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A REVIEW OF THE GCMRC REPORT ON AN "ANALYSIS OF BIOPHYSICAL AND SOCIO-CULTURAL IMPACTS OF FOUR EXPERIMENTAL OPTIONS"

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By GCD AMP SCIENCE ADVISORS[1]

INTRODUCTION

In 2005 the GCD AMP requested that GCMRC and TWG develop flow and non-flow recommendations for a Long Term Experimental Plan. A Science Planning Group (SPG), structured by the GCMRC and TWG, developed several experimental plan options over 12 months in 2005/2006. These were reduced to three options for comparison to the current Record of Decision (ROD), referred to as Modified Low Fluctuating Flows (MLFF).

To understand more fully how each of the three options might affect CRE recources, the SPG requested that statements of work (sow) and resource impact assessment reports be developed by GCMRC. A sow and assessment report of economic impacts on hydropower resources has been conducted by the Western Area Power Authority (WAPA). The sow and assessment of impacts of the differing options on biophysical and socio-cultural resources has been prepared by GCMRC program managers and scientists.

The SPG realized that significant uncertainty would exist in developing these assessments. As such, the impact assessments are in major part to be considered preliminary.

Assistance in external review of the statements of work and assessments was requested of the Science Advisors Executive Secretary. Four hydropower economists external to the Science Advisors (SAs) were selected to provide review input to the Hydropower Economic Statement of Work and the final Hydropower Economic Impact Assessment. The AMP Science Advisors provided review input to the Biophysical and Socio-Cultural Statement of Work and final assessment.

[1] The GCD AMP Science Advisors are currently comprised of eight discipline specialists. The individuals and their disciplines are presented in Appendix A.

A review of the statement of work for an “Analysis of Biophysical and Socio-Cultural Impacts of Three Experimental Options” was completed by the SAs in September, 2006. The review was filed with the SPG Task Team and GCMRC, who revised their Biophysical and Socio-Cultural Resource Impact Assessment Report based on the review (Appendix B).

REVIEW CHARGE

This report captures the Science Advisors review of “An Analysis of Biophysical and Socio-Cultural Impacts of Four Experimental Options” developed by GCMRC. A fourth option was presented in the final phases of this assessment, requiring a Technical Work Group (TWG) conference call to resolve its inclusion. In the call, a second option previously discussed by the SPG was also proposed for consideration. In requested votes, the new option was approved for evaluation by GCMRC, and the option previously considered by the SPG was rejected from evaluation.

GCMRC developed descriptions for each of the four options which are summarized in Table 1. The assessment report completed by GCMRC was presented to the Science Advisors for review on October 13, 2006 as scheduled.

The charge to the Science Advisors was to contrast the projected impacts in the assessment with the impacts that would be expected when applying current scientific knowledge. Five work days were allotted to completing these reviews to conform to scheduled reviews by TWG and the Adaptive Management Work Group (AMWG).

Table 1. Summary of flow and nonflow components of the four experimental options under consideration by the Glen Canyon Dam Adaptive Management Program. BASE operations (modified low fluctuating flow regime) are provided for comparison. Each option is described as it would be implemented under an annual release of 8.23 million acre-feet.

	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 down ramping rate increased 100% in all months)	Yes (hourly down ramping rate increased 100% in Apr–Oct and 167% in Nov–Mar)	No	Yes (hourly down ramping rate increased by 100% in Nov–Jul only)
Nonflow	Temperature control device	No	Yes	Yes	Yes	Yes, 2 units assumed
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	[1]Yes
Nonflow	Humpback chub refuge(s)	No	Yes	Yes	Possibly	[1]Yes
Nonflow	HBC population augmentation planning	No	Yes, Planning efforts toward implementation, as needed	Yes, Planning efforts toward implementation, as needed	No	[1]Yes, planning phase
Flow and Nonflow	[2]Mini experiments	No	Yes	Yes	Yes	[1]Yes
Experimental Design		Not applicable	Reverse Titration	Reverse Titration	Factorial	Forward Titration

NOTE: 1) For Option C: Ancillary projects not considered part of the main experiment; implementation decision includes consideration of confounding the main experiment. 2) Mini experiments are short-term field experiments that do not confound main experimental treatment

STRUCTURE OF THE REVIEW

This review was conducted by responding to ten science questions as follows:

Are the proposed resource impacts supported by scientific knowledge as reported in the Knowledge Assessment?

Do you feel that the specific or general impact assessments documented by the scientists are reasonable and accurate given current scientific knowledge?

Are the specific assessment methods utilized by the scientist(s), i.e., questions, guidelines, models an acceptable application of the current scientific knowledge?

Are the models used appropriate and reasonable for the application specified, and do they provide outcomes that you feel would be generally accepted by scientists in the discipline.

In obtaining the assessment presented, have the scientists over extended the reasonable bounds of existing knowledge or extrapolated beyond the reasonable limits of available models.

Are specified assumptions applied in the assessment appropriate? Are assumptions clarified?

Is the assessment complete, or are there other factors impacting the outcomes that are not identified in the analysis?

Does sufficient uncertainty and conflicting analysis exist relating to some impact assessments that an outcome should not be predicated at all?

Would you rate any outcome of this specific resource assessment to be known sufficiently to designate it as a “management action,” requiring no further science inquiry?

Have the scientist(s) described sufficiently how all interacting factors/resources/impacts in the system are, or will affect outcomes of this assessment?

The reviewers compared resource impacts projected by the scientists against existing knowledge that relates to the projection. Existing knowledge is generally captured in a Knowledge Assessment Report (KAR) developed by

GCMRC, but also can relate to other published science. Some unpublished science, primarily in the form of models, are also used in the assessment.

The assessment is structured to relate impacts of the four differing options on three general categories of resources as follows:

Physical Resources: Sediment, water temperature, and stage resources

Biological Resources: Food base, native and non-native fish, and vegetation resources

Socio-Cultural Resources: Recreation, cultural, and economic resources

The assessment separates in the text the impact assessments related to flow and non-flow actions, discussions of designs, and best options to pursue.

GENERAL FINDINGS OF THE REVIEW

This assessment is in and of itself a significant accomplishment by GCMRC to inform GCD AMP members and the Secretary's Office in their policy deliberations. Following are general perspectives of reviewers on this report.

- The assessment is a thorough analysis of the aspects of the different experimental options. The contrasts among the options are clearly set forth in both text and tables. The researchers are to be complimented on undertaking and completing such a successful analysis.
- The Aug 30, 2006 draft of the Knowledge Assessment presents a very thorough and balanced summary of what is and is not known about physical, biological and cultural resources in the Colorado River Ecosystem.
- This is an excellent document and one that should be very useful in deciding which way the Glen Canyon Dam should be operated in the future.
- Should this document really be considered 4 experimental options or considered 4 different options for flow management? Although The USGS typically likes to talk about effects not influences. Consider a different title for the document.
- Would this analysis be better identified as an assessment of four policy options?

