(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.

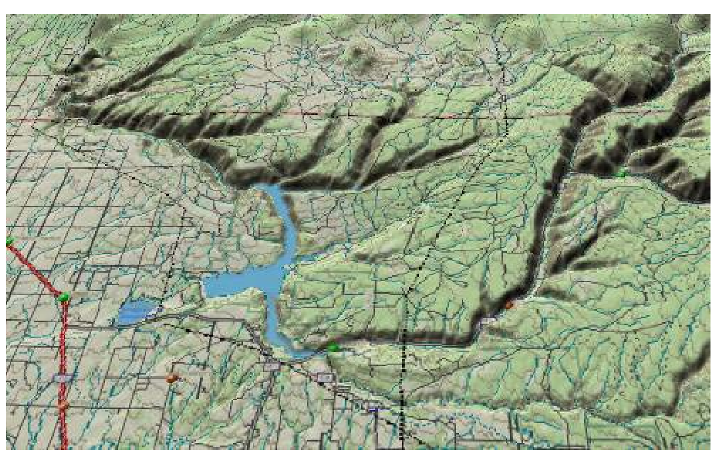
II. Hydrology and Downstream Ecology Pre-McPhee Reservoir through Dolores Project Operations

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.

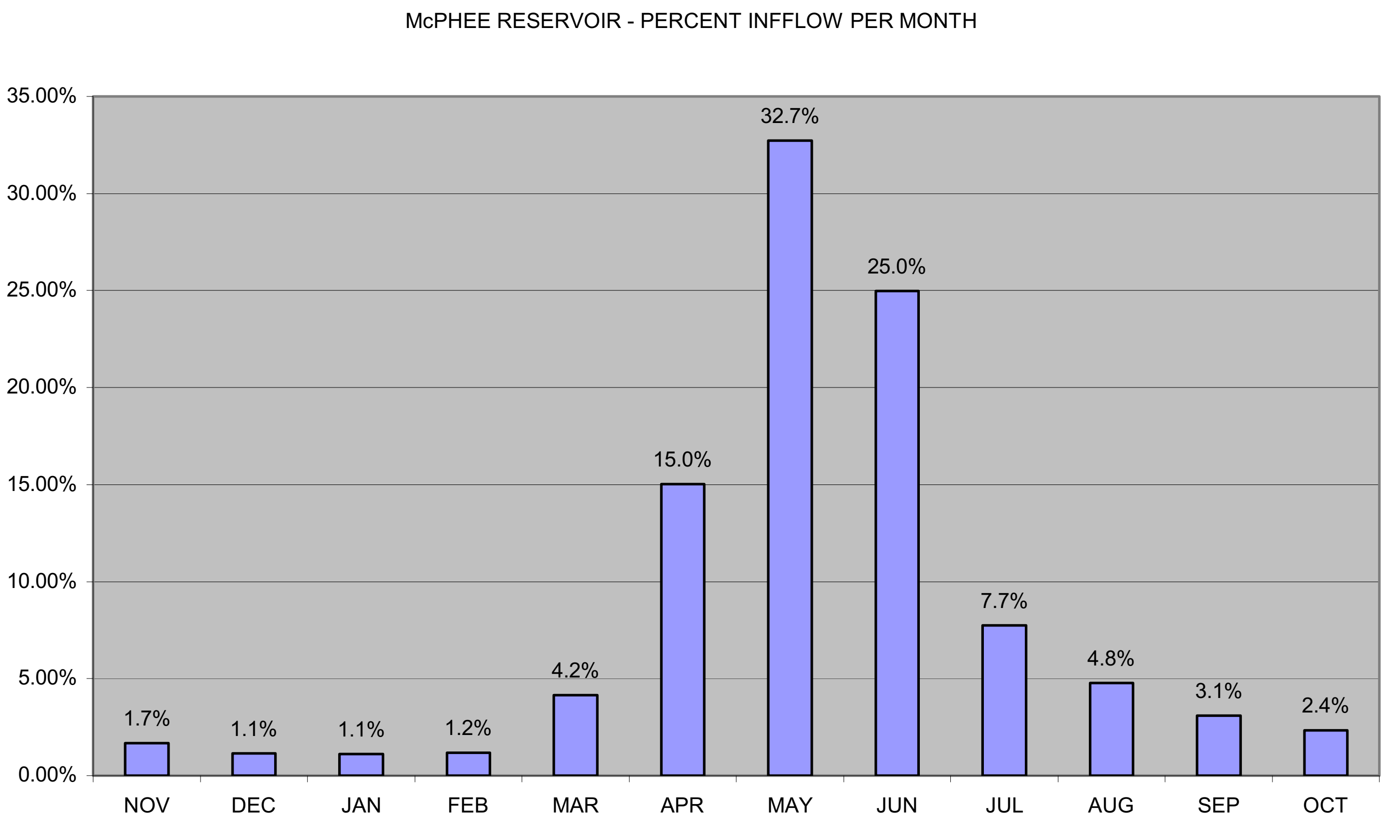


Figure 4. Monthly native inflow to McPhee Reservoir, based on gaged data from the Dolores gage data and accounting for tributary inflow below the gage.

