

GCDAMP Science Advisors Executive Coordinator Review of GCMRC FY18-20 Triennial Plan Draft of May 2017

*Sound Science LLC
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The Glen Canyon Dam Adaptive Management Program (GCDAMP), Science Advisors Executive Coordinator's office has reviewed the U.S. Geological Survey (USGS), Grand Canyon Monitoring and Research Center (GCMRC) Triennial Budget and Work Plan (TWP) for FY 2018-2020, draft of May 16, 2017, and the added draft of Project Element I.3 of June 6, 2017. Our review comes in two forms: (1) the present document, which provides overarching comments about the draft overall and its individual projects; and (2) comments and suggested edits inserted directly into a copy of the draft itself. The two bodies of feedback do not duplicate each other and are meant to be considered side by side.

Introduction

The GCDAMP Triennial Budget and Work Plan for FY 2018-2020 will be the first work plan implemented under the 2016 Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP) and the December, 2016, U.S. Department of the Interior (DOI) Record of Decision (ROD) on the LTEMP Environmental Impact Statement. It is also the first work plan implemented following a rapid Knowledge Assessment, November 2016-April 2017, carried out by expert teams at the request of the GCDAMP Technical Work Group. The purpose of the Knowledge Assessment was to identify critical uncertainties in the knowledge that the GCDAMP will use, under the LTEMP and its accompanying U.S. Fish and Wildlife Service (USFWS) Biological Opinion, to inform its recommendations on adaptive management of dam operations and other actions stipulated in the Record of Decision. Finally, the Triennial Budget and Work Plan for FY 2018-2020 is the first plan completed under the guidance of the January, 2017, "Scientific Monitoring Plan in Support of the Selected Alternative of the Glen Canyon Dam Long-Term Experimental and Management Plan," prepared by the GCMRC. Together, the Knowledge Assessment, the LTEMP, the accompanying Biological Opinion, the Record of Decision, and the Scientific Monitoring Plan identify numerous lines of evidence needed (a) to guide decisions on when twelve different types of experimental dam operations and non-flow management actions should take place, (b) to guide decisions on where some non-flow management actions should be carried out, and (c) to make sense of the data collected during flow and non-flow experiments in order to inform future experimental dam operations and non-flow management actions based on the impacts of these actions on eleven priority resources.

The twelve types of experimental dam operations and non-flow management actions specified in the LTEMP are as follows:

1. Fall High Flow Experiments (HFEs) > 96-hr duration (\leq 45k cfs, in October or November)
2. Fall HFEs \leq 96-hr duration (\leq 45k cfs, in October or November)
3. Humpback chub translocation
4. Larval humpback chub head-start program
5. Macroinvertebrate production flows
6. Mechanical removal of invasive fish species
7. Mechanical removal of rainbow trout from LCR reach
8. Proactive Spring HFEs \leq 45k cfs in April, May, or June
9. Riparian vegetation restoration
10. Spring HFEs \leq 45k cfs in March or April
11. Trout management flows
12. Summer Low Flow Experiments (LFEs) (*second decade only*)

The eleven priority resources to be addressed under the LTEMP, and the LTEMP objectives for these resources, are as follows:

