# Baseline Field Investigations, Science-Based Opportunities and Potential Tools for Improvement of the Downstream Environment on the Lower Dolores River.

**A Report Submitted to the Colorado Water Conservation Board in Fulfillment of the 2008/2009 Severance Tax Trust Fund Grant Awarded to the Dolores River Dialogue**

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# Acknowledgments

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# I. Purpose of Report

The Dolores River Dialogue (DRD) is a collaborative group of conservation, water management, land management, recreational and governmental representatives working since January of 2004 to explore opportunities to manage McPhee Reservoir to improve downstream ecological conditions while honoring water rights, protecting agricultural and municipal water supplies and the continued enjoyment of rafting and fishing. The group includes: The Dolores Water Conservation District, the Montezuma Valley Irrigation Company, the Division 7 Engineer, the Bureau of Reclamation, the Colorado Division of Wildlife, San Juan Public Lands, Montezuma County, Dolores County, the Colorado Water Conservation Board, Fort Lewis College, the San Juan Citizens Alliance, The Nature Conservancy, and the Dolores River Coalition. The group meets at the offices of the Dolores Water Conservancy District.

This report presents the products and deliverables developed by the Dolores River Dialogue Science Committee with the generous support of the Colorado Water Conservation Board 2008/2009 CWCB Severance Tax Trust Fund Operational Account Grant.

The purposes of this report are to:

- **Present Field Investigations.** Report progress and findings from field investigations and baseline studies completed under the 2009-2010 Big Gypsum Monitoring Site grant made to the Dolores River Dialogue from the CWCB's Severance Tax Trust Fund Operational Account Grant. (Section III)
- **Identify Opportunities.** Synthesize scientific information that identifies opportunities for improving the downstream environment, specifically the native fishery and riparian ecology. This section will summarize and cite science-based flow hypotheses to address these opportunities. (Section IV)
- **Report Ideas for Tools.** Report progress on ideas for potential tools to ensure protection of the values of the Lower Dolores River in a manner that protects water rights and Dolores Project allocations in conformance with Colorado water law. It is important to emphasize that at the time of this report, these potential tools have not yet been formally considered or evaluated, and are reported here only as ideas, without any priority nor expectation of implementation.(Section V)
- **Identify DRD Next Steps** (Section VI)

A review of the minutes and notes of the DRD and the Lower Dolores Plan Working Group shows that discussions of the science pertinent to the environment of the Lower Dolores River have focused along two general lines of inquiry. One pursues questions about the nature and

causes of the ecological changes that have occurred on the Dolores and asks “Where have we been and how did we get here?” For the purpose of understanding ecological systems, this is a valid and useful line of inquiry. However, it is not the focus of this report. Rather, this report focuses on the second line of inquiry and discussion: “Where can we go from here?” That is, what are some of the most well supported (by scientific information) opportunities for improvement, and how might they be pursued?

## II. Background

In keeping with its original Plan to Proceed (DRD 2004), the DRD completed a Hydrology Report (Porter and Graf 2005) and a Core Science Report (Siscoe 2005) to compile and summarize the management and hydrology of the Dolores Project and the geomorphology, riparian ecology and warm and cold-water fisheries on the Dolores River below McPhee Reservoir, respectively. The integration of information from these two reports into a Correlation Report (Graf 2006) has provided a foundation for beginning to evaluate strategies involving operational flexibility of baseflows and managed spills, and other options that may include base-flow management or in-channel restoration efforts. The DRD is committed to the systematic monitoring and evaluation of ecological benefits to support good decision making and the efficient allocation of resources.

In November 2009, the DRD-Technical Committee held a strategic retreat, with four key outcomes. First, the group drafted a purpose statement reaffirming the goals and principles that founded the DRD in the first place. Second, the group committed to continue the science efforts the DRD has embarked upon to date, and to expand scientific projects and inquiry around flow-related issues. Third, in order to move forward, the partners agreed to commence using a systematic process, referred to as the “Framework Process”, to evaluate opportunities and proposals for improving the downstream environment. Finally, the DRD-TC decided that some revamping of its structure was necessary so that when opportunities come up, the structure can “move a ball,” and create action on the ground.

The Bureau of Reclamation, Colorado Division of Wildlife, Colorado Water Conservation Board, Colorado Watershed Protection Fund, Dolores Water Conservancy District, Montezuma Valley Irrigation Company, San Juan Citizens Alliance, and The Nature Conservancy have all supported the efforts of the DRD with funds and/or in-kind support. Research partners have included the Bureau of Land Management, Fort Lewis College, Mesa College, the Colorado Division of Wildlife, the USFS and Trout Unlimited. In 2007, the DRD was funded by the Colorado Department of Public Health and Environment to produce a Non-point Source ‘319’ Watershed Plan for the river below the reservoir.

In partnership with a local landowner and the BLM, DRD initiated and conducts ongoing studies

and monitoring at a permanent site in the Big Gypsum Reach of the Dolores River. The Big Gypsum Study Site covers 5 miles of the Dolores River and was established in 2004 to monitor the effects of various flows, flow management opportunities, and restoration efforts on a variety of characteristics, including native fish habitat, cottonwood regeneration, tamarisk and other invasive species, and geomorphology. Between September of 2009 and June 30, 2010, a 2008/2009 CWCB Severance Tax Grant supported investigations, at Big Gypsum and other sites, into water quality, riparian vegetation pattern and process, river channel dynamics, and the functional relationships between flow management and these basic pieces of the ecology of the Dolores River.

## III. Dolores River Dialogue Field Investigations

During the 2009 and 2010 (through June 30) field seasons, the Dolores River Dialogue partnered with several individuals to carry out a variety of field investigations intended to compile and establish baseline data relevant to DRD's 4 focal downstream resources: riparian ecology, river channel dynamics, native fish and the trout fishery, and to the interactions between river flows and these resources. This baseline data is meant to increase the foundation for adaptive management, both of flows and of the resources directly.