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

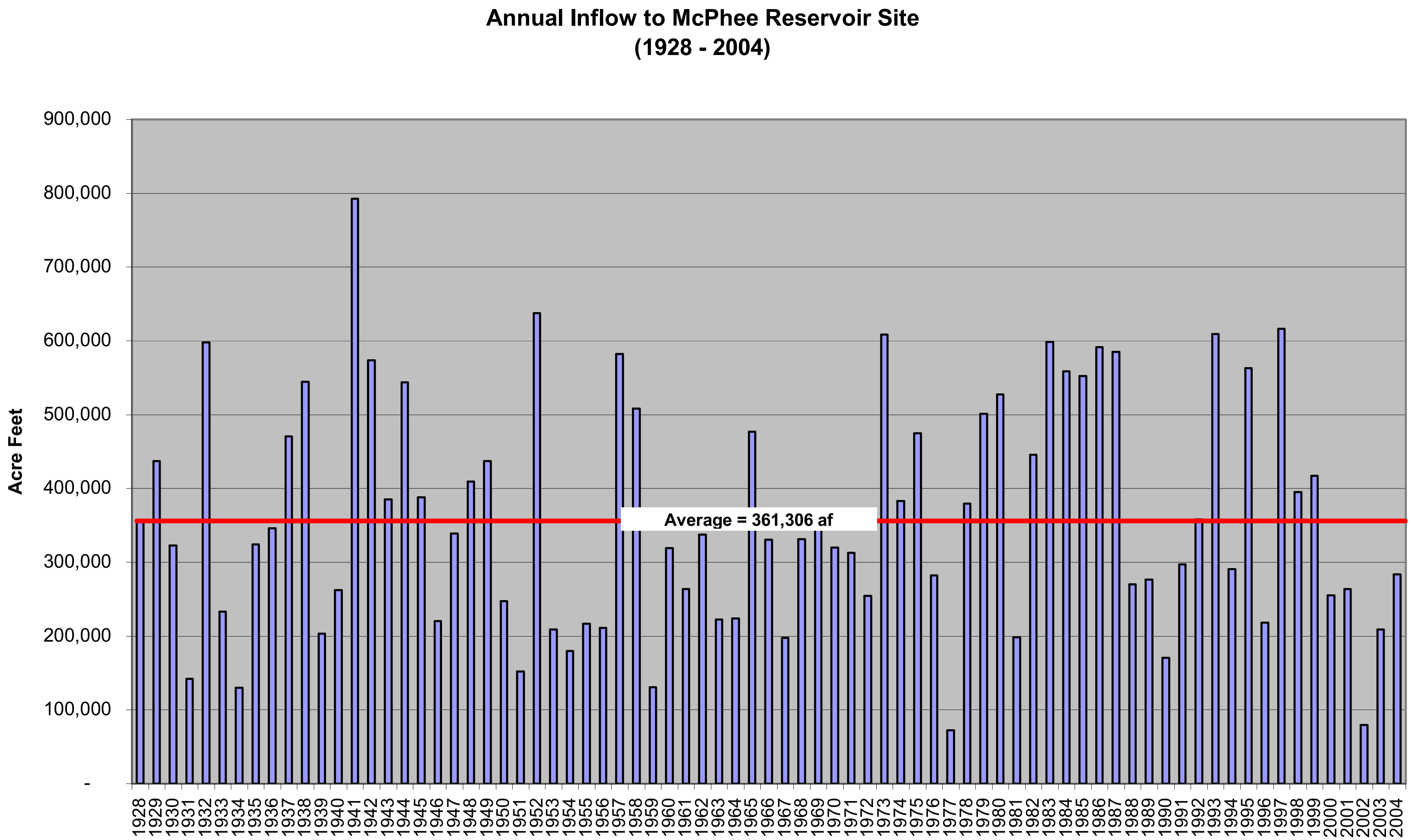


Figure 5 – Compilation of total annual inflow data from 1928-2004. Total inflows range from the driest year in 1977 (72,897 AF) to the wettest year in 1941 (793,000 AF). The average total inflow over the 76 years was 361,306 AF.