1. *Archaeological and Cultural Resources*. Maintain the integrity of potentially affected National Register of Historic Places (NRHP)-eligible or listed historic properties in place, where possible, with preservation methods employed on a site-specific basis.
2. *Natural Processes*. Restore, to the extent practicable, ecological patterns and processes within their range of natural variability, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems.
3. *Humpback Chub*. Meet humpback chub recovery goals, including maintaining a self-sustaining population, spawning habitat, and aggregations in the Colorado River and its tributaries below the Glen Canyon Dam.
4. *Hydropower and Energy*. Maintain or increase Glen Canyon Dam electric energy generation, load following capability, and ramp rate capability, and minimize emissions and costs to the greatest extent practicable, consistent with improvement and long-term sustainability of downstream resources.
5. *Other Native Fish*. Maintain self-sustaining native fish species populations and their habitats in their natural ranges on the Colorado River and its tributaries.
6. *Recreational Experience*. Maintain and improve the quality of recreational experiences for the users of the Colorado River Ecosystem. Recreation includes, but is not limited to, flatwater and whitewater boating, river corridor camping, and angling in Glen Canyon.
7. *Sediment*. Increase and retain fine sediment volume, area, and distribution in the Glen, Marble, and Grand Canyon reaches above the elevation of the average base flow for ecological, cultural, and recreational purposes.
8. *Tribal Resources*. Maintain the diverse values and resources of traditionally associated Tribes along the Colorado River corridor through Glen, Marble, and Grand Canyons.
9. *Rainbow Trout Fishery*. Achieve a healthy high-quality recreational rainbow trout fishery in Glen Canyon National Recreation Area (GCNRA) and reduce or eliminate downstream trout migration consistent with National Park Service (NPS) fish management and Endangered Species Act (ESA) compliance.
10. *Nonnative Invasive Species*. Minimize or reduce the presence and expansion of aquatic nonnative invasive species.

11. *Riparian Vegetation*. Maintain native vegetation and wildlife habitat, in various stages of maturity, such that they are diverse, healthy, productive, self-sustaining, and ecologically appropriate.

We reviewed the GCMRC draft with three general questions in mind:

1. If successful, would the proposed studies meet the needs for specific types evidence under the LTEMP to: (a) guide decisions on when various experimental dam operations and non-flow management actions should take place, (b) guide decisions on where some non-flow management actions should be carried out, (c) make sense of the data collected during flow and non-flow experiments in order to inform future experimental dam operations and non-flow management actions, and (d) ensure efficient and effective learning in support of the overarching purposes of the LTEMP and the GCDAMP.
2. If a proposed study does not specifically address needs for these specific types of evidence, does it address needs for information to support a broader concern of the LTEMP, to avoid "... long-term unacceptable adverse impacts on the [priority] resources..."
3. Does the proposal for each project element make a good case that the proposed work will be the best (most efficient, timely, cost-effective) approach among potential alternatives and, if applicable, will have the fewest (if any) adverse impacts on other resources and values.

We also reviewed the GCMRC draft with a view to the timing needed for different monitoring and research efforts. The LTEMP covers a twenty-year period, 2017-2036. Over the course of these twenty years, implementation of the LTEMP is intended to generate information on the impacts of its various experimental dam operations and non-flow management actions as well as on the impacts of base operations at the dam. In one sense, then, the GCMRC draft triennial budget and work plan should define the first phase of a twenty-year agenda for monitoring and research. However, the LTEMP breaks this twenty-year period into two parts, with a "pause" after ten years when all parties can step back, assess what has been learned through implementation of the LTEMP, and assess any management implications of these findings. That ten-year review will come after the completion of three triennial work plans. The work carried out under these three triennial work plans – starting with the plan for FY 2018-2020 – should focus tightly on the needs for the ten-year review.

General Comments

The present work plan is only for the first of the three 3-year cycles leading up to the ten-year review. The GCMRC investigative teams should feel empowered to think on that ten-year scale, and to pace themselves accordingly. One could conduct a kind of critical-path analysis, identifying the kinds of information that the investigative community presently thinks will be needed in ten years to allow Interior to change (or not) the ways in which it operates the dam and change (or not) the other kinds of non-flow management actions it takes to achieve the objectives of the LTEMP and the GCDAMP overall. Our review found that the twelve projects proposed in the GCMRC draft plan do not always make a clear case for why all of their proposed project elements need to be completed within the next three years. This is particularly true for project elements that are significantly new for the GCDAMP. Sometimes it may indeed be important to

quickly begin new project elements, expand existing elements, or modify investigative methods to fill crucial needs, or to push for completion of particular studies in the next 3 years. But this is not always the case. We therefore recommend that some of the proposed project elements might benefit from taking a slower approach, testing crucial methods in a step-wise manner without trying to promise too much, too soon, with an eye toward a longer-term plan of accomplishments. We also recommend that some proposed new or significantly modified projects or project elements would benefit *greatly* from incorporating a crucial first step, to establish clear objectives for resource condition and for learning, monitoring, and management methods (e.g., for riparian vegetation).

