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

Final 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

Edition II

July 8, 2011

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Contents

List of Figures

List of Tables

Acknowledgments

Funding for this project was provided by a Colorado Water Conservation Board Severance Tax Trust Fund Grant. The Suckla family graciously allowed us to conduct sampling efforts on their lands. We would like to thank Mike Preston, Jim Siscoe, David Graf, Jim White and Marsha Porter-Norton for their dedicated assistance in the completion of these deliverables, and for their valuable insights and background regarding the ecology and interests of the Lower Dolores River. Matt Clark, Ken Curtis, David Graf, Shauna Jensen, Marsha-Porter Norton, Don Schwindt, and Jim White provided valuable review and comments for Edition II.

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 frame testable flow and management hypotheses to address each opportunity, based on existing data and our current understanding of the ecology (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 or expectation of implementation (Section V).
- **Identify DRD Next Steps** (Section VI)

Following delivery of the original edition of this final report, members of the Steering Committee and participants in the Science Committee and Hydrology Committee of the Dolores River Dialogue were invited to review and comment on the document. This Edition II incorporates the comments received.

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 opportunities for improvement, and how might they be pursued?

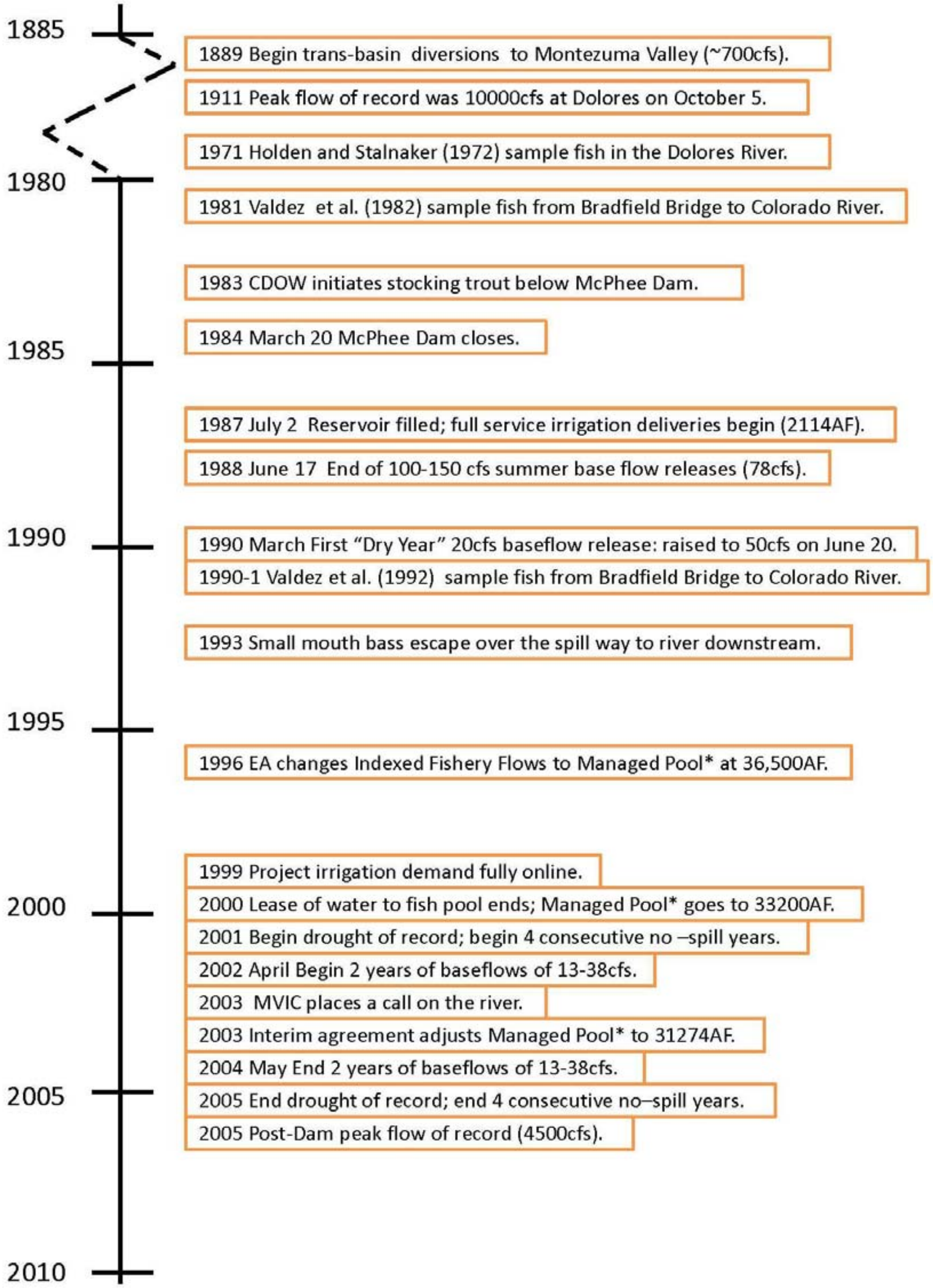
II. Background

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. Information from these two reports was then integrated into a Correlation Report (Graf 2006).

The Correlation Report characterized the hydrology of the river under three major “eras” in the history of the Dolores River: pre-MVIC, MVIC to Dolores Project, and Dolores Project; and summarized the ecological status of reaches below McPhee (Appendix A) (Graf 2006). The report also presents a chart summarizing the estimated frequency and magnitude of modeled spills from McPhee Reservoir from 1928-2005, given the actual gage records at the town of Dolores, and assuming storage in McPhee Reservoir and full Dolores Project demands (Appendix B). This modeled hydrology provides a picture of the magnitude of spills that would have occurred if the Dolores Project had been in place since 1928, and represents the best available prediction of expected future spill hydrology on the Dolores River below McPhee Dam (Graf 2006).