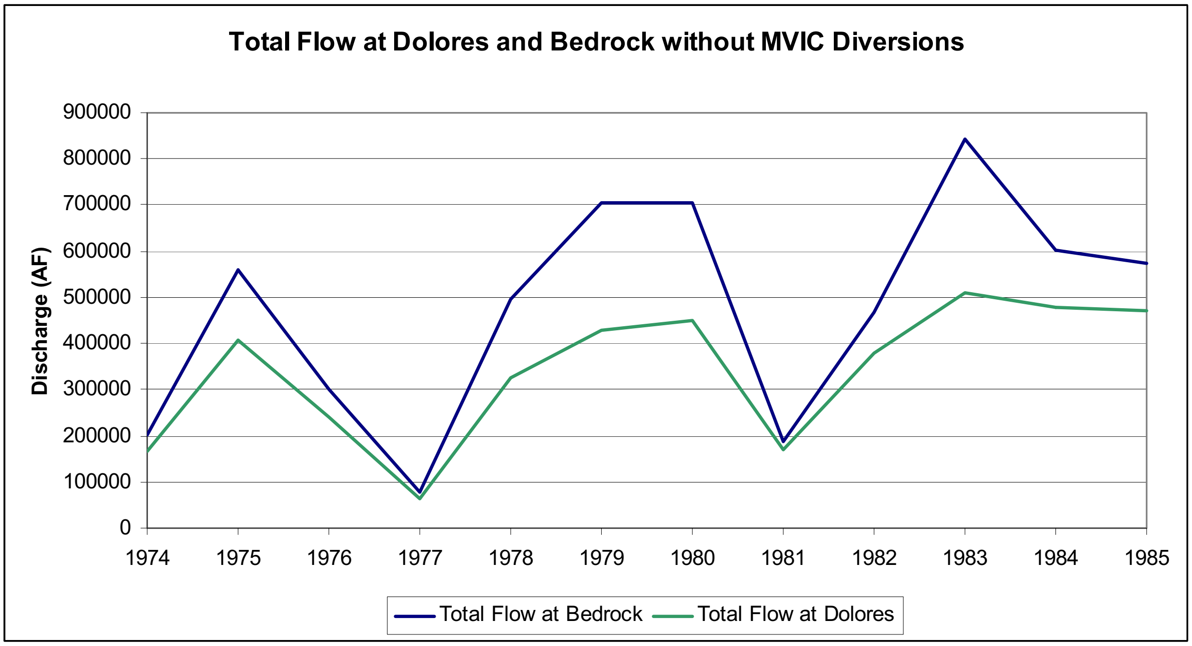


Figure 6. Total annual flow at Bedrock and Dolores gages for 1974-1985, synthesized at the Bedrock gage by adding MVIC daily diversions back into the daily gage record.

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.

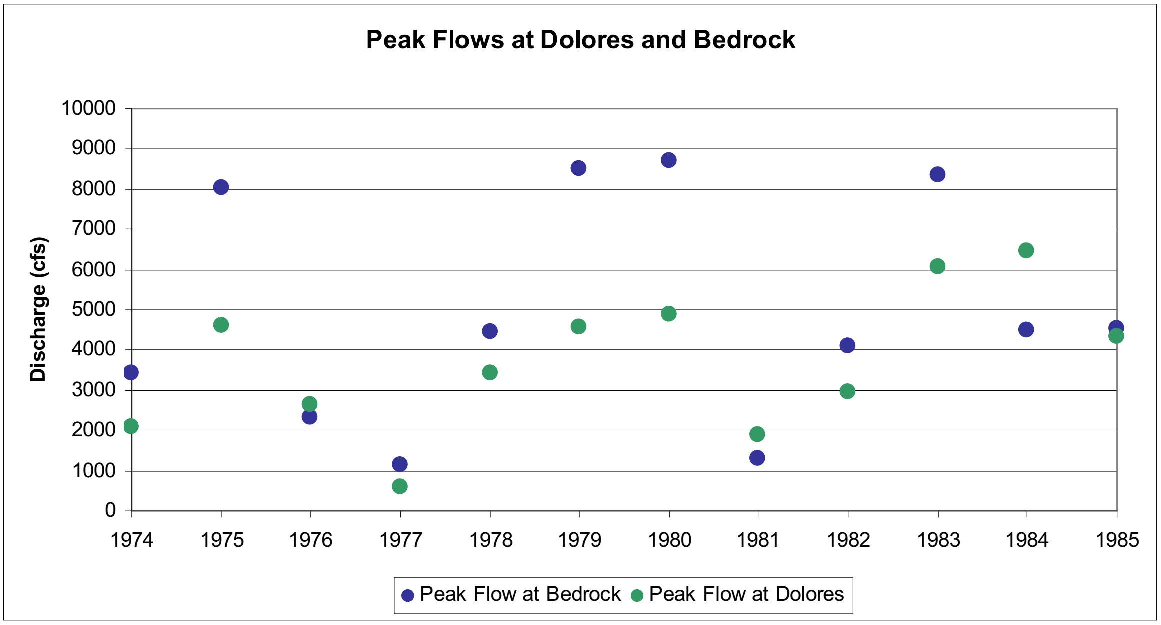


Figure 7. Peak flows at Bedrock and Dolores gages from 1974-1985. Because of timing variability and the relatively small amount of water diverted relative to the size and timing of the peak flow, daily MVIC diversions were not added back into the Bedrock record.

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.

