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Dolores River Dialogue
Correlation Report

Summary of Hydrologic and Scientific Findings and Resulting Matrix Templates

9-5-06

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Dolores River Dialogue
Correlation Report: Summary of Hydrologic and Scientific Findings
And Resulting Matrix Templates (9/5/06)

I. Hydrology – Expected Future Water Availability
   A. Current Management of Downstream Releases from McPhee Reservoir
   B. Current Management Hydrographs
   C. Analysis of Downstream Environments
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III. Current Management – Expected Ecological Conditions
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   B. Blue Sheet Template Displays Expected Ecological Conditions Reach by Reach by the 4 Disciplines (See Template Attachment A)
   C. Green Sheet Template Displays a Series of Specific Alternatives for Addressing Ecological Targets Using Flexible Spill Management Scenarios with Expected Ecological Conditions Reach by Reach by 4 Disciplines, Supported by Hydrographs
   D. Pink Sheet Template Displays Base Flow Enhancements of 3,000 AF and 6,000 AF with Expected Ecological Conditions Reach by Reach by 4 Disciplines (Attachment A)
   E. Brown Sheet Template Displays Specific Alternatives for In-Channel Restoration with Expected Ecological Conditions Reach by Reach by 4 Disciplines (Attachment A)

V. Analysis of Specific Doable Alternatives
   A. Based on Template Analysis Outlined in III. Above, Alternatives Indicating Significant Benefits will be Analyzed to Juxtapose Ecological Costs and Benefits with Changes in Present Operation and Social, Political and Financial Costs.
   B. This Analysis will be Displayed in a “Matrix for Analysis of Doable Alternatives” (Attachment B)

Dolores River Dialogue Correlation Report: Summary of Hydrologic and Scientific Findings And Resulting Matrix Templates

Introduction

The Dolores River Dialogue (DRD) is a multi-stakeholder effort aimed at improving the environment of the Dolores River downstream of McPhee Dam, while protecting or enhancing human uses of the Dolores River resource. After completion of the DRD Hydrology Report (water availability analysis) and the Core Science Report (summary of downstream environments), this Correlation Report is intended to integrate the findings of the two prior DRD studies. The purpose relating these three DRD reports is repeated from the Plan to Proceed, below:

> *"PURPOSE"*
>
> *"This Plan To Proceed outlines the three technical understandings required to get to the point where the Dolores River Dialogue Group can make a responsible decision about what, if any, action to take to implement its goals. First, a water availability analysis needs to be done. That analysis needs to describe the amount of water expected to flow downstream of McPhee Reservoir through spills and base flow releases. It also needs to describe the realistic opportunities to manage or enhance those flows. Second, an analysis of potential downstream environments needs to be made. The science associated with different flow patterns downstream of McPhee Reservoir needs to be described. Third, a correlation between those two efforts needs to be made that will illuminate the practical actions that could result from the efforts of the DRD Group. A matrix of doable alternatives with identified consequences (scientific, institutional, legal, political, and fiscal) will be described. The Plan's finished products are designed to be thorough, credible, and realistic in their analysis of what is possible and what hurdles different actions may potentially face."*

This report presents a summary of the correlation between the water availability analysis and potential downstream environments in order to frame a matrix of doable alternatives with identified consequences.

I. DRD Hydrology and Expected Future Water Availability

Table 1 is a summary model of 77 years of flows (1928-2005) on the Dolores River estimating the frequency and magnitude of spills given actual inflow gage records at Dolores, storage in McPhee Reservoir, and full Dolores Project demands. The purpose of this modeled summary is to provide the best estimate of expected future water availability as a foundation for correlating potential opportunities to manage spills and base flow releases with expected benefits to the downstream environment. Each year in Table 1 is color coded to reflect no spill (white), small spill (pink), medium spill (light green) and large spill (dark green and blue) years. Table 1 provides a quick visual summary of the expected spill patterns over long time spans and will be applied in the correlation analysis that follows.

The baseflow component considered for this analysis includes 29,300 AF of Project water allocated for downstream fishery releases, and 700 AF of Project water allocated for augmentation needs of the BOR's Paradox Salinity Unit. In addition, up to 3,900 AF of water may be released to meet senior downstream water demands, which are non-project bypass flows. No allocation for senior water rights downstream of McPhee Dam exists within Dolores Project allocations. Thus for the purpose of the analysis, 30,000 AF is used to represent the Project allocations for downstream baseflow release. The Paradox augmentation water is not subject to allocation shortages.

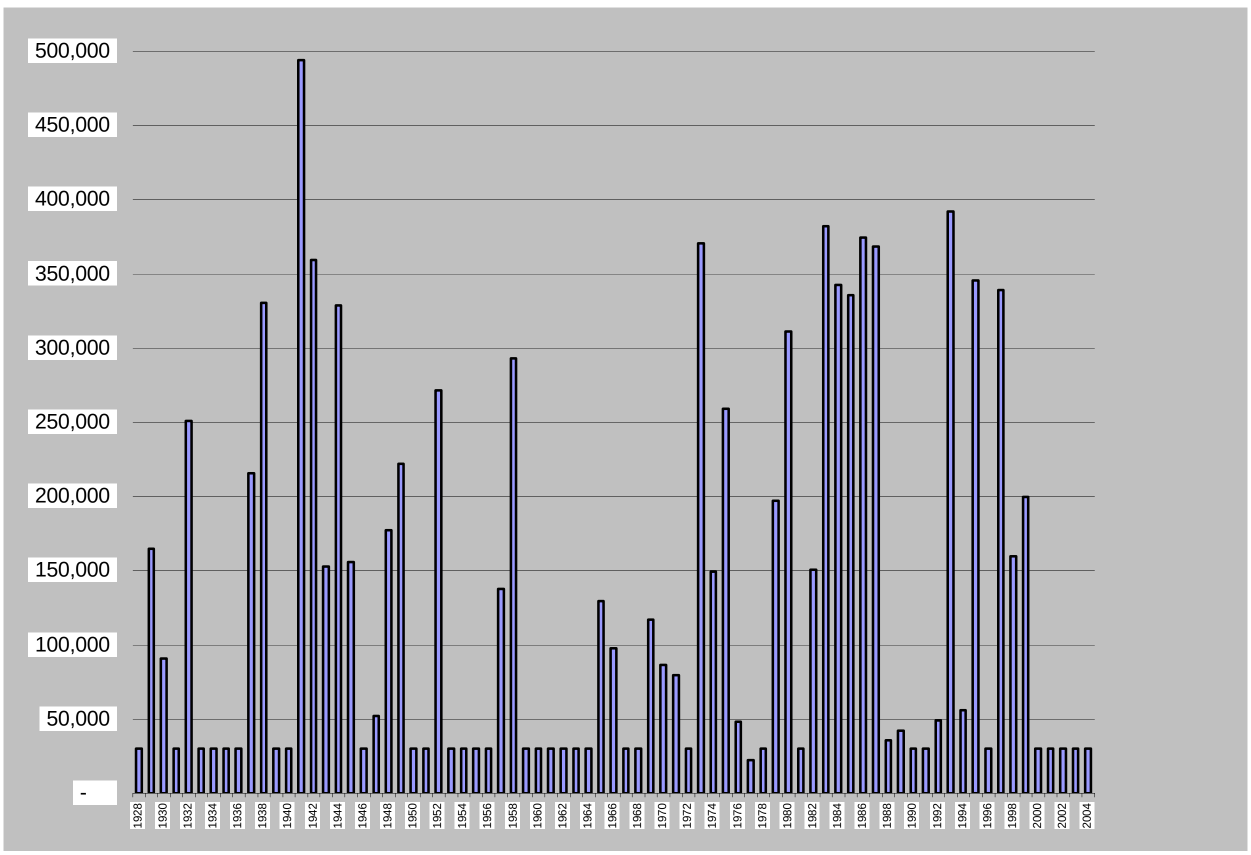


Figure 1. DRD Hydrologic Model output summarized by modeled year. Data includes baseflow (30,000 AF) and one year of modeled shortage in 1977.

Table 1: Model Results Summarized for the DRD Hydrology Analysis

	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
1933	
1934	
1935	
1936	
1937	185390
1938	300298
1939	
1940	
1941	464005
1942	329268
1943	122803
1944	298699
1945	125934
1946	
1947	21945
1948	147226
1949	192220
1950	
1951	
1952	241338
1953	
1954	
1955	
1956	
1957	107804
1958	263062
1959	
1960	
1961	
1962	
1963	
1964	
1965	99335
1966	67568
1967	
1968	
1969	87092
1970	56369
1971	49617
1972	
1973	340592
1974	119428
1975	229032
1976	18317
1977	
1978	
1979	166998
1980	281263
1981	
1982	120428
1983	352232
1984	312359
1985	305518
1986	344394
1987	338143
1988	5685
1989	12281
1990	
1991	
1992	19007
1993	362179
1994	25955
1995	315648
1996	
1997	309241
1998	129724
1999	169450
2000	
2001	
2002	
2003	
2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

No Spill - 35 of 78 years (45%)
Spill < 64,000AF (12%)
64K < Spill < 187K AF (18%)
187K < Spill < 310K AF (14%)
Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Average Spill = 187,010 AF
Maximum Spill = 464,005 AF
Minimum Spill = 5,685 AF
Standard Deviation = 123,141 AF (66% of AVE)

SUMMARY of Spill Interval Data (43 YRS SPILL incl.'05)
CONSECUTIVE SPILL YEARS: 28 OF 43 (65%)
2 YEARS BETWEEN SPILL YEARS: 5 OF 43 (12%)
3 YEARS BETWEEN SPILL YEARS: 5 OF 43 (12%)
4 YEARS BETWEEN SPILL YEARS: 0 OF 43 (0%)
5 YEARS BETWEEN SPILL YEARS: 2 OF 43 (4.7%)
6 YEARS BETWEEN SPILL YEARS: 1 OF 43 (2.3%) - (1999-2005)
7 YEARS BETWEEN SPILL YEARS: 1 OF 43 (2.3%) - (1958-1965)

Note On Table 1 Hydrologic Model:

This modeled hydrology and the analyses that it supports provides the best available prediction of future expected hydrologic conditions on the Dolores River below McPhee Dam.

A. Current Management of Downstream Releases from McPhee Reservoir

Baseflow Management The current management objectives for release of baseflow from McPhee are to provide enough water during the spring, summer, and early fall months to maintain a healthy trout population below the dam. Winter flow studies in the early 1990s indicated that habitat availability is maintained by flows as low as 30 cfs. Provided that the fishery / baseflow pool is full, flows greater than 30 cfs are preferentially released spring through fall to maintain adequate summer temperatures. Releases of 30 cfs generally persist from November through March. Spring flows ramp slowly April through June, and peak annually in July and August to approximately 60 cfs to minimize thermal stress to coldwater species. Flow in September through October ramps down to winter baseflow of 30 cfs, generally beginning sometime mid-October or November, depending on water availability. In addition, a 12-hour fish stocking release of 400 cfs (400 AF) is often scheduled annually near October 1, based on fish availability.

Spill Management Spill management criteria apply to management of water supplies excess to Project and other water demands in McPhee (the "spill water"). Operations criteria that relate to spill management are presented below.

McPhee Operations Criteria (BOR, 2005):

- Fill the Reservoir when possible.
- Do not allow the reservoir to exceed elevation 6920.00 prior to the end of May (this condition allows for 4 vertical feet of freeboard as flood control in the event of rapid snowmelt after May 31).
- Manage releases to provide white water boating opportunities, when possible.
- Try to peak releases over the Memorial Day weekend.
- Manage releases in such as way that it is not necessary to use the emergency spillway (fully utilize the selective level outlet works for ALL managed spills).
- Provide a minimum of 2,000 cfs for seven days for channel maintenance.
- Try to limit releases to less than 4,000 cfs.
- Provide a minimum raftable release of 800 cfs as long as possible.

Managed spill releases end when reservoir inflows match the project demand. The resulting hydrology over the last 20 years suggests that when there is a large spill anticipated, there is often one occasion prior to June 1 when a large quantity of water is released rapidly for a short period to ensure the flood capacity restriction is maintained (maximum water surface elevation of 6920 ft before June 1). The target for the maximum release is the Memorial Day weekend. Although there is no provision for ramping flows noted above, when flows are less than 800 cfs, ramping of no more than 200 cfs over a two day period is usually maintained.

B. Current Management Hydrographs

This section presents a composite hydrograph for four McPhee release scenarios: baseflow releases only, and small, average, and large spills. Baseflow only conditions (30,000 AF) are defined as those years in which there is no excess supply available for downstream releases. Based on the modeled hydrology, an average spill is approximately 187,000 AF. The standard deviation from the average spill was used to define a specific release for the small and large spills. One standard deviation was approximately 123,000 AF, so a small spill was defined as the average minus one standard deviation (187,000 AF – 123,000 AF = 64,000 AF). A large spill was approximately 310,000 AF (187,000 AF + 123,000 AF).

Figure 2 presents a composite plot of these four hypothetical hydrologic scenarios. Notable features that have bearing on the expected ecological outcomes are the relative magnitudes of peak flows, duration of a flow that performs work on the channel (raftable flows > 800 cfs generally provide this amount of stream power), and the rate at which peak flows taper to the baseflows (the 'recession limb' of the hydrograph). These are not actual operations hydrographs, but represent a coarse integration of management objectives and water availability given the range of scenarios described above.

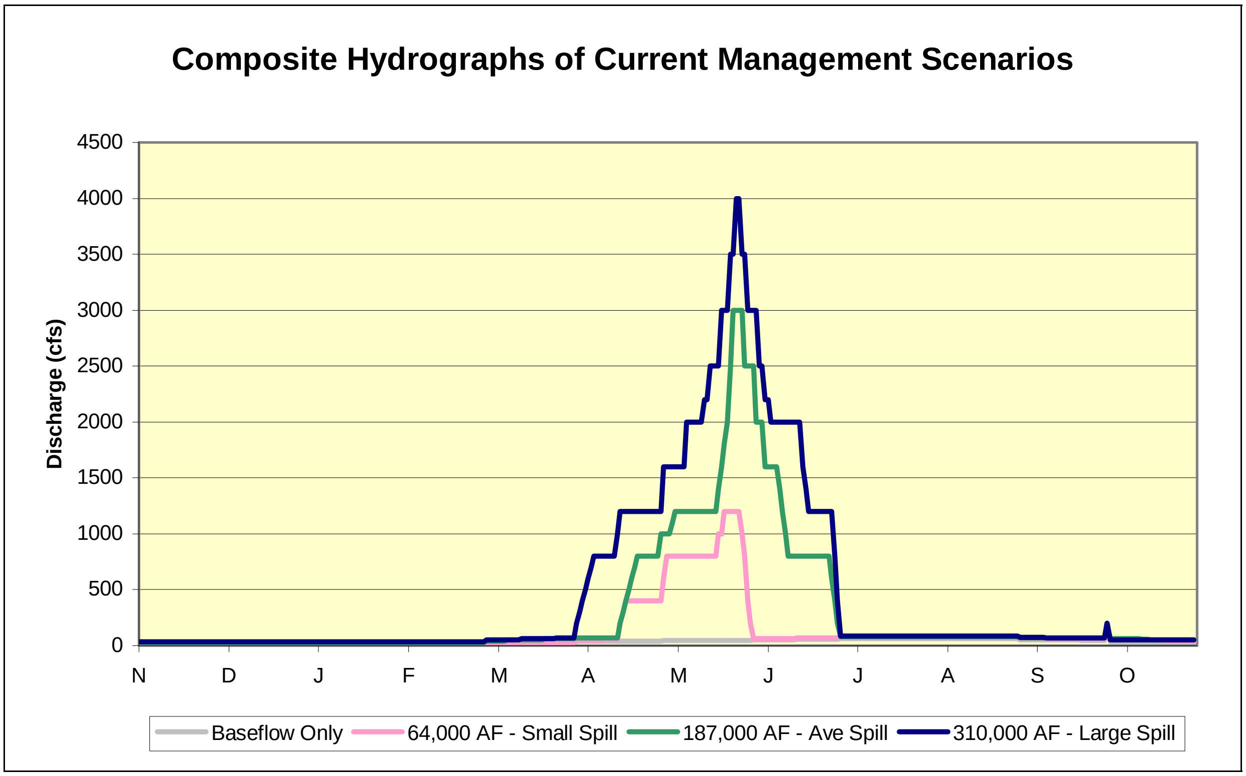


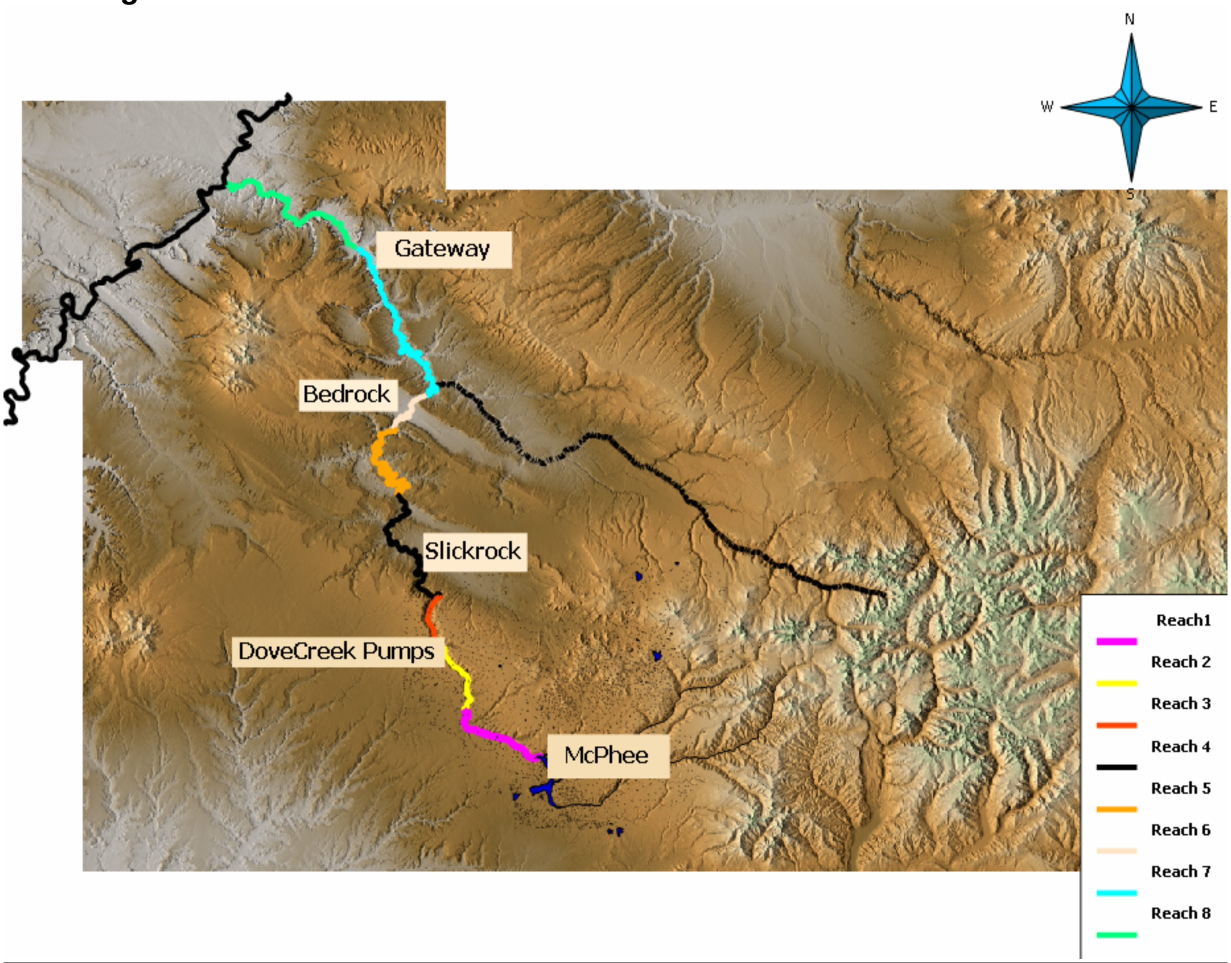
Figure 2. Composite Hydrographs for the four current management scenarios being discussed in this section. The small spike October 1 is the 12-hour, 400 cfs release for fish stocking between McPhee Dam and Bradfield Bridge.

C. Analysis of Downstream Environments

Reach Delineations

In order to provide a framework for analysis of conditions along the lower Dolores River and illuminate potential future management opportunities, the study area has been divided into 8 reaches (Figure 3). These reaches were identified by distinct differences in gradient, sinuosity, chemical parameters (e.g. salts), vegetative characteristics and potential limiting factors to natural stream channel movement and formation. [Core Science Report, Page 6]

Figure 3: Reach Delineations Dolores River Below McPhee Dam



Because the current focus of the DRD is how flow management of McPhee releases affect ecological function downstream, this report limits analyses to reaches 1-6, which as the Figure above indicates are above the confluence with the San Miguel River. Reaches 1-6 are briefly described below:
[DISCUSSION ITEM: TO WHAT EXTENT ARE 'DATA/CONCLUSIONS' APPROPRIATE FOR THIS SECTION (AS PART OF THE 'REACH DESCRIPTION')?]

<u>Reach 1</u> McPhee Dam to Bradfield Bridge (12 miles) – This low-gradient reach has a riparian area dominated by narrow-leaf cottonwood, box-elder and willow. The reach is contained within a wide valley bottom, and the channel is characterized by meandering pools-riffle sequences typical of alluvial environments. This reach is well known as the "Catch and Release" area and because of the investment in the coldwater fishery, has been the focus of base flow management. This entire reach is accessible by gravel road running along the right bank.

<u>Reach 2</u> Bradfield Bridge to Dove Ck Pumps (19 miles) – This reach has a steeper gradient, and channel pattern and structure are controlled by bedrock outcrops and boulders introduced from hillslopes and cliffs above the river. Riparian vegetation is characterized by a Ponderosa Pine woodland with willows and oaks along the stream corridor. This reach is secluded and can only be accessed by hiking in or floating the river. A naturally reproducing brown trout population at about 15 lbs/ac is sustained without the benefit of re-stocking. Surveys in 2005 suggest that native warm water sucker species (flannelmouth sucker, bluehead sucker) have been nearly eliminated from this reach (CDOW 2005).

<u>Reach 3</u> Dove Creek Pumps to Joe Davis Hill (9 miles) – A relatively steep river gradient and a channel confined by steep cliffs and large boulders characterize this reach, with the valley broadening in the downstream direction. A 2-track dirt road on the left bank provides access throughout this reach. Ponderosa pine/ box elder dominate the riparian area with some old cottonwood stands on river terraces. The pine-box elder canopy gives way downstream to willow and sedge-dominated streambanks, with juniper and pinon pine occupying habitat above the active channel. Fifteen (15) years of survey data from a site 1.3 miles from the Dove Creek pumps (upper end of Reach 3) indicate declining populations of native sucker species (flannel-mouth and bluehead), highly variable populations of roundtail chub, and recently increasing populations of non-native green sunfish, notably in 2000-2004. This reach has fewer brown trout w/ distance downstream. Desert bighorn sheep utilize stepped cliffs and canyon rims. "Snaggletooth" rapid, a class V run at high water, is the major recreational boating attraction.