- Excellent document. Great deal of thought, hard work and careful writing went into the assessment. The authors and participants are to be congratulated for this product. It is an outstandingly clear description of what is known, what is not known. I think it is an excellent description of the difficulties and trade-offs involved with a decision about what sort of flow regimes should be implemented over what period of time.
- One of my concerns in this review is whether the AMP will continue to embrace adaptive management, or will it be driven by other values. A key indicator of this would be how much of the decision about alternative options and plans would be based upon achieving learning objectives. Simply put, I asked the question: which proposed actions would produce the most learning over both the short and long term? This is a difficult proposition and one which the authors and managers have struggled with greatly. I think that they are finding a satisfactory conclusion, and very much keeping learning front and center.
- There cannot be a best flow option, because too many factors are at play. They have been asked to meet multiple objectives (physical, biological and cultural resources), i.e. the actions taken have to be directed towards achieving some management goal. They must deal with issues of power revenue, maintaining RBT while recovering HBC and other listed taxa. I agree with the authors, that one cannot optimize or pick the best among these multiple objectives simple because there are too many of them. I think the authors provide a balanced perspective on how to deal with these competing agendas and move forward.
- This complex system must be considered in a holistic and nonlinear fashion. By disentangling all of the components and discussing them separately, the report presents a logical and clear analysis, yet the system aspects definitely needs to be considered. Therefore, the issues raised in chapter 6 are essential.
- The assessment suffers from a lack of realistic management goals having been set forward. Clearly, returning to the past is not possible – yet parts

of the assessment seem to focus on such goals. This report sets the stage for a careful evaluation of what can be done once the management goals are set. Yet setting those goals will involve compromises amongst the stakeholders. I do not see in the outline of planned activities when or how that agreement on goals will occur. As is, the options do not seem to be designed to ask – what is good enough to achieve certain goals.

- When one reads this scientist assessment and the struggle to identify best options, it becomes clear that more effort is needed by managers in defining desired future resource conditions, and defining more explicit priority goals.
- Both strengths and weaknesses of this report exist in its focus on desegregation of resource impacts. In this complex system scientists must try to tease out individual resource impacts of management actions. Knowing how these individual process elements work in the overall system is critical to learning, and to help explain what really happens to the system when significant change occurs.

  How all of the individual elements of the system work today is important to know, but also important is how they may change when they interact in response to strong stimuli, i.e. warmer water, a new predator, high flow events, etc. over longer time intervals. These long term system issues are critical when one begins to consider the range of options proposed. For example, do the responses projected hold the same under prolonged drought and wet periods, or will changes in the overall system overwhelm current individual resource responses.

Reviewers General Responses to Review Questions

Q.1. Yes, but there are concerns over how uncertainty is expressed; new findings need greater treatment (HBC).

Q. 2. Generally yes, but some are not. Table 3.2 should align with text. The point of adaptive management is to uncover those issues not addressed.

Q. 3. Yes; But how to proceed without dfc is a concern. Also a concern is how complexity in the design will be handled. The approaches' using a blend of techniques is good.

Q. 4. Probably. Some are and some are not. But more definition of model uncertainties are needed; and, given issues like climate change and exogenous effects, variance makes modeling far from being statistical, i.e. HBC were at 2000 in one model and 5000 in another.

5. No. Scientists have been careful to mentioned caveats. Also, in all options issues are not treated the same.

Q. 6. Yes. Although many assumptions are covered in original science, not all are covered in this assessment. References are provided and suitable.

Q. 7. Maybe. Although external issues such as land use in adjoining areas, climate change, increased water use, invasive species, etc. are not always addressed.

Q. 8. In some cases. However, some parts are better known than others. To be accurate the word predict should be replaced with projected. Predicted implies more certainty then actually exists in most cases. Relative differences should be used rather than absolute differences.

Q. 9. In most cases probably not. Most of the document references existing uncertainty. Scientific inquiry must continue on most issues to place findings in an acceptable management context. However, much depends on the willingness to take risks. In some cases, like RBT, control, management action seems reasonable. But on most issues there are many things that are not known.

Q. 10. In most cases no. Some interactions have been addressed, but most have not. This is a complex ecosystem and improved efforts are needed to evaluate interactions. The important impacts are being identified and their effects need to be determined. Some small impactors will never be determined, which is an acceptable outcome.

SPECIFIC REVIEW FINDINGS ON
PHYSICAL RESOURCE IMPACTS

Fine Sediment Impacts

Fine sediment is linked to both BHBFs and daily flow regimes. The report establishes the different triggers for MLFF (hydrologic) and the four proposed options (sediment inputs). It clearly articulates current science findings from the KAR and other sources that link higher fluctuating flow regimes and ramping rates to increased sediment transport, and ranks the options from lessor to greater impacts as B, C, A, A/V. Relative differences in resources impacts were determined for the four options under dry and wet hydrology.

Specific Comments of Reviewers

- Option B appears to be the best option when fine sediment is considered. I would suggest reducing the constraints on the timing of the BHBF. Allow it to occur when it is best. The increased sand in the channels may help the HBC more than anything else. Use other means to get rid of trout, such as a new catch and release policy, shocking.

In this type assessment, this approach is much preferred to the authors attempting to determine the explicit resource impact of an option. The current status of science can generally project which options are likely to have more or less impact on a resource, and that is what the authors have accomplished.

If HBC populations are steady this seems to be the most important issue. Therefore, option B seems to be the best flow option. The daily ramping and more importantly downramping of Options A and its variant seem to be the worst flow option.

The term “basic differences between the options are expected to hold under both conditions”, does not seem consistent with comments at the top of page 25. Under wet hydrology would not the differences be dampened since steady flows would be elevated above 12,000 cfs.

In the physical resources section, there is a useful comparison of the influence of the flow and sediment options. The report seems up front about the ability to ask questions of the system.

The BHBF trigger issue of the base (hydrologic) versus options A, A/V, C&B options (sediment) relates the expected greater degradation of sediment under base flows due to BHBFs not being implemented. The physical findings fully support this thesis. However, not mentioned is the policy question of whether or not managers will permit the sediment trigger to be functional in years of low lake elevation or low in-flow.

The trigger has now been met three times in drought like years, but it may only be used once, wherein it received significant negative publicity. Is it possible that over time the operational policy of the sediment trigger will actually be the BHBF hydrologic trigger?

The section on sand export reports the science findings as currently exists relative to potential impacts from the various options. However, the wording used to predict the outcome is moderate to high flows, implying that "flows only" for none of the options could be effective. Is option "B" considered in this statement?

Did not evaluations from the 2004 BHBF indicate that post flow loses under normal flows were not at expected higher levels. This is not mentioned, but could it be relevant?