A small number of instances crop up, where a project element or sub-element is proposed “if funding is available.” While these kinds of “pitches” are appropriate during the give-and-take process of preparing the three-year plan, it may not be appropriate to include these studies in the final triennial work plan unless you are specifically requesting funds for them. Otherwise, it is not clear how such proposed additional studies would be addressed in the work plan overall, given that the May 2017 draft GCMRC budget for this three-year plan exceeds the proposed funding ceiling. One line of thinking would be that, if there is no room for these additional (let’s call them “second-tier”) studies in the present budget under the funding ceiling, they should not be included in the final plan, unless you plan to seek funding outside of the GCDAMP altogether. Alternatively, the final plan could explicitly recognize that you may spend less on the first-tier projects than what you have planned, or additional sources of funding could be brought to bear (if procedurally feasible). You will then need procedures in place to allocate “freed-up” funds to deserving second-tier projects. The present document could then explicitly identify second-tier studies that will be considered if such funds become available. We would recommend that latter approach (if procedurally feasible), because we think it is useful to provide a forum where investigators can at least briefly identify what second-tier studies they have in mind. The descriptions of these potential additional studies communicate the creative thinking of the investigative community about knowledge gaps and ways these might be closed; and queue up ideas for consideration in future work plans. However, the overwhelming attention of the present plan should be on what will be funded. Ultimately, this is not the best forum for discussing anything else.

As a final general comment, we note that the document needs thorough editing, not only for formatting but for consistency in terminology. Several project descriptions repeat the definitions of key acronyms (e.g., for GCDAMP, LTEMP, LCR, BiOp, etc.), and either repeat or omit the definitions of crucial terms such as river “reaches,” “river miles,” and other terms of reference that readers must understand in order to follow the project descriptions. The presentation of spatial terms of reference should cover Lake Powell and the Colorado River ecosystem (CRe) all the way to Lake Mead, since this is the combined geographic scope of the projects. This may need to be supported by a series of maps, covering the major sections of the system (with Lake Powell mapped to show the locations mentioned in text, including inflows, Wahweap, lake profiling areas, etc.). A watershed map encompassing the Little Colorado and Paria watersheds (and other tributaries to the CRe) would also help readers better follow the discussions about tributary inputs below the dam. A glossary and a brief explanation of spatial terms of reference would be very helpful, the latter perhaps best placed immediately following the overall document introduction.

Project A

This is a straightforward matter since the project addresses core monitoring needs to track hydrology, sediment inputs and outputs, and basic water quality parameters at fixed gaging stations. There is some inconsistency in terminology, using terms “reaches” and “segments” in both formal and informal ways that seem to overlap, with no map showing the “official” management reaches used by the GCMRC and others for reference purposes.

A few difficult-to-parse paragraphs need editing for clarity.

Project B

This is a bundle of several project elements all focused on the broad topic of how hydrologic and geomorphic factors affect sandbar deposition and erosion, with particular emphasis on the effects of LTEMP actions. The project has three objectives: (1) to monitor the effects of *individual* HFEs on sandbars, (2) to monitor the *cumulative* effects of successive HFEs and intervening operations on sandbars and sand conservation, and (3) to increase scientific understanding of the interactions between dam operations, sand transport, and eddy sandbar dynamics. The third objective will result in a greater ability to predict the effects of individual HFEs based on antecedent conditions and hydrograph shape. There are six proposed elements. Project Element B.5 is unique in that it concerns improvements to the geospatial “control network” for the entire canyon system, for all geospatial data.