<u>Reach 4</u> Joe Davis Hill through Big Gypsum Valley (38 miles) – This reach is fairly flat with a near-stream corridor dominated by sage, rabbitbrush, and greasewood on the upper banks with increasing tamarisk downstream. Riparian areas include fairly dense willow-sedge communities, with increasing presence of *phragmites* sp. in the downstream direction. Silver buffaloberry, a native shrub, is occasionally dominant through the upper-most reaches. There are large older cottonwoods in places, disconnected from river dynamics. The reach has three distinct sub-reaches: Joe Davis Hill to Disappointment Ck (confined, mainly colluvial and bedrock controls); Disappointment Ck to Big Gypsum Valley (mainly confined, but heavily affected by sediments from Disappointment Creek); and the alluvial reach through the Big Gypsum Valley. The combination of high fine sediment loads from tributary watersheds draining Disappointment and Big Gypsum Valleys and vegetation that aggressively colonizes fresh sediment (mainly tamarisk, willow, and *phragmites)* has narrowed and entrenched the active channel through alluvial portions of Reach 4. Surveys indicate a prevalence of non-native aquatic species. Only one brown trout was sampled in five years of surveys in the Big Gypsum Valley, and this reach is not considered a cold water fishery.

Reach 5 **Big Gypsum Valley to Wild Steer Canyon (42 miles)** – Reach 5 Slickrock Canyon) has a low gradient, high sinuosity, and is confined by steep canyon walls. The river through most of this reach is only accessed by hiking in or floating the river. Few to no trout are found in this part of the river and salinity levels rise downstream. A fairly distinct change in riparian vegetation occurs just upstream of Coyote Wash, where native communities of box elder, New Mexico privet and willow change to a tamarisk-dominated riparian area. A few scattered spring-fed cottonwoods occur in side tributaries (e.g., Bull Canyon), but they are not a component of the main channel riparian community. A BLM Wilderness Study Area surrounds this reach of the river. The reach has not been sampled for native fish since 1992, when a relatively complete assemblage of native fish was identified.

Reach 6 **Wild Steer Canyon to San Miguel River (12 miles to Saucer Basin)** Flat and wide with high concentrations of salt, this area is dominated by tamarisk. Large stands of very old cottonwoods still exist, disconnected from channel dynamics, and there is little or no evidence of regeneration. A salt dome beneath the Paradox Valley introduces high salt loads into surface water through this reach. High salinity, fine sediment accumulations, and lack of channel structure result in poor habitat quality for native fish through the Paradox Valley. The last few miles enter a broad but confined canyon, where increasing gradient and channel structure improve instream habitat potential above the confluence with the San Miguel River. A county dirt road allows access throughout the canyon portion of Reach 6.

D. Core Science: Discipline Summaries

[SAME DISCUSSION ITEM: TO WHAT EXTENT ARE 'DATA/CONCLUSIONS' APPROPRIATE FOR THE DISCIPLINE SUMMARIES?]

To evaluate the various strategies and determine the preferred alternatives, the Dialogue has convened a Core Science Team (CST) with technical expertise in several disciplines. This team was established in early February of 2005 to study and ultimately integrate four primary areas of investigation; Native warm water fisheries, Cold water fisheries, Geomorphology and Riparian Ecology…"
[Core Science Report, page 1]

Below, the four disciplines that frame the Core Science Report are briefly defined as they will be used throughout the Correlation Report: Geomorphology, Riparian Ecology, Cold Water Fishery and Warm Water Fishery:

Geomorphology: Geomorphology is described as the set of interactions between flow, sediment transport, local geology, and in some cases, vegetation, that result in the physical template for aquatic and riparian life forms. For the purposes of the Dolores River Dialogue, geomorphology is focused on how past and future predicted flows affect this physical template; thus it is considered the driving force behind ecological community potential for a given reach. The main conclusion of the Geomorphology authors in the Core Science Report is that flows are the dominant factor affecting physical and ecological processes, and flow management for ecological objectives presents a key opportunity to improve ecological conditions below McPhee Dam.

Riparian Ecology: Riparian ecology is the study of near-stream vegetation that in some way, is dependent upon or determined by river flows or river processes to satisfy the habitat requirements for riparian vegetation. Most changes in community structure do not result from a single event or single stressor but from multiple interacting causes within a particular riparian corridor. Riparian vegetation plays a key role in the human-valued services provided by rivers and also provides the fundamental structure for diversity of flora and fauna found along the river. A variety of factors influence the structure and composition of riparian vegetation growing along a particular reach of river, such as flows, salinity and soil type. The DRD should remain informed about how flow management affects the succession of riparian communities on the Dolores below McPhee Reservoir. When opportunities for restoration arise, especially with respect to tamarisk abatement or recruitment of native vegetation, the DRD needs to assess how flow management can support the restoration objectives.

Cold Water Fishery: Cold water fisheries support fish that prefer clear, cold waters. Cold water species are not tolerant of extreme temperature changes and cannot survive for long periods with temperatures above 68 degrees F. In the Dolores River below McPhee these are primarily rainbow trout and brown trout in the upper reaches described above. Limiting factors for cold water fisheries below the dam remain high summer water temperatures during baseflow periods, and a lack of high quality trout habitat, especially in Reach 1 (McPhee Dam to the Bradfield Bridge). Prolonged non-spill periods affecting geomorphic processes such as flushing of fines from pools and riffles and sorting of spawn-sized gravels also affect trout reproduction and survival through the upper reaches.

Warm Water Fishery: At some point below McPhee Dam (generally in Reaches 2 and 3), warm water temperatures favor fish adapted to warm water conditions. The focus of the DRD for warm water fisheries is on the population viability of endemic native fish, specifically diminishing populations of roundtail chub, flannelmouth sucker, and bluehead sucker. State fisheries managers have prioritized additional monitoring of native fish populations in the Dolores to discern population trends at different representative sites between McPhee Dam and Bedrock in order to define more clearly what factors are affecting native fish populations in the Dolores. Some possible factors include poor habitat quality (especially below Disappointment Creek), the presence of non-native predators and competitors for available habitat, water temperature, and hydrologic modification such as changes to the magnitude, timing, and frequency of peak discharges. There also remains uncertainty as to the reproductive strategies of these fish within the Dolores River, and ultimately, their population viability under current or proposed alternative flow management scenarios.

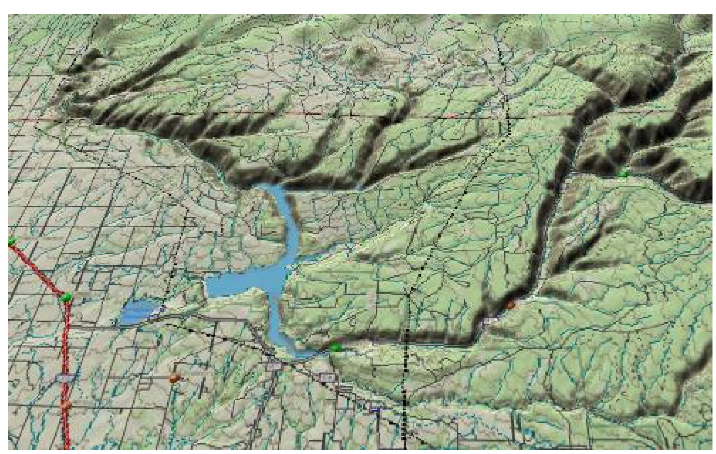
II. Hydrology and Downstream Ecology Pre-McPhee Reservoir through Dolores Project Operations

While the purpose of this correlation report is to provide a framework “to describe the amount of water expected to flow downstream of McPhee Reservoir through spills and base flow releases” [and] “realistic opportunities to enhance those flows”, such opportunities need to be evaluated based on “an analysis of potential downstream environments.” (DRD ‘Plan to Proceed’)

To set the stage for the analysis of potential downstream environments, the hydrology and downstream ecology of the Dolores River prior to McPhee dam will briefly be considered. Data from this period include gage records at Dolores and Bedrock, diversions from the Montezuma Valley Irrigation Company’s (MVIC’s) canals, and mainly anecdotal accounts of ecological conditions. Irrigation diversions from the Dolores were initiated in the late 1870s and early 1880s, and large irrigation diversions out of the basin through MVIC’s Main Canal No. 1 began in 1886. Below is a brief discussion of the hydrology and downstream ecology prior to water diversions from the Dolores River, followed by a description of the period from initial MVIC diversions until McPhee Dam was closed in 1986.

A. Pre-MVIC - Hydrology and Downstream Ecology

Geologic evidence suggests that the Dolores River Canyon below McPhee Dam is a remnant course of the San Juan River, which was separated and redirected to the south by a geologic uplift.



“The small town of Dolores is just to the right of the south end of McPhee Reservoir. The Dolores River then turns abruptly toward the northwest and enters Dolores Canyon in the upper left quadrant. Dolores Canyon continues northward across the anticline with the river forming a canyon over 2,000 feet deep.

The ancestral San Juan River established this path some 50 million years ago. 50 million years ago, all drainage on the western slope of the Rocky

Mountains was from south to north toward the Lake Uinta lowlands (Northeast Utah, Northwest Colorado, and Southwest Wyoming), and the anticline did not exist yet.

Some 20 to 30 million years ago, renewed uplifts from the La Plata Mountains southward forced the San Juan to relocate further south into New Mexico, but the upper Dolores River which was formerly just a tributary, inherited the entire route. Since then, the anticline has been uplifted, but the Dolores was entrenched and simply dug deeper to form Dolores Canyon. The zigzag path within Dolores Canyon is probably a remnant of another ancestral river (the ancestral Chaco River) that joined the ancestral San Juan before it too was truncated some 20 to 30 million years ago." [Bill Butler, Appendix to the Evolution of the Colorado River and its Tributaries (Part 5)]

For purposes of this correlation report conditions immediately prior to European settlement will be broadly described. The pre-settlement flow regime in the Dolores River was characterized by high spring runoff flows in April through June which tapered down to the lowest flows in December, January and February. Figure 4 below depicts the monthly percentage of total flows extrapolated from Dolores gage data to include McPhee Reservoir tributaries below the gage (e.g., Plateau Creek). These data will be used in conjunction with annual inflow data for the 76 years from 1928 through 2004 as the best approximation of pre-MVIC flows during dry, wet and average flow years.

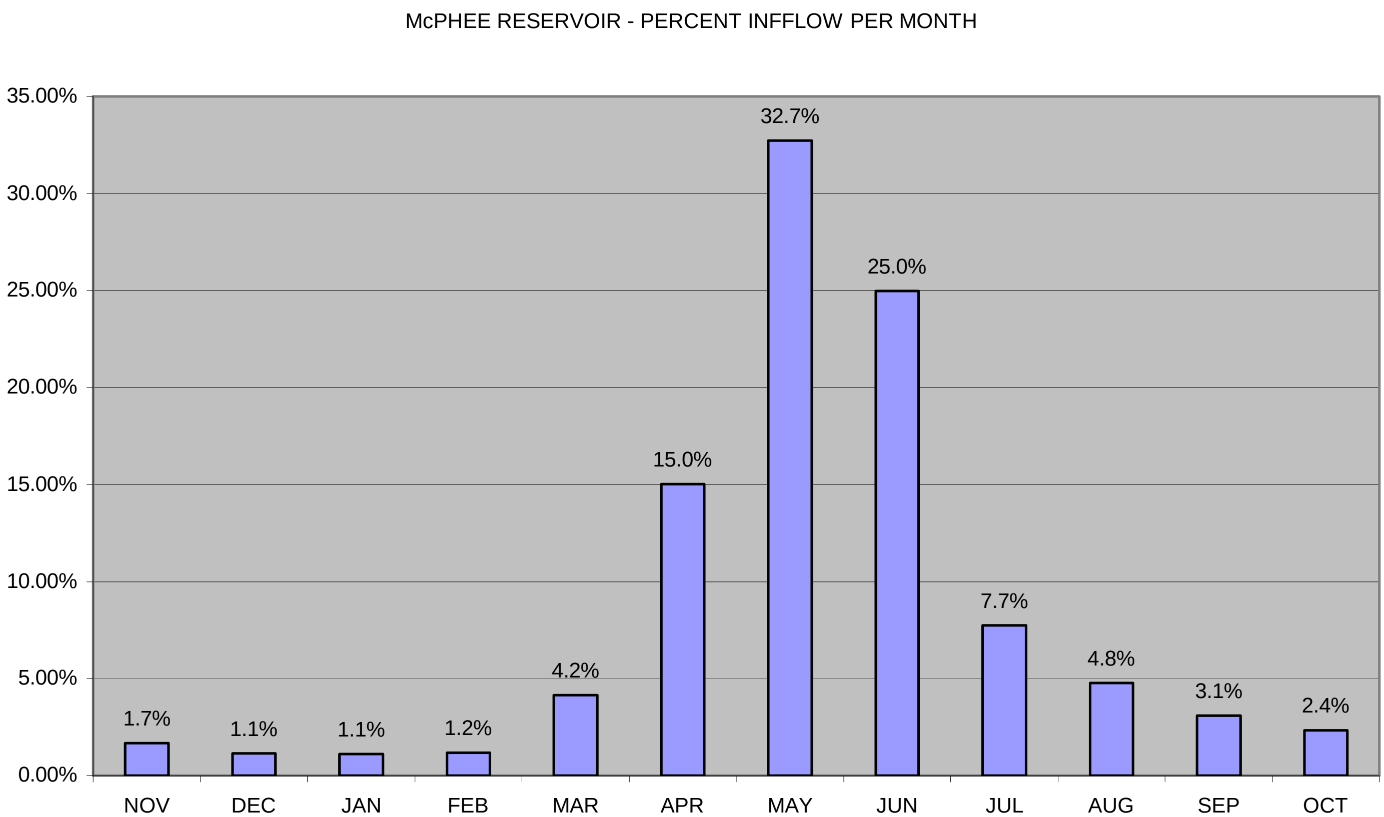


Figure 4. Monthly native inflow to McPhee Reservoir, based on gaged data from the Dolores gage data and accounting for tributary inflow below the gage.

Total annual inflow from 1928-2004 into the McPhee Reservoir site is presented below, and it should be clear that inflows to the Dolores River at McPhee is highly variable. The standard deviation of these 76 years of data is nearly 160,000 AF, meaning that for approximately 2/3 of the years, the 'expected variability of inflow' is ± 44% of the average total inflow. The other 1/3 of the years lie outside the 'expected variability', suggesting that outside of the monthly precipitation and snowpack forecasts, it is difficult to predict inflow to McPhee with any certainty.

A hydrologic analysis of the differences in total flows at Bedrock and Dolores was done to assess how the total flows varied at these locations in the pre-MVIC period. The analysis used daily flow data between 1974 and 1985 to assess how total flow, mean peak daily flow, and the timing of peak flows may have compared at these two gage locations absent any significant diversions. For total flow analyses, daily diversion records at the MVIC Canals Nos. 1 and 2, available from the State's Colorado Decision Support System (CDSS) hydrologic database, were added back into the gage record to determine the relationship of these variables over this 12-year period, which encompassed very dry (1977), very wet (1983) and average (1974) water years.

This analysis showed that even during dry years, total flow at Bedrock was greater than that at Dolores (Figure 6). This would be expected due to the nearly 4-fold difference in watershed area at these two gages. What is notable from this comparison is the insignificant flow contribution of tributary watersheds downstream of Dolores during dry periods, when flow at Dolores is nearly the same as that at Bedrock. During wet years, (e.g., 1979, 1980, 1983) total flow downstream is 50-60% greater than upstream at Dolores, indicating that contributions from downstream watershed increase proportionally to total moisture in the watershed.

Peak flows are an important ecological variable, as they perform the work necessary to flush sediments, rejuvenate floodplain habitats, and maintain channel form in alluvial reaches. In the geomorphic literature, the 'bankfull flow' is often related to the peak flow with a recurrence interval of approximately 1.5 years. Also called the 'effective flow' or 'dominant discharge', it is that flow which because of a relatively high frequency of occurrence combined with high stream power, does the most physical work on the channel over time. It is especially important in alluvial rivers (rivers with mobile bed and bank sediments), where the instream and floodplain habitats become a reflection of the balance between the dominant discharge, sediment flux, and vegetation. Cottonwoods are a species that is particularly dependent on periodic very high flows to scour near-channel and floodplain sites so that seeds can deposit on moist, bare surfaces in order to germinate and survive absent competition from other species.

Figure 5

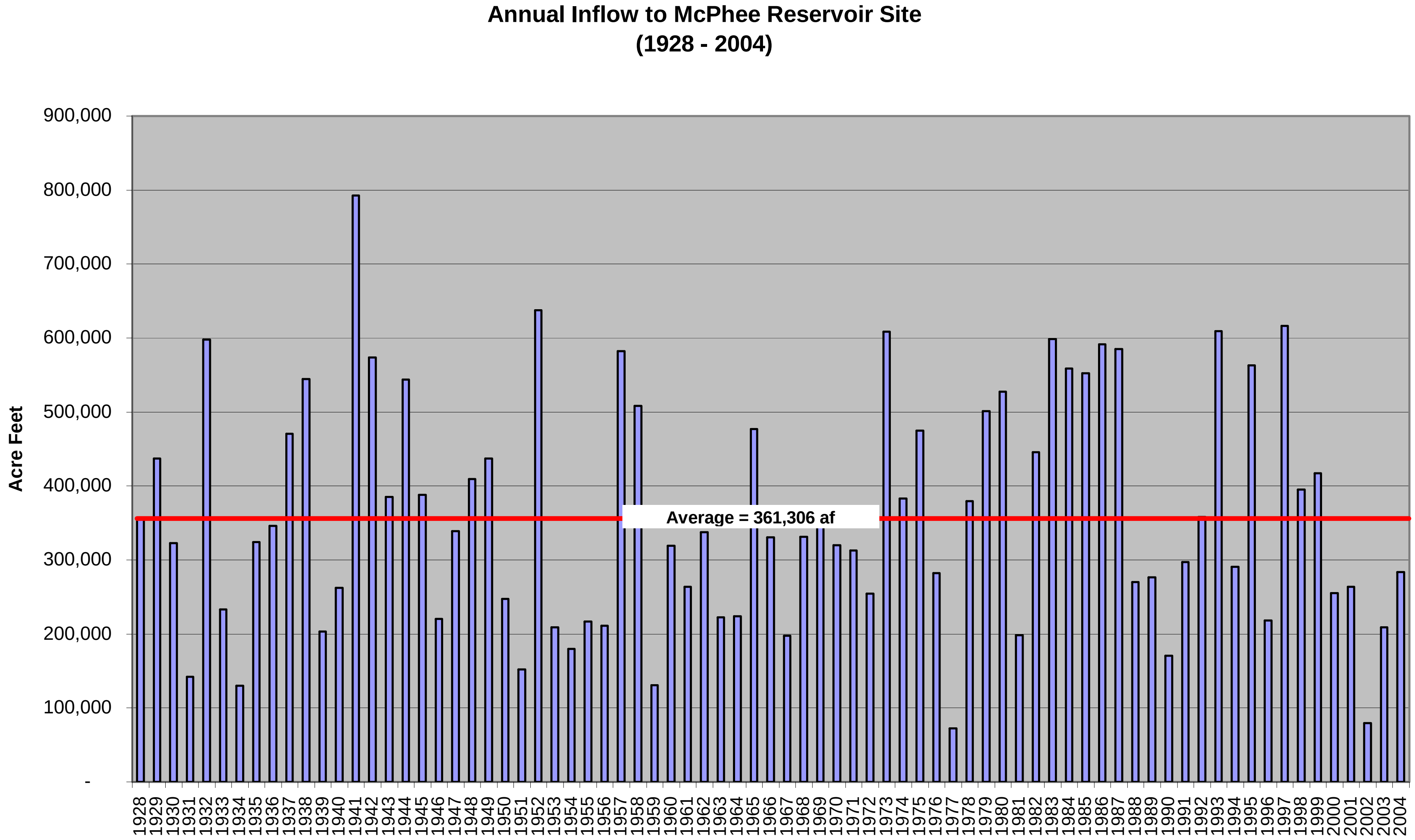


Figure 5 – Compilation of total annual inflow data from 1928-2004. Total inflows range from the driest year in 1977 (72,897 AF) to the wettest year in 1941 (793,000 AF). The average total inflow over the 76 years was 361,306 AF.

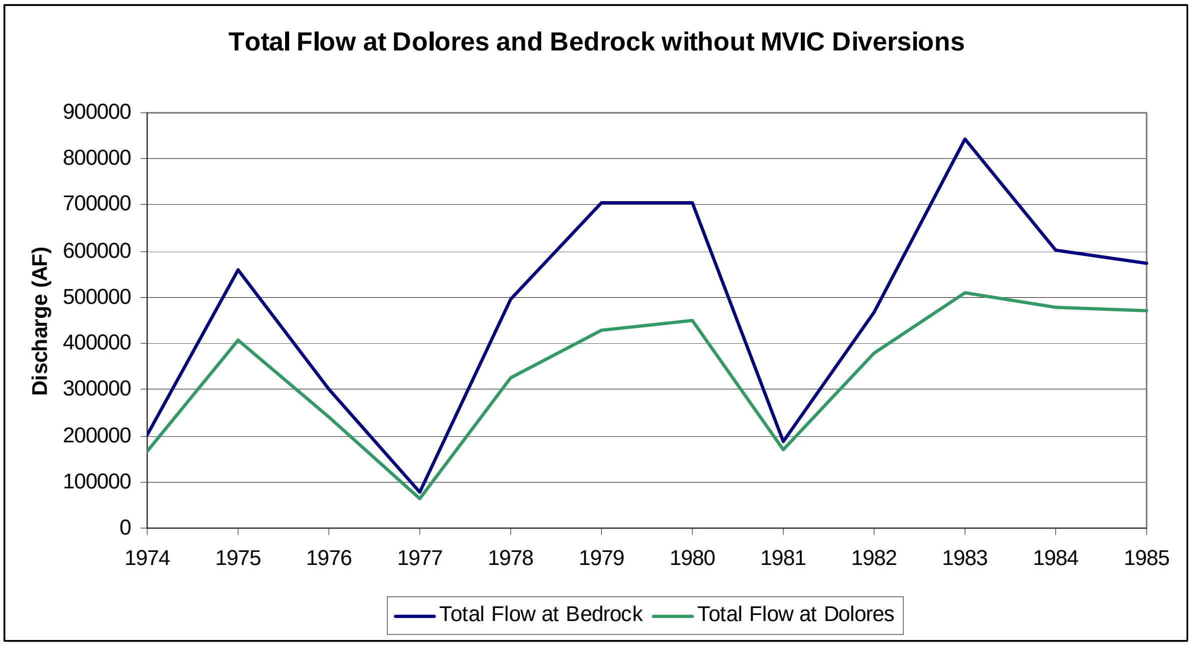


Figure 6. Total annual flow at Bedrock and Dolores gages for 1974-1985, synthesized at the Bedrock gage by adding MVIC daily diversions back into the daily gage record.