It is useful to be aware of the hydrologic “era” during which data was collected when thinking about improving the ecological conditions below McPhee. Figure 1 shows a timeline of these eras and other significant hydrological and ecological events. The pre-MVIC era (pre-1889) can be characterized as a natural river, not subject to modern man’s influences. The MVIC to Dolores Project era (1886-1984) was not subject to McPhee Dam capturing spring run-off or all summer thunder shower flows, but had significant irrigation season diversions that drastically reduced downstream flows after early summer. Flow data collected from 1939 to 1952 at a gage at the town of McPhee, located below the main MVIC diversion and now inundated by the reservoir shows that from August through November, flows were less than 10 cfs 50% of the time (Appendix C, Figure 5) (Anderson, C. 2010b).

Figure 1. Timeline of significant hydrological and ecological events on the Dolores River:



* The phrase "Managed Pool" is used here to include all water available for downstream uses during baseflow periods at any given time: fishery water, downstream senior water rights, leases, etc.

The Dolores Project era (1984-present) has itself been characterized by three distinct periods. First, between the closing of McPhee Dam and the 1999 completion of the project irrigation delivery system, the river below McPhee benefitted from all the un-used project supply. All of the planned but as-yet un-used trans-basin diversions for project supply, approximately 78,000 acre feet, were released downstream during spills and as higher-than-planned base flows during this period. Second, in 2002 when the infrastructure came on-line to divert the full designed irrigation demand from the project, the basin was in a drought which was significantly greater than any drought reflected during the 46 year hydrologic record (1928-1973) available when the Dolores Project was planned. Only as the basin has recovered from the 2001 drought has the Dolores River below McPhee Reservoir experienced a flow regime more similar to that which guided the planning and construction of the Dolores Project. This third sub-era, beginning about 2005, may represent the most appropriate conditions on which to base adaptive management for ecological improvements. The relevant hydrology sections of the Correlation Report are included in Appendix A.

The Correlation Report thus provides a foundation for evaluating 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 developing 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, while protecting Dolores Project allocations and water rights. 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 has 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 five 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 four 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 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 (2010b) (Appendix C).

> 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 to predict 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). 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 and higher water temperatures associated with upper level releases. Anderson, C. (2011) presents the Phase 2 results, including improved models, comparisons of modeling results to observed data, and some management recommendations.

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 (2010a) (Appendix D).

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 E).

This effort established sixty permanent vegetation sampling points through the current riparian zone at 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 F).

This effort established three 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 regeneration in the Big Gypsum Study Site and the Lone Dome State Wildlife Area on Dolores River, CO by Rob Anderson (2011) (Appendix G).

This investigation focuses on assessing whether 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 assesses the pre and post-spill dynamics of these factors for the 2010 spill. The investigation includes the acquisition and installation of monitoring equipment that can provide data for, at minimum, the three years, allowing for subsequent annual monitoring and analysis in addition to the data presented in this report.

IV. Science-Based Opportunities on the Lower Dolores River

This section synthesizes information identifying opportunities for improving the downstream environment on the Lower Dolores River. 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 ecology, 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. They can be viewed as some of the anticipated benefits of any flow management or other management actions that the DRD may consider through the "Framework Process" (See Section V. and Appendix H).

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

Science Focus	**Objectives for improving the downstream environment**
Riparian Ecology	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 greater 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)
Channel Function	Scour fine sediment as a 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. The reasons for focusing on these two include that these native resources are the focus of current local and regional initiatives (e.g. the Range-Wide Conservation Agreement and Strategy For Roundtail Chub *Gila Robusta*, Bluehead Sucker *Catostomus discobolus*, and Flannelmouth Sucker *Catostomus latipinnis* (Utah Division of Wildlife Resources (2006) and the Dolores Riparian Restoration Partnership), and that improvement of these native resources depends in part on channel function.

For each of these focal resources the following will be summarized:

- Information available regarding their status on the Dolores River
- 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 and management hypothesis will be provided, with citations.
- In some cases, data needs for further refining opportunities will be identified

In order to appropriately understand and evaluate information regarding the ecology of the Dolores River over time, it is important to understand the history and context of the River. The Dolores has gone through several major and minor hydrologic periods, as well as significant management events (Graf 2006). These periods and events are defined by both human management and natural occurrences. Figure 1 captures some of the many changes which have affected and continue to affect the hydrology and ecology of the Dolores River, especially below McPhee Reservoir.

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 sucker. This review of status and trends will focus primarily on information specific to the roundtail chub and flannelmouth for several reasons. The San Juan Public Lands identifies the roundtail as an Outstandingly Remarkable Value of the Lower Dolores River (USDOI and USDA 2007) in its assessment of the Dolores River for eligibility under the Wild and Scenic Rivers Act, and there is recent heightened concern about declines in roundtail chub numbers within the Colorado River Basin. 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 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).

This review will soon be followed by a more in-depth review of the status of all three of the large-bodied native fish in the Lower Dolores by independent fisheries biologists contracted under the “A Way Forward” process. This inquiry was conceived and funded by the Legislative Subcommittee of the Lower Dolores Plan Working Group in the fall of 2010 to provide a status review and identify opportunities for protecting native fish in the Dolores.

The Dolores River below Bradfield Bridge is managed by the CDOW for the recovery, conservation, protection, and enhancement of native fishes, including large and small-bodied native fishes (CDOW Administrative Directive No. W-6; 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 related to research, represents the best available data on the status of the native fish in the Dolores River.

CDOW biologists recently summarized sampling data over time for the three native fish species in the Dolores in two presentations, one to the Dolores River Dialogue (Kowalski et al. 2010) and one 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 relative abundance in catch per mile, or catch per hour. There are challenges to inferring population trends from these 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 the time of sampling, season, etc. (Kowalski et al. 2010, White 2009). Nevertheless, relative abundance estimates are commonly used to assess three species status across their distribution in the Colorado River Basin, and these sampling data are the best information available on the status of these fish on the Dolores.