These investigations not only assess the historic and/or current patterns and conditions of the resource in the Big Gypsum Reach and at other sites, but also go further to analyze and provide predictive tools that can offer insights into the implications of various flow management opportunities and/or opportunities for managing other factors for the benefit of the downstream environment.

The following are brief descriptions of each investigation. The complete reports to date of each effort are included as stand-alone appendices to this report:

***Modeling the Relationship between McPhee Dam Selective Level Outlet Operations, Downstream Algal Biomass, Dissolved Oxygen and Temperature: Phase 1, Background Data and Model Development*** by Chester Anderson, BUGs Consulting. Appendix A.

This investigation collected and summarized existing data on temperature, dissolved oxygen, conductivity, pH and algal biomass in the Dolores River. BUGS also measured additional field data on these parameters. Anderson then developed a model for predicting maximum daily water temperature at Bradfield Bridge based on the following parameters: maximum temperature of water discharged from McPhee, discharge from McPhee, average air temperature at Bradfield Bridge, angle of sun and water temperature at Bradfield Bridge. This model can be useful in predicting how water temperature downstream could be managed using the Selective Level Outlet Works

(SLOWs) to their fullest potential. The SLOWs have not been fully utilized since construction of the dam due to concerns around live escapement of non-native fish to the downsteam environment.

***Technical Memo: Factors affecting populations of flannelmouth suckers on the Dolores River between McPhee Dam and the San Miguel River*** by Chester Anderson, BUGS Consulting. Appendix B.

A memo submitted to the DRD Steering Committee providing an overview of factors that may be limiting flannelmouth sucker populations in the Dolores, based on a rapid review of scientific literature and personal communications with managers and researchers. The memo identifies some key questions needing further investigation.

***Baseline sampling of riparian vegetation in Big Gypsum Monitoring Site*** by Adam Coble and Rob Anderson. Appendix C.

This effort established 60 permanent vegetation sampling points through the current riparian zone the Big Gypsum Monitoring Site. The species composition and cover of woody vegetation at each point was identified. This data provides a baseline sample of vegetation through this reach and will allow assessment of change over time and with any changes in land and/or water management.

***Baseline channel cross sections at Big Gypsum Monitoring Site*** by Rob Anderson. Appendix D.

This effort established 3 permanent cross-sections within the Big Gypsum Reach. These cross sections show the current channel geometry and, together with additional future permanent cross-sections, will allow measurement and analysis of channel changes over time and under different flow regimes.

***Evaluating Potential Barriers to Cottonwood Establishment in Big Gypsum Valley and Lone Dome Reaches of the Dolores River*** by Rob Anderson. Appendix E.

This investigation focuses on assessing the level to which the factors of soil salinity, groundwater drawdown rates and soil moisture levels in the riparian zone might be limiting the establishment of cottonwood seedlings. The investigation generates data that has never been collected at these sites, and is intended to assess the pre and post-spill dynamics of these factors. The investigation includes the acquisition and installation of monitoring equipment that will provide data for, at minimum, the next three years, allowing for subsequent annual monitoring and analysis in addition to the data presented in this first report.

# IV. Science-Based Opportunities on the Lower Dolores River

This section identifies opportunities for improving the downstream environment on the Lower Dolores River, as supported by scientific information. Focus is given to those science-based

opportunities for which specific flow hypotheses have been or can be developed. Emphasis is on information developed on the Dolores River itself through research, monitoring, and/or observation. Information developed from other similar systems and/or on the same species present in the Dolores will also be included.

In 2004, the Dolores River Dialogue Plan to Proceed (DRD 2004) outlined four areas of focus for improving the downstream environment: the native fishery, channel function, riparian areas, and the trout fishery. In 2006-2007, the group developed a list of more specific science based objectives by which to gage proposals for "improvement of the downstream environment" relative to those four focal disciplines (Table 1) (Graf 2006). These objectives constitute some, but not necessarily all, of the potential opportunities for improvement, and can be viewed as some of the anticipated benefits of any flow management or other management actions that DRD may consider and evaluate through the "Framework Process" (See Section V. and Appendix F).

Table 1. DRD Science disciplines and associated objectives (Graf 2006).

| **Science Focus** | **Opportunities for Improving the downstream environment** |
|---|---|
| Riparian Health | Floodplain scour/ deposition. |
| | Floodplain saturation (nutrient cycling). |
| | Cottonwood seedling establishment. |
| Native Fish | Successful spawning. |
| | Year class recruitment. |
| | Adult fish survival. |
| | Reduced non-native fish populations. |
| Trout Fishery | Combined biomass great than 30 pounds per acre (3-year average) |
| | Stocked fish survive to the next year. |
| | Maintain 10 trout per acre over 14" (3-year average). |
| River Mechanics | Scour fine sediment as result of "flushing flows". |
| | Frequently mobilize channelbed surface. |
| | Periodic channelbed scour/ coarse sediment flux. |
| | Infrequent channel resetting flow. |

This synthesis will focus on science based opportunities to support and/or improve the Native Fishery and Riparian Ecology on the Lower Dolores River. For each of these focal resources the following will be summarized:

- Information available regarding their status on the Dolores River
- Well supported opportunities and specific flow hypotheses with anticipated benefits for improving conditions, recognizing that hypotheses related to flows have potential to support more than one of the DRD objectives. The scientific basis for each flow/direct management opportunity will be provided, with citations.

## Native Fish

### Status and Trends

There are currently three large bodied native fish present in reaches of the lower Dolores River: the roundtail chub, flannelmouth sucker and bluehead chub.