The peak flow data comparison over these years reinforces the general patterns for total flow described above (Figure 7) in that during wet years, peak flows at Bedrock were much larger than those at Dolores; during dry years, the difference between peaks at Dolores and Bedrock was diminished. However, there is greater variability in the peak flow data, especially when comparing the date that peak flows occurred. The four peaks greater than 8000 cfs at Bedrock all occurred between April 19 and April 26, while the peaks for the same years at Dolores occurred between May 30 and June 11. For dry years (e.g., 1974, 1977, 1981) the timing of peaks is even more variable, with peaks at Bedrock in 1974 and 1977 occurring in mid-July in response to monsoonal moisture. Peaks at Dolores generally shift forward (May 11 and April 18 in 1974 and 1977). In 1981, peak flow at Dolores and Bedrock were one day apart, indicating the direct relationship of snowmelt runoff and peak flow for this particular year. In general, these data indicate that the relationship between the peak flows at these two gage sites is not directly correlated.

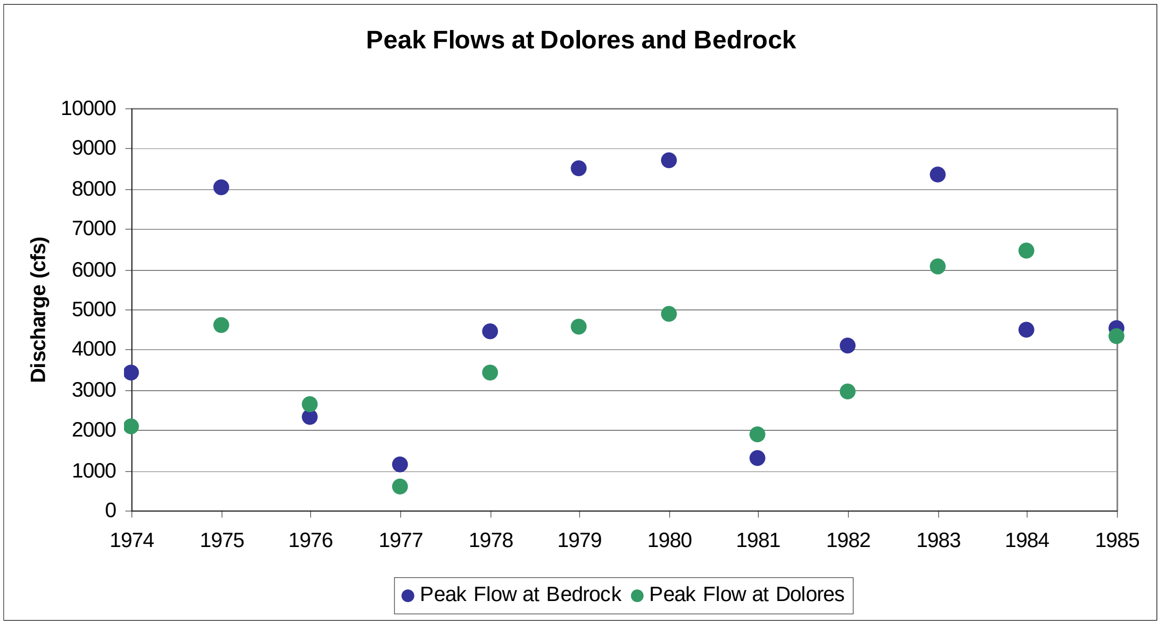


Figure 7. Peak flows at Bedrock and Dolores gages from 1974-1985. Because of timing variability and the relatively small amount of water diverted relative to the size and timing of the peak flow, daily MVIC diversions were not added back into the Bedrock record.

The annual inflow data for McPhee presented in Figure 5 were also used to examine average daily flows over dry, average, and wet years (Figure 8). The relative amount of geomorphic work done on the channel to flush fines and mobilize bed sediments is shown by the magnitude of average flows, especially over the months of April-June. In the wettest years, average daily flows were an order of magnitude (10 times) more than those in dry years, indicating that channel form, especially in the alluvial reaches, was predominantly controlled by flows in the average to wet range. However, as shown by daily peak flow data (Figure 6), even dry years had flows that were able to flush fine sediments from pools and to scour fines from riffles, though the amount of work to reshape alluvial environments was relatively insignificant compared to wet years.

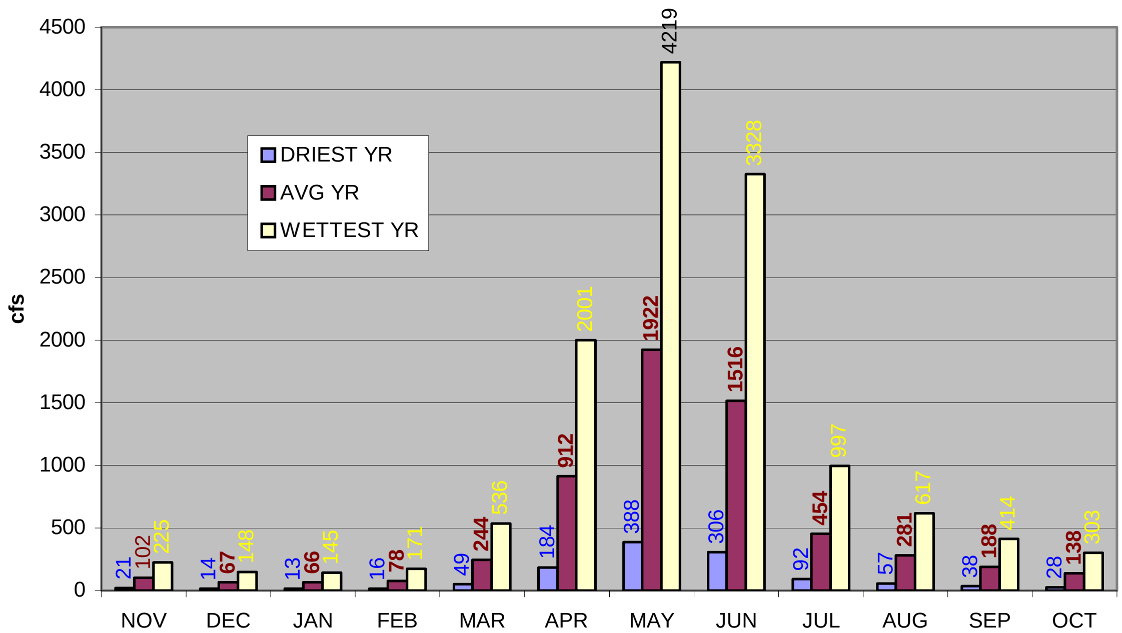


Figure 8. Monthly acre-foot inflow converted into average daily cubic feet per second flow comparing the driest, average and wettest years.

A pre-McPhee bankfull discharge in Reach 1 created a fairly large channel with significant floodplain habitats of mixed deciduous trees assumed to be a mix of willow, box elder and cottonwoods. In Reach 1, is it probable that cottonwoods were a significant component of the riparian forest. Further downstream, their numbers probably dwindled, as the timing of peaks and the relative ‘flashiness’ of peak flows were probably less conducive to cottonwood germination and growth. In addition, cottonwoods through Reach 4 are often in close proximity to historic settlement, and there does not appear to be many younger trees represented.

In this `natural' condition, the alluvial system was allowed access to a substantial portion of valley bottom, and was characterized by a dynamic stability that allowed for rates of erosion and deposition that, over time, maintained the river's floodplain and in-channel habitats. Based on current vegetative patterns it can be assumed that most of the riparian vegetation along reaches 1-4 was similar to current vegetative patterns, with the exception of tamarisk, which did not become a significant riparian component until they became established in the upper Colorado River basin in the 1930s-1950s.

The low flows during dryer years between September and March as depicted in Figure 4 above would suggest that the river did not (with the possible exception of deep pools in Reaches 2 and 3) support perennial occupation by native cutthroat trout, but did support the native warm water fishes adapted to low-flow warm water conditions.

B. MVIC – Dolores Project (1886-1986) Hydrology and Downstream Ecology

Using the MVIC diversion data from CDSS (the same data that were added back into the hydrologic record to simulate total flow at Bedrock in the last section), flow conditions immediately below the MVIC diversions could be simulated for representative dry, average, and wet water years (1974, 1978, and 1979 respectively). Extreme dry and wet water years in 1977 and 1983 were avoided, as they are less representative of expected variability. A detailed analysis and discussion of MVIC effects on total flows, peak flows, and low flows is presented in the larger "Correlation Report"; this section presents the hydrographs from that analysis and summary conclusions about the resulting ecologic effects.

With the exception of a few cfs of bypass flows necessary to meet senior water demands in Reach 1, MVIC's diversions took all the river's flow irregardless of total flow for the year (figures 9-11). Because the scour functions of peak flows were still occurring annually, tributary sediments were flushed, deep pools were maintained through all reaches, and channel maintenance functions of high river flows were preserved. Below Bradfield Bridge, the combination of seepage past the MVIC diversions and occasional tributary inflow from ephemeral drainages may have maintained some year-round flow, or at a minimum, standing water in the deeper pools. Native warm water fish populations were able to persist, but their numbers were probably annually limited by habitat availability during the dry periods. Coldwater native species – specifically Colorado River cutthroat trout – were probably not generally found below the MVIC diversion, although it is possible that they occasionally occupied deep pool habitat within the upper three reaches.

Cottonwood establishment and germination through Reach 1 was probably limited to wet water years with good late-summer precipitation, when there was a gradual water table recession beneath the sites where cottonwoods became established. Early or rapid stream dry-up without supplemental rainfall would dessicate newly established seedlings.

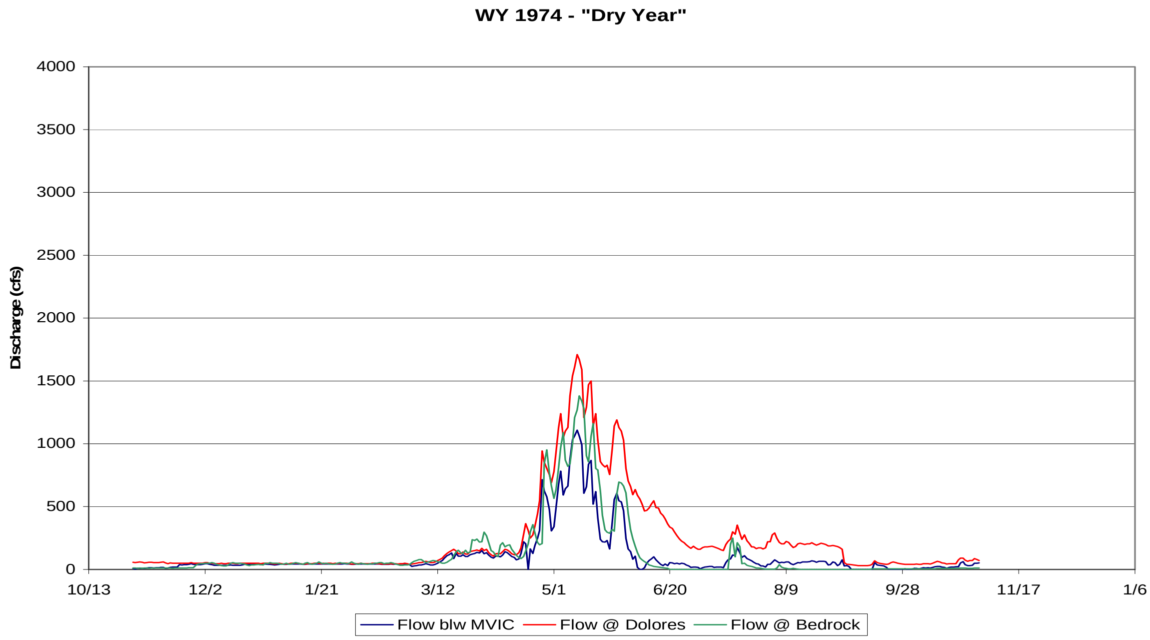


Figure 9. Calculated flow below the MVIC diversions, and gage data from Dolores and Bedrock gages for WY 1974.

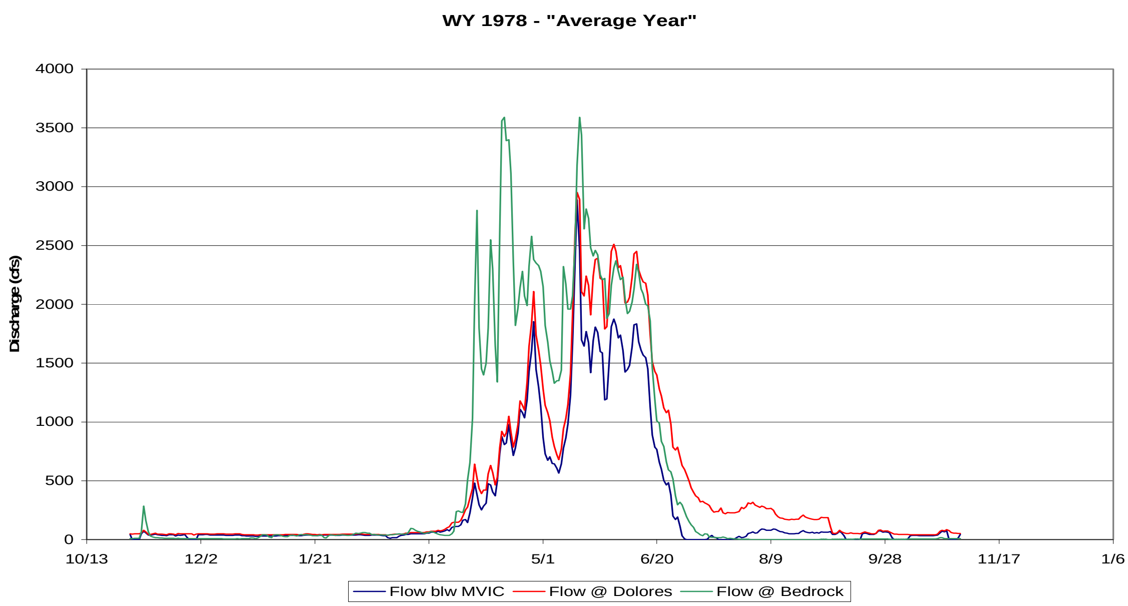


Figure 10. Calculated flow below the MVIC diversions, and gage data from Dolores and Bedrock gages for WY 1978.

Remnant cottonwood and older tamarisk stands located well above the current floodplain elevation indicate historical floodplain surfaces in the Big Gypsum Valley (Reach 4) and below Coyote wash (Reach 5), where tamarisk has played a morphologic role shaping the channel and decreasing the river's interaction with its floodplain. The introduction of tamarisk into the Dolores River watershed probably dates back to the 1930s -1950s. However, even as tamarisk began invading during this period, according to a joint agency report, “Cottonwoods remain the dominant tree, especially notable in large groves through the Gypsum Valley” (CO DNR, U.S. DOI, 1976).

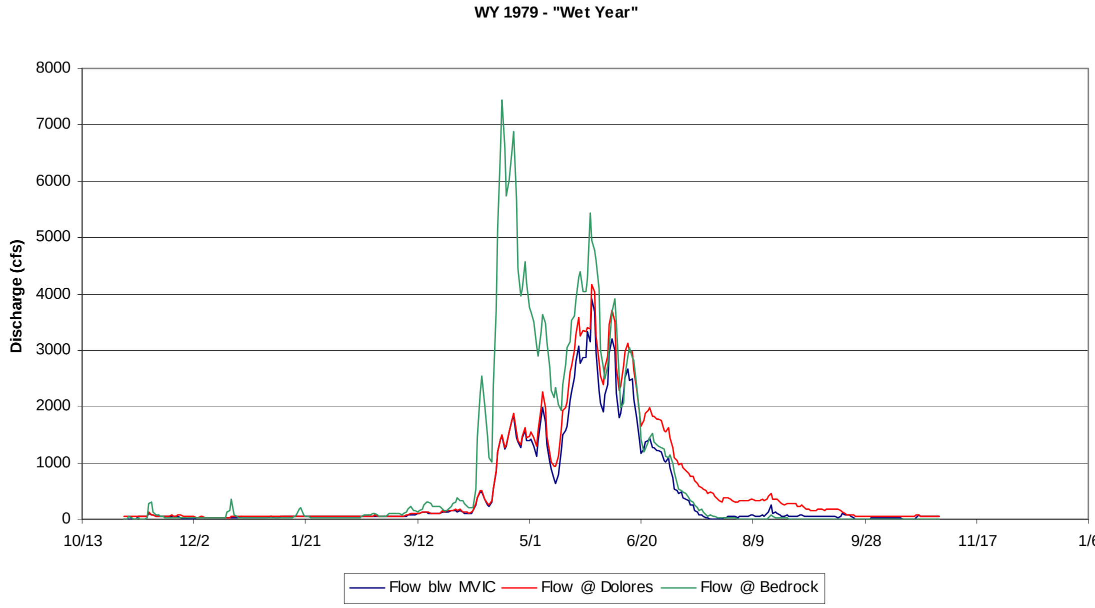


Figure 11. Calculated flow below the MVIC diversions, and gage data from Dolores and Bedrock gages for WY 1979. Note scale change on vertical axis.

Table 2 immediately below summarizes largest, smallest, and average run-off volumes into McPhee, MVIC diversions, and flow-by river volumes with MVIC diversions. This table is based on historic flow data and MVIC diversion data from 1928 to 1973.

Table 2: Comparison of Flow-by with MVIC Diversions

1928-1973	Largest	Smallest	Average
Run-Off Volume	793K af	130K af	350K af
MVIC Only			
MVIC Diversions	150K af	64K af	131K af
Flow-by (occurs every year)	643 K af	28K af	219K af
Flow-by as % of run-off vol.	81%	22%	63%

As the flow-by line highlighted in green in Table 2 indicates, the volume of water during the driest year (28K af) is close to the fish pool (29.3K af) that will be described in the Dolores Project period write-up below, but as the ‘dry-year’ hydrograph shows (Figure 9), flow-by in dry years occurred prior to mid-June, leaving extended periods during the summer when the River did not flow except during rain storms. During the driest year the flow-by volume was only 22% of the total run-off volume compared to 81% on the wettest year and 63% on an average year.

While MVIC agricultural diversions were out of the Dolores basin, this period saw the introduction of agricultural practices and livestock grazing on public and private land within the Dolores River corridor. There is extensive literature on the effects of grazing on riparian vegetation and river habitat, that generally concludes that historic grazing practices destabilized riparian ecosystems throughout the western U.S. However, specific details of how the introduction of livestock affected riparian and river health on the Dolores is speculative; literature on the effects of livestock region-wide can only be generally applied. It is important to recognize the effects that poor grazing management can have on riparian health, which can be especially detrimental to alluvial reaches where livestock can destabilize the fairly delicate balance of stream flow, sediment flux, and vegetation. Addressing grazing management within the Dolores River watershed, including significant sediment contributors such as Disappointment Creek, will require the participation of public land managers and private property owners responsible for managing lands within the watershed.

C. Dolores Project (1986 to 2005) Hydrology and Downstream Ecology

1. Dolores Project (1986-2005) – Hydrology

The Dolores Project was designed to supply an average annual of 90,900 af for irrigation, 8,700 af for M&I use, and 25,400 af for downstream fish and wildlife purposes. The Project will provide irrigation water for 61,600 acres of land, including full-service irrigation water for 27,920 acres in the Dove Creek area and 7,500 acres on the Ute Mountain Ute Indian Reservation, and supplemental irrigation water for 26,300 acres served by the MVIC.

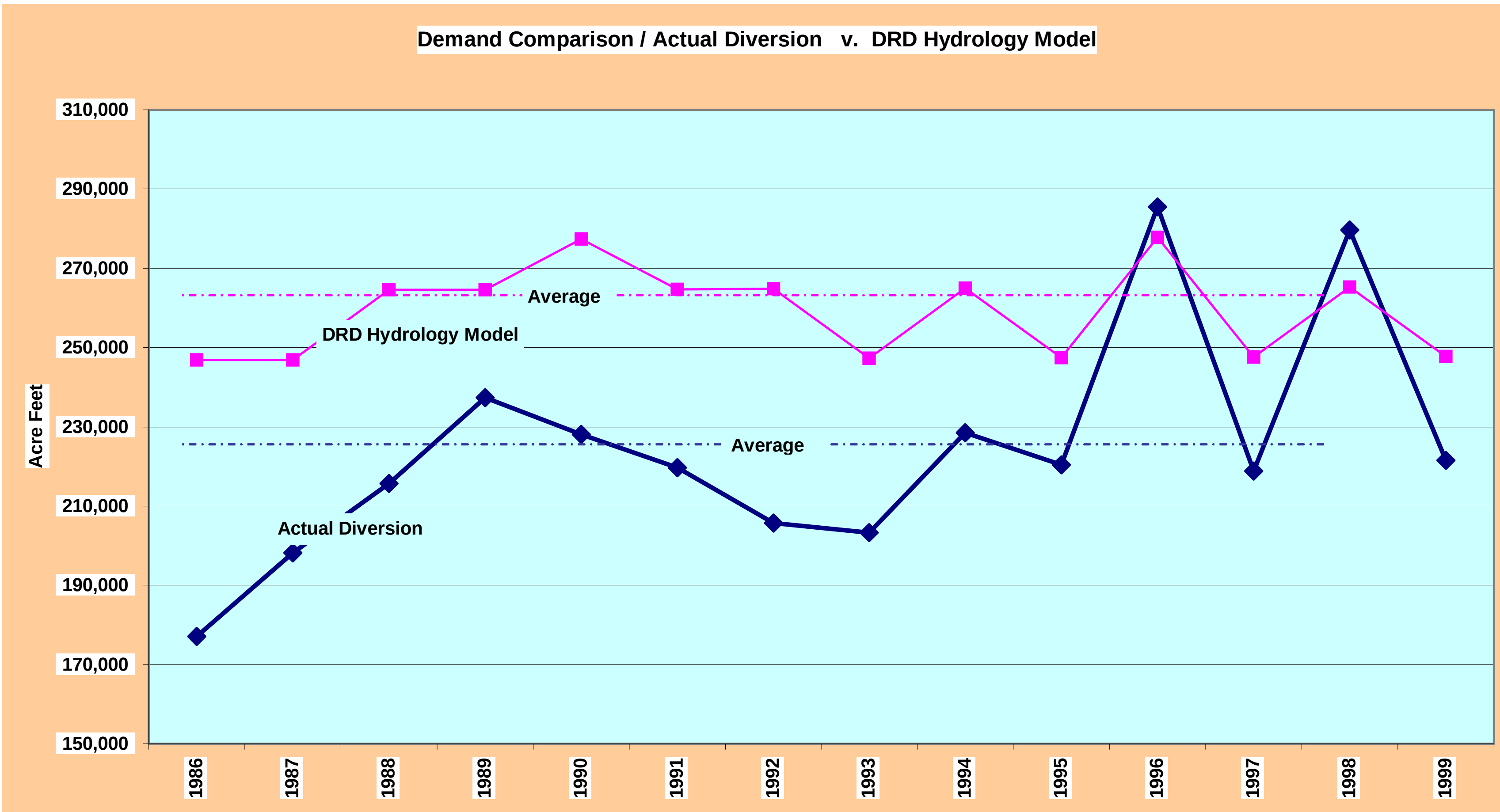
The original operating criteria for McPhee Reservoir were specified in the Final Environmental Statement (FES) and Definite Plan Report (DPR), published in 1977. Based upon records from 1928 to 1974, the FES/DPR indicated that an average of 25,400 af/yr of storage was available to supply flows for a trout fishery downstream of McPhee Dam. It was anticipated that the downstream releases from Project supplies and supplemental spill water would create a recreational fishery, to be enhanced by stocking and fishing regulation (e.g., catch and release). Releases from McPhee Dam were determined each year based upon how much water was in storage in McPhee Reservoir and how much snow pack was available in the watershed. Based upon these two indexes, the year was declared ‘dry’, ‘normal’, or ‘wet’ on March 1 of each year. If the water year was declared dry, for the next 365 days, 20 cfs would be released to support the downstream fishery. In a normal year, 50 cfs would be released and in wet years, 78 cfs.