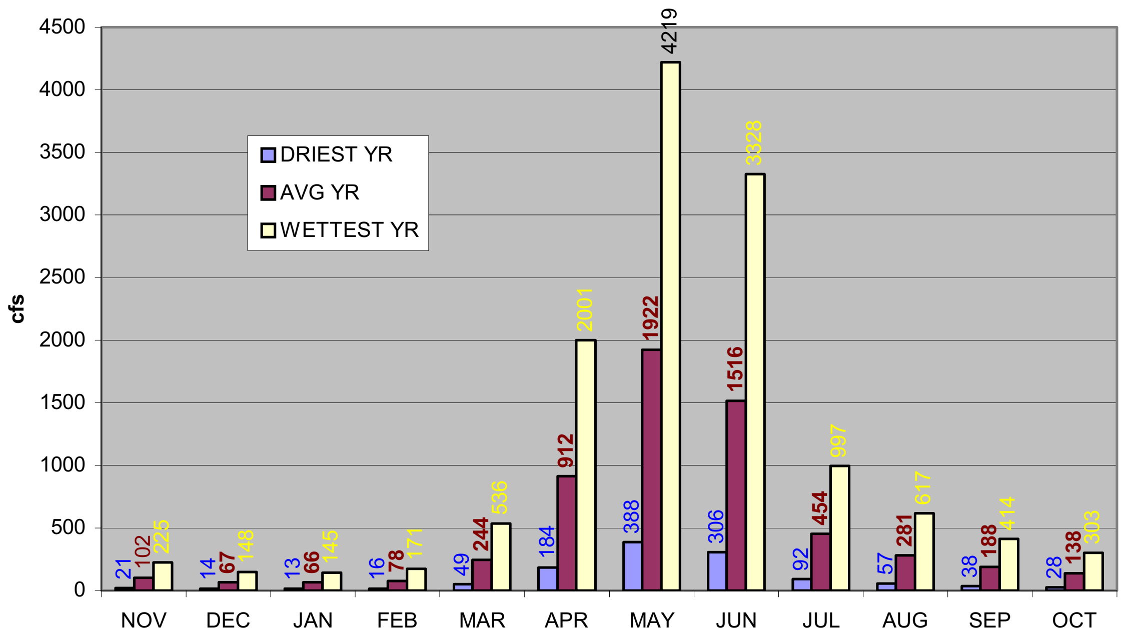


Figure 8. Monthly acre-foot inflow converted into average daily cubic feet per second flow comparing the driest, average and wettest years.

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.

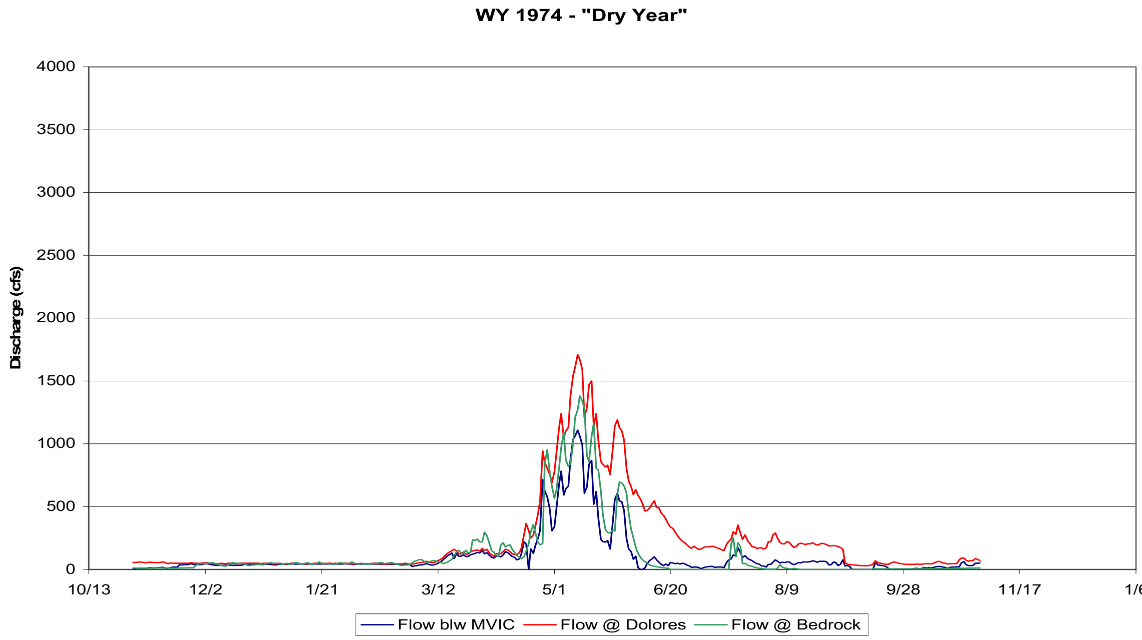


Figure 9. Calculated flow below the MVIC diversions, and gage data from Dolores and Bedrock gages for WY 1974.