This review of status and trends will focus primarily on information specific to the roundtail chub and flannelmouth for the following reasons. The roundtail is identified as an Outstandingly Remarkable Value of the lower Dolores River (SJPL 2008), and there is recent heightened concern about declines in roundtail chub numbers within the Colorado River Basin and the species was found to be warranted (but precluded) for listing in the Lower Colorado River Basin (USDOI 2009). The flannelmouth is the most common native sucker on the Dolores (Anderson and Stewart 2007), and the Dolores appears to be one of the few large Colorado River tributaries in Colorado without a robust population of introduced white suckers(Anderson and Stewart 2007). Where present, white suckers hybridize readily with flannelmouths (and blueheads), reducing the genetic purity of those populations (USDOI 2009, Anderson and Stewart 2007

The management objective for the lower Dolores River is to maintain healthy populations of large bodied native fish (CDOW 2008). The primary ongoing source of information on the status of native fish in the Dolores River is produced by the Colorado Division of Wildlife's Aquatic Biologists based in Montrose and in Durango. These managers have had the lead responsibility for any regular sampling that has been accomplished on the Dolores. Their monitoring, together with a number of special sampling efforts, represents the best available data on the status and trends of the native fish in the Dolores River.

CDOW biologists recently summarized data on the status and trends of the three native fish species in the Dolores in two presentations: to the Dolores River Dialogue (Kowalski et al. 2010) and to the Lower Dolores Plan Working Group (White 2009). The majority of the sampling data presented does not estimate the populations of the various species by reach, but rather reports catch per mile, or catch per hour. There are challenges to inferring actual population trends from this data. Among these challenges are year to year and/or reach to reach

differences in sampling methods, catchability of fish species, units of comparison, flows at time of sampling, time of year, etc (Kowalski et al. 2010, White 2009). Nevertheless, these sampling data are the best information available on the status and trends of these fish on the Dolores.

Kowalski et al. presented summarized sampling data for 7 sampling reaches on the Dolores River: Metaska to Bradfield; Bradfield to Dove Creek Pumps; Pyramid to Disappointment Creek; Big Gypsum Reach; Slickrock Canyon; Below San Miguel to State Line; Gateway to State Line); and 1 sampling site (Dove Creek Pumps) These sampling reaches cover portions of the Dolores mainstem from just below McPhee Dam, to the Colorado Stateline. The number of years sampled varies greatly by reach.

For the roundtail chub, only 2 out of 8 reaches for which sampling results were reported provide multiple years of quantitative sampling results where a trend is observable. The trends in Catch and Catch per Unit Effort(CPUE) of roundtails for these 2 areas, Dove Creek Pumps Site and Big Gypsum Reach, are both variable but trending downward since their maximums in 1999 and 2000, respectively.

For the flannelmouth sucker, 4 out of the 8 reaches for which sampling results were reported provide more than 1 year of quantitative results where a trend can be observed: Metaska to Bradfield, Bradfield to Dove Creek Pumps, Dove Creek Pump Site, and Big Gypsum Reach. The trends in catch and/or catch per unit effort for these 4 sampling areas are all downward since at least 2005, and earlier in most cases.

It is important to note that, in samples reported for the Pyramid to Disappointment Reach in 2007, both roundtails and flannelmouths were caught, but in very small numbers with the catch dominated by non-native small mouth bass and brown trout (Kowalski et al. 2010, White 2009). Also of note is that in 2007, when regular sampling was reported for the Bradfield to Dove Creek reach, the Dove Creek Pumps Site and a “Longitudinal Survey” of the Dolores below Dove Creek Pumps was completed, sampling the Pyramid, Big Gypsum, Slickrock and Gateway to Stateline reaches at roughly the same time of that year, the reported data suggests that the areas where roundtail chub were most catchable were: the Dove Creek Pumps Site, the Big Gypsum Reach, and the Slickrock Canyon (Kowalski et al. 2010).

Areas where flannelmouth sucker appear to have been most catchable in the 2007 sampling efforts were: Big Gypsum, Slickrock and Gateway to Stateline (Kowalski et al. 2010). As Kowalski et al. point out, whereas large Flannelmouth suckers were commonly caught at the Dove Creek Pumps Site (and upstream) between 1989 and 1994, by 2007 the number of flannelmouth suckers caught in the Dolores River upstream of Disappointment Creek to McPhee Dam during reported sampling has been extremely low (Kowalski et al. 2010).

There is very little quantitative sampling data available prior to the closing of McPhee Dam in 1984. Reports include Holden and Stalnaker (1975), Valdez et al. (1982), and Valdez et al. (1992). Valdez (1992) concluded that native fish numbers and distribution were similar to 1982

study. Kowalski summarized Catch per Unit Effort (fish/hour) for sampling conducted between from Dove Creek to Gateway in 1990 and 1991 by Valdez (1992) and in 2007 (Kowalski et al 2010). For roundtail chub this summary showed no clear trend over the three years of sampling. For flannelmouth sucker, the three years of sampling trended downward.

In addition to sampling and study of these fish on the Dolores River, there are ongoing efforts throughout the Colorado River Basin to monitor and assess the status of these species. The most current comprehensive basin wide review available of the status of these fish is (Bezzerides and Bestgen 2002) available online at http://warnercnr.colostate.edu/images/docs/lfl/status%20review.pdf.

By collecting data on presence and absence from rivers throughout the Basin, the study found that as of 2002, both Roundtail chubs and Flannelmouth suckers were absent from about 55% of their historical range in the Colorado River Basin, with the Roundtail absent from about 45% and the Flannelmouth absent from about 50% of their historical habitats in the upper Colorado River Basin (upstream of Lees Ferry, UT) (Bezzerides and Bestgen 2002).

The Colorado Division of Wildlife is currently researching and developing a statewide management plan for the 3 native warm water species (bluehead sucker, flannelmouth sucker, and roundtail chub). This plan will include more detailed data on the status and trends of these fish within tributaries and mainstem rivers in the state of Colorado (Paul Jones, CDOW Personal Communication)

## Opportunities for Improvement and Associated Hypotheses

Several factors likely play a role in the apparent declines in the roundtail chub and flannelmouth sucker. Several recent documents have provided very thorough reviews of the literature supporting a whole suite of potential factors contributing to the declines of these fish across their range (USFWS 2009, Division of Wildlife Resources 2006, Bestgen and Bezzerides 2002), and opportunities for improving conditions for these fish.

