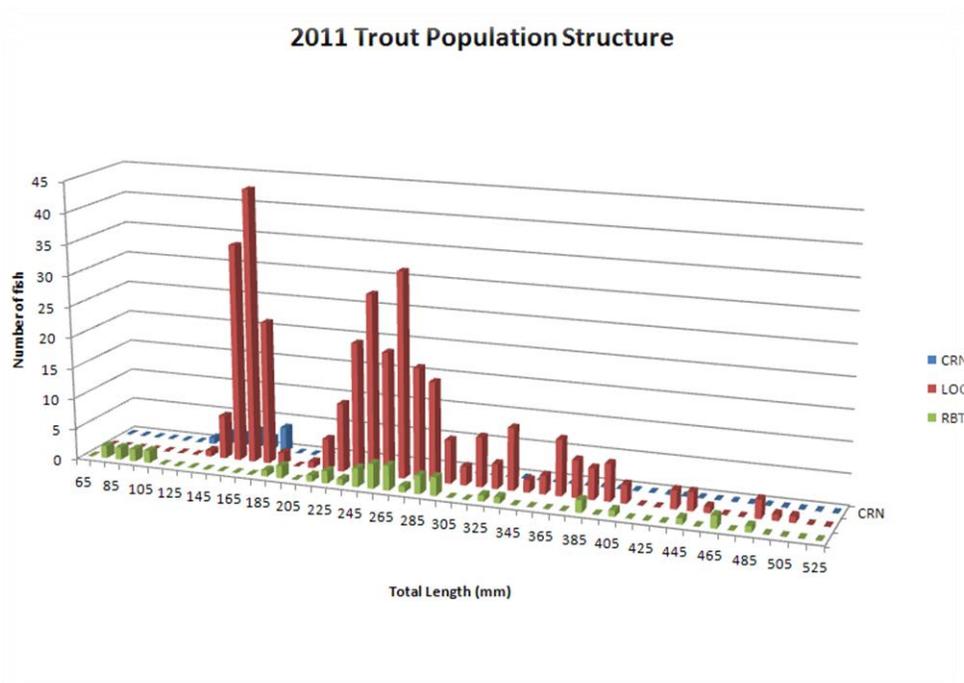
Brown trout are not stocked in the Dolores River below McPhee Dam. Brown trout, and to a lesser extent, rainbow trout naturally reproduce (**Figure 11**). Rainbow and cutthroat trout are stocked at conservative numbers of fish per surface acre (SA) of water relative to the basepool allocation. To put this into context in the Dolores, rainbow and cutthroat trout are stocked at an average of 243 fingerlings per SA compared to 1,241 fingerlings per SA on the Animas River. The management goal of a “quality trout fishery” is the same for both rivers, but the stocking rates for the two rivers reflect the reality that the habitat in the Dolores below McPhee is limited by the water supply.

Movement of coldwater species from where they were stocked to downstream habitats occupied by native fish was also brought up as an issue by AWF scientists, and was likely one reason why they made the suggestion to cease stocking of trout. In the early 1990s 183 brown trout were marked in the first 3 miles above Bradfield Bridge. Despite high water in 1993, none of the marked brown trout were recaptured below Bradfield Bridge. Of the 614 brown trout tagged above Bradfield Bridge, most were classified as “sedentary” or moved only a small distance away (in both upstream and downstream directions). It is unlikely significant yearly emigration occurs from above to below Bradfield into habitats occupied by native fish. In addition, surveys around the Dove Creek pump station suggest limited natural reproduction of brown trout in this reach of the Dolores River.

Ceasing stocking of rainbow and cutthroat trout would do little to improve the status of native fishes in the Dolores River and may only serve to alienate and disenfranchise the angling public and private businesses. Rainbow trout density in the Dolores River below Bradfield Bridge is

less than 8 fish per mile<sup>14</sup>. Above the bridge, rainbow trout numbers average 55 fish per mile since 2000 (brown trout average 176 f/mi). The AWF scientists acknowledged the low probability of improving the native fish status by ceasing stocking of rainbow and cutthroat trout. Trout populations below Bradfield Bridge will be periodically assessed by electrofishing but given the transitional nature of the cold- to warmwater habitat, low densities of rainbow and cutthroat trout, and preference for eating invertebrates, at this time CPW will continue to stock and manage the Dolores River above Bradfield Bridge for rainbow and cutthroat trout.

**Figure 13.** Size structure of brown, rainbow, and cutthroat trout populations in the Dolores River, McPhee Dam to Bradfield Bridge (Reach 1).



## B. Regulatory Controls

Currently the harvest regulations for coldwater species between the dam and Bradfield Bridge require the method of take to be flies and lures only, and limit the angler to two fish, which in general, serves to minimize over-harvest of the resource and to preserve what limited coldwater sport fish opportunities exist.

<sup>14</sup> Trout densities (# fish per mile) were statistically determined by Nehring et al. in 1993, 2005, and 2007. The 2010 Narraguinne Canyon Fire resulted in a substantial fish kill below the mouth of the canyon located just downstream of Bradfield Bridge; thus the density of both rainbow and brown trout may be substantially lower.

