Appendix A - Spill Management Hydrograph Development

In 2011, a sub-committee of the Implementation Team met at the Grand Junction office of the Bureau of Reclamation to discuss how to best incorporate the ecological needs of native fish into existing spill management practices seeking to provide the best boating conditions consistent with NEPA commitments and Dolores Project (Project) documents. The intent of the special meeting was to craft hypothetical 'composite hydrographs' for different representative volumes of forecasted “surplus” water that best represent the needs and limitations of the Project and interests in water supply management in the Dolores River basin. Hypothetical release profiles were developed by American Whitewater to illustrate the interests of each party and to contrast each spill scenario with historical releases of similar volumes to illustrate areas where operations can be improved to benefit native fish and whitewater boating.

The prospect of surplus water (i.e., 'spill' water) was regarded by the *A Way Forward* fishery scientists as a critical opportunity necessary for native fish recruitment and survival. In addition, Project purposes require filling the reservoir first as a priority on years of minimal runoff since a *forecasted surplus* does not ensure that water will materialize in McPhee Reservoir. Finally, surplus water is released downstream to meet boating commitments identified in the 1977 Final Environmental Impact Statement, and planning scenarios outlined in the 1977 Definite Plan Report. The boating community relies on spills to provide sufficient flows to sustain the recreational values in the Lower Dolores River. Meeting the needs of the native fish while recognizing these two objectives - namely, filling the reservoir and providing the best boating conditions with surplus inflow - was the theme of the meeting.

Attending the meeting were: Kristina Wynne, Bishop, Brogden, & Associates (appearing under contract for American Whitewater); Nathan Fey, American Whitewater; Ken Curtis, Dolores Water Conservancy District; Vern Harrell, US Bureau of Reclamation; David Graf, Colorado Parks and Wildlife; Ed Warner, US Bureau of Reclamation; Peter Mueller, The Nature Conservancy.

Each of the participants presented their 'best case' narrative objectives, or preferred practices, for how spill water in a given year-type might be managed. These criteria were analyzed using a representative suite of spill scenarios: 25,000 AF, 50,000 AF, 100,000 AF, and 200,000 AF. The results of the meeting were specific hypothetical hydrographs (presented here), which included an analysis of how boater days would be altered by early release of projected surplus water for temperature suppression. Finally, data from historical reservoir operations that most closely approximated the surplus volumes contemplated in the hypothetical analysis was incorporated into these tables, including reservoir storage and pool elevations under actual historical conditions. A 66,000 AF spill scenario was later included in the analysis, consistent with the DPR’s projected 'average spills' of 66,000 AF for whitewater boating.

The objectives presented at the meeting and resulting hydrographs, provide a starting point for water managers, recreation interests, and fishery managers to begin analyzing the opportunities and effects of operations on native fish and whitewater boating based on the best available scientific information and a commitment to monitor the effects of releases on the native fish communities below the dam (see Section II.B and Table 3 of the Implementation Plan). In addition, the Implementation Plan describes other monitoring that will be important to track:

- downstream water temperatures to refine the flow-temperature model;
- effects of 'flushing flows' on riffle and cobble spawning sites;
- effects of larger, habitat maintenance flows;

- systematic survey monitoring of the boating community to evaluate visitor experience;
- effects of spill flows on the riparian community (likely carried out by Dolores River Restoration Partnership or the Dolores River Dialogue).

Combined with the monitoring of fish populations, these data will allow for an adaptive, iterative approach to managing spills to meet multiple downstream flow objectives:

Colorado Parks & Wildlife Objectives (*A Way Forward* suggestions and Aquatic Biologist recommendations, combined):

1) Temp Suppression - rising limb of hydrograph:

- 125 cfs by May 1st/ 200 cfs by May 15th. Flow rates based on Chester Anderson's flow-temperature model; objective is to keep temps below 15°C prior to spill.

- Prefer a slow ramping rate…but variable by year-type. +5 cfs every 2 days (assumed ramping rate for initial guide development). See also note below re: mimicking natural flow patterns, and the potential for indexing releases to inflows at Dolores gage if forecasts allow.

2) Clean cobbles (flushing flows):

- 400-800 cfs sufficient to clean fines from cobble (above Disappointment),

- 24 hours duration, but longer the better,

- Ramping from 0-400 cfs can trigger sediment movement,

- Rapid fluctuations/adjustments in flow once 400 cfs is achieved, can keep fines suspended,

- Recognize can't do it every year; 25% of time or 1 year in 4 but would prefer this to have a higher frequency; pre-spawn, pre-peak every year when water is available and consider use of fish & wildlife pool if no spills have occurred in 3-4 years.