When the Project first came on line, the indexes dictated a baseflow release of 78 cfs, but in addition to 'Wet' water years, Project demand was light and water was relatively plentiful; summer flows from 1986-1989 were routinely between 100-150 cfs. The first dry year was declared in 1990, and the flow rate was changed from 78 cfs to 20 cfs on March 1. Biologists soon realized that the releases were not sufficient to sustain the downstream trout fishery, so negotiations began in earnest to alleviate the stress to the downstream trout fishery. In 1996, an environmental assessment (EA) was completed which evaluated a permanent operating regime for fish flows, the principal component of which was the concept of a fishery pool as a discrete allocation within McPhee Reservoir. [Source: Colorado River Basin Study Final Report, Dale Pontius, Principal Investigator In conjunction with SWCA, Inc. Environmental Consultants Tucson, Arizona Report to the Western Water Policy Review Advisory Commission August 1997]

At that time the fishery flow management changed from the indexed flows to a managed pool, and the Dolores River Biology Committee annually made flow recommendations to the BOR for baseflow releases from the pool, based on an April 1 – March 31 water year. Initially, the total allocation to the pool was comprised of 25,400 AF of Project allocation, 3,900 AF that BOR purchased from DWCD, up to 3,900 af/yr of senior downstream water rights (as quantified in the DPR), and 3,300 AF/yr under temporary lease from the Ute Mountain Ute Tribe for an initial managed pool of 36,500 AF. As of 2006, the Ute Tribe lease has expired, and the downstream senior water has been re-assessed as a non-Project, demand-based allocation, which is now 1,274 AF. In addition, 700 AF of Project water has been negotiated to meet augmentation needs at the Paradox Salinity Unit, which is a firm supply not subject to allocation shortages. Thus on a full allocation year, the current baseflow pool is ~31,274 AF. In water short years (e.g., 2003 and 2004), the managed pool shares proportionately in shortages with other project allocations, and senior downstream water rights may be further limited by river administration. The Dolores Biology Team still makes recommendations to the BOR for the baseflow pool releases.

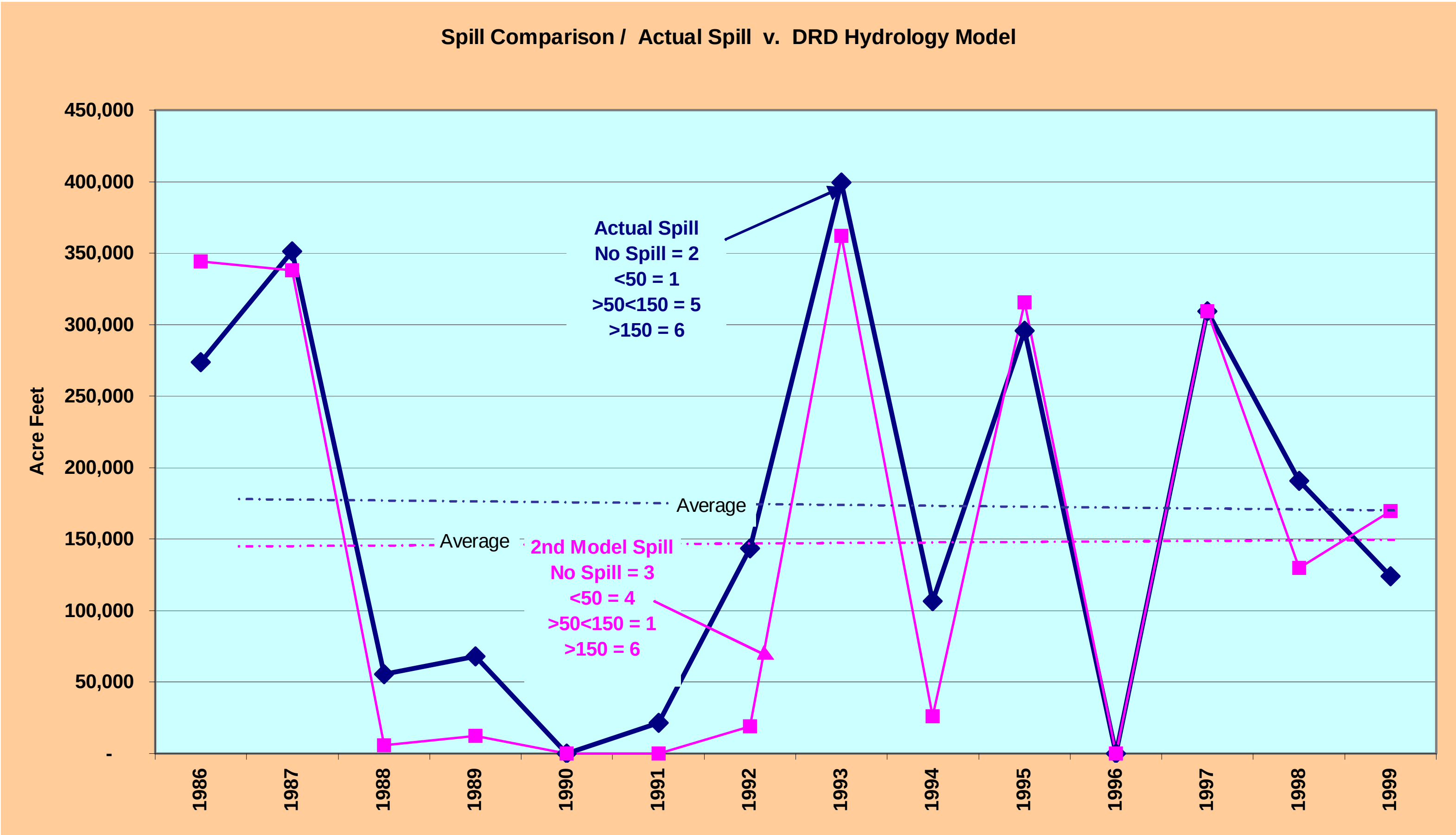
Figure 12 below shows actual diversions (blue line) as the Project came on line compared to modeled diversions assuming full Project use adjusted for weather patterns (pink line). Figure 13 compares the modeled spill (pink line assuming full Project use), with the actual spill. Since the project water demand was not fully on line, medium spills in 1988 and 1989 were modeled as negligible spills, and the medium spill of 1994 would have been a small spill at according to the full Project use model. In general, the model under-predicts the actual spills through 1994, but afterwards, both actual Project use and spill volumes are well correlated with the DRD model. However, despite minor adjustments to the wet-ave-dry year demands, the model does tend to over-predict demand during wet years, and under-predict demand when it is drier, but these discrepancies do not appear to affect the ability of the DRD model to make a reasonable estimate of spill volumes.

Figure 12: Water Demand During Dolores Project Development



Note: DRD Hydrology model adjusts full allocations of project users by modified usage resulting from wet and dry weather patterns.

Figure 13: Spill Volumes During Dolores Project Development



Spills 1986-99	# Yrs. No Spill	# Yrs. Small Spill	# Yrs. Medium Spill	#Yrs Large Spill
Actual Spill	2	1	5	6
Model Spill	3	4	1	6

Figure 14 presents the changes in difference in McPhee Reservoir release patterns relative to native inflow into McPhee since dam closure in 1986. The inflow data is the same that was presented in Figure 4; the release data was compiled from the gage below McPhee Reservoir operated by the Division of Water Resources. Relative to the timing of native inflow, operation of McPhee has increased the percentage of monthly flow in April and May, and diminished the percentage of monthly flows in March, June, July, and August. There are minor changes in monthly releases of baseflow in September through February, but the ecological variables of interest remain the spring and summer changes.

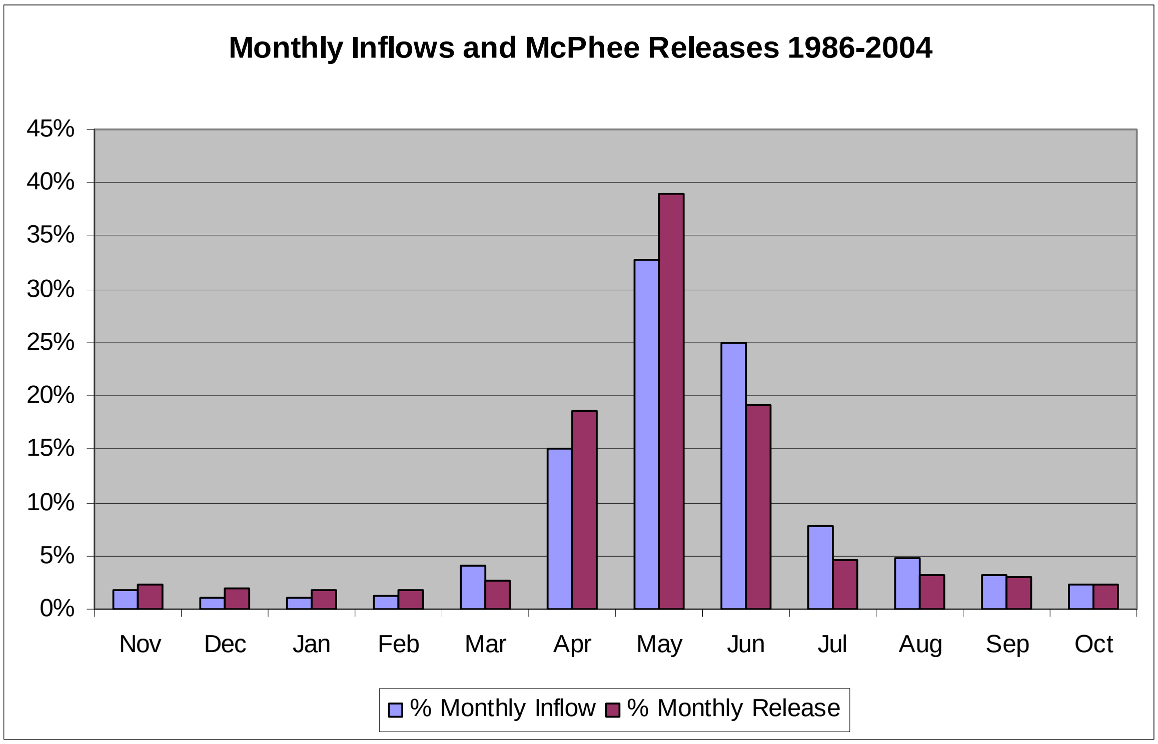


Figure 14. Comparison of the percentage of annual inflow by month into McPhee Reservoir and the percentage of water released by month from McPhee.

Understanding the specific nature of post-McPhee hydrology helps elucidate the ecological response that has occurred sicne dam closure, but predicting future response based on the last 20 years is compounded by the variable hydrology over this period (Figure 15). As has been noted elsewhere, 1986-1995 was relatively wet (and had been preceded by wet years), and the Dolores Project had not yet been fully developed. In contrast, average inflow at the Dolores gage from 2000-2004 was 38 percent below average, with a record low of 24 percent of total annual average inflow in 2002. Table 3 depicts spill hydrology from 1986-2005, noting hydrologic variables that have bearing on ecological response, specifically total spill volumes, timing and duration of spills, and annual daily peak flows. It is easy to see the wet pattern of the early McPhee years taper to average, then very dry conditions over 2000-2004. In addition to a lack of spill, shortages to baseflow in 2002 and 2003 reduced releases as low as 14 cfs, reflecting low-flow conditions not observed since the pre-McPhee era, when late-summer diversions dried the river immediately below the MVIC diversion canals.

Table 3 – Post-McPhee Spill Hydrology, 1986-2005

YEAR	SPILL START	SPILL END	# DAYS	Spill Volume (AF)	Peak Q (cfs)
1986	3/29/1986	7/28/1986	122	274633	4461
1987	3/1/1987	7/31/1987	153	319827	3324
1988	4/28/1988	6/15/1988	49	54955	1201
1989	3/31/1989	6/5/1989	60	67149	1001
1990	**NO SPILL**				81
1991	5/13/1991	5/31/1991	19	21971	851
1992	4/16/1992	6/19/1992	65	143171	3030
1993*	3/16/1993	7/15/1993	122	403853	4140
1994	4/28/1994	6/16/1994	50	106108	1970
1995	4/11/1995	7/19/1995	100	296784	3140
1996	**NO SPILL**				85
1997	4/1/1997	7/1/1997	92	310285	3640
1998	3/31/1998	6/18/1998	80	207145	3360
1999	5/16/1999	6/29/1999	45	105250	3520
2000	4/10/2000	5/28/2000	49	71633	1230
2001	**NO SPILL**				75
2002	**NO SPILL**				165
2003	**NO SPILL**				41
2004	**NO SPILL**				92
2005	4/18/2005	6/29/2005	73	191380	4530

*1993 - spill started for 2 days 3/1 - 3/2; stopped until 3/16 re-start

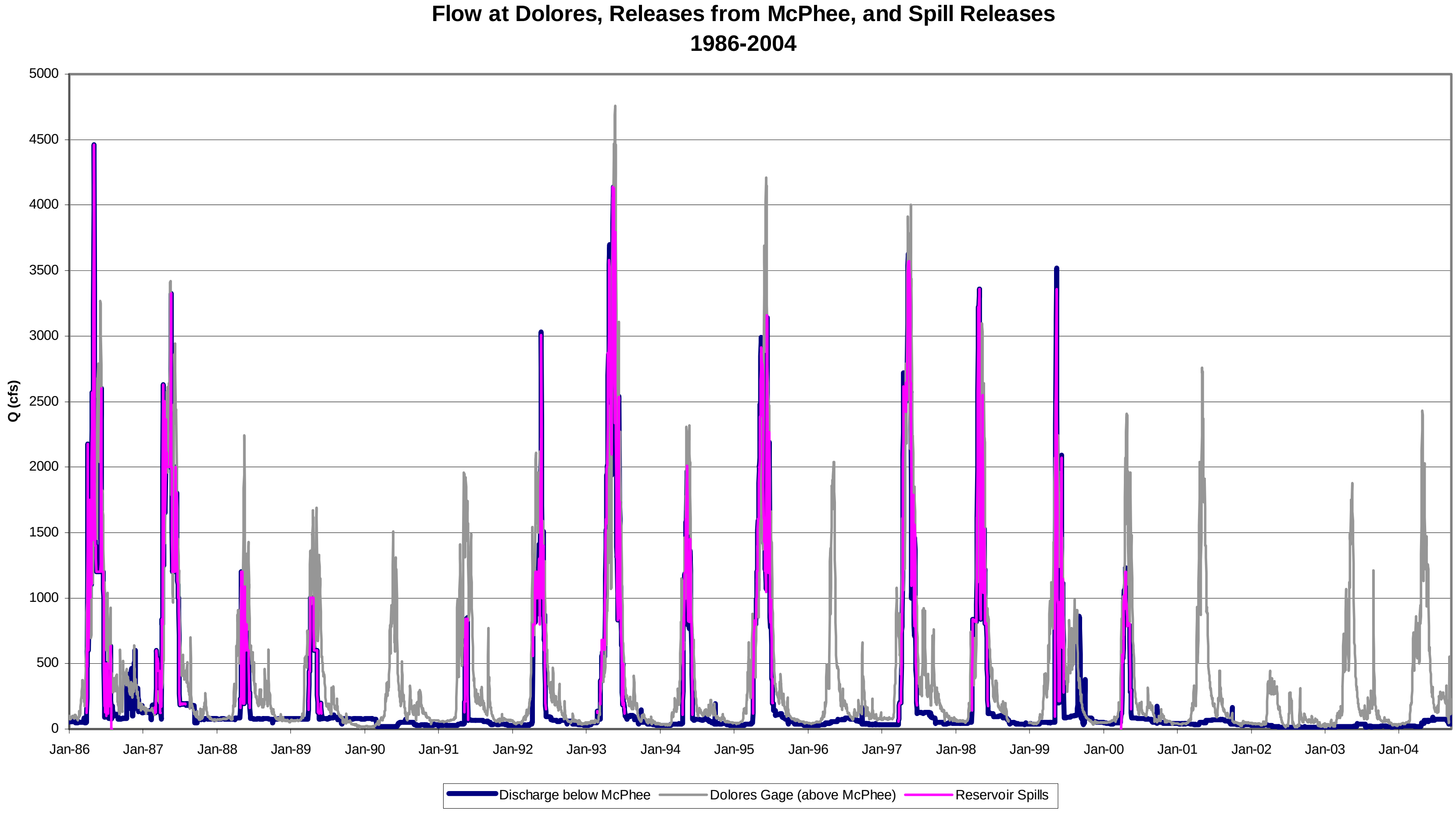


Figure 15. Post-McPhee Hydrology showing gaged inflow at Dolores, and both spill and baseflow releases from McPhee Reservoir.

2. Dolores Project (1986 to 2005) Downstream Ecology

Water management during this period has focused on managing fish pool releases for the recreational fishery in Reach 1 from McPhee Dam to Bradfield Bridge. Spill management has attempted to maximize the number of rafting days with flows of 800-1,000 cfs, and to peak flows over the Memorial Day weekend. During wet years there have been releases up to 4500 cfs. In addition, Bureau of Reclamation (BOR) policy requires that a minimum four foot freeboard capacity (17,587 AF) be maintained until June 1 for flood protection. In addition, spillway releases are not permitted due to concerns that uncontrolled releases from the top-most layer in the reservoir introduce non-native warm water fish species into the Dolores that could affect native fish populations, specifically the four Federally listed species within the Colorado River Basin. In wet years, the combination of the operational constraints has often resulted in a somewhat truncated hydrograph on the recession limb, as large pre-June 1 releases were required to meet freeboard criteria. After June 1, storage availability and increasing agricultural demand reduced downstream releases well below the pre-June peaks.

One of the difficulties in extrapolating future ecological conditions based on the environmental response downstream of McPhee since dam closure is the different rates at which ecological changes have occurred, both between the different disciplines and the different reaches. Using geomorphology as one example, habitat restoration in Reach 1 has attempted to encourage channel narrowing, effectively downsizing the active channel to more efficiently utilize reduced overall stream power in the post-McPhee period to perform geomorphic functions. In contrast, channel narrowing in Reach 4 has rapidly occurred, especially over 2000-2004, as willow and phragmites have colonized and stabilized in-channel sediment deposits. In this case, the result has been to narrow and entrench the active river channel, disconnect the river from its floodplain, decrease the availability of quality instream and riparian habitat, and to increase competitive stressors on native fish.

The remainder of this section presents brief summaries of the findings of each ecological discipline from the Core Science Report, supplemented with field observations following the 2005 spill, and fisheries data compiled since the completion of the Core Science Report.

Geomorphology

The main conclusion of the Geomorphology report is that flows are the limiting factor to physical and ecological processes. Because fluvial processes play a significant role creating and maintaining instream and riparian habitats, flow management to maintain or restore these processes offers the most practical opportunity through all reaches below McPhee Dam.

In the alluvial Reach 1, target flows of near 1000 cfs for rafting and periodic channel maintenance (and historical bankfull) flows near 2,000 cfs have created two discernible floodplain benches that correspond to these two flow releases. Low-flow vegetative mats of sedge and grass species adjacent to the low-flow channel in Reaches 1, 2, 3, and upper sections of Reach 4 illustrate the effects of stable low flows and consecutive years without spills. During lengthy non-spill periods, tributary sediments accumulate in pools until a spill can mobilize these fines. Because of structural controls on morphology in canyon reaches (bedrock and boulders), these reaches are slower to reflect changes in hydrology that more quickly affect alluvial reaches. Reach 5 is little-studied due to its remoteness, but may represent a hybrid of the more resilient canyon reaches and one influenced by the introduction of fine sediments. Reach 6 probably reflects many of the geomorphic issues of Reach 4, but poor habitat conditions in this reach are exacerbated by generally less water, high salinity, and a heavy infestation of tamarisk.

The influence of sediment from Disappointment Creek on channel morphology and habitat, especially below the confluence of the Dolores River in Reach 4, remains an important question for future research efforts. Field evidence suggests that channel narrowing, entrenchment (dislocation of a channel from its floodplain), and subsequent infill during sequences of dry years is related to the large amounts of fine sediments introduced from Disappointment Creek and other tributaries underlain by fine-grained shale.

After a spill of nearly 4200 cfs in 2005 (adjusted data from the BOR shows the spill was ~4500 cfs), scoured pools, sorted riffles, point bar deposition, and floodplain rejuvenation (fine sediment deposition and general plant vigor) indicated that this spill had a beneficial effect on downstream ecology throughout the river. The stream energy in 2005 moved fine sediment out of the channel in reaches 1-3 and sorted coarser materials to create glides suitable for trout spawning. At one surveyed site near the Big Gypsum Valley boat launch in Reach 4, over 6 vertical feet of fine material was scoured and 300% more cross-sectional area was created by removal of these fines.