The writing is choppy in places, as noted in Comment fields, jumping over key steps in arguments. The proposal narratives concerning computer modeling and physical (flume) modeling may over-promise or leave out crucial steps, and the study goals may not be fully achievable in the three-year timeframe of the TWP. In fact, it is not at all clear why there would be a 3-year rush on some of these efforts. The results will not be needed until Year 10, the first “off-ramp” milestone. Might it be possible to reduce the present 3-year costs by taking a longer time to carry out some parts of some project elements? (Other project elements are time-sensitive: it is crucial to monitor every HFE and Trout Management Flows (TMF) event, because there will be so few of them over time and because they are affected by so many uncontrolled factors.) The proposal also does not discuss how well the results of the flume experiments can be translated into an improved understanding of the CRe, or how the resulting integration of field and flume data can be parlayed into an improved ability to predict and design HFEs to maximize sandbar benefits while minimizing other, perhaps less desired side effects. The proposal also notes the importance of understanding how sediment dynamics affect aquatic habitat conditions, but does not pursue this topic.

The proposal narrative for Project Element B.5, covering improvements to the geospatial “control network” for the entire canyon system, does not make it clear why this should be exclusively a GCDAMP expense, since it will benefit all agencies active in the canyons. It is also not clear if it will provide any benefit below Diamond Creek, nor how much of an improvement in geospatial positioning data will be achieved and whether that improvement is needed for GCDAMP purposes. The element proposal is also not written for the audience level and technical background of many likely TWP readers and reviewers.

Project C

Project C proposes five elements, three of which are specifically focused on vegetation assessment and monitoring (elements C.1, C.2, C.5). The remaining two are focused on vegetation management. As presented, there appears to be little interaction among these elements. Each is presented as a stand-alone project with no reference to the other projects. This is surprising as, for example, both Element C.2 and Element C.5 are focused on historical changes in vegetation distribution and extent. Similarly, Elements C.1 and C.2 include aspects of vegetation composition, but neither acknowledges the other. We have no doubt that the researchers are aware of others' work, and so this is likely a presentation issue and not a substantive one. However, the reader is left to try to make all the pieces fit together, whereas it is the authors' responsibility to do so.

The LTEMP discussion of the project areas vegetation (Section 3.6) succinctly demonstrates the depth and breadth of data and knowledge of the vegetation communities with the canyons. A huge amount is currently known. However, the proposed Riparian Vegetation Monitoring and Research Project proposal does not seem to draw upon this understanding. Rather, it is largely a proposal to continue existing data collection and to add additional data (e.g., Element C.5). Given the long and diverse history of research on the CRE vegetation, it seems more appropriate for the vegetation science team to step back and create an adaptive management framework for the ecosystem. Indeed, the Riparian Vegetation Knowledge Assessment proposal calls for the development of “a science-based vegetation management (e.g., restoration, rehabilitation, or other active management) plan with measurable goals. Allocate time and money based on goals to track success.” Unfortunately, it doesn't appear that this guidance was followed during the development of this Project.

The Project Summary references the LTEMP vision that the CRE's vegetation communities are “in various stages of maturity, such that they are diverse, healthy, productive, self-sustaining, and ecologically appropriate” and that dam operations under the new ROD have the expected result of “more native plant community cover, higher native plant diversity, a lower ratio of native to nonnative plants, less arrowweed, and more wetland”. These goals need to be placed into an adaptive management context that includes the development of some measurable metrics. For example, many of the “expected results” are scale dependent. Species-area relationships ensure that diversity increases with the scale of assessment. So, at what scale is a “higher native plant diversity” appropriate: the patch, community, reach, or river-wide scale? Similarly, the ratio of native:non-native plants isn't terribly informative (note that the document states a desire for a “lower ratio of native to non-native plants” implying a desire for MORE non-natives. We assume a higher ratio is what is intended). A management focus on those non-native species that are both invasive and system-changing (e.g., tamarisk) might be more appropriate from a management perspective. Not all non-native species are system-changing, and a sound management plan should set priorities based on knowledge of which non-native species are or are not significant ecological threats—and on needs to develop this knowledge if it is lacking.