Kowalski et al. presented summarized sampling data for seven 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 one sampling site (Dove Creek Pumps). These sampling reaches cover portions of the Dolores mainstem from just below McPhee Dam to the Colorado/Utah state line. The number of years sampled varies greatly by reach.

For the roundtail chub, only two out of eight reaches for which sampling results were reported have more than two years of quantitative sampling results. The Catch or Catch Per Unit Effort (CPUE) of roundtails for these twp reaches, Dove Creek Pumps Site and Big Gypsum Reach, are both variable but down from the maximums sampled in 1999 and 2000, respectively.

For the flannelmouth sucker, four out of the eight reaches for which sampling results were reported have more than two years of quantitative results: Metaska to Bradfield; Bradfield to Dove Creek Pumps; Dove Creek Pump Site; and Big Gypsum Reach. The maximum Catch and/or CPUE for these four sampling areas occurred in 1993, 1993, 1989 and 2001, respectively. As of November 2010, from Metaska to Bradfield, and from Bradfield to Dove Creek Pumps, flannelmouths have been absent from the two most recent sampling events: 2000 and 2005, and 2005 and 2007, respectively. At the Dove Creek Pumps site, flannelmouths have been absent from the last five sampling events: 2005-2009. At Big Gypsum, the number of flannelmouths caught per mile has varied greatly, but the fish have been present in each of the six samples reported (Kowalski et al. 2010).

In the 2007 sampling of the Pyramid to Disappointment Reach, both roundtails and flannelmouths were caught, but in very small numbers. The catch was dominated by non-native smallmouth bass and brown trout (Kowalski et al. 2010, White 2009).

For 2007 the CDOW reported sampling results from a “longitudinal survey” conducted in most of the sampling areas from McPhee Dam to the Colorado/Utah state line. This sampling at many different sites in the same year (including the Bradfield to Dove Creek reach, the Dove Creek Pumps Site, the Pyramid, Big Gypsum, Slickrock Canyon, and Gateway to Stateline) provided data that 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 Canyon, 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).

Interestingly, in Anderson and Stewarts (2007) sampling conducted at eight sites on four rivers between 1998 and 2005, Big Gypsum consistently had the highest percentage composition (by far) of roundtail chub (Figure 2), but only the third to fourth highest biomass of roundtail for the years it was sampled (the Gunnison and Colorado sites had the highest) (Figure 3). Similar to the native suckers, roundtails sampled at Big Gyp were small (Anderson and Stewart 2007). Small adult fish are more likely to be preyed upon, have fewer reserves available to survive periods of low food availability, and may have limited fecundity (White, pers. comm.).

Figure 2. Roundtail composition (% of all fish collected) from eight sites sampled between 1998 and 2005 (Anderson and Stewart 2007).

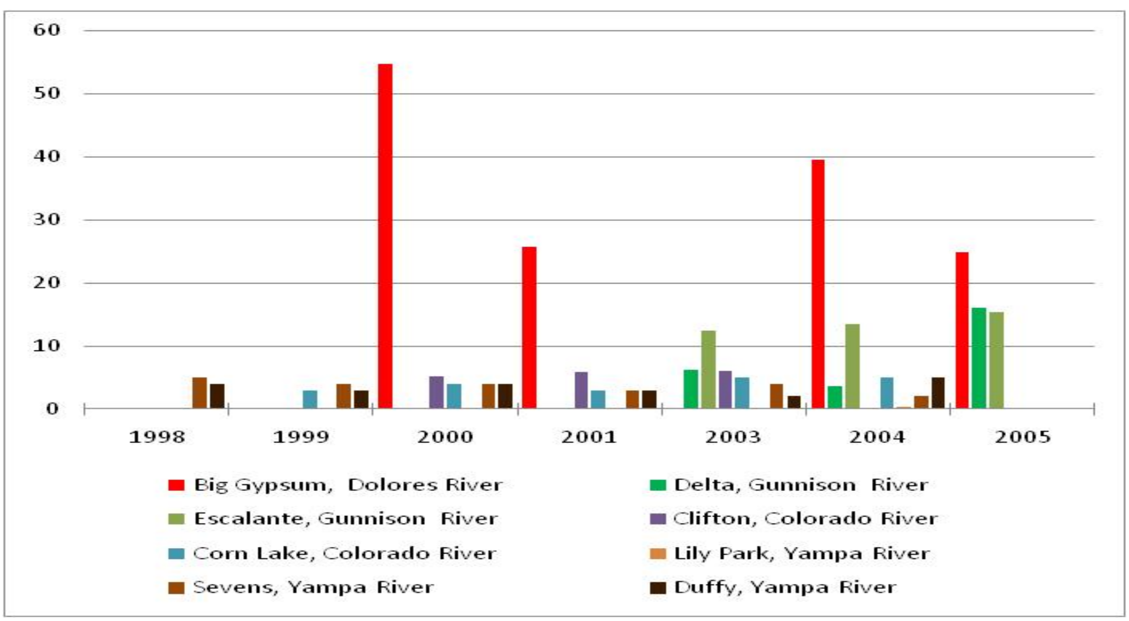
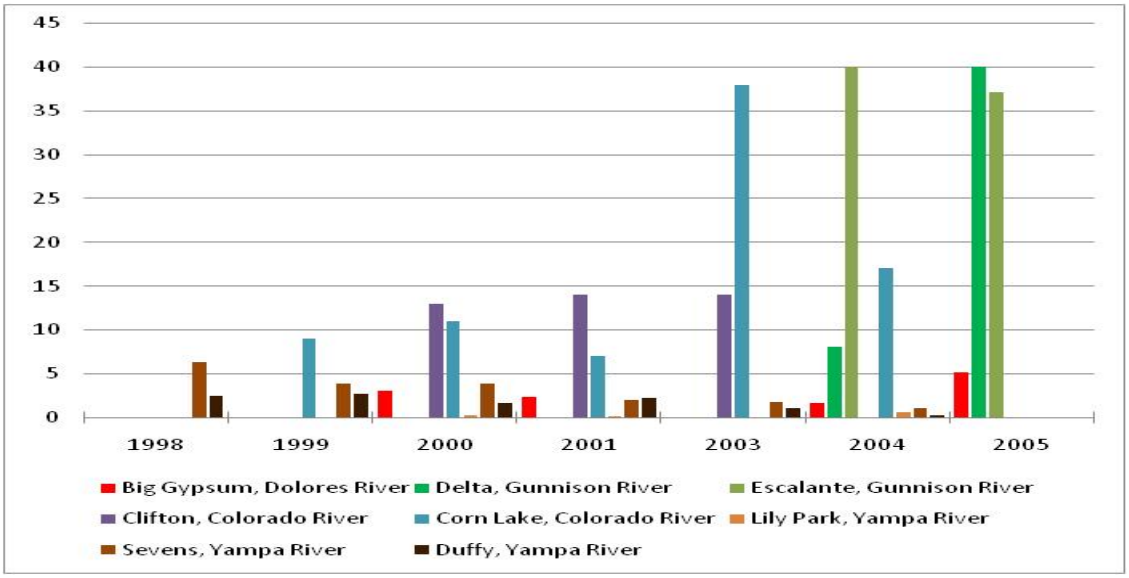


