Assessment of the Estimated Effects of Four Experimental Options on Resources Below Glen Canyon Dam

Technical Work Group Meeting

November 8 and 9, 2006

U.S. Department of the Interior
U.S. Geological Survey

Overview

- Background and Option Descriptions (Hamill)
- Assessment Results (Melis)
- Economic Assessment Results (Palmer)
- Evaluation of Experimental Designs (Hamill)
- Scientific Recommendations (Hamill)
- Peer Review Process (Garrett)

Part I

Background and Option Descriptions

Background

- 1996 Record of Decision Goal: “permit recovery and long-term sustainability of downstream resources while limiting hydropower capacity and flexibility only to the extent necessary to achieve recovery and long-term sustainability”
- SCORE evaluated resource responses to MLFF
- SPG established to develop effective long-term direction for future experimental research and management activities
- Three experimental options identified through SPG process
- A fourth option was added by TWG in Oct 2006

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Purpose of the Assessment

- Provide information about how each of four proposed experimental options is likely to

    (a) affect downstream biological, physical, and sociocultural resources;

    (b) influence hydropower resources and associated economic benefits; and

    (c) contribute to the understanding of the relationships between actions and desired resource conditions.

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General Methods

- 2005 knowledge assessment final report
  - Peer-reviewed literature
  - Expert opinion
- New models
  - Daily stage variation
  - Downstream temperature (mainstem)
- Hydropower economic analysis (WAPA)
- Independent peer review

Experimental Options

	Flow/Nonflow Treatment	BASE operations	Option A	Option A Variation	Option B	Option C
Flow	Increased daily flow fluctuations	No	Yes (increased by 50% to 66% in winter months and by 25% in summer months)	Yes (increased by 25% to 66% in all months except April and May)	No	Yes (increased by 50% to 66% in winter months)
Flow	Stable flows	No	No	No	Yes, (tests of 4, 8, and 12 months)	Yes, (September through October)
Flow	Beach/habitat-building flows	Possible, but only under hydrologic triggers	Yes, as tests under sediment input triggering	Yes, as tests under sediment input triggering	Yes, as tests under sediment input triggering	Yes, as tests under sediment input triggering
Flow	Alternative ramping rates	No	Yes (hourly downramping rate increased 100% in all months)	Yes (hourly downramping rate increased 100% in Apr–Oct and 167% in Nov–Mar)	No	Yes (hourly downramping rate increased by 100% in Nov–Jul only)
Nonflow	Temperature control device	No	Yes	Yes	Yes	Yes, 2 units assumed

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Experimental Options (cont.)

Flow/Nonflow Treatment	BASE operations	Option A	Option A Variation	Option B	Option C	Flow/Nonflow Treatment
Nonflow	Control of nonnative coldwater fish	No	Yes, as needed	Yes, as needed	Yes, as needed	Yes
Nonflow	Control of nonnative warmwater Fish	No	Yes, as needed, with R&D starting in 2007	Yes, as needed, with R&D starting in 2007	Yes, as needed, with R&D starting in 2007	Yes, with R&D starting 2007
Nonflow	Humpback chub disease/parasite research	No	Yes	Yes	Yes	Yes, with R&D starting 2008
Nonflow	HBC translocation	No	Yes	Yes	No	Yes
Nonflow	Humpback chub refuge(s)	No	Yes	Yes	Possibly	Yes
Nonflow	HBC population augmentation planning	No	Yes, Planning efforts toward implementation, as needed	Yes, Planning efforts and implementation	No	Yes, planning phase
Flow and Nonflow	Mini experiments	No	Yes	Possibly	Yes	Yes
Experimental Design		Not applicable	Reverse Titration	Reverse Titration	Factorial	Forward Titration

Part II

Assessment Results

"Resource Responses for Flow & Non-Flow Treatments"

Flow - Water Temperature (No TCD)

1. Main channel – Differences between the options typically small (< 0.5 °C) and within model uncertainty

2. Nearshore – Steady flows enhance nearshore warming. Option B ranks first, followed by Option C. Options A and A Variation are not expected to differ from BASE.