Based on a study done by the BLM a peak discharge greater than 2500 cfs would be needed to mobilize the median grain size (D50) of bed sediments below Disappointment Creek, and a flow of 5600 cfs would be needed to move larger bed sediments (D84) (Dolores River Instream Flow Assessment, BLM 1990). However, the spill of 2005 did not generally mobilize riffles nor completely re-set point bars, despite some new deposition. It was suggested in the geomorphology section that the prolonged drought combined with fine sediment introduction has imbedded the riffles so that flows much larger (i.e., 7000 cfs) than the current outlet capacity from McPhee (5000 cfs) would be needed to move these materials.

Many areas along Reach 4 and 6 are channelized due to roads next to the channel, vegetative encroachment or channel entrenchment that inhibits the river's interaction with a floodplain except at very high flows. This limits fluvial processes that are important for seed establishment of native cottonwoods, but do not limit the ability of tamarisk to spread.

Riparian Ecology

Riparian vegetation plays a key role in the human-valued services provided by rivers and also provides the fundamental structure for diversity of flora and fauna found along the river. Most changes in riparian community structure do not result from a singe event or single stressor but from multiple interacting causes within a particular riparian corridor. A variety of factors influence the structure and composition of riparian vegetation growing along a particular reach of river, such as flows, salinity and soil type. The variable reach responses of riparian communities of the Dolores River to historic changes in flow from irrigation diversion and the Dolores Project reflects the different character of the river below McPhee. Because different ecological communities respond at different rates to change or disturbance, existing conditions on a reach or sub-reach below McPhee may not reflect the most probable successional trajectory of the community.

Reach 1 demonstrates a typical narrow leaf cottonwood community at this elevation. Recruitment of native species appears to be primarily by vegetative reproduction. Reach 2 is unusual because of the dominance of Ponderosa Pine. Reach 3 is characterized by juniper and pinon pine on the near-bank and low terraces, and fairly dense willow communities with a sedge/ grass understory growing nearer the bank and down into the active channel. Reaches 4 and 6 are characterized by remote stands of older cottonwoods with limited age class distribution. Parts of reach 4, Reach 5 below Coyote Wash, and most of reach 6 contain dense stands of tamarisk. In many areas, concentration of surface salts may be preventing the potential for native vegetation to become established. Many side tributaries, however, do have an abundance of plains cottonwood which is the specie of cottonwood on the lower reaches below Disappointment Valley.

The riparian communities below McPhee Dam have been significantly altered by changes to native flow patterns since 1886. Decreases in native cottonwood regeneration, increases in near-bank perennial wetland species, and increases in non-native tamarisk broadly characterizes these changes in riparian community structure. In contrast, the San Miguel River is a relatively free-flowing river to its confluence with the Dolores. As such, the San Miguel may provide some guidance for native restoration objectives for the Dolores below McPhee. Determining how proposed flow strategies can encourage or inhibit the success of native riparian communities needs to be recognized if ecological restoration is to meet its objectives.

Cold Water Fishery

Reach 1, at least from McPhee Dam to Bradfield Bridge, has been intensively surveyed since the closure of McPhee Dam to evaluate whether or not the recreational fishery objectives for the Project have been met. As noted in the post-Project Hydrology section (II.C.1), hydrologic conditions were relatively wet following dam closure through about 1997, and were followed by drought during 2000-2004. Trout biomass through Reach 1 has directly correlated with the flow conditions described, including mean flow, baseflow, and the availability of spills (Figure 16). In addition, abundance of adult fish is closely correlated with total biomass and with general hydrologic conditions below McPhee (Figure 17). The presence of whirling disease in the Dolores below McPhee is also responsible for the lack of propagation of rainbow trout, and certain areas have been identified as 'hot spots' for the host worm for the whirling disease parasite (e.g., the settling pool below the dam).

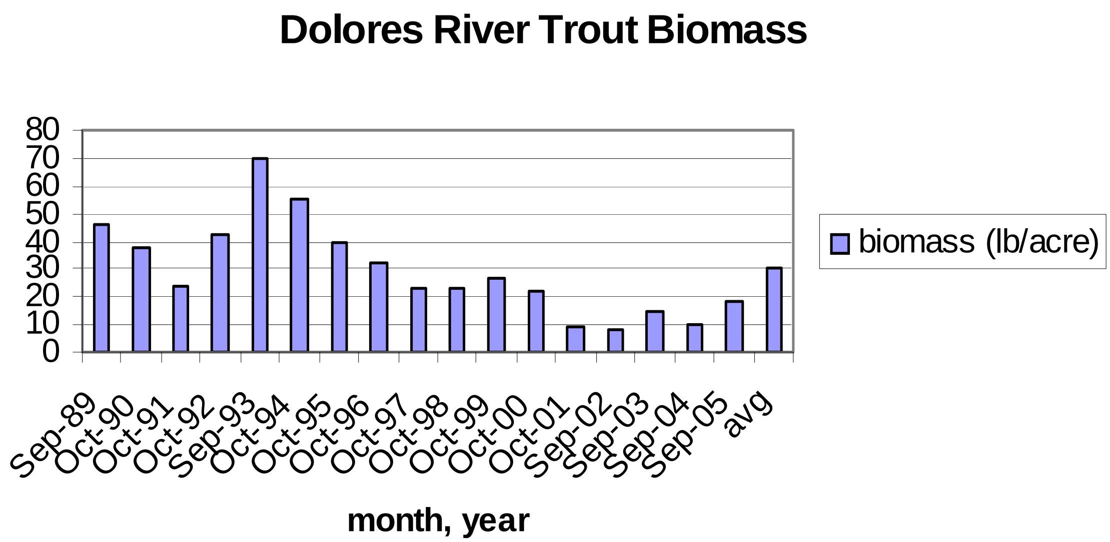


Figure 16. Trout biomass in Reach 1 of the Dolores below McPhee Dam as sampled at 2-3 sites annually from 1989-2005.

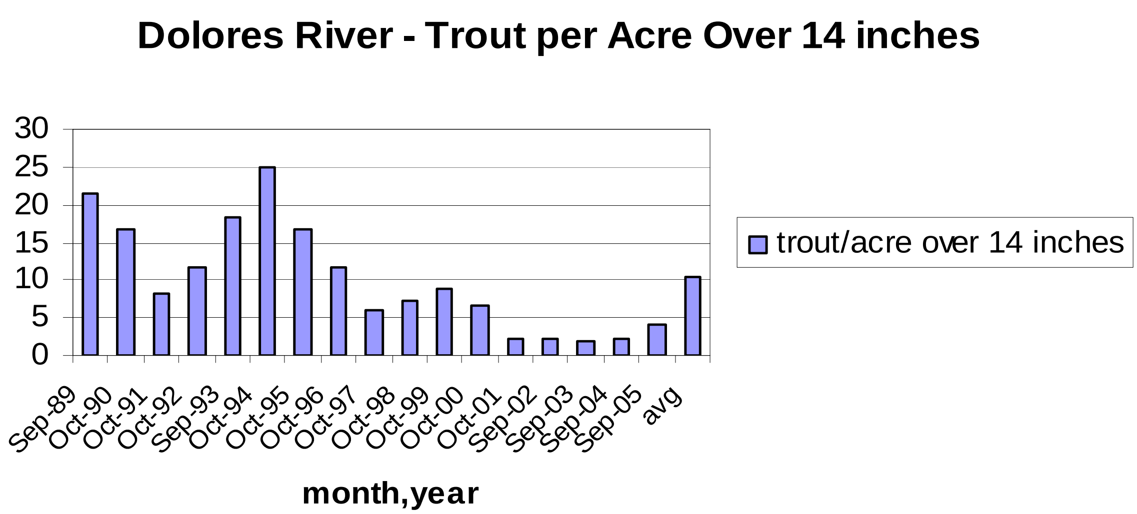


Figure 17. Trout per acre greater than 14 inches through Reach 1 below McPhee Dam, from survey data, 1989 – 2005.

Water temperature during low-flow periods may be affecting trout population viability from Lone Dome to Bradfield Bridge. In 1990, releases of 20-50 cfs resulted in water temperatures regularly in excess of 70 F degrees at Bradfield Bridge, including 10 days over 74 degrees. Six miles upstream, 20 over-70 F days were recorded (Nehring, 1993 Report to BOR).

In light of the low flows in 1990 and the observed effects on water temperature and trout from the survey data through 2005, Nehring's 1993 assessment of flow requirements for trout in Reach 1 remain relevant: "(1) continued availability of water over the long-term; (2) allocation of more water for the maintenance of the stream ecosystem; (3) wise and judicious use of water allocated for the stream ecosystem (especially during periods of extended drought); and (4) a recognition of and commitment to the concept that a 20 cfs discharge during the spring to fall period is incompatible with the maintenance of a healthy coldwater fishery in this river." (Nehring, 1993). Survey data continues to be collected at three sites above Bradfield Bridge (Reach 1), and at a fourth site 1.3 miles below the Dove Ck. Pumps in Reach 3. These data reflect that despite very poor flow conditions from 200-2004, a self-supporting brown trout fishery persists from the dam well down Reach 3. However, rainbow trout propagation and survival remains affected by the presence of whirling disease. Supplemental stocking of fingerlings on a near-annual basis has allowed some fish to grow to adult size, but additional research may be necessary to determine the fate of rainbow trout fingerlings after they are introduced to the river.

Habitat improvements in Reach 1 could be beneficial and should be focused on enhancing physical habitats for juvenile and adult trout, as monitoring data suggest these are limiting age classes to maintain a healthy population. Habitat manipulation should include enhancing pool structure and availability, improving width-depth ratios, and improving pool-riffle sequencing. Over the longer term, spawning site availability and condition should not be a limiting factor on trout reproduction if spills fall roughly every other year.

Data collected in 1993 and again in 2005 on trout populations from all of Reach 2 also support the notion that trout biomass was higher in the early 1990s under favorable conditions of flow, and has been impaired by low flows from 2000-2004 (Table 4). Other data collected by Japhet from 1986 – 2005 at the Dove Creek sample site below the pumps in Reach 3 also support the correlation between flow conditions in the river and trout populations (Figure 18).

Below Reach 3, trout have been captured during surveys, but are an infrequent component of the population, probably due to increasing summer water temperatures in the downstream direction. One coldwater native species, the mottled sculpin, is still relatively abundant throughout reaches 1-3. However, systematic sampling specifically to detect trends in sculpin populations has not been undertaken.

Table 4: Trout Presence in Reach 2 - 1993 and 2005

		Section 1 (kg/ha)	Section 2 (kg/ha)	Section 3 (kg/ha)	TOTAL - Reach 2 (kg/ha)	TOTAL - Reach 2 (lbs/ac)
1993	Brown	30.4	49.3	9.6	89.3	79.7
	Rainbow	5.9	4.9	5.5	16.3	14.4
2005	Brown	8.4	6.3	2.3	17	15.2
	Rainbow	5.4	0.7	1.1	7.2	6.4

Nehring, CDOW 2005. The three sections referenced in Table 4 refer to the reaches sampled each day, all between Bradfield Bridge and the Dove Creek Pumps.

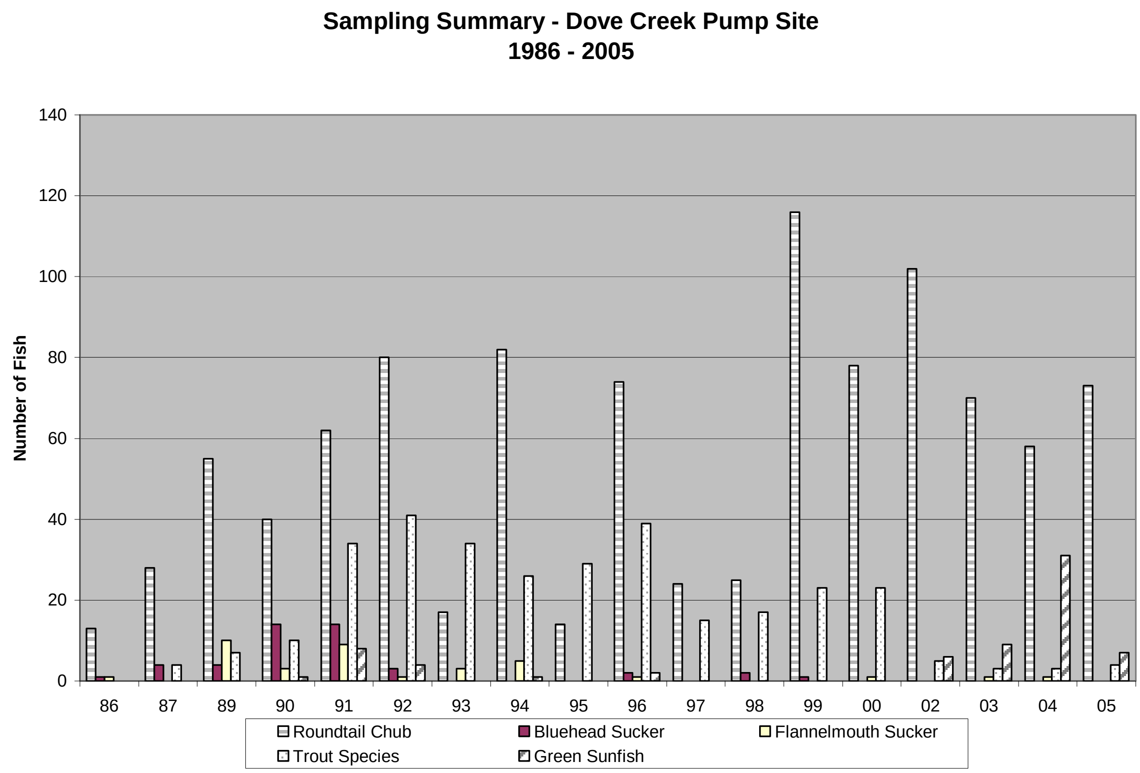


Figure 18. Trout, native warm water, and non-native green sunfish sampled at the Dove Creek pump fish sampling site, 1.3 miles below the Dove Ck pumps in Reach 3. Note: no sampling occurred in 2001.

Warm Water Fisheries

The CDOW currently has three 1000-ft fish monitoring sites established on the Dolores River through Reach 1, a 1000-ft station located 1.3 miles below the Dove Creek pumps (upper end of Reach 3), and a 2-mile reach in Big Gypsum Valley (lower end of Reach 4). Only the Reach 1 and Dove Creek pump sites have been consistently monitored since dam closure; Rick Anderson's 5-year study in the Big Gypsum Valley ended in July 2005. Nehring's 30 miles of mark-recapture surveying in 1993 (reaches 1 and 2) was re-sampled in 2005 to assess population changes over this period. Valdez and BioWest also did river-wide sampling in

1980 and the early 1990s to identify species presence or absence, but density and population biomass data from these samples were not collected.

Figure 18, above, summarizes sampling results from the Dove Creek pump site over nearly 20 years of sampling. Of note are the relatively strong but variable numbers of roundtail chub; the near-elimination of sucker species (five bluehead suckers were sampled from 1993-2005; four flannelmouth suckers were sampled since 1995); and the increasing number of green sunfish in 2002-2005, when surveys picked up 53 individual sunfish during this period.

CDOW's monitoring data indicate roundtail chub and flannelmouth sucker had a secure population in the Dolores River until recently. Although roundtail numbers at the Dove Creek pump site and Big Gypsum sites continue to be fairly strong, the age class structure is poor (few adult-sized fish), and biomass is low. Flannelmouth suckers showed strong populations from the dam downstream in initial surveys in the early 1990s, but they are now rarely found in sampling efforts between McPhee dam and the Dove Ck pump site in Reach 3. Anderson's surveys showed highly variable numbers, ranging from a high of 28 percent of species composition in 2005 to 3.3 percent of the species sampled in 2004. The higher numbers in 2005 are thought to have been washed downstream by spill water from more favorable sites upstream sites rather than to have been recruited locally. Bluehead suckers were always an uncommon component in the upper reaches, but they are now nearly absent from reaches 1-2 (and the Dove Ck Pump site in Reach 3). Bluehead suckers were a significant component of the Big Gypsum samples in 2001, but decreased significantly in the 2004 and 2005 surveys to less than 1 percent of species composition in 2004 and 2005. Anderson's concluded that "… bluehead suckers have just barely survived the current drought, and immediate surveys are needed to establish the status of this species" (Anderson DRAFT Completion Report, 2006). Japhet's long-term site below the Dove Ck pumps and Nehring's repeat samples through Reaches 1 and 2 also support this conclusion for upstream sites.

The increasing numbers of non-native species at both the Dove Creek pump and Big Gypsum sampling sites remains an important issue that needs monitoring and potentially, remedial action. The effects on native fishes from invasive fish species moving upstream from the Colorado River, or by escapement from McPhee Reservoir have also not fully been analyzed, but both issues pose threats to the viability of native populations. However, the lack of white suckers in the Dolores is a positive sign that hybridization with the two native sucker species is currently not a concern.

The decline of these species from McPhee Dam to the San Miguel River is thought also to be related to changes in flow regimes, such as the recent lack of flushing flows, the relation of flows to habitat availability, or water temperature issues that may be affecting native fish spawning success.

A 6-State Range-Wide Conservation Agreement and Strategy for roundtail chub, and flannelmouth and bluehead suckers, signed in 2004 by Colorado River basin states (NM, UT, AZ, WY, NV, CO), emphasizes additional monitoring and research, and where applicable, habitat protection for these species. Native fishery management in the Lower Dolores has become a priority issue for State fishery managers, and CDOW's approach will involve additional monitoring and data collection, determination of habitat needs for all life stages, and continued efforts to optimize flow management for these native warm water fish.

The important question facing fishery managers is to more clearly describe how changes to the existing flow regime, predator mitigation and potential habitat improvements would improve the reproductive success and survival of the native fisheries. At this time, CDOW will continue to monitor the Big Gypsum and Dove Creek pump sites, and at three sites in Reach 1. Discussions are underway that would add additional long-term monitoring sites near Disappointment Creek and above Bedrock, and to determine the best methods to repeat samples in logistically difficult canyon reaches, requiring multi-day float trips with substantially more water than is typically released under baseflow-only conditions. An additional short-term focus will be the identification of ***when*** native fish spawn, ***where*** the most prolific reproduction sites for natives are located, and the relationship of native fish reproduction to water temperature. The significance of predation by non-native warm water fish also needs to be discerned more clearly, as the trends noted above show non-natives to be a growing threat, especially during consecutive non-spill years.

III. Current Management – Expected Ecological Conditions

A. Ecological Objectives for Downstream Flow Management

The Dolores River Dialogue has developed a process that can be used to analyze the effects of current reservoir management on the downstream environment. If alternatives to current management are proposed, such as purchasing or leasing more water, construction of additional facilities, instream habitat modification, or tangible changes to operating policy, the same analytical process can be used to discern the likely benefits or costs to the downstream ecology. The first step has been to develop the underlying 'status' documents pertaining to hydrology and the ecological circumstances described herein and in the Core Science Report. What follows is an analysis of how current reservoir management determines an 'expected ecological outcome' downstream. By analogy, the same process can be used to examine the likely ecological effects of any 'proposed action' on the downstream environment. After using the ecological filter just described, the DRD will then utilize a second layer of analysis, yet to be clearly developed, that may elucidate the costs and benefits of alternatives on economic, political, social, or cultural values represented by the DRD or the regional community as a whole.

Thus prior to presenting the following analysis of "Expected Ecological Conditions under Current Management", it is important to understand what the specific objectives for each resource discipline are. This will allow for a coarse assessment of whether a particular ecological resource is positively affected (+), negatively affected (-), or whether the effects are neutral or unknown (=). This section also describes some specific values that the DRD has suggested as long-term sustainability goals for the lower Dolores River. Also included are shorter-term, tangible objectives for science and monitoring that will enable the DRD to continue to refine its understanding of how flow management will affect downstream environments. An underlying focus of the objectives and research needs itemized below is the role of flow management to affect ecological processes; specifically, how do ecological variables respond to the timing, duration, frequency, and overall quantities of water released from McPhee Reservoir?

<u>Geomorphology objectives</u>

1. Scour fine sediment from pools and interstices of riffle substrate (annually, if possible).

2. Maintain channel dimensions through alluvial reaches; scour pools of coarse sediment; sort gravels; mobilize bar sediments and other in-channel depositional features (annually if possible; hydrology modeling suggests 2-4 years likely).

3. Inundate floodplains and backwater/ remnant channel habitats; deposit fine sediment on floodplain/overbank areas (annually if possible; hydrology modeling suggests 2-4 years likely).

4. Occasionally provide the stream power to mobilize riffles, resetting primary productivity within the river; release imbedded channel sediments; scour near channel or low-floodplain surfaces (5-10 yr recurrence); induce downstream meander migration in alluvial reaches.

5. Investigate the effect of sediment introduced from Disappointment Creek on downstream habitats and geomorphology. In general, investigate sediment flux by reach and ability of river to move sediment contributions from tributaries.

6. Refine the notion of bankfull flows for alluvial reaches; compare with hydrologic expectations to discern optimal channel dimensions to meet habitat needs of aquatic communities.

Riparian Vegetation objectives

1. Promote the formation of newly opened sites suitable for recruitment of native species by releasing flows capable of scouring existing vegetation and/or mobilizing and re-depositing bed sediments to form new germination sites (hydrology suggests 2-4 years).

2. Promote recruitment of native species (i.e., cottonwood) by timing peak flows with seed dispersal to ensure colonization of suitable sites occurs at the appropriate time; taper the recession limb of the hydrograph to maximize the survival of seedlings (site specific – once in 5-10 years).

3. Promote heterogeneity in riparian habitat and in standing vegetation by re-connecting the active channel to its floodplain, ensuring alluvial processes of meander migration, chute cut-off, oxbow abandonment, and floodplain deposition continue to occur.

4. Preservation and enhancement of riparian meadow habitats through floodplain inundation or high water tables in the growing season (annually).

5. Enhancement of ‘terrestrial’ riparian habitat through tamarisk removal and re-vegetation of native wood plant species where appropriate.

6. Determine to what extent salinity pre-determines ecological community, especially important in Reach 6 and Reach 5 downstream of Coyote Wash.

Cold Water Fishery objectives

1. Collection of thermograph data from 9 stations along the Dolores River from Lone Dome SWA to Gateway, CO. Correlate seasonal temperature changes with flow releases.

2. Continue habitat enhancement program between McPhee Dam and Bradfield Bridge (focus is on improving structure and adjusting width-depth or other channel hydraulic parameters to meet expected hydrology)

3. Continue fisheries inventory from McPhee dam to the Dove Creek pumps to refine relationships between population biomass and hydrology.

4. Enhance fish populations primarily by stocking Rainbow Trout or native cutthroat trout through Reach 1.

5. Determine whether other water quality issues such as fine sediment or nutrient loading is impairing cold water fish productivity.