Figure 3. Roundtail biomass (kg/ha) estimates from eight sites sampled between 1998 and 2005 (Anderson and Stewart 2007).



There is very little quantitative sampling data available prior to the closing of McPhee Dam in 1984. Reports include Nolting (1959), Holden and Stalnaker (1975), Valdez et al. (1982), and Valdez et al. (1992). Valdez (1992) concluded that native fish numbers and distribution in 1991 were similar to the 1982 study. Kowalski summarized CPUE (fish/hour) for sampling conducted 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 studying these fish on the Dolores River, there have been 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 three 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) and will serve as the state’s implementation guide for the "Range-Wide Conservation Agreement for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker"

(Utah Division of Wildlife Resources 2006). This agreement has been signed by six western states, the Department of Interior, and United States Department of Agriculture (USDA), and is supported by Technical Conservation Assessments produced by the USDA for each of the three species. The Technical Conservation Assessments are available online at: www.fs.fed.us/r2/projects/scp/assessments/#fishes

Opportunities for Improvement and Associated Hypotheses

Several factors likely play a role in the apparent declines in the upper Colorado River Basin of 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, Utah 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 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 (Appendix D), White 2009), reduction in spawning success (Anderson and Stewart 2007, Graf personal communication 2007), and water quality issues (Anderson, C. 2010b (Appendix C), 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 a hypothesis that says 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 non-native 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).

Research and monitoring of fishes on the Dolores River are constrained by several factors. Unlike many Upper Colorado River Basin rivers, which are navigable by boat (raft or motorized) during much of the year, the Dolores River upstream of Big Gypsum Valley is only raftable during regulated reservoir releases in the Spring. This section of river is virtually impassible at low flows which occur throughout most of the summer field season. Spring releases from McPhee are conditioned on a number of factors that result in uncertainty around flows. This uncertainty makes planning and implementing consistent large scale fish inventories and monitoring projects difficult. Much of the Dolores River above the San Miguel River is contained within remote and roadless canyons that can only be accessed by boat under limited conditions. These limitations explain why much of the sampling and research on the Dolores River has been done in its open, alluvial reaches. It is important to keep these physical realities in mind when discussing management opportunities.

Native Fish Opportunity A: 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 2001 and 2007. Anderson and Stewart utilized standard field based methods to develop models ("two-dimensional modeling") which provide managers with the ability to predict 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. This "Fish Flow Investigation" was requested of CDOW's Aquatic Research Unit by the CWCB and completed with Federal Aid wildlife grant 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, depths and velocities. They used this field data to develop two-dimensional "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 wherever 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 availability 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, where they had collected the data used to develop the curves, and less well, but still valid, at two sites on the Gunnison River (Stewart and Anderson 2007).

There are some limitations to the predictive models developed on the Dolores. First, the models were developed based on sampling of larger fish only (>150mm) at sites on the Colorado and Yampa Rivers, so they are not intended to predict biomass of small fish (smaller than 150mm) (Stewart and Anderson 2007). At Big Gypsum, the surveys found that juvenile-sized native suckers (12-23cm) far outnumbered adult-sized suckers (Anderson and Stewart

2007). If adult native suckers tend to be smaller at Big Gypsum than at sites on the Colorado and Yampa, then the habitat suitability models for the Big Gypsum site may poorly predict the biomass of adult native suckers.

To improve the accuracy of the models in predicting biomass as a function of flows, the authors suggest developing habitat suitability curves for Big Gypsum based on habitat criteria for juvenile suckers, which prefer shallower and slower habitats (Anderson and Stewart 2007). Also, they suggest it would be useful to develop models at an additional site with higher quality habitat (and higher observed biomass) for flannelmouths and roundtails (e.g. steeper gradient and clean cobble substrates) (Anderson and Stewart 2007).

A second limitation to note is that 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 as a function of flow for other species (e.g. roundtail chub) is not 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).

To date, we are only aware of one habitat suitability index developed for the roundtail chub, based on surveys conducted on the Animas, La Plata and Florida rivers (Miller et al. 1995). Anderson and Stewart (2007) attempted to develop a model, but found no ability to predict roundtail 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 roundtails were 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. 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, while roundtail biomass was associated with pools (presumably due to daytime sampling) (Anderson and Stewart 2007), as a predator the roundtails' biomass at a given site is highly dependent on riffle habitat, because riffles are the most productive habitat of food for all fish species. Riffle habitat 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 of flow effects on habitat availability for the three native fish species (Anderson and Stewart 2007).