The current riparian vegetation assemblage along the CRE is unique and does not reflect historic vegetation structure, composition, or location. Because of this, the value (for the adaptive management of the river) of Element C.5, the system-wide repeating historical photography study is not clear. It is well documented that the pre-dam vegetation is now perched above the river and well above the river's influence and the current vegetation is an artifact of the current

flow management regime and lack of natural sediment loads from the Upper Basin. The value of comparing current and future vegetation to the vegetation of 1923 and 1940 should be clarified. Alternatively, permanent oblique photo monitoring can be hugely powerful for interpreting and communicating quantitative vegetation data and remote sensing imagery.

Unlike many of the other Projects proposed, this Riparian Vegetation Project seems to lack a clear conceptual framework, and thus it is not clear how this project will help inform the adaptive management of the river's riparian communities. With the exception of Element C.4, it seems that the common goal is to document change over time. This is a common failing of ecological monitoring efforts. Ecological systems are dynamic and change constantly, so simply documenting change doesn't inform management. Further, the ability to document change is driven by the sampling design and sampling intensity. Monitoring for adaptive management needs to be able to extract the signal of management effect from the ecological noise. This is most effective by identifying the important signals to be measured before implementing any data collection.

Project D

This project mostly concerns the causal relationships through which the river and riparian vegetation affect sediment dynamics at archaeological sites that lie within the zone of impacts of the river on the surrounding geomorphic landscape. Specifically, most of Project D focuses on two core topics concerning the geomorphic integrity of archaeological sites: (1) altered aeolian inputs versus outputs of river sand at archaeological sites and (2) destabilization and resulting bank-collapse of the landforms on which some archaeological sites occur. The wind-blown sand at archaeological sites is thought to originate as sand exposed along the river itself. Alteration of aeolian inputs versus outputs of river sand at archaeological sites is thought to result from change in the area of the sand exposed along the river—change brought about by changes in riverine deposition versus erosion of sand and changes in riparian vegetation cover on the river sand deposits. Changes in riverine deposition versus erosion of sand are thought to be consequences of dam operations and sediment supply to the river. Dam operations are also implicated in direct landform erosion. LTEMP flow experiments will alter these dam operations and therefore potentially alter aeolian sand dynamics as well as potentially alter direct landform erosion. LTEMP manipulation of riparian vegetation potentially will alter aeolian sand dynamics, too. The proposed project (D) will measure and evaluate the strengths of these proposed causal relationships and their outcomes. Additionally, a small part of Project Element D.4, focuses on synthesizing information on past surveys, investigations, and “mitigation” work encompassing NRHP cultural properties within the Area of Potential Effects under the Programmatic Agreement (PA).

The Background section is not well organized, and repeats itself in several ways; and it combines background information with information about the planned project itself. This results in a jumping back and forth among different topics, making for some confusion. Comments entered alongside the text raise questions about (a) how much of the proposed work can be accomplished within the three-year planning cycle, and (2) distinguishing between the quantification of conditions in the field from efforts to determine how and why these conditions may vary in relationship to river hydrology and riparian vegetation cover. Project Element D.3, for working

with Project C to design vegetation removal experiments, sounds like a good idea but the plan is very skimpy and suggests a need for a pilot effort to figure out what needs to be done and how.