- Flushing flow target (400-800 cfs for prolonged period optimal) to prepare cobble beds prior to spawn

3) Provide Monitoring Flows:

- Back-end of spill/ later during irrigation season. (~2000 AF could be utilized in late-season for sampling Pyramid to Disappointment if deemed necessary, i.e., if no monitoring had been done due to a sequence of no spill years)[1]

[1] In 2012 the option to lease water to enable late season monitoring, either on the back side of a receding hydrograph to maintain the necessary flows of 500-800cfs, or potentially for monitoring/ bass abatement during a string of non-spill years, were considered viable management options. Management options may also consider use of fishery pool water to meet monitoring flow-needs if approved by the Biology Committee. The 'fishery pool' remains 4702 AF short of what was agreed to in the 1996 EA.

- 2 days at 500 cfs (Pyramid to Disappointment) - See Ramping Criteria; use at a minimum but could revise on downside of hydrograph (800 cfs to 200 cfs) to accommodate a 3-day shocking flow of 500 cfs (2 days needed for float; 1 extra day for stabilizing flow through reach)

- 3-4 days at 800-1000 cfs (Slickrock canyon) Lower flows (e.g., 500 cfs) may provide better sampling success, but 800-1000 accommodates 'rafting flows' for recreation and better floating conditions through constrictions. May be some compromise to recreationist's experience due to generator noise.

- not necessary every year

Note: CPW fishery biologists have not had success shocking in April or even early May, when cold water temperatures suppress fish activity, particularly Smallmouth Bass. Native fish moving up the Dolores from below the San Miguel confluence (or further) may not have migrated into the upper reaches for spawning. Much better sampling success occurs post-spill (receding limb), at flows ~500 cfs (Pyramid to Disappointment) or ~800-1000 cfs (Slickrock Canyon). Bradfield to Dove Creek Pumps can be sampled at 400-500 cfs. If spill water cannot be timed correctly to provide for late season sampling, a variety of water sources should be considered, particularly when no longitudinal sampling has occurred over a 3-5 year period[1].

4) Mimic pattern of natural flow for timing of release

- Mimic natural peak timing

5) Channel Maintenance Flows

- re-setting of in-channel substrate and interaction with floodplains, where present. 2000-2200cfs target; >3400+ cfs for bankfull flows on alluvial reaches (see Big Gypsum geomorphic study).

6) Recession Limb

- Ramping Rates provided by BOR - see also comment above re: monitoring needs for ~500 cfs for Pyramid (or upper Ponderosa Gorge) reach - can be done on backside of hydrograph if recession ramping is modified w/out changing quantity of water used.

American Whitewater Objectives for Whitewater Boating: Timing and duration of releases, volume of flow, and reliability/advance notice are the variables that make recreation possible on the Dolores River below McPhee Reservoir. To make efficient use of available water releases, AW proposes the following criteria:

Timing: Group boatable days before Memorial Day and extending through 1st weekend in June to the extent possible. This closely mimics historical timing of peak flows above McPhee and supports local recreation economies and events including the Dolores River Festival.

Magnitude: When possible, optimal flows for Whitewater Boating (defined in AW's Recreational Flow-Evaluation Report) should be delivered below McPhee Dam. Optimal flows meet the needs of the greatest number of users, in all craft-types and for all ability levels. Low and high flows, while boatable, are reported as meeting more niche boating experiences, such as low, technical or high challenge trips.

Acceptable and Optimal Flows for Whitewater Boating.
Dolores River below McPhee Dam

Lower Dolores River Segment	Lowest Acceptable Flows (CFS)	Optimal Flows (CFS)	Highest Acceptable Flows (CFS)[2]
1) Bradfield to Dove Creek	900	1900-2100	10,000+
2) Dove Creek to Slickrock	900	2100-2500	10,000+
3) Slickrock to Bedrock	900	2100-2500	10,000+
4) Bedrock to Gateway	900	2100-2700	10,000+
5) Gateway to Colorado River	900	1900-2700	10,000+

Duration: 5 consecutive boatable days above 500cfs is the minimum required to provide recreational opportunities below the Dam (FEIS 1977). Each Section of the Dolores is normally a two-night, three-day trip requiring a raft. Trips on rivers with comparable elevation drop typically travel 10-12 miles at 800 cfs. Lower flows necessitate more boatable days for canoes, kayaks, and may not provide opportunities for rafting/raft support.

1. Bradfield to Dove Creek, 19 miles - 2 days
2. Dove Creek to Slickrock, 28 miles - 2-3 days.
3. Slickrock to Big Gyp, 14 miles - 1 long day
4. Big Gyp to Bedrock, 36 miles, (popular section for families) - 3 days/two nights.