On the Dolores, field research, sampling, observations and findings from other river systems suggest a "short list" of factors that are likely stressors on native fish populations: reduction in the availability and quality of key aquatic habitats during low flow periods (Anderson and Stewart 2007, Kowalski et al. 2010, White 2009), predation and/or competition by non-native fish (Anderson and Stewart 2007, Kowalski et al. 2010, Anderson, C. 2010a, White 2009), reduction in spawning success (Anderson and Stewart 2007, Graf personal communication 2007), water quality issues (Anderson, C. 2010b, Valdez 1992).

This report will not try to prioritize among these stressors, but rather will treat them all as management hypotheses supported by scientific information and insight, and therefore as opportunities for improvement in an adaptive management setting. As Stewart and Anderson (2007) point out, the question of "Is factor A acting to limit native fish?" is a different question

than “Is factor A the primary factor limiting native fish?”. On the Dolores, application of the full adaptive management cycle (i.e. hypothesis, management action, targeted data collection/monitoring, evaluation) would be one way, perhaps the only way, to get any certainty around either question. However, see Kowalski et al. (2010) and Anderson and Stewart (2007) for discussion of hypothesis that altered low flows are the primary factor, versus altered peak flows.

It is important to note that there is evidence to suggest that these and other factors can act together to create a larger effect. For instance, Anderson and Stewart (2007) found that on the Yampa River reduced base flows during the 2000-2004 drought were associated with dramatic increases in certain nonnative species, decreases in total fish biomass, and increased rates of predation and increased rates of hybridization with native suckers. They note that “in times of low flows, predator avoidance would be more difficult because prey and predators are confined to the remaining habitats” (Anderson and Stewart 2007)

**Opportunity: Low availability of optimal habitat can limit growth and survival.**
The most recent studies of this factor on the Dolores River were conducted by Richard Anderson and Gregory Stewart between x and 2007. Anderson and Stewart utilized robust field based methods to develop predictive models, which provide managers with the ability to predict expected benefits to flannelmouth suckers (and bluehead suckers) for different base flows at the Big Gypsum Site on the Dolores River, as well as at sites on the Colorado, Gunnison and Yampa Rivers. The “Fish Flow Investigation” was requested of CDOW by the CWCB and completed with some federal funding.

From 1998 to 2001, at sites on the Yampa and Colorado Rivers, Stewart and Anderson (2007) sampled native fish biomass in different habitats (e.g. pool, riffle, run) while also mapping channel widths and depths and sampling velocities. They used this field data to develop “habitat suitability models,” which are graphs that can be used to predict, for a given species, the biomass (kg/ha) that you would expect to find at a given depth and velocity. The key assumption behind this modeling is that where total sampled biomass is highest for a given species, that is the optimal habitat for that species (Stewart and Anderson 2007).

An additional assumption is that flow and channel shape at a given site determine the avialability of fish habitat at that site (Anderson and Stewart 2007). Therefore, having established the relationship between biomass and optimal habitat at a given site, the authors then looked at how the area of optimal habitat (and predicted biomass) changes when you increase or decrease the flow through that site. The authors generated predictions of the biomass of flannelmouths for different sites, and compared those predictions to actual biomass data measured at those sites. They found that their models performed well on the Colorado and Yampa Rivers (r2 =.9 and .74), where they had collected the data used to develop the curves, and less well, but still valid, at 2 sites on the Gunnison River (Stewart and Anderson 2007).

It is important to note some limitations to the predictive models they developed. The models were developed based on sampling of larger fish only (>150mm), so they are not intended to predict biomass of young or small fish (smaller than 150mm) (Stewart and Anderson 2007). At Big Gypsum, the surveys found that juvenile-sized native suckers far outnumbered adult-sized fish (Anderson and Stewart 2007). Therefore the habitat suitability models developed for the Big Gypsum site may underestimate the actual biomass of native suckers. The authors suggest developing habitat suitability curves for the native suckers at the site based on habitat criteria for juvenile suckers, which apparently prefer shallower and slower habitats (Anderson and Stewart 2007). Also, it might be useful to develop models for the sucker species at an additional site with higher quality habitat (and/or higher observed biomass) for flannelmouths and roundtails (e.g. a steeper gradient and clean cobble substrates) (Anderson and Stewart 2007).

Another limitation to note: the models are species **and** site specific. On the Dolores, they were only developed to predict flannelmouth and bluehead sucker biomass at the Big Gypsum site (i.e. the reach from the BLM boat launch to the county road bridge 3.3km downstream). Use of these models to predict biomass based on flows for other species (e.g. roundtail chub) is not be appropriate. Nor is it appropriate to generalize the conclusions drawn at Big Gypsum to other sites on the Dolores, nor to the river as a whole. Application to other sites on the Dolores might be acceptable, provided, as the authors conclude, they have similar channel characteristics and similar fish community structure (Stewart and Anderson 2007). Interestingly, of 9 sites sampled on 4 rivers between 2000 and 2005, Big Gypsum had the highest percentage composition of roundtail chub (by far), but only the 5$^{th}$ highest biomass of roundtail (the Gunnison sites had the highest ): similar to the native suckers, roundtails sampled at Big Gyp were small (Anderson and Stewart 2007).

As far as we have been able to ascertain, there is currently no habitat suitability index available for the roundtail chub on any river. Anderson and Stewart (2007) attempted to develop a model, but found no ability to predict biomass based on depth and velocity. The authors provide an interesting discussion of why this may be, and why the roundtail chub would not be a good indicator of habitat availability related to flows. The chub is a predator that uses different habitats at different times of day: the authors observed the species in deep pools during daytime, but common in runs and riffles during nighttime, presumably feeding (Anderson and Stewart 2007, Byers et al 2001, Rees and Miller 2001). Because they may have been concentrated in pools when the researchers were sampling, and because the boat electrofishing method is not as efficient in pools, roundtail chub biomass may have been underestimated (Anderson and Stewart 2007).