The presentation of Project Element D.4 does not make clear why it is important to complete the proposed synthesis of work efforts at this time, as a contribution to LTEMP or PA goals. Implementation of the LTEMP must effectively address two resource goals related to cultural resources and tribal values (*1, Archaeological and Cultural Resources: Maintain the integrity of potentially affected NRHP-eligible or listed historic properties in place, where possible, with preservation methods employed on a site-specific basis. 8, Tribal Resources: Maintain the diverse values and resources of traditionally associated Tribes along the Colorado River corridor through Glen, Marble, and Grand Canyons*). The synthesis report for Project Element D.4 presumably will help ensure that the implementation will accomplish this, but the proposal does not make clear how it will do so. The proposed analysis of site photography, in turn, seems to be only vaguely conceived and probably warrants a pilot effort to figure out the “why” (including how it will help accomplish the two aforementioned LTEMP goals) and “how” before any consideration is given to funding an entire project.

Project E

The primary purpose of this project is to figure out how the limiting nutrient, soluble reactive phosphorus (SRP), actually ‘works’ in the Lake Powell and CRe ecosystems. There are three parts to this primary effort:

- (1) Developing a nutrient (mostly P) budget (mass balance, fate and transport) for Lake Powell, to understand how lake dynamics affect what gets exported and how HFEs and other releases may affect exports.
- (2) Developing a parallel P budget for the CRe below, to understand how transport, uptake, sequestration and release from sediments, and tributary inputs affect SRP along the river.
- (3) Evaluating how SRP availability along the river affects primary productivity, and how this relationship plays out both longitudinally along the river and over time, constrained by other factors such as temperature and other aspects of water quality.

The proposal makes a strong case for these three efforts, built around a series of 20 hypotheses that need to be tested and for which the proposed investigations will generate the needed test data. The results will strengthen the ability of the GCDAMP crucially to understand how and why HFEs and other types of dam releases affect the ecosystem, particularly fishery production and stability.

Secondarily, the project seeks to begin “connecting the dots” from nutrients to primary productivity to aquatic macroinvertebrates to fish, both conceptually (conceptually assessing cause-effect relationships and constraints) and in the actual dynamics of the river in general and in response to HFEs in particular. Things get a little less specific when it comes to how the project will achieve these secondary purposes, including proposals for a floating research laboratory to study causal relationships in microcosm and for computer-based modeling of ecosystem dynamics.

In parallel, this project proposes updating the statistical model used to predict water temperatures downstream from the dam. This is a clearly important, stand-alone effort, the results of which will support HFE planning efforts and many other investigations.

There is some repetition of background information concerning the primary purposes of this research project – some is provided in the Project Summary, some in the Background section, some in the overall description of each project element, and some in the description of each project sub-element (of which there are several for each project element). This is somewhat understandable given that the different project elements and sub-elements complement each other but also require separate justifications. However, if time is available, the authors could substantially improve readability with some reorganizing and elimination of some repetition. More importantly, for some of the secondary purposes and their associated plans of attack, the justifications and descriptions of methods become less specific as one moves from Project Element E.1 to E.3. The result is that the proposal does not make a clear case for some later sub-elements, or at the very least does not provide enough information on which to evaluate methods, feasibility, costs, or ability to deliver key information within the 3-year timeline of the plan. It is also not clear for these less-developed parts of the proposal why they (or all of their parts) need to be completed within three years.

Project F

This project focuses on further improving understanding of the factors that affect the abundance, condition (food quality), and longitudinal distribution and drift of aquatic macroinvertebrates that comprise the food base for humpback chub, rainbow trout, and some other fishes (e.g., brown trout, razorback sucker) during one or more life stages. It specifically looks at effects of water temperature, hydrology (inundation/exposure of insect eggs), and hydro-geomorphology (substrate scour); explores the possibility that consumption by fishes (especially brown trout) may affect or have affected the composition and abundance of macroinvertebrates; and explores issues concerning shifts in the aquatic macroinvertebrate community in recent years (fewer *Gammarus*, more New Zealand mudsnails). It dovetails with Project E, which looks at how the potential effects of variation in aquatic primary production, driven by variation in nutrient availability, affects aquatic macroinvertebrate production itself.