Research on management activities to both store sand and conserve it through time are still areas of needed focus in physical resources over the next five years.

Uncertainties are still unresolved regarding both actions to store sand (BHBFs impacts) and actions to minimize losses (conservation flow regimes).

The expression of potential sand/sediment impacts of the differing options aligns with existing science, which points to the need for further study of BHBFs and conservation strategies.

Water Temperature Without TCD

"Uncertainty" is only mentioned in the lead sentence of key sections of the text on human health and water quality (p. 50) and visitor safety and navigation (p. 52). Yet, it is a part of all of the components of the system and is discussed in many of the sections. It would be useful to have a

discussion of the relative sensitivity of the system to various changes and the uncertainties that are in the system. I was very pleased to see Table 3.2, for it is a useful summary. However the uncertainties mentioned in that table are not well related to the text. It would be useful to have a rough measure of uncertainty in this and other tables. That would require some rough definition on what the authors mean by “likely,” “may,” and “potential” (the IPCC climate change report provides an example of defining such terms). It is not clear what the difference is between “uncertain”, “somewhat uncertain” and “highly uncertain” as used in the report. Only sometimes is uncertainty defined in the context in which it is used (as it is on age 25 in the last paragraph).

Figure 3.2 does not seem intuitive for the September/October period. One would think that a lower sustained water flow in lower water years would warm more through the system than higher fluctuating flows. Does the model average the expected temperature rise of two different flows (low and high) for fluctuating flows? Although it was used to calibrate the model, the research reported from the 2000 low steady flow experiments would not seem to support the outcomes in Figure 3.2. Are the lines color coded correctly?

Too much about the uncertainty of the present models is described. The relative differences in downstream waters caused by the differences in flow should be valid even if the models are completely accurate. These differences in temperature can be offset or accentuated by the TCD. Are more detailed modeling studies really needed? Normally I would say yes; however, here I think we are only trying to say which flow option provides the warmest backwater habitats and that can be decided without more modeling.

The authors have appropriately proposed words of caution in this section due to obvious uncertainties, especially in near shore temperature differences. Considering these uncertainties would it be better to use a more conservative statement in option B such as “hypothesized to result in

warmer nearshore areas", rather than "expected to result in" or as in the summary "generally thought that".

It would help to use consistent colors on all graphics for the four options.

The projected differences for the four options track with the modeled outputs, and are intuitive.

The temperature model does not predict the differences one might assume to exist in low water years between option A and B by intuition alone. That is, more shallow slower water warms more that faster, deeper water. Is this an aberration of model specification for fluctuating flow? Will these combinations of models be reviewed?

Work on the temperature model should continue. However, if it has not been accomplished, perhaps a review of the model approach might assist in the modeling process. Each of the combined models have been reviewed, but has the combined set been reviewed?

Projected differences in near shore water warming for the options, especially A, AV & C vs B tracks with existing science. However, it becomes less clear if differences between A, AV and C can be determined effectively except in early fall.

Diurnal Stage Variations by Reach

The dsv model would seem to have high potential interpretive application in several areas; i.e. recreation, food base, near shore warming, etc. High quality geo-reference land form data combined with the model would be helpful in predicting several potential resource impacts. It was calibrated to CRE data. However, it is not clear if the HEC-RAS model was verified in this application.

The HEC-RAS model was calibrated on 2000 LIDAR cross sections. Was their a test of the model on similar data? If so, in this application, what was its accuracy in different reaches?

There is little indication that the authors extended the current knowledge beyond rational limits in their predictions.

SPECIFIC REVIEW FINDINGS ON AQUATIC AND

VEGETATION RELATED RESOURCE IMPACTS

In this section responses to the ten questions proposed for the overall review will be developed for four areas of science: aquatic food base, native and non-native fish, disease and parasites, and riparian vegetation.

Aquatic Food Base

Effects of differing flow regimes on the aquatic food base has been a continuing focus of science for two decades. Shortly after appointment of the Science Advisors, questions were posed regarding the ability of the food base research and monitoring program to answer critical questions regarding flow impacts. In 2005 a new food base program was initiated, which will require several years before substantive outcomes can be realized.

Specific Reviewers Comments

Predicted responses of food base to the different options is generally related to conventional science related to areas of wetted surface, temperature and flow stability. In combination they would normally (in the CRE) result in higher productivity in flow regimes maintaining greater volumes of consistently wetted surface. For the options being evaluated this knowledge would place B highest and C, A, and AV as less productive generally.

- The general statements do not misrepresent or overextend existing science.
- Although no models, assumptions or data bases are given, cited scientific literature does contain findings that generally support the projections.
- An important point is raised regarding the base case; that its continuation would be most supportive of science knowledge generally and most probably would best benefit the resource.
- Question 10 is a critical question regarding this resource. The projections do not evaluate interactive resource impacts.
- The issue of biotic regimes that respond to disturbance surface in this resource issue. Over the long term (5-10 years), would the production function for the CRE food base best respond to disturbance regimes?

Native and Non-native Fish

Native and non-native fish exhibit differing habitat preferences and possibly needs. Generally RBT are associated with clear, colder faster water and HBC clouded, warmer, and slower water.

If HBC populations are steady, do we want to keep the downstream waters cool to prevent upstream migration of warmwater fish, especially during low water levels in Lake Powell? Can a TCD help with this by not only having capabilities to release warmer water but also having capabilities to release cooler water.

It is stated that the HBC population has stabilized in recent years while the mainstem temperatures have been warming. However, did the population actually stabilize prior to the water temperatures increasing? The stabilization is based on 4+ age fish, so the inference to the effects of warmer water may not be warranted. The comments about the stabilization of the population appear to be added on to the paragraphs already written (first paragraph and last paragraph) rather than directly incorporated.

For years, the HBC population was considered to be in peril. Now, recent studies have shown that the population never reached critically low numbers and that the population has been relatively steady for several years. This is stated several times in this document. However, if HBC populations are steady, do they really need to discuss all of the non-flow components, especially the HBC translocation, HBC disease, and HBC refuges, and HBC population augmentation? Is too much emphasis put into these areas?

The authors have cited increased temperature as the one factor that could improve both fishes, all other factors equal. This could be extended to other fishes as well. Current science (as presented in the new temperature model) would indicate that no option provides benefit over the base for increased temperature. Only the TCD could produce increased temperatures.

The authors cite predation, habitat, spawning success, adult maturation, food availability, and competition as potential limiting factors on HBC. The KAR presents significant uncertainty in understanding associated impacts of these factors for HBC. The reviewers generally propose the same position.

The authors have reported the findings of current science adequately regarding various flow impacts to HBC. Science findings have not been misrepresented and are generally cited as inconclusive.

The biologists do not propose continuation of MLFF in relation to current status of knowledge on HBC science. It would seem to be critical to have this occur in view of ongoing predation control and natural warming.