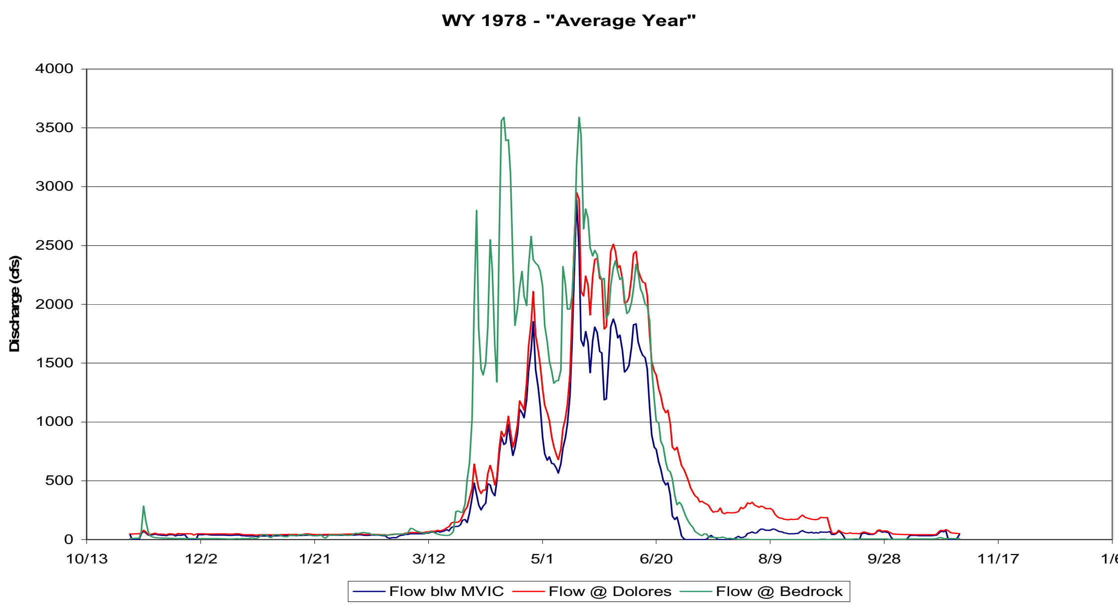


Figure 10. Calculated flow below the MVIC diversions, and gage data from Dolores and Bedrock gages for WY 1978.

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).

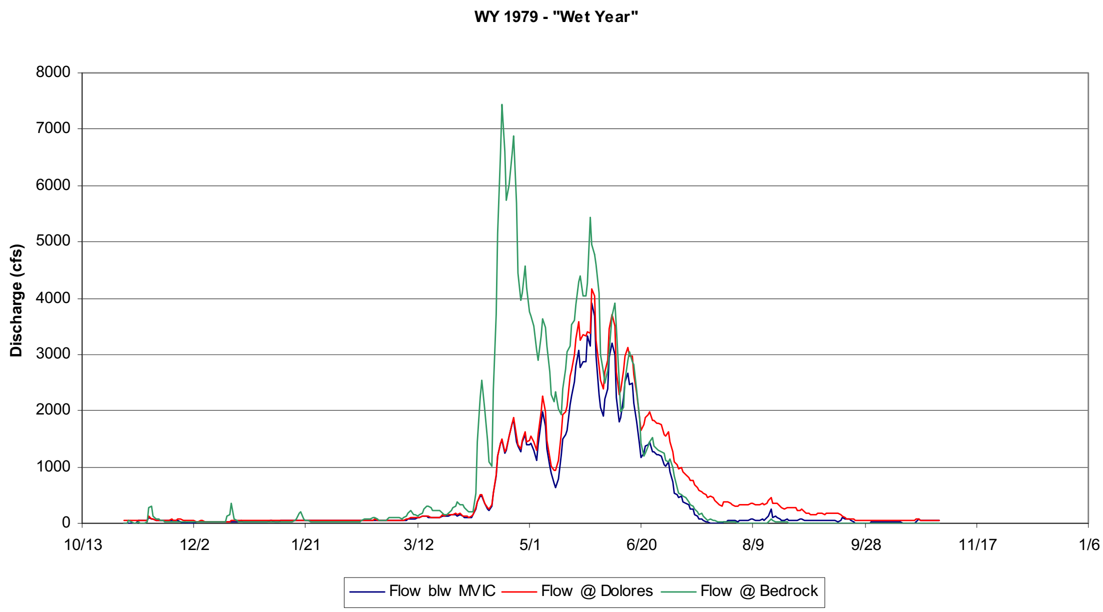


Figure 11. Calculated flow below the MVIC diversions, and gage data from Dolores and Bedrock gages for WY 1979. Note scale change on vertical axis.

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.