Warm water fishery objectives

1. Continue native fisheries study and establish other sites.

2. Examine relationships of spawn cycles of native fish to water temperatures and flow releases.

3. Discern the effects of predation of non-native fish (green sunfish, channel catfish, black bullhead) on native fish recruitment and survival.

4. Develop flow strategy that enhances to the greatest extent possible, reproductive habitat and viability of native fish populations in the lower Dolores River.

5. Maintain self-sustaining populations of native fish: roundtail chub, flannelmouth sucker, bluehead sucker; speckled dace.

6. Investigate water quality effects on native species, including sediment, selenium, salinity, or nutrient loading.

B. Current Management Hydrographs and Existing Operations Criteria

This section repeats the presentation at the beginning of this document of the set of hydrographs for four McPhee release scenarios: baseflow releases only, and small, medium, and large spills (30,000 AF baseflow only, 64,000 AF spill, 187,000 AF spill, and 310,000 AF spill, respectively). Based on the DRD Hydrology Model and frequency analysis of the data, a ‘small spill’ as defined here (64,000 AF) would occur on average every 2.3 years; the ‘medium spill’ (187,000 AF) would occur about once in 4 years; and a ‘large spill’ (310,000 AF) would be expected to occur once in 8 years. The repetition here is to reinforce the basis for the environmental descriptions and conclusions that follow in Section III.C, Expected

Ecological Conditions: Current Management (by Reach). These coarse assessments of expected ecological conditions are based on the ability of each of the four flow scenarios to achieve specific ecological goals, and are stratified in the first sheets by flow. In the second set of sheets, the DRD 'modeled spill' results are also repeated to emphasize the variability of the size of the spills as well as the expected frequencies of both wet and dry cycles. The analyses are presented by ecological discipline (geomorphology, riparian ecology, cold water fishery, and warm water fishery) and include a description of each reach, and a brief summary of expected ecological conditions given existing hydrology and management criteria.

Figure 19 again presents the composite plot of these four hypothetical release scenarios. Note that given the amounts of water contemplated by these hydrographs, actual releases from McPhee would not replicate these scenarios. The hydrographs presented below are constructed based on how existing management criteria could affect the general shape of the releases for representative water supplies.

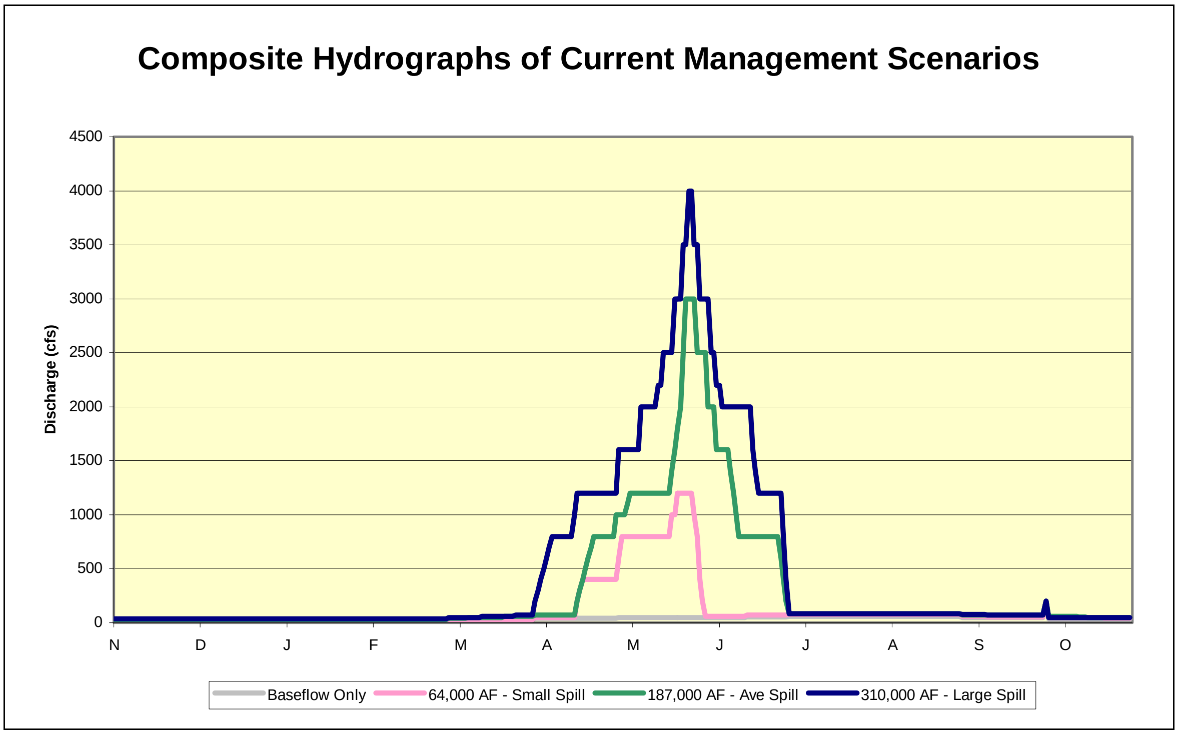


Figure 19. Composite Hydrographs for the four current management scenarios being discussed in this section. The small spike October 1 is the 12-hour, 400 cfs release for fish stocking between McPhee Dam and Bradfield Bridge.

Baseflow Management The current management objectives for release of baseflow from McPhee are to provide enough water during the spring, summer, and early fall months to maintain a healthy trout population below the dam. habitat availability is maintained by flows as low as 30 cfs, so flows greater than 30 cfs are released spring through fall to maintain adequate summer temperatures. Ramp-up from winter releases of 30 cfs run April through June, and peak annually in July and August to approximately 60 cfs. Flow in September through October ramps down to winter baseflow of 30 cfs A 12-hour fish stocking release of 400 cfs (400 AF) is often scheduled annually near October 1, based on fish availability.

Spill Management Spill management is a result of the following BOR Operations Criteria: (BOR, 2005):

- Fill the Reservoir when possible.
- Do not allow the reservoir to exceed elevation 6920.00 prior to the end of May (4 feet of flood control freeboard).
- Manage releases to provide white water boating opportunities, when possible.
- Try to peak releases over the Memorial Day weekend.
- Manage releases in such as way that it is not necessary to use the emergency spillway (fully utilize the selective level outlet works for ALL managed spills).
- Provide a minimum of 2,000 cfs for seven days for channel maintenance.
- Try to limit releases to less than 4,000 cfs.
- Provide a minimum raftable release of 800 cfs as long as possible.

Managed spill releases end when reservoir inflows match the project demand. Although there is no provision for ramping flows noted above, when flows are less than 800 cfs, ramping of no more than 200 cfs over a two day period is usually maintained.

C. Expected Ecological Conditions: Current Management – Yellow Sheet Template (Reaches 1-3)

Current Management	Reach 1 McPhee Dam to Bradfield Bridge	Reach 2 Bradfield Bridge to Dove Creek Pumps	Reach 3 Dove Creek Pumps to Joe Davis Hill
Supported by 4 Hydrographs Base Flow, Small, Medium and Large Spill NOTE: "+" - flow will enhance/ meet objective or resource described "-" – flow will not meet objective or will degrade resource described "=" – effect of flow on objective / resource described are neutral or uncertain (emphasized with "?")	**Base Flow** (-) sediment transport, mobilize cobble, embedded channel; riparian vegetation; aquatic organisms, cold water trout (+) low-channel veg mats **Small Spill** (=) coldwater fish; limited sediment trans-port (flushing of fines); woody plant, wet meadow persistence; low-channel veg **Medium Spill** (=) aquatic organisms viability/health stabilized (+) modest sediment transport; woody veg. recruitment (CW dependent on recession timing); sort gravel, mobilize cobbles; moderate increase coldwater fish production. **Large Spill** (+) mobilize bar cobbles, re-work in-channel deposition, flush riffles and pools; potential channel migration; woody plant recruitment (CW = F(timing)); aquatic life forms; general riparian health; cold water fish production. (-) low-channel veg mats scoured note: 'CW' – cottonwoods produced	**Base Flow** (-) no opportunity to mobilize cobbles or tributary sediment inputs; aquatic organisms, cold water trout; native ww species (+) low-channel veg mats **Small Spill** (=) flush fines; willow recruitment along water's edge; cold-water fish production maintained; low-channel veg (+) native ww fish production??? **Medium Spill** (=) aquatic organism health (+) modest sediment transport (flushing riffles and pools, sort particle sizes); willow recruitment; cold water fish production; native ww fish production???; riparian health **Large Spill** (+) Mobilize in-channel depositional features; woody plant recruitment (willow); increase in aquatic life forms; increases in coldwater fish production. (-) low-channel veg mats scoured	**Base Flow** (-) no opportunity to mobilize cobbles or tributary sediment inputs; aquatic organisms, cold water trout; native ww species (+) low-channel veg mats **Small Spill** (=) flush fines; willow recruitment along water's edge; cold-water fish production maintained; low-channel veg (+) native ww fish production??? **Medium Spill** (=) aquatic organism health; cold water fish production ??? (+) modest sediment transport (flushing riffles and pools, sort particle sizes); willow recruitment, riparian health; native ww fish production??? (-) low-channel veg mats **Large Spill** (+) Mobilize in-channel depositional features; riparian health; aquatic life forms; coldwater fish production???; ww fish production??? (-) low-channel veg mats scoured

C. Expected Ecological Conditions Current Management – Yellow Sheet Template (Reaches 4-6)

Current Management	Reach 4 Joe Davis Hill to Big Gyp	Reach 5 Big Gyp to Wild Steer Canyon	Reach 6 Wild Steer Canyon to Saucer Basin
Supported by 4 Hydrographs Base Flow, Small, Medium and Large Spill	**Base Flow** (-) sediment flux; instream ww fish habitat; ww fish viability; riparian veg recruitment (=) low-channel veg mats (+) non-native ww competitors/ predators **Small Spill** (=) flushing fines; recruitment of willows along water's edge; ww native fish habitat/ productivity; non-native ww competitors **Medium Spill** (=) aquatic organism health (+) recruitment of willows; ww fish habitat/ ww fish viability; pool/ riffle fine sediment mobilization (-) non-native ww competitors **Large Spill** (=) aquatic organism health; ww fish reproduction (may wash larvae) (+) ww fish habitat; potential channel migration; recruitment of willows; tamarisk; other woody plant recruitment ??? (hindered by channel morphology); significant sediment transport but may downcut channel (-) (-) non-native ww competitors; low-channel veg mats scoured	**Base Flow** (-) sediment flux; instream ww fish habitat; ww fish viability; woody veg recruitment (=) low-channel veg mats (phragmites/ saltgrass) (+) non-native ww competitors/ predators **Small Spill** (=) flushing fines; recruitment of willows along water's edge; ww native fish habitat/ productivity; non-native ww competitors **Medium Spill** (=) aquatic organism health; (+) recruitment of willows; ww fish habitat/ ww fish viability; pool/ riffle fine sediment mobilization (-) non-native ww competitors **Large Spill** (=) aquatic organism health; ww fish reproduction (may wash larvae) (+) ww fish habitat; potential channel migration; recruitment of willows; new sites for tamarisk recruitment ds of Coyote Wash (-) non-native ww competitors; low-channel veg mats scoured	**Base Flow** (-) no opportunity to mobilize cobbles; water quality; native fish habitat and productivity; woody veg recruitment - Non-native competitors??? (=) low-channel veg mats **Small Spill** (=) flushing fines; recruitment of willows (???) and tamarisk; ww native fish habitat/ productivity (???); non-native ww competitors (???); water quality **Medium Spill** (=) aquatic organism health (+) recruitment of willows; ww fish habitat/ ww fish viability; pool/ riffle fine sediment mobilization; water quality (-) non-native ww competitors **Large Spill** (=) aquatic organism health; ww fish reproduction (may wash larvae) (+) ww fish habitat; potential channel migration; recruitment of willows; tamarisk recruitment; water quality (-) non-native ww competitors; low-channel veg mats scoured

Year	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
1933	
1934	
1935	
1936	
1937	185390
1938	300298
1939	
1940	
1941	464005
1942	329268
1943	122803
1944	298699
1945	125934
1946	
1947	21945
1948	147226
1949	192220
1950	
1951	
1952	241338
1953	
1954	
1955	
1956	
1957	107804
1958	263062
1959	
1960	
1961	
1962	
1963	
1964	
1965	99335
1966	67568
1967	
1968	
1969	87092
1970	56369
1971	49617
1972	
1973	340592
1974	119428
1975	229032
1976	18317
1977	
1978	
1979	166998
1980	281263
1981	
1982	120428
1983	352232
1984	312359
1985	305518
1986	344394
1987	338143
1988	5685
1989	12281
1990	
1991	
1992	19007
1993	362179
1994	25955
1995	315648
1996	
1997	309241
1998	129724
1999	169450
2000	
2001	
2002	
2003	
2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

- No Spill - 35 of 78 years (45%)
- Spill < 64,000AF (12%)
- 64K < Spill < 187K AF (18%)
- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Current Management Reach 1: McPhee Dam to Bradfield Bridge (12 miles)

Shallow gradient, alluvial reach with wide valley bottom and meandering pools and riffles; riparian area dominated by narrow-leaf cottonwoods, box elder and willow; wet-meadow wetland habitats; accessible by gravel road; trout fishery focus for base flow management.

Geomorphology: "Dominant discharge" remains an elusive concept as minimal target rafting flows and historical bankfull flows (target for 'channel maintenance') are not the same. Low flows over prolonged drought unable to perform minimal geomorphic functions (pool flushing; gravel sorting). May be impossible to mobilize imbedded riffles and enhance primary productivity without mechanical treatments. General goal to enhance natural process of 'channel downsizing' to accommodate overall decrease in stream power, and continue instream habitat projects to improve structural diversity, pool depth, and juvenile habitat.

Riparian Ecology: Current flow management presents minimal opportunities to encourage sexual reproduction of cottonwoods and may be reducing long-term viability of off-channel wet meadow habitats. Woody vegetation (sandbar willow) primary colonizer of 'low floodplain' habitat and serving to narrow channel naturally. Combining riparian plantings with mechanical treatments is a feasible approach.

Cold Water Fishery: Drought cycles (consecutive non-spill or shortage years) have significant impacts to recreational fishery. Whirling disease continues to affect juvenile rainbow trout survival. Continue re-stocking program, improve instream habitat structure, and utilize hydrologic opportunities to maximize reproductive success and population viability, while minimizing population declines associated with droughts. Continue monitoring of trout populations, and note trends in native sculpin population.

Warm Water Fishery: Little to no persisting warm water species in Reach 1.

Summary: Reach 1 has been managed primarily for trout whose populations will fluctuate downward during no spill periods and recover with active stocking during extended spill periods. Spill management for rafting has produced a low floodplain bench of 800-1000 cfs, perhaps at the expense of the historic floodplain associated with 2,000 cfs. Challenge is to maintain historic floodplain community and off-channel meadow habitats while encouraging channel narrowing now occurring through natural processes.

Research Needs:

- Correlate downstream temperature and thermal stress on trout with McPhee releases.
- Determine the effects, if any, of otter predation on trout populations.
- Determine mobility of bed sediments under various peak flow scenarios. Assess mobility of imbedded riffles, and/or effects of immobile riffles on primary productivity and aquatic function.
- Detail locations where natural channel narrowing is hindered by entrenchment or bank hardening. Focus habitat restoration in these reaches.

Year	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
1933	
1934	
1935	
1936	
1937	185390
1938	300298
1939	
1940	
1941	464005
1942	329268
1943	122803
1944	298699
1945	125934
1946	
1947	21945
1948	147226
1949	192220
1950	
1951	
1952	241338
1953	
1954	
1955	
1956	
1957	107804
1958	263062
1959	
1960	
1961	
1962	
1963	
1964	
1965	99335
1966	67568
1967	
1968	
1969	87092
1970	56369
1971	49617
1972	
1973	340592
1974	119428
1975	229032
1976	18317
1977	
1978	
1979	166998
1980	281263
1981	
1982	120428
1983	352232
1984	312359
1985	305518
1986	344394
1987	338143
1988	5685
1989	12281
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1991	
1992	19007
1993	362179
1994	25955
1995	315648
1996	
1997	309241
1998	129724
1999	169450
2000	
2001	
2002	
2003	
2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

- No Spill - 35 of 78 years (45%)
- Spill < 64,000AF (12%)
- 64K < Spill < 187K AF (18%)
- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Current Management Reach 2: Bradfield Bridge - Dove Creek Pumps (19 miles)

Steeper gradient, confined bedrock-controlled channel. Riparian community dominated by ponderosa pine woodland with willows and oaks along stream corridor. Secluded, only accessible by hiking and floating. Self-sustaining brown trout population.

Geomorphology: Current flow management maintains geomorphic function of pool scour and sediment transport through reach. Tributary sediments will accumulate in pools, diminishing habitat quality over prolonged dry (non-spill) periods.

Riparian Ecology: Ponderosa pine/ oak woodland community is unique in Dolores River basin. Current management appears to preserve this community. Main threat is increasing non-native forbs in understory (e.g., Dalmatian toadflax; knapweed). Non-spill periods encourage development of dense low-flow sedge/grass/willow associations.

Cold Water Fishery: Reproducing populations of brown trout and wild rainbow trout (self-sustaining populations) remain the goal for fishery managers in this reach. Monitoring suggests significant fluctuations in populations related to presence/absence of spills and adequate baseflows. Continue to monitor when flow opportunities permit. Rainbow reproduction remains affected by whirling disease.

Warm Water Fishery: Little to no persisting populations of sucker species in Reach 2; (based on sampling in the upper 2 miles of Reach 3) roundtail chub populations also fluctuate; threats from non-native sunfish may be mitigated by periodic spills, which also improve habitat availability for roundtails.

Summary: Reach 2 is geomorphically more resilient than the alluvial reach upstream, but lack of sediment flux during prolonged droughts degrades habitat conditions and reduces productivity of both cold water and warm water aquatic species. Riparian community also appears resilient to changes in long-term flow management, but affects on short alluvial reaches and narrow floodplain habitats not well understood in this reach.

Research Needs:

- Determine when and where native roundtail spawn, and temperature cues that trigger spawning cycles.
- Determine whether sucker species are compatible with cold water releases from McPhee.
- Determine effects of non-native predation on native warm water species.
- Determine extent of non-native weed invasion in riparian areas. Spot treat as feasible.

Year	Spill Total (AF)
1928	
1929	134822
1930	61005
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1932	220738
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1937	185390
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1979	166998
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1982	120428
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1984	312359
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1988	5685
1989	12281
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1992	19007
1993	362179
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1997	309241
1998	129724
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2004	
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* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

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- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Current Management Reach 3: Dove Creek Pumps to Joe Davis Hill (9 miles)

Steep gradient, confined colluvial/ bedrock controlled channel. Ponderosa pine box-elder, some old cottonwoods in upper reaches; valley widens and ponderosa declines downstream. Declining native warm water fish populations and increasing non-native sun fish. Two track road on left bank, class V "snaggletooth rapid" near low end.

Geomorphology: Current flow management maintains geomorphic function of pool scour and sediment transport through reach. Tributary sediments will accumulate in pools, diminishing habitat quality over prolonged dry (non-spill) periods.

Riparian Ecology: Ponderosa pine/ oak woodland grades downstream into box-elder, willow, and silver buffaloberry in near-stream environment. Non-spill periods encourage development of dense near-channel sedge/grass/willow associations. Current management preserves this community. Main threat is non-native weeds in understory, potential reduction in historical, higher elevation wet meadow habitats.

Cold Water Fishery: Fishery changes from primarily coldwater to warm water through this reach. Some reproducing populations of brown trout and wild rainbow trout may remain in deep pools.

Warm Water Fishery: Based on sampling 1.3 miles below Dove Ck pumps, population viability of native sucker species in doubt, but the extrapolation of Reach 3 conditions based on the Dove Ck site is uncertain. Roundtail chub populations also fluctuate with poor age-class structure; threats from non-native sunfish may be partially mitigated by periodic spills, which also improve habitat availability for roundtails.

Summary: Similar to Reach 2, Reach 3 is geomorphically fairly resilient, but lack of sediment flux during prolonged droughts degrades habitat conditions and reduces productivity of both cold water and warm water aquatic species. Riparian community also appears resilient to changes in long-term flow management, but value of short alluvial reaches and narrow floodplain habitats important for species diversity not well understood in this reach. Trends in native and non-native warm water fish populations are of critical interest to state fishery managers.

Research Needs:

- Determine when and where native fish populations spawn, and temperature cues that trigger spawning cycles.
- Determine effects of non-native predation on native warm water species.
- Discern downstream extent of viable cold water fish populations.
- Determine extent of non-native weed invasion in riparian areas. Spot treat as feasible.

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1945	125934
1946	
1947	21945
1948	147226
1949	192220
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1952	241338
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1957	107804
1958	263062
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1965	99335
1966	67568
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1969	87092
1970	56369
1971	49617
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1973	340592
1974	119428
1975	229032
1976	18317
1977	
1978	
1979	166998
1980	281263
1981	
1982	120428
1983	352232
1984	312359
1985	305518
1986	344394
1987	338143
1988	5685
1989	12281
1990	
1991	
1992	19007
1993	362179
1994	25955
1995	315648
1996	
1997	309241
1998	129724
1999	169450
2000	
2001	
2002	
2003	
2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

- No Spill - 35 of 78 years (45%)
- Spill < 64,000AF (12%)
- 64K < Spill < 187K AF (18%)
- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Current Management: Reach 4

Joe Davis Hill through Big Gypsum Valley (38 miles) This reach is fairly flat with a riparian corridor dominated by sage and greasewood on the upper banks, silverberry and sedge mats closer to channel. Increasing tamarisk downstream. Sparse older cottonwoods dislocated from river processes. High sediment loads introduced below Disappointment Ck; non-native competition and predation with native warm water fish species.

Geomorphology: Current flow management maintains geomorphic function of pool scour above Disappointment Ck; significant accumulation of fines below Disappointment Ck during non-spill periods impairs habitat quality. Riparian vegetation encroachment on sediments induces 'channelization' and reduces floodplain connectivity in downstream alluvial reaches.

Riparian Ecology: Above Disappointment Ck, willow/sedge and silverberry community relatively stable. Below Disappointment Ck, channel narrowing and entrenchment reduces diversity, and increasing tamarisk and understory knapweed threatens native communities. Remant gallery cottonwoods not dominant and disconnected from dynamic river processes necessary for proper age class structure. Debate remains whether they were native or induced by settlement.

Cold Water Fishery: Only fish may be a few found in deep holes in upper reach, or those flushed downstream by spills. Not considered cold water fish habitat below Reach 3.

Warm Water Fishery: Based on sampling in the Big Gypsum Valley (low end of reach), population viability of bluehead sucker species in doubt. Flannelmouth sucker and roundtail chub populations both fluctuate with few reproducing adults; threats from non-native channel catfish and black bullhead may be partially mitigated by periodic spills, which also improve habitat availability for natives.