The projected effects of the differential flow regimes on RBT properly reflect KAR information.

The question of a reproducing population of RBT in Marble Canyon reflects recent science data of 2006, which, as noted, are not conclusive.

The assessment has taken a conservative approach on RBT in differentiating impacts from the options. It correctly represents knowledge that higher fluctuating flows will likely reduce population size but increase condition. The reverse is cited for stable flows. The fact that one situation is not indicated to be preferred over the other, i.e., numbers vs quality defends the conservative approach of not ranking the options. This does point to concerns as to whether managers know what dfc they want.

Another question that I had was; why have some experimentation in the program been successful and others haven't? One idea is that the reason that predator control and BHBF experiments have been successful is that they are relatively short-term (and low cost) experiments, with a better (at least perceived to be better) idea of costs and benefits. Another idea is that been sufficient flexibility in the negotiations to 'allow' such experiments. In, the social capital in the AMP has generated enough trust to experiment with the entire system, but only for a short period of time. One problem with all of the proposed options is that it is a relatively

longer-term agreement. Since folks will likely feel locked in to this, there is a lot at stake.

The authors approach not to rank these options on RBT best fits with current knowledge and desires for the fishery, i.e. no clear overall preference for number vs quality.

This section on native and non-native fishes points to significant science accomplishment but still sufficient uncertainty to permit clear ranking of flow options..

Invasive Species

Is the neutral offset of option C on invasive species expected to hold in high and low water years?

Disease and Parasites

I agree that little knowledge exists in this area on the CRE.

The authors appear to represent prediction ability correctly. Knowledge is too limited.

Riparian Vegetation

- The assessment of vegetation impacts of differential options adequately reflects current knowledge in the three flow zones covered.
- Discussion of science associated with willow fly catchers and KAS habitat disturbance properly reflects current knowledge relative to BHBFs.

SPECIFIC REVIEW FINDINGS ON RECREATION AND CULTURAL RESOURCE IMPACTS

Angling Opportunity

- Generally the predicted effects of the four options reflect current knowledge. However, proposed knowledge on impacts of wide fluctuating flows on RBT redds and trout numbers appears contrary to the literature and contrary to the biology section conclusions on trout. Does this paragraph (pg 46, paragraph1) state that fluctuating flows will not affect redds, trout populations, trout condition etc.?
- Generally angling opportunity reflects the literature and recent recreation PEP findings.

- The effects of BHBFs appear to properly reflect current science.

Recreational Experience

- the projected impacts of various options relates science findings correctly, except for statements related to water temperature benefits from option B. Is this benefit hypothesized or known to exist? Do these findings conflict with the water temperature predictions?
- Concerns exist over conflicting statements such as effects are “possibly positive” or “possibly negative” when labeled “uncertain in the KAR”.

Cultural Resources

- The reviewers generally agree that the author properly represents the current knowledge in projecting impacts of options.
- A concern exists over use of statements like “effects to cultural resources are uncertain but possibly positive”. In the KAR they are uncertain (pg 56, paragraph 4).

NON-FLOW ACTIONS

Temperature Control Device

The TCD can be used to do more than raise water temperatures, it can also be used to modify the dissolved oxygen in release waters. If low oxygenated waters were to occur near the intake depth for the Base Case, then the TCD can be used to select water with higher dissolved oxygen concentrations. This may become more and more important with the aging of Lake Powell.

The TCD can also be used to cool the water during years with low water level in Lake Powell, if the TCD is designed properly. If warm water fish are found to move into the Grand Canyon with warmer water temperatures, the TCD can be used to reduce water temperatures and keep the warm water fish from entering the system.

Given that the HBC populations are now considered to be stabilized without increasing the water temperature, I am not sure that the SAs are the total risks of warming the water with this device acceptable? Of the four options

proposed, I think that Option B is by far the most appropriate given the current state of the river ecosystem and the current state of our knowledge

- The fourth paragraph page 62 states that TCD effects will reduce the temperature differentials attributed to the four options. The modeled outcomes in the physical resources section concludes no statistical differences will exist. This appears to be inconsistent.
- In balance positive benefits of the TCD to the CRE as reflected in KAR and other reports support its implementation. However, have risk levels changed with positive projections of HBC.
- Generally hypothesized impact information of warm water on native and non-native fish, aquatic resources, recreation, etc., are supported by the literature. However, in the CRE all remain uncertain.

Non-native Fish Control

- The KAR only supports knowledge on RBT control in the CRE, which is known to be positive. Implications to other resources presented, i.e. HBC, food base, etc. are hypothesis to be tested.
- Implications to recreation fishing in some river reaches and tributary inputs could be hypothesized to be negative. Have surveys documented these impacts?

Translocation of HBC

- The affects of translocation is hypothesized to improve mainstem HBC populations in time, but the proof has not been demonstrated in science.
- Can you assign a positive benefit to an option if the science is not complete? We can assume a benefit but the science is not in the KAR.

Humpback Chub Refuge

- The same reasoning applies here as in translocation. An option supporting a refuge would seem to benefit the resource but the knowledge does not exist to demonstrate the benefit.
- Should the 4 options for flow (A, A variant, B, and C) be separated from the experimental design/approach? As it is written it can result in one deciding on which flow option to choose (for example Flow Option C)

based on the experimental approach rather than the Flow options (the main thing being examined, for example Flow Option B). The best experimental approach (forward titration) seems to be well written on Page 18.

- I would suggest first choosing which is the best of the 4 options for flow, including how to trigger the BHBF. Then choose the best experimental approach (similar to Page 18); I prefer the forward approach better than back titration, especially since HBC populations are not so critical right now.
- I remain concerned that it will not be possible to determine cause and effect of out comes. Particularly, under the reverse titration approach (option A), the order of removal and time frame may greatly affect the results. It is said in the report that in for this type of approach that the benefits outweigh the scientific learning and that is clearly the case. Hence, the forward titration approach is more defendable from a statistical perspective.
- It would be useful to glean some cross cutting themes that are mentioned in only option C that should be a part of all options. Such themes include consideration of the time needed for response of the system, ongoing and subsequent analysis of treatment via monitoring timely analysis of the data, and early involvement of biostatisticians.

EXPERIMENTAL DESIGNS

- Although it is potentially helpful to contrast the options from the perspective of learning, is the information presented based on all current knowledge of potential statistical and other potential learning capabilities?
- This section and the proposed option designs could potentially benefit from a review by 3-5 specialists in biometrics.
- On the surface, options B and C seems to offer the greatest opportunity for learning in the long-term, but a review by statisticians might help.