Finally, it is important to recognize that habitat suitability curves predict biomass as a function of flow based on data representing a very limited suite of environmental factors: width, depth and velocity at a site. They do not incorporate well many other factors that can also affect the biomass of a given species at a given site, in a given year (e.g. forage base, habitat productivity, fish community composition, water temperature, water chemistry, etc.).

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.

Native Fish Flow Hypothesis A1:
In spill years, providing a 60 cfs base flow through the Big Gypsum site will result in habitat availability of 61% pool, 34% run, 5% riffle, and flannelmouth sucker biomass of about 20kg/ha at the Big Gypsum site (up from 6.6 kg/ha in 2005) (Anderson and Stewart 2007, Kowalski et al 2010). Note that the reach between McPhee Dam and the Big Gypsum site is a “losing” reach, so that to achieve 60 cfs through the Big Gypsum site requires a higher cfs release from McPhee (D. Graf, Pers. comm.).

Native Fish Flow Hypothesis A2:
In non-spill years, providing an 80 cfs base flow through the Big Gypsum site will help mitigate the absence of the biological benefits of high flows by making available more suitable habitat during low flows (50% pool, 42% run, 8% riffle). Predicted flannelmouth biomass would be about 37 kg/ha at the Big Gypsum site (up from 6.6 kg/ha in 2005) (Anderson and Stewart 2007, Kowalski et al 2010).

Native Fish Opportunity B: Predation and/or Competition by Non-natives
Species of non-native fish have been documented in the Dolores River since at least 1945 (Nolting 1959). As of 2005, the following 13 non-natives 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 (Siscoe 2005). 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 (Appendix D), Graf personal communication). The species of non-natives present and the proportion of the total fish community that they comprise in the Dolores 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	no data	23.4	Bradfield to Dove Creek Pumps	no data
			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 through 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 primarily 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 both native and non-native fish, through their affect on the velocity and depth of water, as well as the temperature regime. During their 1998-2004 sampling on the Yampa and Colorado Rivers, Anderson and Stewart (2007) observed increased recruitment of non-native species, including smallmouth 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 a non-native predator 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's 2007 sampling showed increased recruitment of non-natives on the Colorado River after years with reduced spring flows. Conversely, their sampling on the Yampa River suggested that survival of smallmouth bass age one year and older was lower when spring flows were higher. They also found increased recruitment of small mouth bass older than one year following years with higher summer water temperatures (Anderson 2005).

With respect to trout below McPhee Reservoir, flows and their affect on water temperature can be a tool for management, depending on manager's goals for this fishery. Anderson, C. (2010b) documented that water temperature at Bradfield Bridge exceeds the Colorado standard for cold water fisheries at flows less than 60 cfs during the summer months, and that dissolved oxygen at Bradfield Bridge is less than the Colorado standard at flows less than 40 cfs and perhaps higher discharges as well, during the summer months (Appendix C).

To accurately evaluate the role of a given flow regime on non-native fish in the Dolores, it is important to understand the management goals, life history and habitat requirements of each species of non-native in question (White, J. personal communication). Studies of a March 2008 high flow experiment released from Glen Canyon Dam found a large increase in non-native rainbow trout survival and numbers following the release, raising concerns about increased trout predation on the endangered humpback chub (Korman and Melis 2011).

Native Fish Flow Hypothesis B1: 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 pers. comm.).

Native Fish Flow Hypothesis B2: Consecutive years of low spring flows and/or low base flows will result in increased populations of non-native warm water fish (Anderson and Stewart 2007).

Native Fish Flow Hypothesis B3: Releasing warmer temperature water from McPhee Reservoir will result in increasing the abundance and distribution of smallmouth bass population upstream (from Pyramid Park) (White 2010, Anderson and Stewart 2007).

Native Fish Flow Hypothesis B4: Keeping baseflows (June-September) 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) (Appendix C).

Native Fish Management Hypothesis B1: 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) (Appendix D).

Native Fish Opportunity C: Reduced Spawning Success 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 one-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 five 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 8-10 years 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 (Appendix D), 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 monitor such dynamics by developing size class distribution graphs from sampling data.

Native Fish Flow Hypothesis C1: Keeping water temperatures low through releases of at least 300cfs only from the McPhee Dam Bypass Gate at the bottom of the reservoir in the 60 days prior to the peak will help cue the timing of native fish spawning appropriately, resulting in a more successful spawn (Anderson, C. 2011; Anderson and Stewart 2007; Graf D. pers. comm.).

Native Fish Flow Hypothesis C2: 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, D. Graf pers. comm. 2007).

Data Needs:

- What are the ranges of water quality parameters such as dissolved oxygen, temperature, and others that support native fish spawning and survival? How do current levels "measure up" by reach in the Dolores River? (Anderson C. 2010a (Appendix D), 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)

Native Fish Opportunity D: 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 spawning; 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 out 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 relatively slow to moderate waters (USDOI 2009). Flannelmouth suckers are found over a range of substrates, but appear to be more abundant over harder substrates (e.g. cobble and gravel) than finer sand and silt (Bezzerides and Bestgen 2002). Anderson and Stewart (2007) characterize adult flannelmouth as preferring deep run habitat. Spawning generally occurs in shallow water over sand and gravel bars, and young flannelmouths prefer slow water habitats (i.e. backwaters, eddies, and shallow riffles) (Bezzerides and Bestgen 2002).

Native Fish Flow Hypothesis D1: Flows of greater than 1000 cfs for ≥7 days every 1-2 years will promote movement of the channelbed surface, and maintain channel geomorphology and habitats that fish require during base flow periods (Richard and Anderson 2007, Anderson and Stewart 2007, Graf 2006, Vandas 1990).

Riparian Ecology

Status and Trends

There is no one “native riparian community” along the Dolores. There are substantial gradients and shifts in temperature, precipitation, land uses, etc. as one moves downstream from McPhee Dam to the confluence with the Colorado River. These changes drive a shifting composition and abundance of both native and non-native plant species.