Because studies have shown that emigration of trout below Bradfield appears insignificant, removal of a bag limit for trout above Bradfield Bridge may only diminish opportunities for future anglers through this reach without having the desired positive effect for the native warmwater species. Removing bag limits for brown trout below Bradfield Bridge may be one area that CPW needs to further evaluate and seriously consider, since this reach is managed for native fish, considered transitional in nature, and is clearly occupied by both cold- and warmwater species for certain times of the year. In summary, CPW management actions will focus on reducing brown trout abundance and distribution below Bradfield Bridge in the near term. Over longer time periods, CPW with the help of the Implementation Team partners will evaluate the effects of brown trout predation on native fish where both are present, and also re-assess the potential for downstream migration of the brown trout population above Bradfield Bridge.

#### Specific Management Actions and Evaluation (see Table 7)

- Annual removal of adult brown trout by electrofishing below Dove Creek pump station (DCPS)
- Periodic removal of brown trout by electrofishing from Bradfield Bridge to Disappointment Creek confluence. Annual monitoring of brown trout abundance trends at the DCPS.
- Periodic monitoring of brown trout abundance trends in Ponderosa Gorge and Pyramid reaches.
- Removal of protective regulations on brown trout below Bradfield Bridge.
- Evaluate brown trout diet through examination of stomach samples and stable isotope analysis.

## VIII. SUPPLEMENT NATIVE FISH POPULATIONS

Supplementing warmwater native fishes by stocking was an opportunity called out by the *A Way Forward* science report as one potential management tool that could be used to improve the status of native fishes in the Dolores River. Developing warmwater captive fish broodstocks is a relatively new conservation strategy in the State of Colorado. Colorado Parks and Wildlife (CPW) has developed and maintained a captive roundtail chub broodstock from the San Juan River Basin since 2002 but has no similar program for bluehead and flannelmouth sucker.

Suitable habitat for warmwater native fish species must be present before stocking fish; otherwise the goal of a sustainable fishery will not be met. For example, the San Juan River Basin Endangered Recovery Program addressed the timing, magnitude, and duration of flows

from Navajo Dam before embarking on an aggressive stocking program for Colorado pikeminnow and razorback sucker. A non-native predator suppression strategy was also implemented at the same time as stocking.

The operation of McPhee Dam to mimic a more natural spring hydrograph, implementation of non-native fish suppression efforts, and improving baseflows will set the stage for native fish augmentation by stocking. Currently, roundtail chub stocking is not warranted. Although roundtail chub abundance appears to be in decline, their numbers do vary greatly from one year to the next and the current abundance and distribution of chubs is within the range of historic variability.

Flannelmouth and bluehead sucker populations in the Dolores River are extremely low and precarious. Relatively large numbers of adult flannelmouth sucker were documented in the early 1990s as far up as Bradfield Bridge. These fish, along with smaller numbers of bluehead sucker, essentially disappeared in the Bradfield Bridge to Disappointment Creek reach in the past 20 years. The presence of adult fish but lack of any young fish suggest suitable conditions for recruitment may not exist under the current habitat and non-native fishery conditions. Thus, there is no reason to expect stocking of young bluehead and flannelmouth suckers would be successful until implementation of the strategies outlined in this document occurs.

#### **Broodstock Development Steps:**

- Assess genetic variability in native suckers between Colorado River Sub-Basin Streams to determine appropriate source of broodstock fishes.
  - ◇ Status: CPW has determined that genetic variability among BHS and FMS in sub-basin streams appears to be high and significant variability between sub-basins appears to be low, suggesting well connected populations in the recent geologic past. Thus, a Dolores River Basin BHS broodstock may be used in the Dolores River and possibly in other Colorado River Basin streams.
  - ◇ Capture and translocate adult fish (and/or fertilized eggs) to Native Species Fish Rearing Facility in Alamosa, Colorado.
- Status: CPW captured, tagged, and moved 30 adult BHS from the San Miguel River to the Native Species Fish Rearing Unit in Alamosa. Care, feeding, and breeding techniques will be worked out over the next several years.
- Spawn and successfully raise BHS young to 1+ years old before stocking. Culture techniques and hatchery space requirements need to be worked out.
- Periodic augmentation of broodstock with wild fish or wild spawn takes to maintain high genetic integrity and variability of brood fish progeny.
- Experimentation with unique life-history 'strains' of BHS in the Dolores River. Some fish show unique adaptations to ecological conditions (i.e., cold- or warmwater preference, migration or resident tendencies, etc.). In theory, aquatic managers may someday identify and utilize a unique life history attribute of BHS in a stocking strategy, but presently no strain of fish exists or plans to develop wider sub-basin BHS broodstocks have been identified.

In anticipation of moving forward with the opportunities preceding this section, CPW is in the early stages of developing a wild broodstock of bluehead sucker for the Dolores River (see “Broodstock Development Steps” above). Bluehead sucker are the most imperiled fish occupying the Dolores River. The best opportunity to re-establish bluehead sucker may exist between Bradfield Bridge and the Dove Creek pump station, where predator populations are low and a relatively steep and confined channel exists. There are no current plans for a flannelmouth sucker broodstock program at this time. Once efforts to improve habitat conditions are implemented, broodstocks fully developed, and fish reared to a suitable size for stocking (2 inches or more), fish will be marked and stocked by raft. Monitoring of stocked fish will be accomplished through routine fish monitoring efforts by CPW and possibly with a stationary PIT tag array. The goal of monitoring is to document recruitment of these young stocked fish into the adult population, reproduction, and eventual recruitment by their progeny into a new generation of bluehead suckers. This cycle defines a self-sustaining population of native fishes in the Dolores River, a primary goal for conservation of 3-species.

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For electronic version of this paper and appendices, see the Dolores River Dialogue website:

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