SELECTING AN EXPERIMENTAL OPTION

- The scientific arguments for continuation of MLFF for 2-4 years is sound and should be embraced for the next 36 months.
- The administrative reality and probability of completing an EIS on all of the experimental options proposed and relating a preferred alternative in less than 36 months should bolster support for conducting science on the MLFF for the next three years
- The Aug 30, 2006 draft of the Knowledge Assessment presents a very thorough and balanced summary of what is and is not known about physical, biological and cultural resources in the Colorado River Ecosystem.
- I agree with the GCMRC recommendations that the current experiment be completed by continuing to implement the modified low fluctuating flow regime for at least another 2-4 years, the question of what constitutes the best flow regime cannot be answered by scientists until managers provide clearly defined resource response conditions, a temperature control device be implemented and scientifically tested, testing of sand-enriched BHBFs continue, flow and non-flow treatments be isolated from one another to limit confounding effects, testing of a more stable flow regime continue, and (vii) model development continues as a means to support management decisions.

APPENDIX A

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APPENDIX B
SA REVIEW OF THE STATEMENT OF WORK FOR BIOPHYSICAL SOCIO-CULTURAL ASSESSMENT

A REVIEW OF THE STATEMENT OF WORK FOR AN "ANALYSIS OF BIOPHYSICAL AND SOCIO-CULTURAL IMPACTS OF THREE EXPERIMENTAL OPTIONS"

By

GCD AMP SCIENCE ADVISORS
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EXECUTIVE SECRETARY

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A REVIEW OF THE STATEMENT OF WORK FOR AN "ANALYSIS OF BIOPHYSICAL AND SOCIO-CULTURAL IMPACTS OF THREE EXPERIMENTAL OPTIONS"

By GCD AMP Science Advisors[2]

INTRODUCTION

The GCD AMP has requested that GCMRC and TWG develop cooperatively recommendations for a Long Term Experimental Plan. A Science Planning Group (SPG), structured by the GCMRC and TWG, developed several experimental plan options over 12 months in 2005/2006, which were reduced to three options for comparison to the current Record of Decision (ROD),referred to as Modified Low Fluctuating Flows (MLFF).

Attributes of the MLFF (baseline conditions) and three proposed options, i.e. SPG A, B, and C, are presented in Table 1.1. Both flow and non-flow attributes of the options are presented.

To understand more fully how each of the three options might effect CRE resources, the SPG requested two assessments be developed by GCMRC. Statement of Work (SOW) were development for each assessment.

One assessment will determine economic impacts on hydropower resources, conducted by WAPA under GCMRC direction. A second is an assessment of impacts of the three differing options on biophysical and socio-cultural resources, conducted by GCMRC program managers and scientists.

The SPG realized that significant uncertainty would exist in developing these assessments. As such, the assessments are in major part considered preliminary.

Assistance in external review of the statements of work and assessments was requested of the Science Advisor Executive Secretary. Four reviewers external to the Science Advisors are providing review input to the Hydropower Statement of Work (SOW), and five members of the Science Advisors are

[2] The GCD AMP Science Advisors are comprised of eight specialists. Five were available to provide comments on this Statement of Work.

DRAFT Table 1.1 Comparison of Base Scenario with Three Experimental Options including Flow and Non-Flow Treatments, and Other Conservation Measures.

Flow/Non-Flow Treatment or Conservation Measure	**BASE Scenario** **Modified Low-Fluctuating Flows**	**Option A**	**Option B**	**Option C**
Increased Daily Range in Fluctuating Flows	N/A	Yes (daily range increased by from 50% to 66% in winter months and by 25% in summer months)	No	Yes (daily range increased by from 50% to 66% in winter months)
Stable Flows	N/A	No	Yes, (tests of 4, 8 and 12 months)	Yes, (Sep.thru Oct.)
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
Ramping Rate Studies	N/A	Yes (2X increase in down ramping rate in all months)	No	Yes (2X increase in down ramping rate Nov. thru Jul.)
Control of Exotic Warmwater Fish	N/A	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
TCD	Yes	Yes	Yes	Yes
Humpback Chub Translocation	N/A	Yes	No	Yes
HBC Refuge(s)	N/A	Yes	Possibly	Yes
HBC Population Augmentation	N/A	Planning Activities	No	Planning Activities
Control of Coldwater Fish	N/A	Yes, as needed	Yes, as needed	Yes, as needed
Design	N/A	Reverse Titration	Factorial	Forward Titration
Mini Experiments	N/A	Yes	Yes	Yes

NOTE: 1) Cells highlighted in GREEN indicate HBC conservation measures. 2), Mini-experiments are short-term field experiments that do not confound main experimental treatment effects, N/A, Not Applicable.

presenting input to the Bio-physical and Socio-Cultural Statement of Work (SOW).

This report captures the review of the Biophysical and Socio-Cultural Statement of Work (Appendix A).

REVIEW CHARGE

GCMRC program managers and scientists developed the statement of work (SOW) for conducting an analysis of bio-physical and socio-cultural impacts associated with three GCD AMP experimental options. The SPG specified that the Science Advisors review the statement of work and determine if the methods for the assessment will provide reasonable evaluations.

Science Advisors were requested to provide a response to the following question for this review.

- Will the proposed GCMRC method(s) for analysis of bio-physical socio-cultural resource impacts of three experimental options provide reasonable evaluations?

GCMRC program managers propose to use research methods, Findings, i.e., current scientific knowledge, as expressed in recently developed report; eg, “Status of Colorado River Ecosystem” (SCORE Report) and a “Knowledge Assessment”, as well as other recently developed science.

RESULTS OF REVIEW

Due to availability five GCD AMP Science Advisors provided inputs to this review. Their responses to the review question are presented as a group.

- The Science Advisors in this review of the abbreviated statement of work and methods for a bio-physical socio-cultural assessment find them to provide a “reasonable approach” for the evaluation. The basis for this finding is that current scientific knowledge, by definition, and as defined above, is the most reasonable information to use for this type of evaluation. It is, by definition the best science information and methods available. Having made this evaluation, there are many variants possible on how the proposed knowledge is used to both conduct the evaluation and draw conclusions. Clearly, some

approaches could be used that would falsify the available knowledge in its application. Some concerns are as follows.

- The current data bases are incomplete with significant data voids in some areas.
- Knowledge exists in varied forms of completeness, i.e. ranging from raw data to verified and replicated results.
- Existing knowledge may result from univariate data assessments that could be invalid in a multivariate setting.
- The Knowledge Assessment did as good of a job at identifying areas of uncertainty as areas of good knowledge. And, it clearly presents the reality that much of the desired knowledge base to answer key questions is uncertain at best, or even void. Many of these key areas are listed in the methods section outline for this assessment.
- Any scientist is encouraged to conduct assessments with utmost caution when using knowledge bases of limited certainty.