Advance Notice: Planning a multi-day river trip typically requires arranging equipment, shuttles, and food, including preparation of frozen goods. Advance notice of reservoir releases, and reliability of boatable flows significantly affect public use of the Dolores River. Lack of advance notice does not support efficient use of available releases, and user numbers are shown to have declined without advance scheduling and notice of reservoir releases.

1. National Visitation: 3-week advance notice of release schedule
2. Regional Utilization: 2-week advance notice; Expect visitation from 500-mile radius (Salt Lake 350 miles, Denver 470, Phoenix 420 miles)
3. Local Utilization: 1-week advance notice; Expect visitation from SW Colorado
4. No visitation: 1-day advance notice and/or erratic flows

[2] While Highest boating flows below McPhee exceed 10,000 cfs, it should be noted that a maximum of 5,000 cfs can be released through the River Outlet Works. Higher flows may occur; however, Managers make every attempt to avoid using McPhee's spillway to prevent release of non-native fish into the downstream environment.

Bureau of Reclamation/Dolores Water Conservancy District Objectives:

- Fill McPhee Reservoir

- Target peak releases around May 20th to mimic Dolores Gage.

- Fish clock is off, when BOR determines (due to operational considerations) it is necessary to begin managed releases.

- Follow operational guidelines, including ramping criteria, relative to annual specific conditions

- Continue improving coordination & communicating with recreational & fishery interests

- Continue improving forecast technology & accuracy

Overall Goals for Utilization of McPhee Releases

As managed release projections increase, the following priorities emerge related to projected spill scenarios:

Goals for 25K Acre-foot Release Scenario:

- Temp Suppression flows (to 125 or 200 cfs)

- Sediment flushing flows (400-800 cfs for minimum 3 days). Brian Bledsoe (CSU Engineering Dept.) suggested a 3-day minimum period for this 'whisking' of the river cobbles to improve spawning potential

- Boatable flows (beginning at 500 cfs; preferably 800-1000 cfs) for a minimum of five consecutive days

- Maximize boatable flows, while providing higher flows within acceptable range when possible.

Goals for 50K Acre-foot Release Scenario:

- Temp Suppression flows (to 125 or 200 cfs)

- Sediment flushing flows (400-800 cfs for minimum 3 days).

- Boatable flows (beginning at 500 cfs; preferably 800-1000 cfs) for a minimum of five consecutive days

- Prolonged boating and habitat maintenance flows of 2000cfs

- Maximize optimal boatable flows, while providing higher flows within acceptable range.

- Monitoring flows (500-800 cfs for 2-4 days) on recession of hydrograph (post-peak)

Goals for 100K Acre-foot Release Scenario:

- Temp Suppression flows (to 125 or 200 cfs)

- Sediment flushing flows (400-800 cfs for minimum 3 days).

- Boatable flows (beginning at 500 cfs; preferably 800-1000 cfs) for a minimum of five consecutive days

- Prolonged boating and habitat maintenance flows of 2000cfs

- Maximize optimal boatable flows, while providing higher flows within acceptable range.

- Channel maintenance flows between 2600 and 3400 cfs for 7 days

- Monitoring flows (500-800 cfs for 2-4 days) on recession of hydrograph (post-peak)

Goals for 200K Acre-foot Release Scenario:

- Temp Suppression flows (to 125 or 200 cfs)

- Sediment flushing flows (400-800 cfs for minimum 3 days).

- Boatable flows (beginning at 500 cfs; preferably 800-1000 cfs) for a minimum of five consecutive days

- Maximize optimal boatable flows, while providing higher flows within acceptable range.