The authors go on to hypothesize that the chub may not be a good indicator of flow effects on habitat availability for the native fish community because of the combination of it being a predator that prefers deep pool habitats (at least during the day). Assuming daytime sampling, biomass estimates will be higher in deep pools. Of the three basic habitat types, riffles, runs and pools, pools are the least sensitive to low flows: the percent of pool habitat in a given reach actually tends to increase with decreasing flows. However, in spite of the roundtail biomass

being associated with pools (presumably due to daytime sampling), as a predator, the roundtail's biomass at a given site is very dependant on riffle habitat (Anderson and Stewart 2007). Riffle habitat is the most productive habitat of food for all fish species, yet it is by definition a relatively shallow habitat and therefore the most sensitive to low flows (Anderson and Stewart 2007, Nehring 1979). Anderson and Stewart concluded that bluehead sucker abundance is a good indicator of riffle habitat availability, and that both flannelmouth and bluehead are good indicators indicators of flow effects on habitat availability for the 3 native fish species (Anderson and Stewart 2007).

In their subsequent paper, Anderson and Stewart (2007) present habitat suitability curves for Bluehead Sucker and Flannelmouth at the Big Gypsum site. These curves provide a basis for formulation of flow hypotheses. The following are two such hypotheses, put forward by the authors, but others could be developed using the habitat suitability curves, depending on the desired biomass outcome for flannelmouth or bluehead suckers at the Big Gypsum sampling site.

***Flow hypothesis:***
In spill years, providing a 60 cfs base flow will result in habitat availability of (61% pool, 34% run, 5% riffle) and a flannelmouth sucker biomass of about 20kg/ha at Big Gypsum site (up from 6.6 kg/ha in 2005).

***Flow hypothesis:***
In non-spill years, providing an 80 cfs base flow will help mitigate the absence of the biological benefits of high flows by making available more suitable habitat (50%pool, 42% run, 8% riffle); predicted flannelmouth biomass would be about 37 kg/ha. (Anderson and Stewart 2007, Kowalski et al 2010)

## Opportunity: Predation and/or Competition by Non-natives

Non-native fish have been documented in the Dolores River since at least 1971 (Holden and Stalnaker 1975). As of 2005, the following 13 species had been documented: white sucker, bluegill, green sunfish, largemouth bass, common carp, red shiner, sand shiner, fathead minnow, plains killifish, black bullhead, channel catfish, rainbow trout and brown trout. In 1993, smallmouth bass escaped from McPhee Reservoir into the river downstream when it became necessary to release spill water over the spillway (Anderson, C. 2010a, Graf personal communication). The species of non-natives present, and the proportion of the total fish community that they comprise both appear to vary strongly by reach (Kowalski et al. 2010, Anderson and Stewart 2007, Valdez 1992) and the proportion appears also to have generally increased over time (Table 2).

**Table 2.** Non-native fish composition by reach, sampled in 1981 (Valdez 1982), 1991 (Valdez 1992) and 2007 (Kowalski et al. 2010).

| **1981 and 1991 Sampling Reach (Gill nets, trammel nets and electrofishing)** | **1981 % Non-natives** | **1991 % Non-natives** | **2007 Sampling Reach (Boat electrofishing)** | **2007 % Non Natives** |
|---|---|---|---|---|
| Bradfield Bridge to Disappointment Creek | . | 23.4 | Bradfield to Dove Creek Pumps | . |
| | | | Pyramid Park to Disappointment Creek | 90 |
| Disappointment Creek to Bedrock | 8.7 | 17.3 | Big Gypsum Reach | 6 |
| | | | Slickrock Canyon | 21 |
| Salt Creek to UT-CO Stateline | 47.4 | 29.3 | Gateway to Stateline | 49 |

Non-native species can affect native fish communities, with detrimental impacts to their biomass and structure (Anderson and Stewart 2007, CDOW 2008, Courtenay and Moyle 1992, Scoppettone 1993). Bryan and Hyatt (2004) sampled population size, size structure, condition, and habitat use of a rapidly declining roundtail chub population in the lower Salt and Verde Rivers and found the population to be comprised of large adult sized fish in good condition. They concluded that the probable causes for the very low survival of young fish in the population were non-native sport fish and/or a sustained lack of high peak flows (Bryan and Hyatt 2004).

Flows can have an effect on non-native fish. During their 1998-2004 sampling on the Yampa and Colorado Rivers, Anderson and Stewart (2007) observed increased recruitment of nonnative species, including small mouth bass on the Yampa, during the drought years. They felt that low flows during the drought explained a very large increase in smallmouth bass numbers, and that this growing population of non-native predators was likely more of a challenge to a rebound in the native fish community in their sample reaches than low base flows (Anderson 2005). Reduced spring flows may also be problematic: Anderson and Stewart 2007 sampling showed increased recruitment of nonnatives on the Colorado River after years with reduced spring flows. Conversely, their sampling on the Yampa River suggested that survival of smallmouth bass age 1 and older was lower when spring flows were higher. However, Valdez et al. (2001), concluded that a test flood conducted in the Grand Canyon did not decrease nonnative fish populations in a substantial way, but hypothesized that repeating similar floods in subsequent years could reduce the success of non-natives and improve native fish survival.

Anderson, C (2010b) documented that, for trout, temperature exceeds the Colorado standard for cold water fisheries at flows less than 60 cfs during the summer months and that dissolved

oxygen is less than the Colorado standard at flows less than 40 cfs and perhaps higher discharges as well, during the summer months.