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Flow - Diurnal Stage Variation (DSV)

1. DSV is the difference in stage between the daily high flow and daily low flow

2. Option B: reduced DSV in all months, ~3 ft for steady flows, ~1.5 ft during constrained fluctuations

3. Option C: reduced DSV in Sep-Oct steady flows (~3 ft); increased DSV (~2 ft) during winter increased fluctuations

4. Options A and A Variation: Similar in winter as Option C, also increased DSV (~1 ft) during summer increased fluctuations

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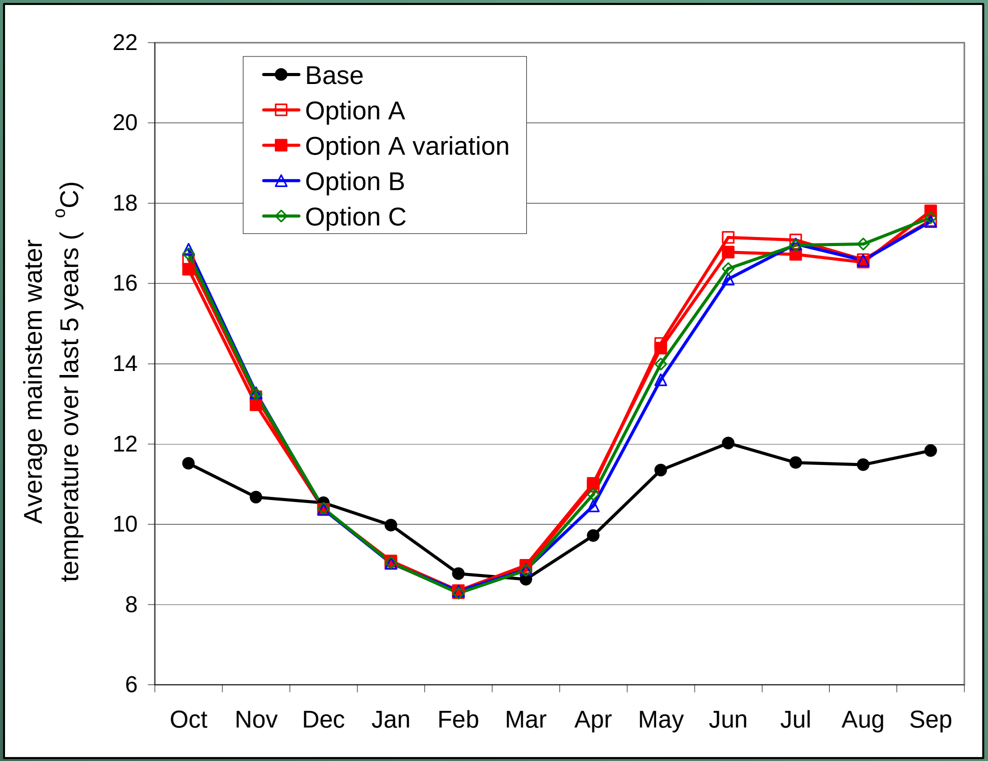
Flow – Fine Sediment

Experimental options ranked in order likelihood of fine sediment retention

1. <u>Option B</u> - BHBFs increase sandbar size, sandbar erosion is least under stable flows
2. <u>Option C</u> - BHBFs increase sandbar size, fall stable flows limit sand export, relaxed constraints on fluctuations may offset effects of stable flows on sand retention
3. <u>Option A</u> - BHBFs increase sandbar size, relaxed constraints on fluctuations may offset effects of BHBFs on sandbar size
4. <u>Option A Variation</u> - BHBFs increase sandbar size, most relaxed constraints on fluctuations likely offset effects of BHBFs on sandbar size