There is very little information available that documents trends in vegetation on the Dolores River (Merritt 2005). Kreighauser and Somers (2004) appears to be the longest term study available. They measured vegetation at one transect on what is now the Lone Dome State Wildlife Area annually from 1988 through 2001, except in 1992 (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 silver buffaloberry on the transect. They hypothesize that both the lack of cottonwood recruitment near the river and the loss of silver buffaloberry from inland meadows along the transect are due to a long-term lowering of the water table due to the post-dam reduction in the magnitude, duration and frequency of overbank flows (Krieghauser and Somers 2004).

In 2008 the Dolores River Dialogue helped fund Master’s Degree candidate Adam Coble at Northern Arizona University to use tree cores to compare cottonwood recruitment and growth over time on the Dolores River above and below McPhee Reservoir, and on the San Miguel River, where there is no mainstem dam. Coble's 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 Coalition's field inventory sampling data, by DRD reaches.

Table 3. Summary of 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).

Cottonwood species are 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 flow timing and magnitude 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 Pers. Comm.).

Riparian Opportunity A: Limited Cottonwood Seedling Establishment or Survival

As discussed above, 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, and the levels of salinity, rate of soil moisture recession, subsequent scouring, and competition at those sites (Anderson R. 2011 (Appendix G), 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. 2011 (Appendix G)).

Riparian Flow Hypothesis A1: Peak flows of >2600cfs for seven days at a 1.8 to 2.5 year frequency (Richard and Anderson 2007) will support cottonwood establishment and maintain riparian diversity at the Big Gypsum study site (Siscoe 2005, Merritt 2005, Vandas et al. 1990).

Riparian Flow Hypothesis A2: In years when peaks over 2600 cfs (bankfull at Big Gypsum reach per Richard and Anderson 2007) occur, a spill drawdown rate below the 2.5 cm/day threshold for cottonwood establishment (estimated to be about 100cfs/day (Merritt 2005), but should be determined empirically on site) (Anderson, R. 2011 (Appendix G); Mahoney and Rood 1998) will improve seedling survival.

Riparian Flow Hypothesis A3: 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. 2011 (Appendix G); Merritt 2005; Lytle and Merritt 2004; Cooper et al 2003). At Big Gypsum, flows of this magnitude might be achieved in good "low snow" years by timing spill releases to coincide with peak run-off from lower tributaries (e.g. Canyon Creek, Glade Creek, Disappointment Creek, etc.) (D. Graf pers. comm.).

Riparian Flow Hypothesis A4: 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).

Riparian Flow Hypothesis A5: Maintaining July through September base flows at or above the long-term average will sustain regeneration of *P. deltoides* subsp. w*islizenii* (Coble 2011).

Riparian Management Hypothesis A1: 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).

V. Potential Management Tools

This section provides an overview of the Framework Process developed by DRD for evaluating tools proposed for implementation to test the hypotheses presented in Section IV, and to help ensure protection of all the values associated with the Lower Dolores River. Appendix I 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 Legislative 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 IV of this report.

It is important to emphasize that the long list of ideas in Appendix I reflects only the discussions as of July 2010. 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 I 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 be 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 H, 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 the 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 by the stakeholders. The opportunities and hypotheses identified in Section IV provide the basis for actions that may improve the downstream environment, and therefore they 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 "do-able alternatives," for the Dolores. The solutions are not in the science. Ultimately, a "do-able 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. Adopting such an adaptive management approach, while ensuring the protection of Dolores Project allocations and water rights, seems to be a key way to advance the purpose and efforts of the Dolores River Dialogue.

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

1. Further Define the Opportunities: In support of future Framework proposals, DRD can 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 (not completed as of July 2011).
- In 2010, collect 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 (completed as of July 2011; see Anderson C. 2011).
- Test the effects of exclusive use of SLOW 3 (no use of the Bypass Gate at the bottom of the dam) as a tool for reducing high algal biomass and low DO in downstream environmen (completed as of July 2011).

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, via the "A Way Forward" process.

VII. References

Anderson, C. 2007. Draft: Benthic macroinvertebrates Dolores River, McPhee Dam downstream. B.U.G.S. (**B**ioassessment **U**nderwater, **G**IS and **S**tats), Ignacio, CO. http://ocs.fortlewis.edu/drd/pdf/Macroinvertebrate%20Study-2007%20Field%20Season.pdf

Anderson, C. 2010a. Factors affecting populations of flannelmouth suckers on the Dolores River between McPhee Dam and the San Miguel River. Technical Memo to Dolores River Dialogue Steering Committee, 4/7/2010. Watershed llc, dba B.U.G.S. Consulting (**B**ioassessment **U**nderwater, **G**IS and **S**tats). (Appendix D)

Anderson, C. 2010b. Modeling the Relationship between McPhee Dam Selective Level Outlet Operations, Downstream Algal Biomass, Dissolved Oxygen and Temperature: Phase 1, Background Data and Model Development. Watershed llc, dba B.U.G.S. Consulting (**B**ioassessment **U**nderwater, **G**IS and **S**tats). (Appendix C)

Anderson, C. 2011. Draft: Temperature modeling for McPhee Reservoir discharge and the Dolores River downstream of McPhee. Dolores River Dialogue. 25pp.

Anderson, R. 2005. Riverine fish flow investigations. Job Progress Report, Federal Aid Project F-288-R8. Colorado Division of Wildlife, Fort Collins, CO. http://ocs.fortlewis.edu/drd/pdf/coreScienceReport.pdf

Anderson, R. & Stewart, G. 2007. Fish-Flow Investigation II: Impacts of stream flow alterations on the native fish assemblage and their habitat availability as determined by 2D modeling and the use of fish population data to support instream flow recommendations for the sections of the Yampa, Colorado, Gunnison and Dolores rivers in Colorado. In Special Report No. 80. Colorado Division of Wildlife. http://wildlife.state.co.us/NR/rdonlyres/778159B8-1EA2-443C-A0AF-A8DAB3F41473/0/SpecialReportpart2.pdf

Anderson, R. 2011. Evaluating potential barriers to cottonwood regeneration in the Big Gypsum Study Site and the Lone Dome State Wildlife Area on Dolores River, CO. Dolores River Dialogue. (Appendix G)

Bezzerides, N. and K. Bestgen. 2002. Status Review of Roundtail Chub *Gila Robusta*, Flannelmouth Sucker *Catostomus Latipinnis*, and Bluehead Sucker *Catostomus Discobolus,* in the Colorado River Basin. Colorado State University Larval Fish Lab Contribution 118. 149pp.