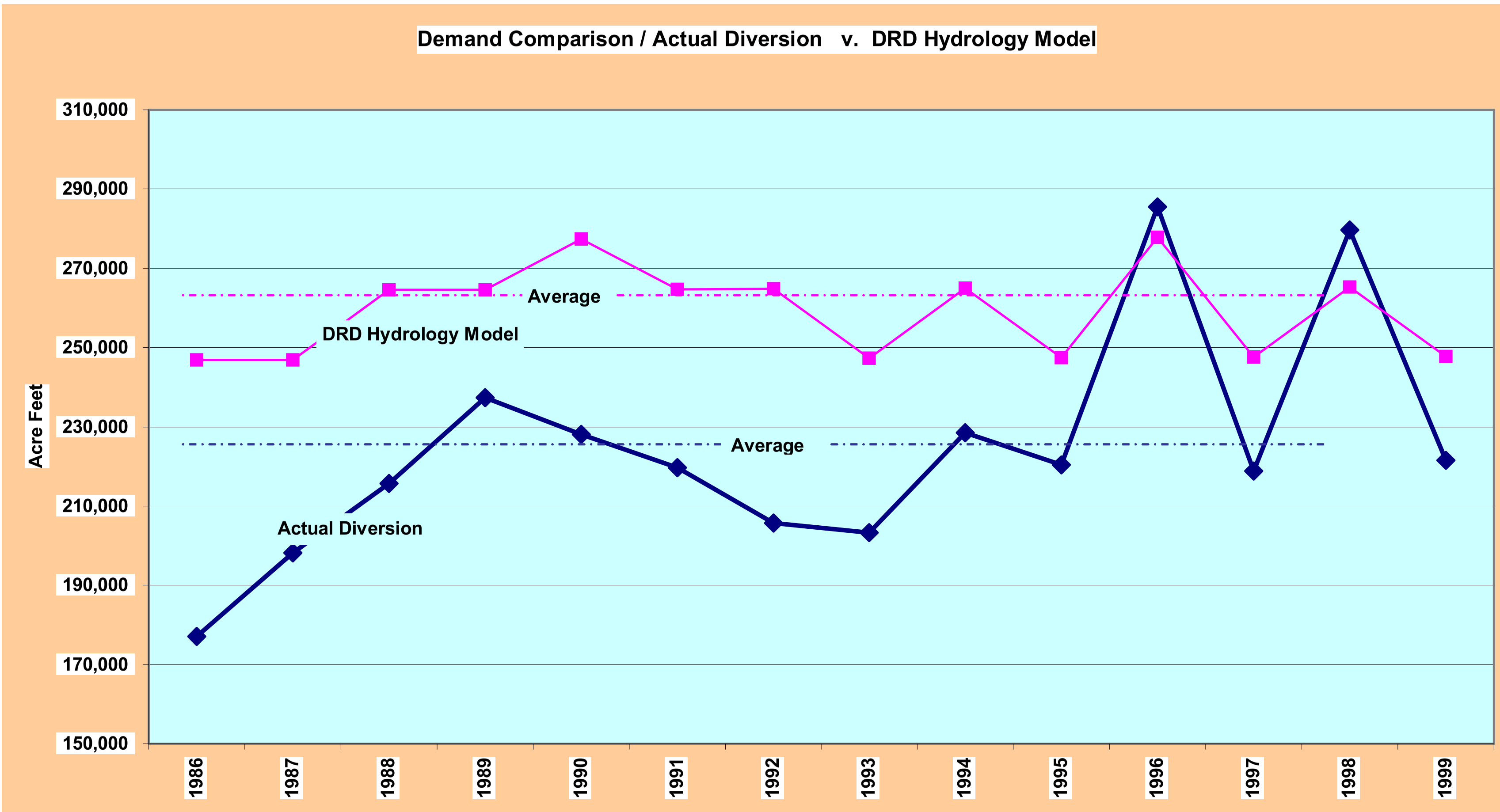
The original operating criteria for McPhee Reservoir were specified in the Final Environmental Statement (FES) and Definite Plan Report (DPR), published in 1977. Based upon records from 1928 to 1974, the FES/DPR indicated that an average of 25,400 af/yr of storage was available to supply flows for a 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.