Non-flow - Water Temperature (with TCD)

- **All options significantly warmer than BASE during spring, summer, and fall. Differences among options (other than BASE) typically small and within model uncertainty.**



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Biological Resources

1. Current Glen Canyon Dam release temperatures are below optimum for most aquatic organisms, including rainbow trout

2. Aquatic organisms (algae, invertebrates, fish) likely to increase growth with warmer water

3. TCD operation and/or natural warming will be necessary for aquatic organisms to exhibit response to warmer temperatures

4. All four options result in similar temperatures

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Aquatic Habitat Stability

1. High DSV, especially Mar-Oct, limits productivity of algae and aquatic vegetation because of habitat destabilization (desiccation, freezing)

2. Limiting DSV increases permanently wetted habitat, increasing area for primary productivity and invertebrate production

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Aquatic Habitat Stability

1. Young humpback chub use shallow nearshore habitats in Little Colorado River
2. High DSV reduces available nearshore habitat for fish in the Colorado River
3. High DSV reduces potential for nearshore warming, reducing fish habitat suitability in the Colorado River

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Aquatic Habitat Stability

1. <u>Option A:</u> Greater DSV reduces habitat stability and nearshore warming

2. <u>Option A Variation:</u> Greatest DSV and increased ramping rates, so least stable habitats among four options and lowest potential for nearshore warming

3. <u>Option B:</u> Least DSV, so creates most stable and potentially warmest nearshore habitats in most months

4. <u>Option C:</u> Habitat instability Dec-Feb with increased DSV; Sept and Oct habitat stability and warming (may have Aug stable flows in future)

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Flow – Cultural Resources

Experimental options ranked in order likelihood of fine sediment retention

1. Option B - BHBFs increase sandbar size and least sandbar erosion under stable flows; most likely to benefit archaeological sites

2. Option C - BHBFs increase sandbar size, fall stable flows limit sand export; relaxed constraints on fluctuations may offset effects of stable flows and limit the amount of dry sand available for redistribution to higher elevations

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Flow – Cultural Resources (Cont.)

3. Option A - BHBFs increase sandbar size, but relaxed constraints on fluctuations may offset effects of BHBFs and keep more sand inundated/wetted, preventing redistribution

4. Option A Variation - BHBFs increase sandbar size, most relaxed constraints on fluctuations; keeps more sand inundated/wetted more of the time, preventing redistribution

Flow – Recreation

Flows have multidimensional affects on recreation. Effects to anglers differ from effects to whitewater boaters, but flow preferences of both user groups show considerable overlap. Effects to important physical and biological resources (trout, campable area, rapids and water temperature, etc.) are considered along with social science surveys data on angler/boater flow preferences.

Flow – Recreation

1. Option B: – appears to offer most beneficial outcomes in terms of retaining campable area, maintaining flows that are preferred by most anglers and boaters, increasing safety, and preserving overall recreation experience quality

2. Options C, A and A Variation: - offer increasingly less optimal recreational conditions for both anglers and boaters overall

3. Option A and A Variation: – potentially most beneficial in terms of reducing pathogen concentrations near camp sites

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Non-flow – Recreation

1. With TCD, all options significantly warmer than BASE during spring, summer, and fall. Warmer temperatures improve safety and enjoyment for recreationists but may also increase pathogen loads.