GCMRC proposes to use current scientific knowledge to evaluate potential impacts of the three experimental options on bio-physical and socio-cultural resources in the CRE. The GCMRC developed draft Knowledge Assessment (GCMRC 2005) is proposed as the primary knowledge base to be used in the assessment, although other current research is also cited as the basis for review, including the 2005 SCORE Report, the 2005 GCMRC Conference Proceeding and other more current work. The Knowledge Assessment available to the SAs is a draft document. If it is now final, how has it changed?

The Science Advisors were asked in 2005 to review the draft Knowledge Assessment. Although the SA review proposed changes in the KA, it accepted the document contents as a reasonable assessment, given the goal for its development and method of development. The SAs reviewed a section of the “State of Colorado River Ecosystem” (SCORE Report) but did not review the 2005 GCMRC Conference

Proceedings report. However, the Science Advisors have copies of the proceeding and assume it represent current knowledge. Did the external reviews of these latter two documents validate the reported science?

One concern with the proposed approach is that it seems to me that deciding among the experimental alternatives is based upon imagined impacts which are difficult to determine, rather than which ones will produce the most information or learning.

The GCD AMP and its assessments of alternative courses of actions often appear to be focused on direct evaluations of alternative stakeholder policies, rather than developing science approaches to create better information or knowledge to develop improved resource conditions and improved policy guidelines. It would be good for the SAs to review detailed write-ups of the three options in the assessment, to see if that is their base intent.

I question the utility of one [SA] review [of these very abbreviated methods]. The most important part of the process is the actual deliberations and discussions that occurred in the science planning sessions.

A concern exists over the assessment of the three options. The outline implicates an extensive review of the impact of the three options on all resources. However, it is not clear what exact source of current knowledge will be used i.e., data, replicated findings, tested models etc. on a specific resource issue. They are not specified in the SOW. This must be disclosed in the write-up of the assessment and for each resource impact evaluated.

The methods section of the statement of work provides little guidance of how assessments are to be made in individual resource areas, except that information and methods from current knowledge, aka Knowledge Assessment will be used. Since the specific information methods for individual resource impact assessments are not revealed in the

statement of work, they must be revealed in the assessment report, or I cannot evaluate the findings.

The assumption exists that the assessment methods related to differing elements of the outline will be fleshed out in the assessment report. This should be a requirement of the report.

- The strategic science questions noted in the work statement references the MPR. However, we were told by the SA Executive Secretary that the MRP is still in revision and will be out mid-September. It is critical to have all referenced material for a review. The previous draft MRP is outdated.
- It became obvious in the review that the final version of the MRP would be an important source of information. The Annual Work Plan (2007)was helpful but lacked reference to long term program strategic questions.
- It is not clear how the assumption of HBC translocation will affect several assessments. The work in the LCR is well known, but in the last year work in other tributaries have been discussed. Is this assumption on HBC translocation identical for all options? And, what is the assumption as to where translocation occurs and how, i.e., just the LCR, or are their other tributaries? If the area of impact is extensive, will it confound the overall experiment?
- The success of mechanical removal of RBT is well known as a research program. Is it still an experiment or management treatment? The SAs have recommended programs on non-native brown trout and warm water fish removal. Does the assumption on mechanical removal include all non-native fish? And what is the extent of research and management actions?
- In some ways this review of methods seems not necessary. In the past 18 months the Center has developed extensive state of knowledge assessments for the CRE. One would assume that these knowledge bases would be the source of methods for assessments.

What could be better? As such, the methods proposed are reasonable. About the only concern that should exist in the methods review is how you apply the knowledge in your assessment. And, since that information is generally not in the methods write-up, the review is significantly constrained.

- The task 3 specifies three options to be reviewed with both flow and non-flow attributes. However, limited information is given on some attributes such as TCD, translocation of HBC, non-native fish control, etc. More clarification would be helpful regarding elements or attributes of the experiment.
- The methods section covers such a broad array of issues. It is difficult to begin to evaluate the method that would be applied without the specific science questions.
- The baseline is alternately referred to as ROD values, a NO ACTION (as though part of an EIS), MLFF etc. Although I understand what it is, i.e. flow regimes, I do not understand its application in the analysis. Is it a true reference condition to which the three options are compared? It has no other value in this analysis? Will it be evaluated with these options in an EIS?
- In Section III I assume one of the science questions is to determine if one option is better than another in the storage of fine sediment. I also assume a model will be used in these assessments, but which model(s)? If I knew the explicit question being asked I might be able to determine the approach, i.e. probable model, to be used and could offer suggestions. It is too difficult to determine both the question you will ask and the method to evaluate the question.
- The methods proposed i.e., current knowledge is reasonable. However it needs greater definition to permit adequate review. I find myself trying to determine which of the science questions in the previous draft MRP is being referenced for the bullet at top of page 6, “Invasive fish species – cold and warm water”. Then I try to envision

from the Knowledge Assessment, or SCORE Report what method will be applied. At the minimum the methods should have that detail. Without it I can only say that current knowledge should be the best method to apply, if applied correctly.

APPENDIX A

A STATEMENT OF WORK FOR
REVIEW OF BIO-PHYSICAL AND SOCIO-ECONOMIC
IMPACTS OF THREE EXPERIMENTAL OPTIONS

Project 10.R1. 07: A Scope of Work For Review of a Report to Evaluate Biophysical and Socio-Cultural Resource Impacts of Implementing Proposed Long-Term Experimental Options in the Colorado River Ecosystem (CRE).

Start Date: August 20, 2006

End Date: November 15, 2006

Principal Investigators:

GCMRC: Biophysical and Socio-Cultural Assessments
M3 Research and GCD AMP Science Advisors: Administration and Review of Reports

Geographic Scope:

The reviewers will focus on the methods section of this Scope of Work and a final resource assessment report developed by GCMRC.

Project Goals:

The goal of this project is for 8-10 reviewers to evaluate the completeness and scientific basis for analysis methods used and conclusions developed in the biophysical and socio-cultural impact assessment outlined in the methods section.

Need for Project:

The Science Planning Group (SPG) of the Glen Canyon Dam Adaptive Management Program (AMP) has proposed four potential new flow and non-flow long-term experimental options. These proposed long-term experimental options are expected to result in differing impacts on downstream physical, biological, socio-cultural, and economic resources of the Colorado River Ecosystem. The Adaptive Management work Group (AMWG) and Technical Work Group (TWG) have requested preliminary evaluation of the proposed long-term experimental options impacts on these resources. The information will be used to determine the most reasonable option to implement over the next five years. One of the requested analysis, hydropower resource impact assessment, is being conducted in a separate assessment. All other resource impacts are represented in this assessment.

Strategic Science Question(s):

This science review project will review preliminary information assessments that respond to a broad cross section of strategic science questions, included in the Monitoring and Research Plan.

Link/relationship to Other Projects:

This project is directly linked to the comprehensive long-term science planning process for all USGS research in the CRE, and specifically planned science on resource impacts associated with proposed long-term experimental options identified in the Task 3 methods section.