Most of the proposed work continues existing efforts, with adjustments and improvements closely tied to the monitoring needs created by implementation of the LTEMP, particularly monitoring to assess the effects of macroinvertebrate production flows as well as other types of flow experiments (fall versus spring HFEs, TMFs). The adjustments and improvements to existing methods are clearly explained. The proposal could do more to point out how it dovetails with Project E (see above) and also with Project G (see below). The latter focuses on humpback chub, and it is not clear in the description of Project F whether the proposed stomach lavage sampling will require a separate capture effort (for the chub) or can use individuals captured as part of regular humpback monitoring. We also pose questions about three other new efforts – acoustic monitoring for birds and bats, and assessments of possible causes and ecological consequences of the decline in *Gammarus* and increase in New Zealand mudsnails – but these are methodological questions that in no way detract from our applauding their inclusion in the plan. None of the proposed project elements appears to promise more than can be accomplished

in the three-year span of the plan, and all aim at long-term needs for knowledge and learning in support of the LTEMP.

Project G

This project focuses on continuing, strengthening, and in a few instances expanding studies of humpback chub in the mainstem, in the LCR, and at translocation sites. The studies are crucial for two purposes: (1) meeting requirements under the Biological Opinion (BiOp) for information on humpback chub abundance and other demographic variables, with some of this information bearing on management action triggers; and (2) understanding how and why humpback chub abundance and distribution vary in relation to other factors. The list of these “other factors” is growing, especially as understanding of food base dynamics and drivers expands, and includes the impacts of flow releases, water temperature, rainbow trout predation/competition, etc.

The proposal narrative summarizes information developed over the course of a fairly long and complicated history of monitoring and research studies. Because of the density of this existing information, the authors use shorthand terms to encapsulate entire bodies of information. Unfortunately, this shorthand results in some very dense paragraphs that need unpacking for readability. Additionally, it would be best if the project description (project summary, at the very start) began with a very brief, one-paragraph recap of the history of investigations (with acronyms defined) that have unfolded over the past few years on which the proposed new work builds.

The Project Summary provides a great deal of explanatory information. This is very helpful, but the Background section and some of the Project Element descriptions (in the Proposed Work section) unfortunately repeat a lot of this information. The Project Summary section should be condensed to focus more on the “what/where/when/how” and less on the “why,” leaving the discussion of “why” to be emphasized more in the Background section. Following the patterns of other Project write-ups, the Project Summary section should be more like a project abstract/executive summary than a major piece of disquisition. A similar pattern of repetition crops up, between these two earlier sections and the descriptions of the individual Project Elements, in this case repetition of information about study designs and methods. The 12 studies described in the Project Summary correspond to the 12 Project Elements in the section on Proposed Work. Some of the studies/elements are presented as “if funding is available.” See our General Comments at the start of the present document about how such proposals are problematic for the work plan and budget.

Project H

Project H focuses on the management of the non-native salmonids, rainbow and brown trout. Trout management in the CRe is complicated, with the conflicting goals of maintaining a high-quality cold-water recreational fishery while simultaneously preventing the expansion of these predators downstream into chub habitat. Concerns about the need to avoid unnecessary taking of life also affect decision-making. Elements H.1, H.2, and H.3 focus on understanding the dynamics and drivers of trout outmigration downstream into chub habitat and the effectiveness of different flow management regimes in controlling this downstream populations. The fourth element, H.4, focuses on the recreational fishery.

This Project is structured around specific questions that are in turn tied to management goals. Each element description begins by stating the specific purpose of the work, making it clear how this work addresses specific knowledge gaps. The proposed methods are clearly described and the work is based on a foundation of previous published work.