2. Trout removal has localized negative impacts on anglers and possible minimal impact on boaters (impacts to wilderness-like experience)

3. HBC translocation may restrict angling opportunities in tributaries and impact wilderness experience of backcountry users

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Non-flow – Cultural Resources

1. Trout removal has been identified by Native American tribes as having a potentially negative impact on traditional cultural places

2. Depending on location, translocation could impact archaeological sites and traditional cultural places because of the associated research and monitoring activities

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Part III - Economic Assessment Results

Western Area Power Administration - provided an evaluation on the economic impacts of the four experimental options. The evaluation concluded that the economic impact apart from the issue of hydraulic head that Option A Variation is consistently above Option A in terms of increased economic value. Both Option A Variation and Option A consistently provided greater economic benefits than those provided by BASE operations in terms of electrical power production. Option C vacillates between positive and negative economic impacts over the 10-year evaluation period. If an August stable-flow trigger is applied to Option C, then the economic impact of the option is strongly tied to hydrology and hydraulic head when compared to BASE operations. Option B reduces economic benefit significantly compared to the other options in most years. However, Option B returns to modified low fluctuating flows (BASE operations) in 2014–16. For example, under the most-probable hydrological conditions, the total annual economic impact of the four options compared to BASE operations, based on a 10-year average, ranges from a $7.5 million increase in the economic value under Option A Variation to a decrease of $28 million under Option B (2006 dollars).

BHBFs - Each of the four options under consideration includes the testing of BHBFs. The cost of a BHBF varies by option, hydrological condition, and time of the year at which the test takes place. Example - if a BHBF was conducted in the fall of a year with the most-probable hydrological conditions, the cost of the BHBF would range from approximately $3.7 million for Options A and B to $4.3 million for Option C when compared to BASE operations (2006 dollars).

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Part IV

Evaluation of Experimental Designs

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Options A and AV Experimental Design

Approach: Reverse Titration

Strengths

Tests implementation of a suite of actions on overall resource responses, including:

- Wider flow fluctuations and steeper ramping rates
- Minimum flows to protect food base
- Implementation of a TCD
- Nonnative fish management
- Translocation of humpback chub to other tributaries

Options A and AV Experimental Design (cont.)

Weaknesses

- Presumes that the actions needed to achieve GCDAMP goals are known
- Simultaneously implementing multiple actions will confound the assessment
- Implementing a new flow regime and other actions will confound the assessment of the current experiment
- The option provides for no testing of steady flows to protect/restore downstream resources
- There is no basis in the literature for the reverse titration concept

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Option B
Experimental Design

Approach: Factorial

Strengths

- Incrementally tests the effects of progressively longer periods of stable flows and increased water temperatures in combination with other treatments on target resources
- Provides for testing under two hydrologic scenarios over period of 14 years
- Test of the effects of steady flows (habitat stability) on target resources by implementing progressively longer periods of stable flows

Option B
Experimental Design (cont.)

Weaknesses

- Natural factors may confound results
- Implementing a new flow regime at this time will confound the ongoing experiment
- Does not include testing of the effects of wider fluctuating flows
- Length (2 years) and timing of steady flow increments may not be sufficient to evaluate the effectiveness on target resources
- Specification of how nonnative fish control and implementation of a TCD will be factored into the experimental design is not provided

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Option C
Experimental Design

Approach: Forward Titration

Strengths

Tests implementation of a series of treatments to improve knowledge of the relationships among treatments and the resources affected by those actions, including:

- September/October steady flows and possible August trigger
- Wider fluctuations Dec. to Feb. to benefit hydropower
- Relaxed ramping rates in 9 months to benefit hydropower
- BHBFs to conserve sand resources
- Implementation of a TCD
- Nonnative fish management

- Includes a formal 5 year review
- Limits treatments that may confound the results of the experiment

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Option C
Experimental Design (cont.)

Weaknesses

- Natural factors may confound results
- Implementing a new flow regime at this time will confound the ongoing experiment
- Specific details on implementation of various treatments using the forward titration design are not provided

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Part V - Scientific Recommendations

- Complete the current experiment (MLFF)
- Specify desired future conditions
- Implement and scientifically test a temperature control device
- Continue testing sand-enriched BHBFs
- Hydrologic variability masks the effects of Glen Canyon Dam operations in wet years
- Limit confounding variables
- Conduct stable flow tests after current experiment is completed, as needed
- Continue model development to support management decisions

Part VI

Peer-Review Process

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