Information Needs Addressed:

This project responds to Research Information Needs (RINs) that are articulated in the 2003 version of the AMP Strategic Plan, the GCMRC 2007-2011 Monitoring and Research Plan and the 2007 Annual Work Plan.

General Methods of the Analyses:

Assumptions
Several assumptions are associated with this analysis that can influence developed resource impact assessments. Some appear in the following Task 3 methods on experimental options. Others are identified as follows:

- All analyses assume installation and operation of a TCD at Glen Canyon Dam beginning 2010.
- All options assume a mechanical removal program for non-native fish to be defined by GCMRC.
- Selected translocation of HBC is assumed to occur in all options as specified by GCMRC.
- It is assumed that the proposed assessments will utilize current knowledge to evaluate the hypothetical impacts. The Knowledge Assessment and 2005 conference proceedings are assumed to be current knowledge.
- Significant uncertainty exists with most assessments, therefore requiring a proposed five year science program to resolve uncertainty. Therefore, it is assumed that these assessments address potential impacts associated with differing options.

Specific Methods of Analysis by Task

Task 1. Describe flow regimes associated with each proposed long-term experimental option. Reclamation (US BOR) will provide computed monthly volumes for each option. Western (WAPA) will produces data tables associated with the daily hydrographs for each option based on these monthly volumes.

Task 2. Establish a biophysical, socio-cultural review team. GCMRC will contract the services of the Science Advisors and independent reviewers to review the analysis,

any modeling assumptions and methodologies, final report and recommendations, and ensure the results are consistent with the Scope of Work. Peer review will be coordinated by the Science Advisors Executive Secretary, a principal of M3 Research. Approximately 8-10 reviewers will be utilized.

Task 3. Evaluate potential/hypothesized biophysical and socio-cultural resource impacts related to each of the long-term experimental options being evaluated.

The assessment methods are as follows:

- The assessment evaluates four alternatives, a baseline and three experimental options (Appendix A).
- The baseline condition will be the current operating criteria for Glen Canyon Dam (GCD) as identified in the 1996 Record of Decision (ROD).
- The assessment will apply current scientific knowledge of the Knowledge Assessment to evaluate potential impacts. The outline of treated subjects science questions and methods are as follows:

Outline of Proposed Methods of Evaluation for Three Experimental Options and a Baseline (ROD)

Section I

Introduction

Background and scope
Purpose
Overview of experimental options

Section II

Description of Each Experimental Option

Option Title:
Goal
Elements of the proposed option
    Flow Regime
    Flow Experiments
    Non flow measures/treatments
Experimental design
Summary of Strengths of Proposal
Summary of Weaknesses of Proposal

Section III

Comparative Resource Assessment of Each Proposed Flow Regime

Part 1. Physical Resources (Fine-Sediment and Quality-of-Water)

- Executive Summary
- Strategic Science Questions from MRP
- Fine-Sediment Storage:
    - above 25,000 cfs stage

- between 8,000 and 25,000 cfs stages
- below 8,000 cfs stage

- Downstream Water Temperature: main channel and near shore
- Estimates of Diurnal Stage Variations by Geomorphic Reach

Part 2. Aquatic and Fisheries Resources

Executive Summary
Strategic Science Questions from MRP
Aquatic Food Base: Glen Canyon and Grand Canyon
Adult Fish Populations
- Humpback Chub
- Flannelmouth Sucker
- Rainbow Trout Numbers and condition in Glen Canyon
- Rainbow Trout Numbers in Marble Canyon

Mainstem Spawning and Incubation:
- Humpback Chub
- Flannelmouth Sucker
- Rainbow Trout, Glen Canyon
- Rainbow Trout, Marble Canyon

YOY/Juvenile Near Shore Rearing:
- Humpback Chub
- Flannelmouth Sucker
- Rainbow Trout, Glen Canyon
- Rainbow Trout, Marble Canyon

Invasive Fish Species -- Cold and Warm Water
Disease and Asian Tapeworm

Part 3. Assessment of Effects to Recreation and Cultural Resources

Executive Summary
Strategic Science Questions from MRP
Angling Opportunity, Quality and Access
Campsites (campable area availability)
Quality of water & human health
Visitor safety and rafting navigability
Recreational Experience quality including access to attraction sites
Archaeological sites and TCPs

Part 4. Hydropower Resources (see Western Area Power Administration's SOW)

- Strategic Science Questions from MRP
- Strategic Science Questions from MRP Load-Following Capacity
- Replacement Power costs

Section IV

Resource Assessments of the Non Flow Measures

(Note: level of detail will be determined by specificity of the non flow measure)

1. Temperature Control Device

Part 1. Physical Resources (Fine-Sediment and Quality-of-Water)

- Executive Summary
- Strategic Science Questions from MRP
- Downstream Water Temperature: main channel and near shore
- Hydropower: Load-Following Capacity and Replacement Power costs

Part 2. Aquatic and Fisheries Resources

Executive Summary
Strategic Science Questions from MRP
Aquatic Food Base: Glen Canyon and Grand Canyon
Adult Fish Populations
- Humpback Chub
- Other natives
- Rainbow Trout Numbers and condition in Glen Canyon

Mainstem Spawning and Incubation:
- Humpback Chub
- Other natives
- Rainbow Trout, Glen Canyon

YOY/Juvenile Near Shore Rearing:
- Humpback Chub
- Other natives
- Rainbow Trout, Glen Canyon

Invasive Fish Species -- Cold and Warm Water
Disease and Asian Tapeworm

Part 3. Assessment of Effects to Recreation and Cultural Resources

Executive Summary
Strategic Science Questions from MRP
Angling Opportunity, Quality and Access
Quality of water & human health
Visitor safety
Recreational Experience quality

2. Non Native Fish Control/Management

Part 1. Aquatic and Fisheries Resources

- Executive Summary
- Strategic Science Questions from MRP
- Aquatic Food Base: Glen Canyon and Grand Canyon
- Adult Fish Populations
- Humpback Chub
- Other natives
- Rainbow Trout Numbers and condition in Glen Canyon
- Mainstem Spawning and Incubation:
- Humpback Chub
- Other natives

- Rainbow Trout Numbers and in Glen Canyon
- YOY/Juvenile Near Shore Rearing:
- Humpback Chub
- Other natives
- Rainbow Trout Numbers and condition in Glen Canyon
- Invasive Fish Species -- Cold and Warm Water

Part 2. Assessment of Effects to Recreation and Cultural Resources

Executive Summary
Strategic Science Questions from MRP
Angling Opportunity, Quality and Access
Recreational Experience quality including access to attraction sites
TCPs

3. Translocation of HBC

Part 1. Aquatic and Fisheries Resources

Executive Summary
Strategic Science Questions from MRP
Adult Fish Populations
- Humpback Chub
- Other natives

- Mainstem Spawning and Incubation:
  - Humpback Chub
  - Other natives

Invasive Fish Species -- Cold and Warm Water

Part 2. Assessment of Effects to Recreation and Cultural Resources

Executive Summary
Strategic Science Questions from MRP
Angling Opportunity, Quality and Access

4. HBC refuge, propagation and genetics management planning

Part 1. Aquatic and Fisheries Resources

Executive Summary
Strategic Science Questions from MRP
Humpback Chub

Section IV

Evaluation of Proposed Experimental Research and Designs

1. **No Action**
2. **SPG –A**
3. **SPG - B**
4. **SPG –C (proposed)**

Table 1. Long Term Experimental Options being evaluated by SPG.