Brouder, M. 2001. Effects of Flooding on Recruitment of Roundtail Chub, *Gila robusta*, in a Southwestern River. The Southwestern Naturalist, 46: 302-310.

Bryan, S. and M. Hyatt. 2004. Roundtail Chub Population Assessment in the Lower Salt and Verde Rivers, Arizona State Wildlife Grant Final Report. Arizona Game and Fish Department, Phoenix, AZ 85023 19pp.

Byers, D., C. Sodergren, J. Bundy and K. Bestgen. 2001. Habitat use and movement of bluehead sucker, flannelmouth sucker and roundtail chub in the Colorado River. Contribution 121, Larval Fish Laboratory, Dept. of Fishery and Wildlife, CSU, Fort Collins CO.

CDOW. 2008. Dolores River Basin Aquatic Wildlife Management Plan,. Colorado Division of Wildlife, Aquatic Wildlife Section, Denver, CO. 54pp.

Coble, A. 2010. Riparian Tree Response to Variation in Climate and Altered Streamflow along the Dolores River, Colorado. Northern Arizona University, Flagstaff, AZ. 113pp.

Cooper, D., D. Andersen and R. Chimner. 2003. Multiple pathways for woody plant establishment on floodplains at local to regional scales. J. Ecol. 91:182-196.

Cooper, D., D. Merritt, D. Andersen and R. Chimner. 1999. Factors controlling the establishment of Fremont cottonwood seedlings on the upper Green River, USA. Regulated Rivers: Research and Management 15: 419-440.

Courtenay, W. and P. Moyle. 1992. Crimes against Biodiversity: The lasting legacy of fish introductions. Trans. N. A. Wildlife & Nat. Res. Conference No. 57. 57:365-372.

Dolores River Dialogue. 2005. Plan to Proceed. http://ocs.fortlewis.edu/drd/pdf/DRD%20Plan%20to%20Proceed.pdf

Graf, D. 2006. Dolores River Dialogue Draft Correlation Report: Summary of hydrologic and scientific findings and resulting matrix templates. Dolores River Dialogue. http://ocs.fortlewis.edu/drd/pdf/DRD_Correlation%20Report_DG%209-5-06.pdf

Holden, P.B. & Stalnaker, C.B. 1975. Distribution of fishes in the Dolores and Yampa River systems of the upper Colorado basin. The Southwestern Naturalist, 19, 403-412.

Korman, J. and T. Melis. 2011. The effects of Glen Canyon Dam operations on early life stages of rainbow trout in the Colorado River: U.S. Geological Survey Fact Sheet 2011-3002, 4 p.

Kowalski, D., J. White, R. Anderson and B. Nehring. 2010. Native Fish of the Lower Dolores River: Status, Trends, and Recommendations. Presentation to Full DRD on March 24, 2010.

Kriegshauser, D. & Somers, P. 2004. Vegetation changes in a riparian community along the Dolores River downstream from McPhee Reservoir in southwestern Colorado. In: *The Colorado Plateau: Cultural, Biological, and Physical Research.* C. Van Riper, and K. L. Cole, editors. University of Arizona Press, Tucson, AZ. http://ocs.fortlewis.edu/drd/pdf/coreScienceReport.pdf

Lytle, D. and D. Merritt. 2004. Hydrologic Regimes and Riparian Forests: A Structured Population Model for Cottonwood. Ecology 85: 2493-2503.

Mahoney, J. and S. Rood. 1998. Streamflow requirements for cottonwood seedling recruitment - an integrative model. Wetlands 18:634-645.

Merritt, D. 2005. Dolores River Dialogue Riparian Vegetation Analysis. In: Core Science Report for the Dolores River Dialogue. J. Siscoe, editor. 133pp. http://ocs.fortlewis.edu/drd/pdf/coreScienceReport.pdf

Merritt, D.M., and N.L. Poff. 2010. Shifting Dominance of Riparian *Populus* and *Tamarix* along Gradients of Flow Alteration in Western North American Rivers. Ecological Applications 20(1): 135-153.

Mueller, G.A., and R. Wydoski. 2004. Reintroduction of the flannelmouth sucker in the lower Colorado River. North American Journal of Fisheries Management 24(1): 41-46.

Muth, R., L. Crist, K. LaGory, J. Hayse, K. Bestgen, T. Ryan, J. Lyons, R. Valdez. 2000. Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam. Upper Colorado River Endangered Fish Recovery Program Project FG-53. 343pp.

Nehring, R. 1979. Evaluation of instream flow methods and determination of water quantity needs for stream in the state of Colorado. Report to the US Department of Interior, US Fish and Wildlife Service. Colorado Division of Wildlife Final Report, Fort Collins, CO.

Nolting, D. 1959. The effects of uranium mill waste disposal on the fish populations and aquatic productivity of the lower San Miguel and Dolores rivers. State of Colorado Department of Game and Fish. 15pp.

Porter, J. and D. Graf. 2005. Hydrology Report for the Dolores River Dialogue. Dolores River Dialogue.

Rees, D. and W. Miller. 2001. Habitat selection and movement of native fish in the Colorado River, Colorado. Miller Ecological Consultants, Inc. Fort Collins, CO.