- Prolonged boating and habitat maintenance flows of 2000cfs

- Channel maintenance flows between 2600 and 3400 cfs for 7 days

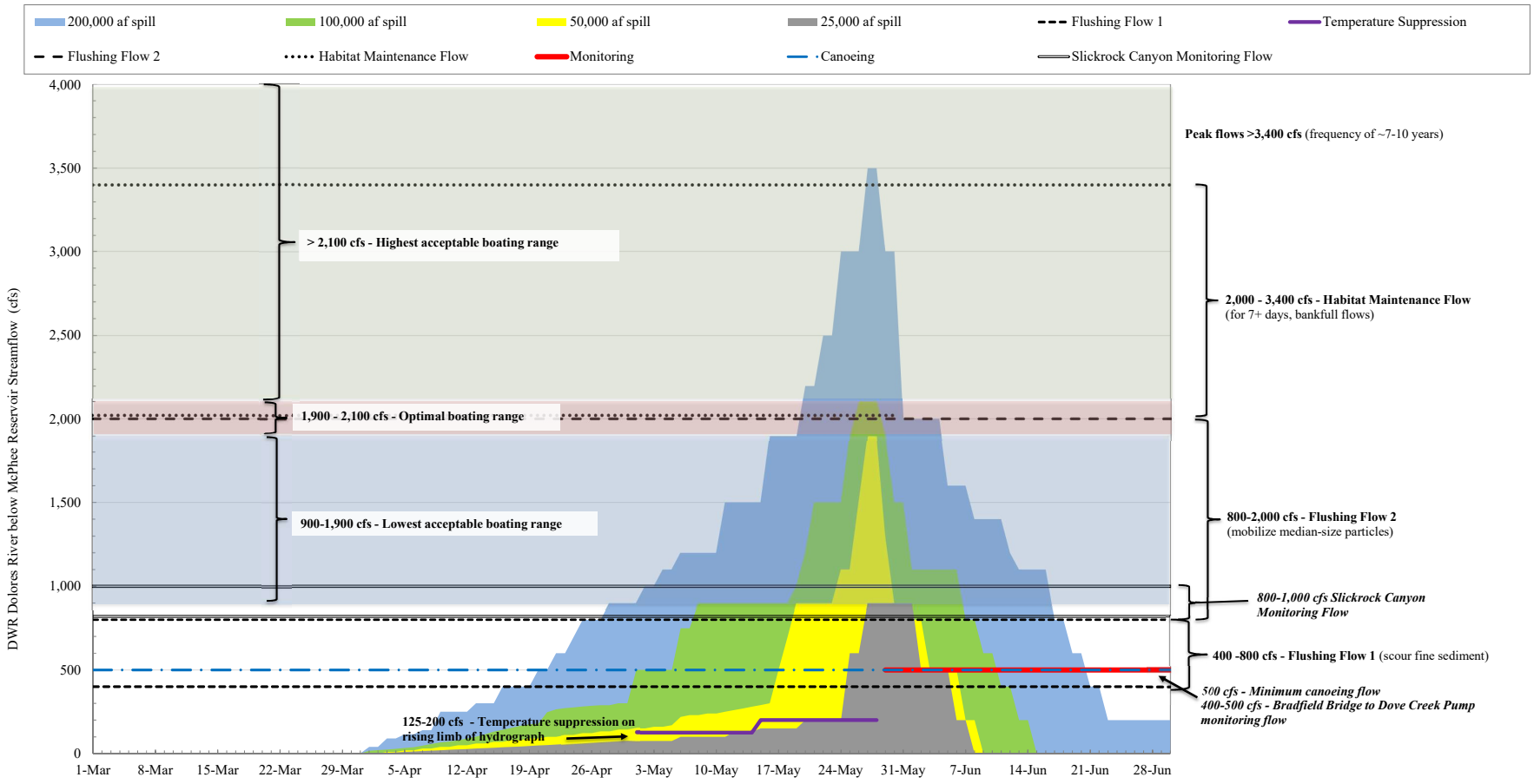
- Floodplain and riparian flows (3400-4000 cfs) for at least 3 days

- Monitoring flows (500-800 cfs for 2-4 days) on recession of hydrograph (post-peak)

SUMMARY

As stated in Section III.2 of the Implementation Plan, it is recognized by all parties that the hydrographs (summarized in Figure 1) reflect hypothetical scenarios that if implemented, could optimize recreation and the ecological needs for native fish and riparian vegetation for the different spill sizes examined. It is also understood that no spill would mimic precisely the hydrographs that are depicted, as antecedent storage and real-time weather and flow conditions will be unique to every spill situation. However, having specific flow guidance as to how a certain size spill could be used to meet multiple objectives should give Project operators the best opportunity to meet the needs of native fish while providing the best boating conditions and meeting water supply needs.

Figure 1
Dolores River Summary of McPhee Reservoir Spill Targets, Ecological Targets, and Preferred Floatboating Flow Ranges



Notes:
•Spill target hydrographs developed cooperatively between American Whitewater (AW), Colorado Parks and Wildlife (CPW), Bureau of Reclamation (BOR), Dolores Water Conservancy District (DWCD), and The Nature Conservancy (TNC).
•Minimum canoeing and lowest acceptable, optimal, and highest acceptable whitewater boating flow ranges are based upon a 2010 American Whitewater survey and are applicable for Segment 1 below McPhee Reservoir (Bradfield to Dove Creek).
• Ecological flow ranges (Flushing Flows 1 & 2, Habitat Maintenance Flow, and Peak Flow) based upon Table 4 of the *Lower Dolores River Implementation, Monitoring and Evaluation Plan* for Native Fish , June 2014.
•CPW Monitoring flows of 400-500 cfs preferred in Bradfield Bridge to Dove Creek Pump reach and 'Pyramid to Slickrock' reach; 800-1,000 cfs flows preferred for monitoring Slickrock Canyon reach (Big Gypsum Valley to Bedrock).