Option	No Action	Option SPG-A	Option SPG-B	Option SPG-C (Proposed)
Flow regime	MLFF (ROD flows)	Increased fluctuating flows in 10 months; ecologically stable flows in September and October	Stable Flow Testing initially in summer/fall (4 mos.), eventually moving toward seasonally adjusted steady flows in all months,	MLFF with stable flows in September and October and increased fluctuating flows in 3 winter months
Implement Expanded Fluctuating Flows Testing	All releases within ROD operating constraints)	Yes, (all months except in September and October)	None (all releases within ROD operating constraints)	Releases within ROD operating constraints in all months except Dec-Feb (increased fluctuations)
Stable Flows	None	Yes, Sep.-Oct. only; includes tests to define ecologically steady flow	Yes, (4-12 months each year)	Yes, September and October only; includes tests to define ecologically steady flow
Beach/Habitat-Building Flow (41,000 to 45,000 cfs, 1-3 days, in spring)	Yes in April following sand enrichment from major tributaries	Yes, in April following sand enrichment from major tributaries	Yes, in Jan-April following sand enrichment from major tributaries & consideration of native fish impacts	Yes in April following sand enrichment from major tributaries
Ramping Rate Studies	Possibly so long as they are within ROD	Yes (November – August)	None (ROD ramping rates)	Yes
Tests of Exotic Fish Control, (Warmwater & Coldwater)	Possible	Yes, as needed	Yes, as needed	Yes
Build & Test (Selective Withdrawal Structure)	Possible	Yes	Yes	yes

HBC Translocation	Possible	Yes	Depends on Further Analysis	Yes
HBC Refuge(s)	Possible	Yes	Depends on Further Analysis	Yes
HBC Population Augmentation Planning	Possible	Planning efforts toward implementation as needed	No activities toward this action	Planning efforts toward Implementation (as needed)
Experimental Design	Forward titration/block design	Forward titration in phase 1	Forward titration—steady flows implemented incrementally in 4 month blocks over 6 years	Implemented in 3 5-year increments with flow regimes remaining constant in phase 1 and 2; implementation and testing of TCD in phase 2; evaluation to determine flows in phase 3

Table 2 Proposed Monthly Flows for each option.

Table 3 Portrayal of Annual Pattern of Experimental Treatments Associated with each

WATER YEAR MONTH	VOLUME (AC X 1000)	MAX. MONTHLY FLOW (CFS)*	MIN. MONTHLY FLOW (CFS)	RANGE OF DAILY FLUCTUATION (CFS)**	UPRAMP/ DOWN RAMP (CFS/ HOUR)
OCTOBER					
NOVEMBER					
DECEMBER					
JANUARY					
FEBRUARY					
MARCH					
APRIL					
MAY					
JUNE					
JULY					
AUGUST					
SEPTEMBER					
Total	8.23MAF				

option

Water Year	Dominant Dam Operation	Measure 1	Measure 2	Measure….n
2003				
2004				
2005				
2006				
2007 –start Phase 1				
2008				
2009				
2010				
2011				
2012-start Phase 2				
2013				
2014				
2015				

2016				
2017-start Phase 3				
2018				
2019				
2020				
2021 - end Phase 3				

Task 4. Draft Project Report. A draft project report will be prepared by GCMRC to present the results of the assessment. At a minimum the following sections are to be developed in the report.

I. Introduction and purpose
   A. Context of the analysis
   B. Purpose of the analysis

II. Objectives
   A. Specific objective sought in the analysis, questions, etc.

III. Methods for Assessment
   A. Assumption for analysis
   B. Analysis methods used

IV. Results and Conclusions
   A. Results: Comparative analysis of hypothesized resource impacts of three experimental options with a baseline option (ROD).
   B. Conclusions: Specification of how differing options could potentially impact resources different then realized from ROD flows and implications to managers.

Task 5. Peer Review Science Advisors. A peer review panel is selected from the Science Advisors to review the methods section of the statement of work and the draft GCMRC report on the assessment. The proposed panel members are as follows:

Dr. Dale Robertson, limnologist, USGS
Dr. James Kitchell, Fish Ecologist, University of Wisconsin
Dr. Don Fowler, Anthropologist, University of Nevada Reno
Dr. Ellen Wohl, Geomorphologist, Colorado State University
Dr. Virginia Dale, Systems Ecologist, Oak Ridge Laboratory
Dr. Jill Baron, Ecologist, USGS
Dr. Lance Gunderson, Adaptive Management Specialist, Emory University
Dr. Harold Tyus, Fish Ecologist, University of Colorado Boulder
Dr. John Loomis, Recreation Economist, Colorado State University

A review will be developed by the panel as follows:

Biophysical/Socio-cultural Impact Assessment Report: The goal of this review is to determine if the objectives of the analysis are met. The review will evaluate appropriate application of assumptions, models, data, current state of science, etc. to obtain the outcomes reported. The review will also evaluate if the conclusions drawn are reasonable for the analysis

Task 6. Outcomes; Final Report and Presentation to TWG and AMWG.

Two outcomes are specified, a final written report on results and conclusions, and a formal presentation to the TWG and AMWG.

Schedule

The schedule proposed for this project is as follows:

1. Review panel established; 8/18/06
2. Scope of Work complete; 8/22/06
3. Experimental options, assumptions fully specified; 8/22/06
4. Science panel review of SOW; 8/29/06
5. GCMRC complete draft report; 9/23/06
6. Science panel review of draft report; 9/30/06
7. Final report presentation to TWG; 10/10/06

Budget

..06	
conomic Implications of Alternative Experimental Flows (FY06)	
	iscal Year 2007
USGS Salaries	
roject Related Travel/Training	-
perations/ Supplies	-
quipment Purchase / Replacement	-
tics Support	-
SGS Contract Science Labor for reviewers (17% Burden Rate)	$28,000
e / Interagency Agreements (6% Burden Rate)	-
b-total	
mer Burden (Combined 6 and 17% rates)	$3,600
tal (Gross)	**$31,700**
tsourced (Out of USGS)	100%
	-