***Flow Hypothesis:*** Flows of between 100-1000 cfs in the 60 days before the peak, will help control non-native warm-water fish populations. (Anderson and Stewart 2007, Graf D. 2006 communication

***Flow Hypothesis:*** Consecutive years of low spring flows and/or low base flows will result in increased populations of non-native warm water species (Anderson and Stewart 2007)

***Flow Hypothesis:*** Warmer water temperatures will result in expansion of the small mouth bass population upstream (from Pyramid Park) (White 2010, Anderson and Stewart 2007).

***Flow Hypothesis:*** Keeping baseflows greater than 60 cfs between McPhee Dam and Bradfield Bridge will avoid exceeding the Colorado standard for temperature in cold water fisheries (Anderson, C (2010b)).

***Management Hypothesis:*** Direct control of non-natives in priority reaches will result in increased survival of native species. (USDOI 2009, Utah Division of Wildlife Resources 2006, Anderson, C. 2010a)

## Opportunity: Reduced Spawning Success and/or Survival of eggs and larvae

Changes in the magnitude, timing and/or duration of peak flows may shift the environmental cues that native fish use in order to time their migration and/or spawning appropriately. Such mis-cueing could limit successful reproduction (Muth et al. 2000) Sampling over an eleven year period on the unregulated Upper Verde River in Arizona showed that the catch rate for 1 year old roundtails significantly increased in years with floods, and decreased in years with no flood (Brouder 2001). Brouder concluded that recruitment of roundtail chub young was dependant on flooding flows and that a reduction in the frequency of floods could cause populations of roundtails (and other native species) to decline (Brouder 2001). Bryan and Hyatt (2004) sampled population size, size structure, condition, and habitat use of a rapidly declining roundtail chub population in the lower Salt and Verde Rivers and found the population to be comprised of large adult sized fish in good condition. They concluded that the probable causes for the very low survival of young fish in the population were non-native sport fish and/or a lack of high peak flows over the 5 years preceding the study (Bryan and Hyatt 2004).

Roundtail chub spawning begins when water temperatures reach from 14 to 24°C, an increase in temperature that typically coincides with the decrease in runoff after the spring peak (Bezzerides and Bestgen 2002). Roundtails spawn over gravel in deep pools and runs (Bezzerides and Bestgen 2002). Eggs adhere to the gravels and hatch after four to seven days at 19°C. Newly hatched roundtail larvae drift in the current or exit into shallow slow water areas for feeding and refuge from predators (USDOI 2009, Bezzerides and Bestgen 2002). Roundtails mature at 3-5 years of age (150-300mm in length) and probably live 8-10years on average (Bezzerides and Bestgen 2002). Larger females tend to carry more eggs (Brouder 2001).

Roundtail chub, flannelmouth suckers and bluehead suckers are relatively long lived fish, so a successful spawn is not necessary every year in order to sustain the populations (Anderson, C. 2010a, Mueller and Wydoski 2004) However, sustained periods of low to no peak flow may result in aging populations of larger fish, and few young small fish (Bryan and Hyatt 2004). Fishery biologists develop size class distribution graphs from sampling data in order to track such dynamics.

***Flow Hypothesis:*** Keeping water temperatures low through releases of 100-1000 cfs in the 60 days before the peak will help cue the timing of native fish spawning appropriately, resulting in a more successful spawn (Anderson and Stewart 2007, Graf D. personal communication).

***Flow Hypothesis:*** *In a spill year, ramping down from peak flows slowly will result in greater survival of eggs and larvae by avoiding stranding in drying or isolated sites and/or by reducing efficiency of predators (Anderson and Stewart 2007, Graf pers. com 2007)*

**Data Needs:**

- What are the desired ranges for Dissolved Oxygen, temperature, and salinity on the Dolores River, and how do current levels "measure up"? (Anderson C. 2010a, Graf 2006)
- What is the role of specific tributaries in supplementing spill flows and/or base flows? What role do tributaries play in native fish spawning success on the lower Dolores River?(USDOI 2009)
- What is the relationship of spill flows to **native** fish recruitment on the Dolores River? What specific functions do native fish rely on from high spring flows in order to successfully reproduce and recruit? (Anderson and Stewart 2007)

## Opportunity: Loss and/or Degradation of Key Habitats Due to Reduced Peak Flows

Native fish depend on a variety of different habitats to complete their life cycle, including slow shallow backwaters for feeding and refuge as very young fish; slow deep pools for holding and refuge as adults, fast and moderately deep runs for spawing and fast and shallow riffles for feeding. High spring flows play a central role in forming and maintaining channel and floodplain shape and size, and in defining and refreshing these habitats for fish (Richard and Wilcox 2005). The larger the flow, the larger the sediment that the river can move (Richard and Wilcox 2005). The power of the river to move sediment accomplishes a range of functions, from flushing fine sediments out of pools and the spaces between cobbles and gravels in riffles and runs, to scouring gravels and cobbles to create and maintain pools, to the formation and erosion of cobble bars and creation of whole new channels (Richard and Wilcox 2005).

Roundtail chubs are often found in the deepest pools and eddies of large streams (USDOI 2009) They have been observed to spawn over clean gravels in pool, run and riffle habitat with slow to moderate waters. (USDOI 2009)

***Flow hypothesis:*** Flows of greater than 1000 cfs for about ≥7 days every 1-2years will promote movement of the channelbed surface, maintain channel geomorphology (flows greater than 2600 cfs), and habitats fish require during base flow periods. (Richard and Anderson 2007, Anderson and Stewart 2007, Graf 2006)

## *Riparian Ecology*

### Status and Trends

As Merritt (2005) pointed out in his review of riparian vegetation for the Dolores for the DRD Core Science Report, there is very little information available that documents trends in vegetation on the Dolores River. Kreighauser and Somers appears to be the longest term study available. They measured vegetation at one transect on what is now the Lone Dome State Wildlife Area in 13 years from 1988 through 2001 (Krieghauser and Somers 2004). They found a significant increase in sandbar willows close to the channel, but no change in the number of narrowleaf cottonwoods. They also documented a complete loss of silverberry on the transect.