Summary: Reach 4 below Disappointment Ck remains impacted by lack or regular sediment transport, which reduces habitat availability and productivity of warm water native species. Riparian community has encroached into channel margins, narrowing channel and inducing entrenchment. Trends in native and non-native warm water fish populations are of critical interest to state fishery managers.

Research Needs:

- Determine when and where native fish populations spawn, and temperature cues that trigger spawning cycles. Determine effects of non-native predation on native warm water species.
- Determine extent of non-native weed invasion in riparian areas, especially tamarisk. Develop habitat improvement strategy supported by existing (or other?) flow regime. (SEE "Opportunity Summary: Big Gypsum Study Proposal")
- Determine effect of sediment flux from Disappointment Ck into Dolores.
- Determine appropriateness of cottonwood as prominent riparian component.

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Year	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
1933	
1934	
1935	
1936	
1937	185390
1938	300298
1939	
1940	
1941	464005
1942	329268
1943	122803
1944	298699
1945	125934
1946	
1947	21945
1948	147226
1949	192220
1950	
1951	
1952	241338
1953	
1954	
1955	
1956	
1957	107804
1958	263062
1959	
1960	
1961	
1962	
1963	
1964	
1965	99335
1966	67568
1967	
1968	
1969	87092
1970	56369
1971	49617
1972	
1973	340592
1974	119428
1975	229032
1976	18317
1977	
1978	
1979	166998
1980	281263
1981	
1982	120428
1983	352232
1984	312359
1985	305518
1986	344394
1987	338143
1988	5685
1989	12281
1990	
1991	
1992	19007
1993	362179
1994	25955
1995	315648
1996	
1997	309241
1998	129724
1999	169450
2000	
2001	
2002	
2003	
2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

- No Spill - 35 of 78 years (45%)
- Spill < 64,000AF (12%)
- 64K < Spill < 187K AF (18%)
- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Current Management: Reach 5

Big Gypsum Valley to Wild Steer Canyon (42 miles) With a low gradient confined by steep canyon walls, this is the only other reach besides Reach 2 that must be accessed by hiking in or floating the river. Few to no trout are found in this part of the river and salinity levels begin to rise as you go downstream. A BLM Wilderness Study Area surrounds this reach of the river.

Geomorphology: This reach represents a 'hybrid' between canyon reaches 2-3 upstream and Reach 4 below Disappointment Ck affected by significant contribution of sediments. Lack of regular spills and sediment deposition in structurally-controlled reach affects habitat for native fish.

Riparian Ecology: Relatively intact riparian community of willow and New Mexico privet above Coyote Wash. Phragmites significant component, which acts to stabilize channel margins with willow. Community changes rapidly to tamarisk-knapweed association below Coyote Wash, which may be due to natural salinity, historical land use, or both. Current management reflected by these community types.

Cold Water Fishery: Not considered cold water fish habitat below Reach 3.

Warm Water Fishery: Significant unknowns with respect to native species composition, age class structure, recruitment, and ultimately, population viability. At this point assuming that Big Gypsum site data reflects species composition in Slickrock Canyon (see Reach 4 description, above). Similar threats from non-native competitors and predators as in Reach 4. Infrequent spills increase competitive stressors and diminishes habitat availability for natives; wet cycles reduce stress and improve habitat quality for natives.

Summary: As noted under the 'Geomorphology' header above, Reach 5 is impacted by irregular sediment transport, which reduces habitat availability and productivity of warm water native species. Riparian community in upper reach above Coyote Wash relatively intact and appears resilient to flows. Riparian community below Coyote Wash is primarily non-native mono-typic, with little floodplain interaction. Trends in native and non-native warm water fish populations are of critical interest to state fishery managers, but systematic sampling of this reach is difficult due to remoteness.

Research Needs:

- Determine community composition of fish populations in the canyon. Subsequent work may include a determination of the effects of non-native predation on native warm water species.
- Determine how sediment flux from upstream effects in-channel habitats for life cycles of native species.
- Determine extent of non-native weed invasion below Coyote Wash. Determine whether strategies developed from Big Gypsum Valley may be applicable to lower end of Reach 5.

Year	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
1933	
1934	
1935	
1936	
1937	185390
1938	300298
1939	
1940	
1941	464005
1942	329268
1943	122803
1944	298699
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1952	241338
1953	
1954	
1955	
1956	
1957	107804
1958	263062
1959	
1960	
1961	
1962	
1963	
1964	
1965	99335
1966	67568
1967	
1968	
1969	87092
1970	56369
1971	49617
1972	
1973	340592
1974	119428
1975	229032
1976	18317
1977	
1978	
1979	166998
1980	281263
1981	
1982	120428
1983	352232
1984	312359
1985	305518
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1987	338143
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1989	12281
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1991	
1992	19007
1993	362179
1994	25955
1995	315648
1996	
1997	309241
1998	129724
1999	169450
2000	
2001	
2002	
2003	
2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

	No Spill - 35 of 78 years (45%)
(pink)	Spill < 64,000AF (12%)
(light green)	64K < Spill < 187K AF (18%)
(teal)	187K < Spill < 310K AF (14%)
(blue)	Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Current Management Reach 6: Wild Steer Canyon to San Miguel River (12 miles to Saucer Basin) Flat and wide with high concentrations of salt, this area is dominated by tamarisk. Large stands of very old cottonwoods still exist, however, there is little or no evidence of regeneration. Salinity and sediment are major factors affecting this reach.

Geomorphology: Active channel entrenched and disconnected from historic floodplain. Current management will perpetuate this condition. Specifics of sediment flux through this reach largely unknown. Geomorphic character changes between the Paradox Valley and the confined canyon above the San Miguel River, which may offer better habitat improvement opportunities.
Riparian Ecology: Significant intrusion of tamarisk throughout this reach, aided by this species high tolerance to salt, giving it a competitive advantage over native woody species. Results of 'Big Gypsum Study Proposal' may have bearing on strategy for improving riparian habitat conditions through Reach 6. Any strategy must contemplate significant salt concentration in surface water, groundwater, and soils.
Cold Water Fishery: Not considered cold water fish habitat below Reach 3.
Warm Water Fishery: Significant unknowns with respect to native species composition, age class structure, recruitment, and ultimately, population viability through this reach. This reach was essentially biologically dead at many times historically during late summer from 1886-1986 when low flows, channel losses, and extreme salinity significantly impaired biological resources. Pre-settlement fish productivity unknown. Current extent of biological 'exchange' between reaches above and below Reach 6 also largely unknown, but speculation is that perennial flow has enabled downstream non-natives upstream access to habitat previously occupied only by native fish species.
Summary: Reach 6 is also impacted by irregular sediment transport, which reduces habitat availability and productivity of warm water native species, but low flows, poor habitat, and high salinity may be more profound effects on native species viability than lack of sediment flux through this reach. Natural regeneration of cottonwoods will not occur without mechanical treatments, and the extent to which cottonwoods represent a native component of the riparian community in this reach remain unknown.

Research Needs:

- Determine community composition of warm water fish populations. Subsequent work may include a determination of the effects of non-native predation on native warm water species, or the extent to which Reach 6 hinders or facilitates upstream-downstream biological exchange.
- Characterize with site-specific data how sediment flux from upstream effects in-channel habitats for life cycles of both aquatic and riparian plant native species.
- Determine whether strategies developed from Big Gypsum Valley may be applicable to riparian restoration of Reach 6.

Year	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
1933	
1934	
1935	
1936	
1937	185390
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2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

No Spill - 35 of 78 years (45%)
Spill < 64,000AF (12%)
64K < Spill < 187K AF (18%)
187K < Spill < 310K AF (14%)
Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Flexible Spill/Study Options Reach 4: Joe Davis Hill through Big Gypsum Valley (38 miles) This reach through Big Gypsum Valley is a fairly flat alluvial reach with a riparian corridor dominated by sage and greasewood on terraces with increasing tamarisk downstream. There are large older cottonwoods in places, but multiple age classes infrequent, and these remnant populations are not connected to active channel processes.

In Channel Restoration/Option: Reach 4
Combine tamarisk removal as a variable to measuring the effects of Flexible Spills

Opportunity Summary: Big Gypsum Study Proposal.

The primary purpose of this study is to field test the findings of the paper presented in *Ecological Applications,* 12(4), 2002, pp. 1071–1087 " PROCESSES GOVERNING HYDROCHORY ALONG RIVERS: HYDRAULICS, HYDROLOGY, AND DISPERSAL PHENOLOGY DAVID M. MERRITT1,3 AND ELLEN E. WOHL2 ".Specifically to use current G.I.S. mapping with high resolution color imagery and the The Five-S Framework for Site Conservation: *A Practitioner's Handbook for Site Conservation Planning and Measuring Conservation Success* © 2000 by The Nature Conservancy approach to study various spill releases from McPhee reservoir.

Benefits:

The proposed benefits from this effort are intended to help improve our current understanding of the abundance and distribution of tamarisk along the lower Dolores River. Further, this study will seek to identify key processes involved in shifting the plant community towards the re-establishment of native species, through the selective removal of tamarisk from "key" areas along the lower Dolores river. This study would also attempt to quantify flow regime components needed to sustain and recover native riparian communities and to maintain fluvial geomorphic processes Enhancement of the native riparian vegetative community will be informed, in part, by procedures developed in a scientific article authored by David Merritt and Ellen Wohl, entitled "Process Governing Hydrochory along Rivers: Hydraulics, Hydrology, and Dispersal Phenology".

Understanding the role that tamarisk plays in influencing channel and sediment dynamics along the Dolores River will aid substantially in our efforts to develop a model for ecological sustainability in a regulated system.

Summary and Benefits of Proposed Work

1. Investigate the role of tamarisk in influencing the geomorphology of the riparian corridor at key study sites.
2. Conduct water quality & sediment studies in order to determine what effects these factors may be having on the dynamics of this river system.
3. Conduct mechanical removal of tamarisk from key areas.

IV. Alternatives Under Analysis – Expected Ecological Conditions

Section IV. of this report contains the analyses of alternatives to current management strategies. Each sub-section follows the same format presented in Section III. for “Current Management”, whereby the alternative is described, comparative hydrographs (if applicable) are presented, and the ecological implications of management under the alternative is presented in each of the two summary formats as presented in Section III. This summary includes a two-page summary of how specific flows under that alternative would affect ecological components, by reach (one column per reach), followed by a six-sheet summary (one reach per sheet) that integrates the expected flows with the management scenario to anticipate ecological outcomes. In cases where the alternative strategies have no effect on specific reaches (e.g., instream habitat improvements for trout in Reach 1 has little to no effect on reaches 2-6) or have minimal effects on most flow scenarios (e.g., adding water to the baseflow pool), the summary sheets for these alternatives note the lack of effects relative to current management.

As noted from the Introduction to this report: “The Dolores River Dialogue (DRD) is a multi-stakeholder effort aimed at improving the environment of the Dolores River downstream of McPhee Dam, while protecting or enhancing human uses of the Dolores River resource.” Thus the ecological objectives itemized in Section III. are not repeated here.

A. Ecological Objectives for Downstream Flow Management – Objectives and Hydrographs

Flow management for ecological objectives entails some specific changes relative to current management. Specific to current BOR operating criteria, these are as follows (*ITALICIZED*):

McPhee Operations Criteria (BOR, 2005):

- Fill the Reservoir when possible. *(Maintained by Ecological Flow Management)*
- ~~Do not allow the reservoir to exceed elevation 6920.00 prior to the end of May~~ (*This condition is dropped in order to maximize opportunities presented by early runoff and improvements in runoff forecasting)*
- ~~Manage releases to provide white water boating opportunities, when possible~~. (*This condition is dropped as a specific objective for spill management. Opportunites for whitewater rafting exist for all spill scenarios, but whitewater rafting is not the sole focus of spill management)*
- ~~Try to peak releases over the Memorial Day weekend~~. (*Rather than choose an arbitrary time for peaking releases, the intent is to mimic the inflow hydrograph by indexing spill releases to the inflow at Dolores. The hydrographs presented in this section utilize the historic average daily flows as hypothetical hydrograph peaks, but in reality, any peak falling between May 18 and May 31 is within 100 cfs of the average annual peak flow. The point is that there is quite a bit of flexibility operating a peak release for ecological purposes that will inherently coincide closely with recreational demand over Memorial Day weekend.)*

- Manage releases in such as way that it is not necessary to use the emergency spillway (*maintain this protective measure to prevent release of non-native warm-water sportfish into the lower Dolores River.*)
- Provide a minimum of 2,000 cfs for seven days for channel maintenance. (*Although this objective is retained, more attention would be paid to the overall water availability, what the current need for channel maintenance is relative to prior years flows, and what competing ecological demands there may be for the quantity of water to be released. Refinement of what flow is required for 'channel maintenance' is an ongoing and adaptive concept as well, which could adjust the target discharge.)*
- ~~Try to limit releases to less than 4,000 cfs~~. (*Releases up to 5000 cfs through the selective level outlet works should be considered, especially when warranted for channel maintenance or significant geomorphic need.)*
- ~~Provide a minimum raftable release of 800 cfs as long as possible~~. (*For fish sampling reasons, a 10-14 day spring flow of 400 cfs has been incorporated into all spill hydrographs. This would allow for mark-recapture surveys of Reaches 1 and 2 (primarily, a coldwater fishery) as well as access to reach 5 – Slickrock canyon – at a flow that would optimize sampling efficiency. 'Sampling flow' quantity and duration would be adjusted according to need and experience, as necessary, and it is hoped that repeat longitudinal sampling could occur on average every 5 years.*)

As configured, this management scenario protects all water yield in McPhee Reservoir for existing human uses. In order to ensure that this occurs, two important assumptions are made: (1) that when supply (inflow) equals demand (baseflow pool flow + out-of-basin M&I and agricultural demand), the spill stops and all releases are from the baseflow pool; (2) the date of spring releases is generally moved forward to address ecological needs, but the 'saved water' due to an official declaration of a 'spill' is based on the average length of a declared spill of similar magnitudes as has occurred over the 20-year post-McPhee record. Thus this option is not considering the important question of officially moving the spill date forward in anticipation of a spill. That option may be considered in a subsequent analysis, with the general conclusion that doing so saves ~100 AF for each day forward that a spill is declared. This 'saved fish water' would be available for use later in the 'fish water year', April 1 – March 31, but could impact out-of-basin demand if the reservoir fails to fill the following year.

This section mimics the presentation in Section III. B. of the set of hydrographs for four McPhee release scenarios: baseflow releases only, and small, medium, and large spills (30,000 AF baseflow only, 64,000 AF spill, 187,000 AF spill, and 310,000 AF spill, respectively). Although there were many ways that ecological flows could have been constructed for these flow scenarios, a central component of the three spill scenarios was an attempt to link early season releases in some way to native runoff flows. In this case, average daily flows for the Dolores gage were used to index when release quantities should begin to increase, peak, and recede. However, the '64,000 kAF' spill scenario was indexed to the 20% excedence flow at Dolores, i.e., the flow that is exceeded by all but 20% of the historic flows for that day, which in general, represents a fairly dry year scenario at the town of Dolores. The terminus of the release period was based on the assumed length of the spill.

Table 5. Details of Release Scenarios for Ecological Flow Releases

FLOW SCENARIO	Assumptions and Comments on Hydrograph Construction
BASEFLOW ONLY	• 29,300 AF Fishery Pool Allocation - Note that this will be supplemented by 700 AF of Paradox augmentation water and also during the irrigation season to meet downstream irrigation rights (2-5 cfs) • Includes one day at 200 cfs for fish stocking in Reach 1 (October 1)
64,000 AF SPILL	• Spill Dates April 16 - May 31 (46 days) • For baseflow scenario - Apr. 16 - May 31 flows were 3650 AF that can be used for other ecological purposes • INDEX TO 20% excedence flow @ Dolores Gage (from historic record) • pre-spill ramp up reflecting historical rate (ie, INDEX release to native flow) • maintain 2+ wk sampling period in April ~400 cfs (begin 4/21) • ensure geomorphic work near historical peak (6 days ~1800 cfs using Q_20 INDEX) saturation of low flood surface; high groundwater on higher surface • provide late summer baseflow relief for rec fishery (78 cfs target)
187,000 AF SPILL	• Spill Dates April 1 - June 30 (91 days) • From baseflow scenario - Apr. 1 - June 30 flows were 7815 AF that can be used for other ecological purposes • Index to historical ave daily values @ Dolores (NOT Q_20) • pre-spill ramp up reflecting historical rate (ie, INDEX release to native flow) • maintain 2+ wk sampling period in April ~400 cfs • ensure geomorphic work near historical peak • ensure overbank flows • taper June hydrograph to reflect historical drawdown for flows between 1000-2000 cfs, < or = 100 cfs/d • provide late summer baseflow relief for rec fishery (78 cfs target) • add 5+ cfs for winter flows to reduce winter stress
310,000 AF SPILL	• Spill Dates April 1 - June 30 (91 days) • From baseflow scenario - Apr. 1 - June 30 flows were 7815 AF that can be used for other ecological purposes • Index to historical ave daily values @ Dolores • pre-spill ramp up reflecting historical rate (ie, INDEX release to native flow) • maintain 2+ wk sampling period in April ~400 cfs (begin 4/4) • ensure geomorphic work near historical peak; maximize opportunity for work • ensure overbank flows • taper June hydrograph to reflect historical drawdown for flows between 1000-2000 cfs, < or = 100cfs/d • provide late summer baseflow relief for rec fishery (78 cfs target) • add 5+ cfs for winter flows to reduce winter stress

Figure 20 again presents the composite plot of these four hypothetical release scenarios. In addition, average daily flows from the historic record were also added for March 1 – August 31 so that the relationship of native flow to the 'ecological hydrographs' can be illustrated. The hydrographs presented below are constructed based on how management criteria based solely on ecological objectives could affect the general shape of the releases for representative water supplies. In all of the spill scenarios, the final recession of the release hydrograph accelerates far faster than native flows would at Dolores, but this is realistic depiction reflecting the assumption that spill releases stop when inflow equates with outflow demand.

Also included in the rising limb in all spill scenarios is a 10-14 day period at ~400 cfs for fishery population monitoring. This monitoring is especially important at present because of uncertainties in population status through large reaches of the Dolores, espcially in Slickrock Canyon (Reach 5). Only sparse trend data exists for Reach 2, and most of Reaches 3, 4, and 6 also are unsurveyed. It is important to determine how representative the existing sampling sites are relative to other reaches, and it will also be important to examine in detail population differences above and below Disappointment Creek, if they exist. A flow of approximately 400 cfs has been suggested as a starting point for acquiring fishery population data through canyon reaches.

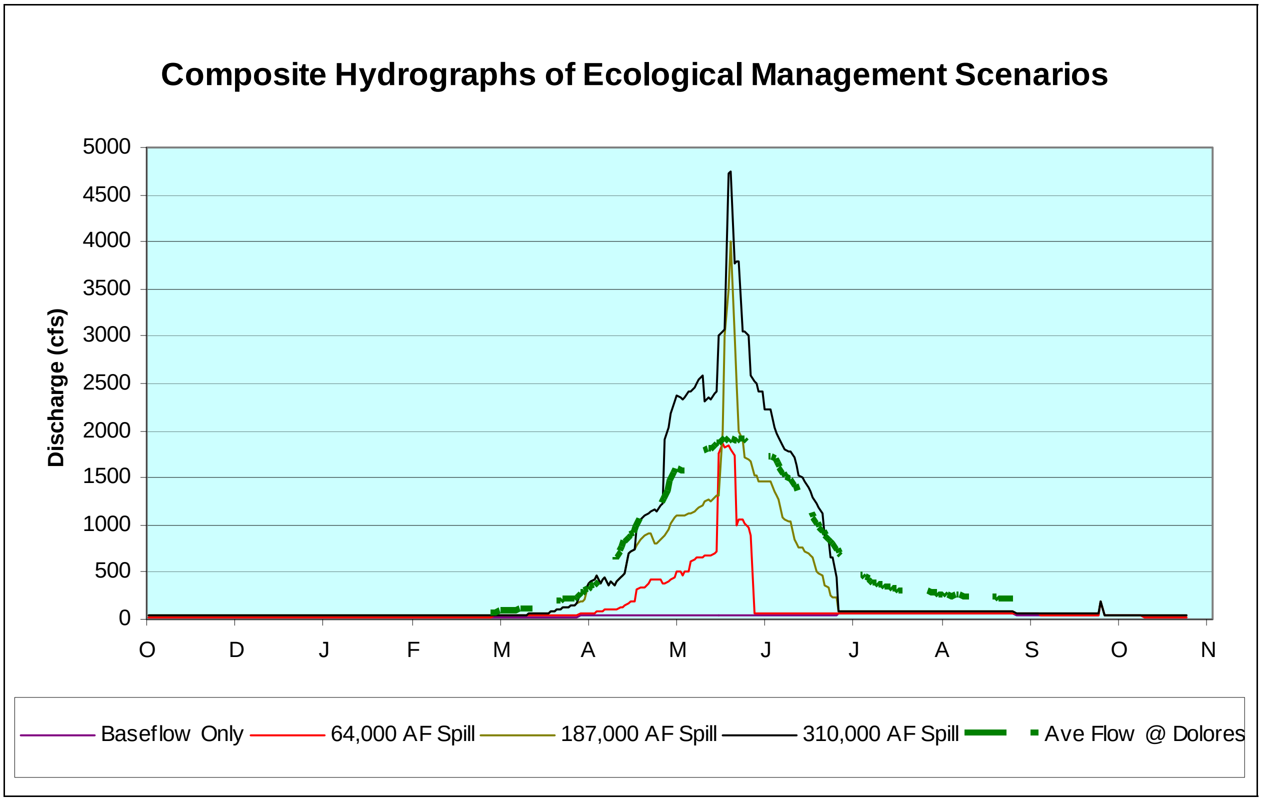

Figure20. Composite Hydrographs for the four ecological flow management scenarios being discussed in this section. The small spike October 1 is the 12-hour, 400 cfs release for fish stocking between McPhee Dam and Bradfield Bridge.