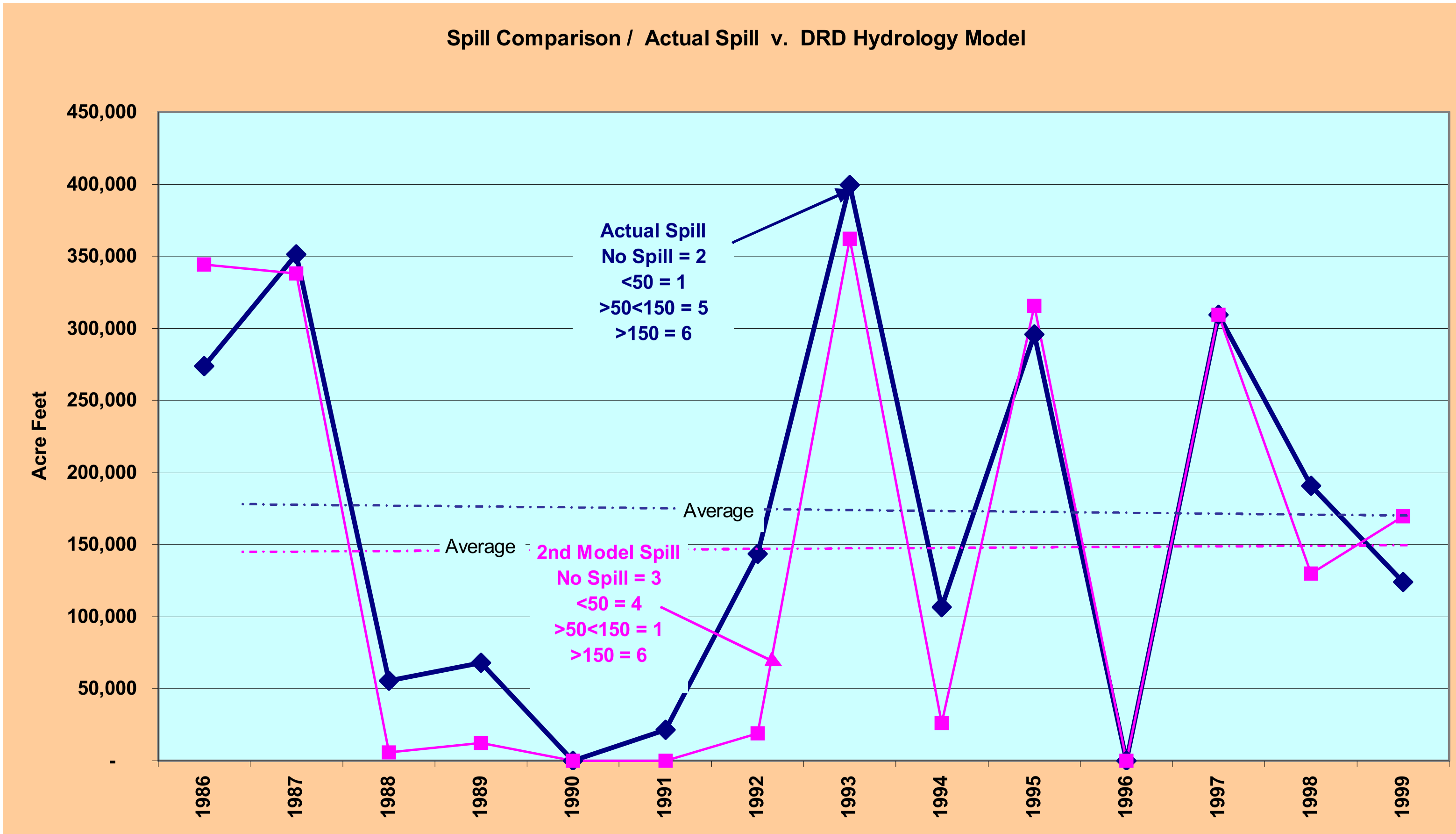
Figure 12 below shows actual diversions (blue line) as the Project came on line compared to modeled diversions assuming full Project use adjusted for weather patterns (pink line). Figure 13 compares the modeled spill (pink line assuming full Project use), with the actual spill. Since the project water 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.