In 2008 the Dolores River Dialogue helped fund Master's Degree candidate Adam Coble at Northern Arizona University to compare cottonwood recruitment on the Dolores River above and below McPhee Reservoir, and on the San Miguel River, where there is no mainstem dam. Preliminary results suggest that the number of recruitment events as well as the radial growth rates of narrowleaf cottonwood between McPhee Dam and Bradfield Bridge has decreased since 1985 (Coble 2010).

Currently, invasive species generally become more prevalent on the Dolores as one moves downstream. Table 3 summarizes the Tamarisk Coalitions field inventory sampling data, by DRD reaches.

**Table 3.** Summary of Tamarisk Coalition tamarisk cover estimates on the Dolores River, by DRD Reach (Tamarisk Coalition 2010).

| DRD Reach | Description | Average Tamarisk Cover (%) |
|---|---|---|
| 1 | McPhee to Bradfield Bridge | 0 |
| 2 | Bradfield Bridge to Dove Creek Pumps | 0-10 |
| 3 | Dove Creek Pumps to Pyramid Park | 0-10 |
| 4 | Pyramid Park to Slickrock Canyon | 26 |
| 5 | Slickrock Canyon to Bedrock | 35 |
| 6 | Bedrock to San Miguel | 47 |
| 7 | San Miguel to Gateway | 42 |
| 8 | Gateway to Colorado River | 37 |

## Opportunities for Improvement and Associated Hypotheses

The central role that periodic high spring flows play in creating and maintaining, over time, the species composition, structure and pattern of the riparian community at a given site is well documented and well summarized in the DRD Core Science Report (Merritt 2005).

The cottonwood species is often the focus of studies of the changes occurring in riparian vegetation after construction of a large dam. This is because of the key role that the magnitude, duration and frequency of floods (over bank flows) play in the establishment and survival of cottonwood seedlings (Coble 2010, Merritt 2005). In addition, as riparian specialists, dependant on flows, cottonwoods are more sensitive and vulnerable to changes in flows than some other species that are able to establish and survive in upland habitats as well (e.g. New Mexico Privet, skunkbrush sumac, etc.) (Rood et al. 2010, Coble Personal Communication)

## Opportunity: Limited Cottonwood Seedling Establishment and/or Survival

As discussed under Status and Trends, field studies provide some limited evidence from the Dolores that cottonwoods may not be establishing as frequently since construction of McPhee Reservoir as prior to the dam (Krieghauser and Somers 2001, Coble 2010). Factors found to affect seedling establishment and survival include: the availability of areas of bare moist sediment, levels of salinity of those sediments, rate of soil moisture recession, subsequent scouring, and competition those sites (Anderson R. 2010, Merritt 2010, Sher and Marshall 2003).

Cottonwood seeds require moist bare sediments in order to germinate. The timing of release of their seeds coincides with the natural timing of snowmelt and the overbank flows necessary to deposit fresh new sediments on the floodplain and on point bars (Merritt 2005, Anderson R. 2010).

***Flow Hypothesis:*** Peak flows of ≥ 2000cfs for ≥ 7 days every 1 in 2 years on average [(or >2600cfs at a 1.8 to 2.5 year frequency (Richard and Anderson 2007) or on a 10 year recurrence interval (Merritt 2005, Scott et al. 1997)] will support cottonwood establishment and maintain riparian diversity (Siscoe 2005, Merritt 2005, Vandas et al. 1990)

***Flow Hypothesis:*** In years when peaks over 2600 cfs (bankfull at Big Gypsum reach per Richard and Anderson 2007) occur, a spill drawdown rate below the threshold for cottonwood establishment (2.5cm/day, or about 100cfs/day) (Anderson, R. 2010, Merritt 2005, Mahoney and Rood 1998) will improve seedling survival.

***Flow hypothesis:*** Channel and floodplain resetting peak flows of ≥5000 cfs at a frequency of 20 or more years will create new sites for plant colonization, reduce channel narrowing and armoring by vegetation, recharge and rinse floodplain soils and promote riparian diversity (Anderson, R. 2010, Merritt 2005, Lytle and Merritt 2004, Cooper et al 2003).

***Flow hypothesis:*** Timing the peak release within the range of historic peak flows (April 13 to

May 28 at Bedrock, CO; median May 18) would support cottonwood establishment, and reduce competition from Tamarisk for appropriate regeneration sites. (Merritt 2005, Cooper et al. 1999).

***Management hypothesis:*** Active and passive control of tamarisk will open up new regeneration sites for riparian species and reduce competition for regeneration sites. (Sher and Marshall 2003).

## VII. Potential Management Tools

This section summarizes various ideas for tools that could be used to test the hypotheses (presented in Section V.) and help ensure protection of the values of the Lower Dolores River. It also provides an overview of the Framework Process developed by DRD for evaluating tools proposed for implementation. Appendix G presents the list of potential tools that have surfaced during the deliberations of the Lower Dolores Plan Working Group, the Lower Dolores Plan Working Group Legislation Committee, the DRD (including the Full DRD, Steering Committee, Technical Committee, Science Committee and Hydrology Committee), and/or partners. Each tool is linked to one or more of the science based opportunities identified and discussed in Section V of this report.

It is important to emphasize that the long list of ideas reflects only the discussions to date. This list is not prioritized nor does it in any way represent a set of recommendations, nor a commitment for future consideration. It should be viewed simply as the "brainstorm" of potential tools generated by a variety of individuals, entities and interests sitting together to discuss issues, opportunities and concerns related to the resources of the Lower Dolores River.

The DRD Steering Committee supports the aim of ensuring protection of the values of the Lower Dolores River in a manner that protects water rights and Dolores Project allocations in conformance with Colorado water law. The committee emphasizes the importance of finding tools that are consistent and doable given water supply constraints. To this end, the Steering Committee has developed and agreed upon a standardized process for evaluating tool proposals known as the Framework Process.