B. Expected Ecological Conditions: Ecological Management – Blue Sheet Template (Reaches 1-3)

Ecological Management	Reach 1 McPhee Dam to Bradfield Bridge	Reach 2 Bradfield Bridge to Dove Creek Pumps	Reach 3 Dove Creek Pumps to Joe Davis Hill
Supported by 4 Hydrographs Base Flow, Small, Medium and Large Spill NOTE: "+" - flow will enhance/ meet objective or resource described "-" – flow will not meet objective or will degrade resource described "=" – effect of flow on objective / resource described are neutral or uncertain (emphasized with "?")	**Base Flow** (-) sediment transport, mobilize cobble, embedded channel; riparian vegetation; aquatic organisms, cold water trout (+) low-channel veg mats grow & persist **Small Spill** (=) coldwater fish; Unknown effect of steep recession on spring spawn (?), small summer baseflow enhancement; woody plant, wet meadow persistence, no opportunity for cottonwood planting; low-channel veg marginally scoured; modest pool scour (+) fines flushed; sorting of gravels **Medium Spill** (+) aquatic organisms viability/ health stabilized; sediment transport - point bar, floodplain deposition; opportunity for woody veg. recruitment (=F(recession timing)); moderate increase coldwater fish production based on habitat and summer baseflow improvement. **Large Spill** (+) mobilize bar cobbles, re-work in-channel deposition, flush riffles and pools, riffles mobilized(?); potential channel migration; woody plant recruitment (CW = F(timing)); aquatic life forms; general riparian health; cold water fish production. (-) low-channel veg mats scoured	**Base Flow** (-) no opportunity to mobilize cobbles or tributary sediment inputs; aquatic organisms, cold water trout; native ww species (incremental negative impacts) (+) low-channel veg mats grow & persist **Small Spill** (=) coldwater fish; Unknown effect of steep recession on spring spawn (?), summer baseflow enhancement; woody plant, wet meadow persistence; low-channel veg marginally scoured (+) native ww fish production based on early season temp. suppression/ spawn delay (?); fines flushed; modest pool scour; sorting of gravels **Medium Spill** (+) aquatic organisms viability/ health stabilized; sediment transport - point bar, floodplain deposition; modest sediment transport (flushing riffles and pools, sort particle sizes); willow recruitment; cold water fish production; native ww fish production(?); riparian health **Large Spill** (+) mobilize bar cobbles, re-work in-channel deposition, flush riffles and pools, riffles mobilized(?); woody plant recruitment (willow), floodplain productivity; increase in aquatic life forms; increases in coldwater fish production. (-) low-channel veg mats scoured	**Base Flow** (-) no opportunity to mobilize cobbles or tributary sediment inputs; aquatic organisms, cold water trout; native ww species (incremental negative impacts) (+) low-channel veg mats grow & persist **Small Spill** (=) coldwater fish; Unknown effect of steep recession on spring spawn; wet meadow persistence; low-channel veg marginally scoured (+) native ww fish production based on early season temp. suppression/ spawn delay(?); fines flushed; modest pool scour; sorting of gravels **Medium Spill** (+) aquatic organisms viability/ health stabilized; sediment transport - point bar, floodplain deposition; modest sediment transport (flushing riffles and pools, sort particle sizes); willow recruitment; cold water fish production; native ww fish production(?); riparian health **Large Spill** (+) Mobilize in-channel depositional features, riffles mobilized(?); riparian health; aquatic life forms; coldwater fish production based on habitat improvements; ww fish production based on habitat and spawn delay (-) low-channel veg mats scoured

B. Expected Ecological Conditions Ecological Management – Blue Sheet Template (Reaches 4-6)

Ecological Management	Reach 4 Joe Davis Hill to Big Gyp	Reach 5 Big Gyp to Wild Steer Canyon	Reach 6 Wild Steer Canyon to Saucer Basin
Supported by 4 Hydrographs Base Flow, Small, Medium and Large Spill	**Base Flow** (-) sediment flux; instream ww fish habitat; ww fish viability; riparian woody veg recruitment (=) low-channel veg mats (phragmites/ sedge) (+) non-native ww competitors/ predators **Small Spill** (=) pool scour, flushing most fines (duration too short for significant work); recruitment of willows along water's edge (+) ww native fish habitat/ productivity based on habitat and spawn delay, inhibiting non-native productivity; summer baseflow enhancement; (-) non-native ww competitors **Medium Spill** (+) ww fish habitat/ ww fish productivity; pool scour, fines mobilized, gravels sorted, floodplain deposition; recruitment of willows, opportunity for CW planting = F(timing) (-) non-native ww competitors **Large Spill** (=) ww fish reproduction (?- may wash larvae); woody plant recruitment (?) hindered by existing channel morphology; significant sediment transport, pool and riffle scour (mobilize riffle?) but may downcut channel, entrench channel (-) (+) ww fish habitat, more baseflow; potential channel migration; floodplain health; CW recruitment = F(timing) (-) non-native ww competitors	**Base Flow** (-) sediment flux; instream ww fish viability; riparian woody veg recruitment (+) non-native ww competitors/ predators **Small Spill** (=) pool scour, flushing most fines (duration too short for significant work) (+) ww native fish habitat/ productivity based on habitat improvelement and spawn delay, inhibiting non-native productivity; summer baseflow enhancement; (-) non-native ww competitors **Medium Spill** (+) ww fish habitat/ ww fish productivity; pool scour, fines mobilized, gravels sorted; riparian productivity based on overbank flow, sediment deposition (-) non-native ww competitors **Large Spill** (=) ww fish reproduction (?- may wash larvae) (+) ww fish habitat, baseflow improvement; significant sediment transport, pool and riffle scour (mobilize riffle?); potential channel migration; floodplain health based on overbank flow and deposition; CW recruitment = F(timing) (-) non-native ww competitors	**Base Flow** (-) sediment flux; instream ww fish habitat; ww fish viability; riparian woody veg recruitment (+) non-native ww competitors/ predators (? – presence/absence unknown) **Small Spill** (=) pool scour, flushing most fines (duration too short for significant work); recruitment of willows along water's edge, but may enhance tamarisk productivity; no opportunity for CW recruitment based on steep recession (+) ww native fish habitat/ productivity based on habitat and spawn delay, inhibiting non-native productivity; summer baseflow enhancement; (-) non-native ww competitors (?) **Medium Spill** (+) ww fish habitat/ ww fish productivity; pool scour, fines mobilized, gravels sorted; recruitment of willows, opportunity for CW planting = F(timing) (-) non-native ww competitors (?) **Large Spill** (=) ww fish reproduction (?- may wash larvae); woody plant recruitment (?); significant sediment transport, pool and riffle scour (mobilize riffle?) (+) ww fish habitat; potential channel migration; floodplain health; CW recruitment = F(timing) (-) non-native ww competitors (?)

	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
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1937	185390
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1965	99335
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1994	25955
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1997	309241
1998	129724
1999	169450
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2004	
2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

Summary of Model Results

- No Spill - 35 of 78 years (45%)
- Spill < 64,000AF (12%)
- 64K < Spill < 187K AF (18%)
- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Ecological Management Reach 1: McPhee Dam to Bradfield Bridge (12 miles)

Shallow gradient, alluvial reach with wide valley bottom and meandering pools and riffles; riparian area dominated by narrow-leaf cottonwoods, box elder and willow; wet-meadow wetland habitats; accessible by gravel road; trout fishery focus for base flow management.

Geomorphology: Ecological flows under 'small spill' allow for geomorphic work consistent w/ channel maintenance objective. Uncertain to what extent 5000cfs will mobilize imbedded riffles, or whether detriments of lateral erosion/ sedimentation would outweigh benefits of channel scour. Goal to enhance natural process of 'channel downsizing' improved by tapering hydrograph on larger spill volumes. Continue instream habitat projects to improve structural diversity, pool depth, and juvenile habitat, and monitor/ adapt flow peaks and durations as instream conditions improve.

Riparian Ecology: Ecological flow management may present opportunities to encourage sexual reproduction of cottonwoods if timing recession feasible w/ inflow/outflow constraints at higher flows. Long-term viability of off-channel wet meadow habitats and floodplains improved by more frequent flows near 1800-2000 cfs on small spill years. Woody vegetation (sandbar willow) primary colonizer of 'low floodplain' habitat and will continue to facilitate channel narrowing. Combining riparian plantings with mechanical habitat treatments is a feasible approach, but needs to be maintained by supportive flow regime.

Cold Water Fishery: Drought cycles (consecutive years of baseflow only) will continue to significantly affect recreational fishery. Whirling disease continues to affect juvenile rainbow trout survival, but habitat improvements/ more scouring flows can minimize effects. Continue re-stocking program; instream habitat improvements. Continue monitoring of trout populations, and note trends in native sculpin population. Baseflow still limiting factor for trout biomass.

Warm Water Fishery: Little to no persisting warm water species in Reach 1.

Summary: Reach 1 has been managed primarily for trout whose populations will fluctuate downward during no spill periods and recover with active stocking, and baseflow improvements during extended wet periods. Spill management for ecological purposes will improve instream habitat through more frequent flows at or near historic bankfull, and habitat projects could address water surface elevations applicable to both minimal rafting and historic bankfull flows. Still uncertain whether high flows designed to maintain historic floodplain community and off-channel meadow habitats will occur frequently enough to allow these habitats to persist.

Research Needs:

- Correlate downstream temperature and thermal stress on trout with McPhee releases.
- Determine the effects, if any, of otter predation on trout populations.
- Determine mobility of bed sediments under various peak flow scenarios. Assess mobility of imbedded riffles, and/or effects of immobile riffles on primary productivity and aquatic function.
- Detail locations where natural channel narrowing is hindered by entrenchment or bank hardening. Focus habitat restoration in these reaches.

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1928	
1929	134822
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2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

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187K < Spill < 310K AF (14%)
Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Ecological Management Reach 2: Bradfield Bridge - Dove Creek Pumps (19 miles)

Steeper gradient, confined bedrock-controlled channel. Riparian community dominated by ponderosa pine woodland with willows and oaks along stream corridor. Secluded, only accessible by hiking and floating. Self-sustaining brown trout population.

Geomorphology: Ecological flow management would maintain sediment transport through reach; higher magnitudes for all spill scenarios will improve pool scour and potential for riffle mobilization. Tributary sediments will accumulate in pools and diminish habitat quality during prolonged dry (non-spill) periods.

Riparian Ecology: Ponderosa pine/ oak woodland community is unique in Dolores River basin. Ecological flow management will preserve this community and may diminish threats of non-native forbs in understory (e.g., Dalmatian toadflax; knapweed) if frequency/ duration of overbank flows is increased. Non-spill periods encourage development of dense low-flow sedge/grass/willow associations.

Cold Water Fishery: Reproducing populations of brown trout and wild rainbow trout (self-sustaining populations) remain the goal for fishery managers in this reach, but rainbow reproduction remains affected by whirling disease. Monitoring suggests fluctuations in trout populations directly linked to baseflow/ spill conditions. Ecological flows will improve instream habitat by maximizing pool scour opportunities, and will result in incremental increase in productivity. Continue to monitor populations, including mottled sculping, during spill years.

Warm Water Fishery: Little to no persisting populations of sucker species in Reach 2 (based on sampling in the upper 2 miles of Reach 3); roundtail chub populations also fluctuate; threats from non-native sunfish may be mitigated by periodic spills, which also improve habitat availability for roundtails. Monitoring frequency/ data acquisition improved by ~ 10 days of target flows of ~400 cfs during spill years.

Summary: Reach 2 is geomorphically more resilient than the alluvial reach upstream, but lack of sediment flux during prolonged droughts degrades habitat conditions and reduces productivity of both cold water and warm water aquatic species. Riparian community also appears resilient to changes in long-term flow management, but affects on short alluvial reaches and narrow floodplain habitats not well understood in this reach. More frequent high peaks will incrementally improve habitat for trout through the reach. Important to acquire population trend data for both coldwater and warm water species through this reach.

Research Needs:

- Determine when and where native roundtail spawn, and temperature cues that trigger spawning cycles.
- Determine whether sucker species are compatible with cold water releases from McPhee.
- Determine effects of non-native predation on native warm water species.
- Determine extent of non-native weed invasion in riparian areas. Spot treat as feasible.

Year	Spill Total (AF)
1928	
1929	134822
1930	61005
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2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

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- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Ecological Management Reach 3: Dove Creek Pumps to Joe Davis Hill (9 miles)

Steep gradient, confined colluvial/ bedrock controlled channel. Ponderosa pine box-elder, some old cottonwoods in upper reaches; valley widens and ponderosa declines downstream. Declining native warm water fish populations and increasing non-native sun fish. Two track road on left bank, class V "snaggletooth rapid" near low end.

Geomorphology: Ecological flow management would maintain sediment transport through reach; higher magnitudes for all spill scenarios will improve pool scour and potential for riffle mobilization. Tributary sediments will accumulate in pools and diminish habitat quality during prolonged dry (non-spill) periods.
Riparian Ecology: Ponderosa pine/ oak woodland grades downstream into box-elder, willow, and silver buffaloberry in near-stream environment. Non-spill periods encourage development of dense low-flow sedge/grass/willow associations (increasing phragmites in downstream direction) on low streambank. Ecological flow management wold preserve near-stream community, but may increase scour of low-flow streambank. Main threats are non-native weeds in understory, and potential reduction in historical, near-channel wet meadow habitats linked to floodplains. Ecoloogical flows aimed toward historic bankfull (~ 2000 cfs) and above should improve conditions of these habitats.
Cold Water Fishery: Fishery changes from primarily coldwater to warm water through this reach. Some reproducing populations of brown trout and rainbow trout may remain in deep pools; pool/ riffle habitat would be enhanced by higher peaks.
Warm Water Fishery: Based on sampling 1.3 miles below Dove Ck pumps, population viability of native sucker species in doubt, but the extrapolation of Reach 3 conditions based on the Dove Ck site is uncertain. Roundtail chub populations also fluctuate with poor age-class structure; threats from non-native sunfish may be partially mitigated by periodic spills, which also improve habitat availability for roundtails. Early 'spawn delay' releases will allow for monitoring/ testing of this hypothesis.
Summary: Similar to Reach 2, Reach 3 is geomorphically fairly resilient, but lack of sediment flux during prolonged droughts degrades habitat conditions and reduces productivity of both cold water and warm water aquatic species. Riparian community also appears resilient to changes in long-term flow management; ecological flows should improve viability of near-channel wet meadow habitats through short alluvial reaches. Trends in native and non-native warm water fish populations are of critical interest to state fishery managers; target flows for population monitoring between the Dove Ck Pump site and Disappointment Ck will improve understanding of life cycles of native fish.

Research Needs:
- Determine when and where native fish populations spawn, and temperature cues that trigger spawning cycles; specifically, if early season releases for temperature suppression delay spawn favorably for warm-water native fish.
- Determine effects of non-native predation on native warm water species.
- Discern downstream extent of viable cold water fish populations.
- Determine extent of non-native weed invasion in riparian areas. Spot treat as feasible.

Year	Spill Total (AF)
1928	
1929	134822
1930	61005
1931	
1932	220738
1933	
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2005	191380*

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Summary of Model Results

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- 187K < Spill < 310K AF (14%)
- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Ecological Management: Reach 4 Joe Davis Hill through Big Gypsum Valley (38 miles)

Fairly flat with a riparian corridor dominated by sage and greasewood on the upper banks, silverberry and sedge mats closer to channel. Increasing tamarisk downstream. Sparse older cottonwoods dislocated from river processes. High sediment loads introduced below Disappointment Ck; non-native competition and predation with native warm water fish species.

Geomorphology: Ecological flow management will maintain and improve geomorphic function of pool scour above and below Disappointment Ck, but significant accumulation of fines below Disappointment Ck during non-spill periods will continue to impair habitat quality. Riparian vegetation encroachment on sediments below Disappointment induces channel entrenchment and reduces floodplain connectivity in some alluvial reaches. Ecological flows would maximize ability to scour fines, but floodplain dislocation in some reaches may require mechanical treatments to improve geomorphic function. Concern that 'large spill' scenario could induce channel entrenchment, further dislocation from the river's floodplain in certain reaches already entrenched by dysfunctional river process and ecology (tamarisk).

Riparian Ecology: Ecological flows will maintain willow/sedge and silverberry community above Disappointment Ck. Below Disappointment Ck, it is possible that increased connection of floodplain to the channel and appropriate recession limb timing could create the conditions for seed propagation of cottonwoods. However, channel narrowing and entrenchment threatens native communities, and as noted above, high spill flows could induce further downcutting in some portions of Reach 4.

Cold Water Fishery: Not considered cold water fish habitat below Reach 3.

Warm Water Fishery: Based on sampling in the Big Gypsum Valley (low end of reach), population viability of bluehead sucker species in doubt. Flannelmouth sucker and roundtail chub populations both fluctuate with few reproducing adults. Ecological flows should improve conditions for native fish based on more frequent pool and fine sediment scouring energy, and if 'spawn delay' strategy (early spring cold-water releases) improves reproductive success of warm water native fish.

Summary: Ecological flows could improve habitat conditions through Reach 4 below Disappointment Ck by more efficient scouring of accumulated sediments. In addition, warm water native fish populations could improve if testable hypothesis re: 'spawn delay' improves success of warm water fish reproduction. Some concern regarding how very large spill flows (5000+ cfs) could potentially increase channel downcutting where significant channel narrowing and entrenchment has already affected channel.

Research Needs:

- Determine when and where native fish populations spawn, and temperature cues that trigger spawning cycles. Determine effects of non-native predation on native warm water species.
- Determine extent of non-native weed invasion in riparian areas, especially tamarisk. Develop habitat improvement strategy supported by flow regime. (SEE "Opportunity Summary: Big Gypsum Study Proposal")
- Determine effect of sediment flux from Disappointment Ck into Dolores.
- Determine appropriateness of cottonwood as prominent riparian component and if so, continue efforts to use flow management to propagate cottonwoods (peak flow timing; recession limb tapering).

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1928	
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2005	191380*

* Actual Spill in 2005; not modeled in DRD Hydrology Report

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187K < Spill < 310K AF (14%)
Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Ecological Management: Reach 5 Big Gypsum Valley to Wild Steer Canyon (42 miles)

Low gradient, confined by steep canyon walls. This is the only other reach besides Reach 2 that must be accessed by hiking in or floating the river. Few to no trout are found in this part of the river and salinity levels begin to rise as you go downstream. A BLM Wilderness Study Area surrounds this reach of the river.

Geomorphology: This reach represents a 'hybrid' between canyon reaches 2-3 upstream and Reach 4 below Disappointment Ck affected by significant contribution of sediments. Lack of regular spills and sediment deposition in structurally-controlled reach affects habitat for native fish. Ecological flows should improve scouring, especially very large peak flows, that could significantly enlarge pool habitats and re-work other channel sediments.

Riparian Ecology: Relatively intact riparian community of willow and New Mexico privet above Coyote Wash. Phragmites significant component, which acts to stabilize channel margins with willow. Community changes rapidly to tamarisk-knapweed association below Coyote Wash, which may be due to natural salinity. Ecological flows will not serve to significantly affect riparian ecology through Reach 5, although there may exist opportunities for natural propagation of cottonwoods given appropriate reach morphology, peak flow timing, and recession of the hydrograph.

Cold Water Fishery: Not considered cold water fish habitat below Reach 3.

Warm Water Fishery: Significant unknowns with respect to native species composition, age class structure, recruitment, and ultimately, population viability. Infrequent spills increase competitive stressors and diminishes habitat availability for native fish; wet cycles reduce stress and improve habitat quality for natives. Ecological flows should incrementally improve habitat quality; more importantly, when an opportunity exists, 'monitoring flows' and the subsequent data will improve fishery managers' understanding of the population status and potential threats to native fish through this reach.

Summary: As noted under the 'Geomorphology' header above, Reach 5 is impacted by irregular sediment transport, which reduces habitat availability and productivity of warm water native species. Riparian community in upper reach above Coyote Wash relatively intact and appears resilient to flows. Riparian community below Coyote Wash is primarily non-native mono-typic, with little floodplain interaction. Trends in native and non-native warm water fish populations are of critical interest to state fishery managers; incorporation of 'monitoring flows' into the ecological flow scenarios will improve understanding of the specific nature of threats to native species.

Research Needs:

- Determine community composition of fish populations in the canyon. Subsequent work may include a determination of the effects of non-native predation on native warm water species.
- Determine how sediment flux from upstream effects in-channel habitats for life cycles of native species. Consider long-term transect monitoring.
- Determine extent of non-native weed invasion below Coyote Wash, and cause-effect relationships between salinity and habitat composition.
- Determin if strategies developed for habitat improvements from Big Gypsum Valley may be applicable to lower end of Reach 5.

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1928	
1929	134822
1930	61005
1931	
1932	220738
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2005	191380*

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- Spill > 310,000 AF (12%)

Average Spill Size = 187,000 AF

Ecological Management Reach 6: Wild Steer Canyon to San Miguel River (12 miles to Saucer Basin)

Flat and wide with high concentrations of salt, this area is dominated by tamarisk. Large stands of very old cottonwoods still exist, however, there is little or no evidence of regeneration. Salinity and sediment are major factors affecting this reach.

Geomorphology: Active channel entrenched and disconnected from historic floodplain. Ecological management will not immediately remedy this situation, but should improve sediment flux. Specifics of sediment flux through this reach largely unknown. Geomorphic character changes between the Paradox Valley and the confined canyon above the San Miguel River, which may offer better habitat improvement opportunities. Large spills will improve pool scour, habitat availability for native fish species.

Riparian Ecology: Significant intrusion of tamarisk throughout this reach, aided by this species high tolerance to salt, giving it a competitive advantage over native woody species. Results of 'Big Gypsum Study Proposal' may have bearing on strategy for improving riparian habitat conditions through Reach 6. Any strategy must contemplate significant natural salinity in surface water, groundwater, and soils. Very high peak flows could scour sites recently colonized by tamarisk, and if timed with seed-set and appropriate hydrograph recession, could enable cottonwood establishment.

Cold Water Fishery: Not considered cold water fish habitat below Reach 3.

Warm Water Fishery: Significant unknowns with respect to native species composition, age class structure, recruitment, and ultimately, population viability through this reach. This reach was considered biologically dead during late summer from 1886-1986 when low flows, channel losses, and salinity significantly impaired biological resources. Pre-settlement fish productivity unknown. Ecological flows could improve habitat for warm water natives in this reach, but surveys of population status are lacking. Current extent of biological 'exchange' between reaches above and below Reach 6 also largely unknown.

Summary: Reach 6 is impacted by irregular sediment transport, which reduces habitat availability and productivity of warm water native species, but low flows, poor habitat, and high salinity may be more profound effects on native species viability than lack of sediment flux through this reach. Natural regeneration of cottonwoods will not occur without mechanical treatments, and the extent to which cottonwoods represent a native component of the riparian community in this reach remain unknown. Ecological flows could improve opportunity for natural reproduction of cottonwoods, but only if peak flow magnitude and recession timing are appropriate.

Research Needs:

- Determine community composition of warm water fish populations. Subsequent work may include a determination of the effects of non-native predation on native warm water species, or the extent to which Reach 6 hinders or facilitates upstream-downstream biological exchange.
- Characterize with site-specific data how sediment flux from upstream affects in-channel habitats for life cycles of both aquatic and riparian plant native species.
- Determine whether strategies developed from Big Gypsum Valley may be applicable to riparian restoration of Reach 6.