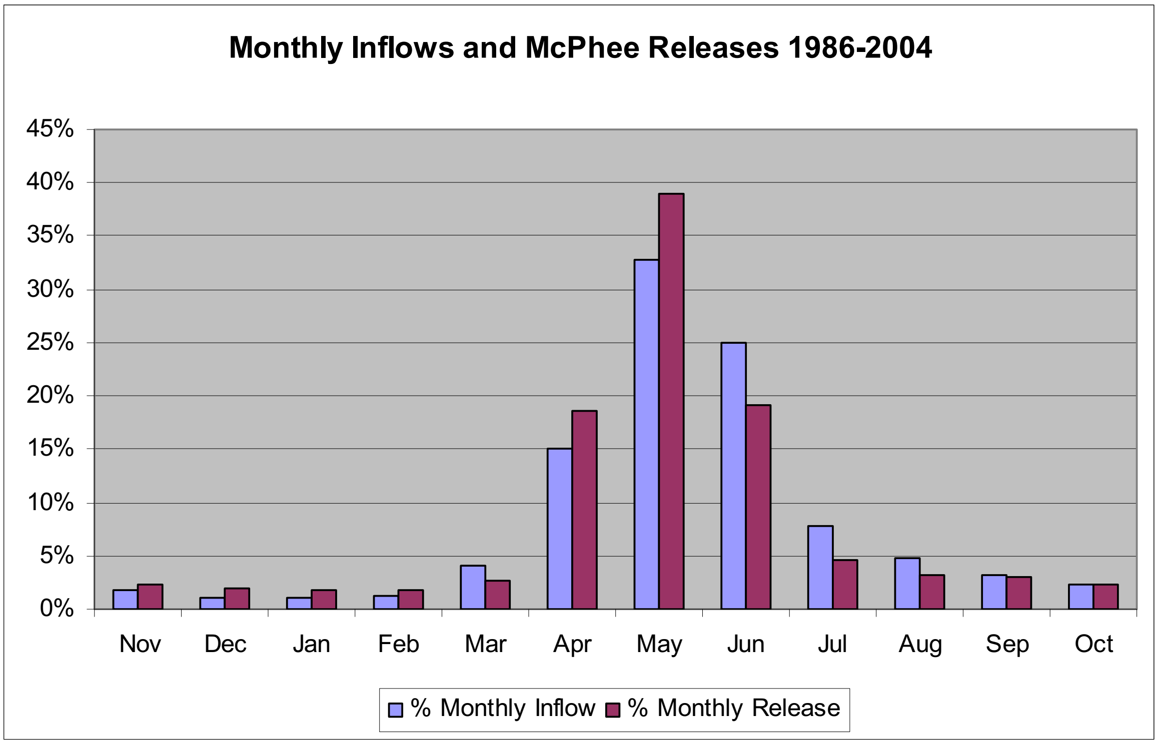


Figure 14. Comparison of the percentage of annual inflow by month into McPhee Reservoir and the percentage of water released by month from McPhee.

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

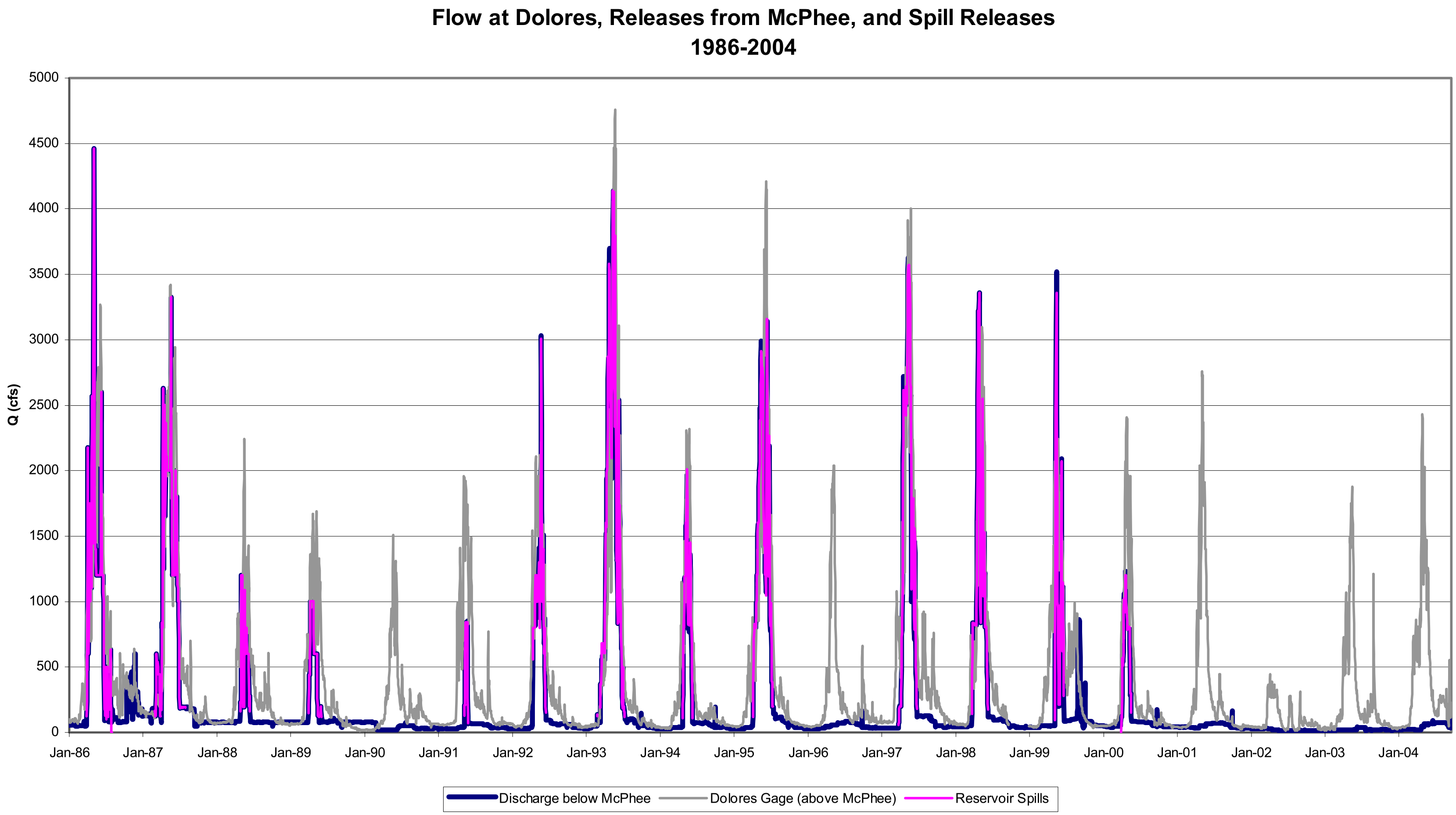


Figure 15. Post-McPhee Hydrology showing gaged inflow at Dolores, and both spill and baseflow releases from McPhee Reservoir.

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