The Dolores River Dialogue Steering Committee will begin use of the Framework Process to evaluate ideas for tools brought forward as Proposals under the DRD Framework Process. Proposals may be based on the ideas for tools listed in Appendix G or they may be completely new ideas. They may be developed by the DRD itself (for instance from the Hydrology Committee) or from members of the Lower Dolores Plan Working Group, from agencies or from

individuals.

**DRD Framework Process**

The following steps describe how proposals for meeting the DRD's purpose statement are discussed and evaluated for action by the DRD-Steering Committee and eventually the full DRD itself. This process is designed to flexible, iterative, interactive and collaborative. The DRD-Steering Committee will serve as the central point for accepting and evaluating proposals, and will make recommendations to the full DRD related to each proposal submitted.

**Phase 1: Initial Discussion with DRD-Steering Committee:** Proposals are discussed in concept at a meeting with the proposal developer(s) and the DRD- Steering Committee. Two ground rules will be used: no proposal is rejected outright and no decision is made in this phase. The purpose of this initial meeting is for the entity/person developing the proposal to have a conversation and exchange with the DRD-Steering Committee stakeholders; to receive and give initial information/feedback; and to learn where resources might be available for proposal development and information gathering.

**Phase 2: Proposal Development:** The proposal developer uses the "Framework" questions (Appendix F; available on the Web site or by emailing the facilitator) and completes a proposal, and then submits it electronically to the DRD-Steering Committee. Proposals can be generated from many sources.

**Phase 3: Education and Common Understanding:** The DRD-Steering Committee works with the proposal developer(s) to hold an educational process or event. The goal is to have all parties involved learn about the proposal *together* in a detailed fashion. The outcome is a common understanding of what exactly is being proposed. The exact shape of a "forum" or "symposia" will be designed based on what is necessary and helpful and of course, in partnership with the proposal developer. Again the ground rules are: no proposal is rejected and no decisions are made.

**Phase 4: DRD- Steering Committee Review and Recommendation-Setting Phase:** The DRD - Steering Committee then further discusses the proposal and makes a recommendation using consensus-based decision making. The DRD-Steering Committee takes their recommendation(s) to the larger DRD. Their recommendations could include any of following: a) The DRD should support the proposal and actively work to implement it. b) The DRD supports the proposal but it will be implemented by a combination of partners. (In other words, it's not a DRD-led project but is supported by the DRD.) c) Some other action should be taken to be defined. d) There should be no action on the proposal at the present time by the DRD.

**Phase 5: Full DRD Review and Recommendation Phase:** Then, at the next scheduled full DRD meeting, the DRD-Steering Committee presents their recommendations and requests the DRD evaluate and act on those recommendations. The full DRD aims to operate with a full consensus but will establish a super majority threshold for voting. If the DRD supports a proposal, plans will then be made for implementation.

# VI. Conclusion and Next Steps for DRD

DRD is actively pursuing the identification of "do-able" alternatives that can be agreed upon the stakeholders. The opportunities and hypotheses identified in Section IV. (and others) provide the basis for alternatives that may improve the downstream environment, and therefore provide a foundation for the development of Framework proposals and "do-able" alternatives for reaching the DRD purpose statement.

Nevertheless, while the scientific information and hypotheses available here and elsewhere are valuable, it is important to emphasize that this information does not provide the solutions, the "doable" alternatives" for the Dolores. The solutions are not in the science. Ultimately, a "doable" alternative for improving the downstream environment is nothing less than the marriage of a science-based flow or management hypothesis with the will of many interests to try something: some action and then measure its success (or failure).

The following steps would advance the science and the development of such development of "do-able" alternatives.

***1. Further Define the Opportunities:*** In support of future Framework proposals, further define and develop the specific opportunities and hypotheses associated with improving the condition of native fish populations and riparian ecology by doing the following:

- In 2011, repeat the collection of pre spill and post spill soil salinity, soil moisture and ground water drawdown data at permanent cross sections in the Big Gypsum Study Site and in Lone Dome State Wildlife Area.
- In 2010, collect temperature and dissolved oxygen during summer, fall and winter periods at sampling sites along the Dolores River to validate the predictive model developed by Chester Anderson, BUGS Consulting.
- Test effects of exclusive use of SLOW 3 (no use of the Bypass Gate at the bottom of the dam) as tool for reducing high algal biomass and low DO in downstream environment.

***2. Develop Framework Proposals:*** DRD partners and/or additional stakeholders develop Framework Proposals to address one or more of the opportunities and hypotheses identified in Section IV.

***3. Support Others in Developing Proposals:*** Provide information, as requested, to the sub-committee formed through the Lower Dolores Plan Working Group, as they work to develop legislation as an alternative to the Dolores River's current status as "suitable" for designation under the Wild and Scenic Rivers Act; and as they determine if a viable alternative(s) can be crafted to improve the condition of the native fish.

# VII. References


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# VIII. Appendices

**A.** ***Modeling the Relationship between McPhee Dam Selective Level Outlet Operations, Downstream Algal Biomass, Dissolved Oxygen and Temperature: Phase 1, Background Data and Model Development*** by Chester Anderson, BUGs Consulting.

**B .** ***Technical Memo: Factors affecting populations of flannelmouth suckers on the Dolores River between McPhee Dam and the San Miguel River*** by Chester Anderson, BUGS Consulting.

**C.** ***Baseline sampling of riparian vegetation in Big Gypsum Monitoring Site*** by Adam Coble and Rob Anderson.

**D.** ***Baseline channel cross sections at Big Gypsum Monitoring Site*** by Rob Anderson.

**E.** ***Evaluating Potential Barriers to Cottonwood Establishment in Big Gypsum Valley and Lone Dome Reaches of the Dolores River*** **by Rob Anderson.**

**F.** ***DRD Framework Process Questions***