Richard, G. & Anderson, R.M. 2007. Channel-forming discharge on the Dolores River and Yampa River, Colorado. Technical Publication No. 44. Colorado Division of Wildlife, Fort Collins, CO.

Richard, G. and A. Wilcox. 2005. Dolores River Dialogue Geomorphology Analysis. In: Core Science Report for the Dolores River Dialogue. J. Siscoe, editor. 133pp.

Rood , S. J. Braatne, and L. Goater. 2010. Responses of obligate versus facultative riparian shrubs following river damming. River. Res. Applic. 26: 102-117.

Scoppettone, G. 1993. Interactions between Native and Non-native Fishes of the Upper Muddy River, Nevada. *Transactions of the American Fisheries Society* 122:599-608.

Scott, M, G. Auble, and J. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological Applications 7:677-690.

Sher, A.A., and D.L. Marshall. 2003. Seedling Competition between Native *Populus deltoides* (Salicaceae) and Exotic *Tamarix ramosissima* (Tamaricaceae) Across Water Regimes and Substrate Types. American Journal of Botany 90: 413-422.

Siscoe, J. 2005. Editor, Core Science Report for the Dolores River Dialogue. Dolores River Dialogue. 133pp. http://ocs.fortlewis.edu/drd/pdf/coreScienceReport.pdf

Stewart, G. & Anderson, R.M. 2007. Fish-Flow Investigation I. Two-dimensional modeling for predicting fish biomass in western Colorado. In Special Report Number 80. Colorado Division of Wildlife. http://wildlife.state.co.us/NR/rdonlyres/1F5A5F31-DDCB-4478-B810-1B37B129627F/0/SpecialReportpart1.pdf

Tamarisk Coalition. 2010. Dolores River riparian Action Plan (DR-RAP). March 2010. Data DVD.

US Bureau of Reclamation. 1996. Proposal to modify operation of McPhee Reservoir and acquire additional water for fish and wildlife resources: environmental assessment (and biological assessment - Appendix A). Bureau of Reclamation, Western Colorado Area Office.

US Department of Interior . 2009. Endangered and Threatened Wildlife and Plants: 12 month Finding on a Petition to list a Distinct Population Segment of the Roundtail Chub (Gila robusta) in the Lower Colorado River Basin; Proposed Rule. Fish and Wildlife Service. 50 CFR Part 17. Federal Register, Vol. 74, No. 128. p. 32352-32387.

US Department of Interior and US Department of Agriculture. 2007. San Juan Public Lands Draft Land Management Plan Draft Environmental Impact Statement. Bureau of Land Management Dolores, Columbine and Pagosa Field Offices and US Forest Service – Region 2, San Juan National Forest.

Utah Division of Wildlife Resources. 2006. Range-Wide Conservation Agreement and Strategy For Roundtail Chub *Gila Robusta*, Bluehead Sucker *Catostomus discobolus*, and Flannelmouth Sucker *Catostomus Latipinnis.* Prepared for Colorado River Fish and Wildlife Council. Publication Number 06-18. Salt Lake City, UT. 59pp. http://wildlife.state.co.us/NR/rdonlyres/C0157052-214D-4E9D-B9C3-CCCE989EE715/0/ChubSuckerRangewideConservationAgreementandStrategy010407.pdf

Valdez, R, P. Mangan, M. McInerny and R. Smith. 1982. Tributary Report: Fishery Investigation of the Gunnison and Dolores Rivers. Pages 321-365 in W.H. Miller et al., editors. Colorado River Fishery Project, Final Report; Part Two, Field Studies. U.S. Fish and Wildlife Service and Bureau of Reclamation. Salt Lake City, UT. 365pp.

Valdez, R., A. Masslich, W.J. & Wasowicz, A. (1992) Dolores River native fish habitat suitability study. UDWR Contract No. 90-2559*.* Prepared for: Utah Division of Wildlife Resource, Salt Lake City, UT. 111pp.

Vandas, S. D. Whittaker, D. Murphy, D. Prichard, L. MacDonnell, B. Shelby, D. Muller, J. Fogg, B. Van Havern. 1990. Dolores River Instream Flow Assessment: Project Report. BLM/YA/PR-90/003+7200. Bureau of Land Management, Montrose, CO. 92pp.

Wilcox, A. & Merritt, D.M. 2005. Effects of modified flow regimes on the Dolores River. Riparian Response to Altered Flow Regimes, Proceedings of the Colorado Riparian Association, 18th annual conference, October 5-7, 2005, Durango, CO, pp. 69-83. http://coloradoriparian.org/conferences/conf2005/2005_proceedings.pdf

White, J. 2009. Presentation to Lower Dolores Plan Working Group on February 17, 2009. Lower Dolores River Fishery Status: Lower Dolores River Corridor Planning Meeting. Colorado Division of Wildlife. http://ocs.fortlewis.edu/drd/handouts/2008%20Dolores%20River%20Update_revised%20Corridor%20Planning%20Feb%2009%20(2).pdf

White, J. 2010. Dolores Biology Team Meeting Summary. Submitted to Biology Team and others on March 30, 2010.

VIII. Appendices

A. **Excerpt of pages 12-29 from the Correlation Report (Graf 2006): "Hydrology and Downstream Ecology Pre-McPhee Reservoir through Dolores Project Operations."**

B. **Table 1 from Correlation Report (Graf 2006): "Model Results Summarized for the DRD Hydrology Analysis."**

C. ***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, 2010.

D. ***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, 2010.

E. ***Baseline sampling of riparian vegetation in Big Gypsum Monitoring Site*** by Adam Coble and Rob Anderson, 2010.

F. ***Baseline channel cross sections at Big Gypsum Monitoring Site*** by Rob Anderson, 2010.

G. ***Evaluating Potential Barriers to Cottonwood Establishment in Big Gypsum Valley and Lone Dome Reaches of the Dolores River*** by Rob Anderson, 2011.

H. ***DRD Framework Process Questions.***

I. ***Potential Tools Identified as of July 2010.***