Project I

Project I contains both monitoring and research elements. Elements I.1 and I.2 focus on monitoring the distribution and relative abundance of both native and non-native warm-water fish species. Element I.1 is a proposal to continue ongoing monitoring of native and non-native warm-water fishes with marginal changes in the sampling design. Element I.2 proposes testing the efficacy of environmental DNA (eDNA) sampling to detect the presence of non-native fish and possibly generate an index of relative abundance. Element I.3 proposes research to investigate the relative importance of different introduced predators on the humpback chub population.

The Arizona Game and Fish Department (AZGFD) has been using catch-per-unit-effort (CPUE) sampling for the past 15 years in an effort to detect population changes in a diversity of target species. Element I.1 simply proposes to continue this monitoring. The sensitivity of CPUE data to detect changes is dependent on the number of individuals captured and a diversity of other habitat and physical variables. Has the AZGFD developed species specific models? Or, has the sampling protocols been optimized for the key native species and other species are reported as incidental?

Element I.2 proposes trial testing of eDNA technology as a tool for detecting new invasions and, possibly, developing an index of abundance of known non-natives. Environmental DNA has been used in other systems and has proven to be valuable.

Element I.3 will examine the likelihood of depredation of chub eggs, alevin, (and fingerlings?) by non-native predators in controlled trials. There has been similar research on native fishes done by researchers working in the Lower Colorado which may be of value to this project team.

Project J

Project J contains two Elements. The first is a project to survey tribal members to ascertain their priorities and preferences associated with river management. The second element will develop a model to assess the cost-effectiveness of different management activities (e.g., trout management). The Project is titled *Socioeconomic Monitoring and Research in the Colorado River Ecosystem*. However there are no proposed elements that address socioeconomic monitoring.

This work plan is written to build upon work done during the current (FY15-17) triennial work plan. However, in doing so it frequently references and seems to be dependent on work not yet completed. The plan frequently references work *in preparation* and documents and reports *in prep*. This leaves the reader unable to place the proposed work into any real context given there are not supporting materials. The document references Neher and others, 2016 in many places. This document is not in the References section of this proposal.

Element J.1 is proposed to be a population survey of all tribes with a link to the CRe and will be dependent on the completion of ongoing work. This survey project's methods are to be based on accepted survey methods utilized elsewhere to study natural resource uses and priorities. However, it is not clear that these methods are appropriate for studying native communities. For example, a random population sample assumes that every individual shares a similar knowledge of the key resources. This might not hold for native communities where certain individuals are the holders of key knowledge, and where there is wide variation in adherence to "traditional" beliefs and practices in these dynamic communities. If so, random sampling is not representative of the tribal preferences and priorities in general, let alone traditional preferences and priorities in particular. It is critical that tribal leadership is supportive of this effort and are willing to communicate its importance to their people.

There have been several attempts to better integrate tribal knowledge and priorities into the Adaptive Management Program's work, with more or less success. The LTEMP references the need to better integrate tribal perspectives and needs into the planning process but acknowledges the significant challenges in doing so. This work plan does not make clear how the proposed project builds upon this experience and overcomes these challenges. The list of investigators for Element J.1 does not include any that are specifically identifiable as anthropologists or as individuals with experience working with Native American communities either in general or in their interactions with adaptive management programs. We suggest that there may be a significant need for such expertise and experience on the investigative team.

Element J.2 proposes to develop models that incorporate economic (cost/benefit) values into resource management decisions. "The objective of this project element is to improve the GCDAMP's ability to consider, organize and prioritize monitoring, research, and long-term management related to the operation of GCD, including proposed experiments in the LTEMP EIS". There is no mention of this need elsewhere in the work plan, and there does not appear any explicit collaboration between this project team and any other project teams. For example, the work plan uses trout management as an example for the value of these decision tools. One would expect that such an effort would involve fisheries staff.

Project K

Project K is not as much a project in and of itself as a collection of tools and services that make the other research and monitoring projects better. The vast majority of the data collected by the GCMRC and its partners are locational or spatial. These data have to comply with Federal Geographic Data Committee (FGDC) data standards before they can be consumed, analyzed, and shared. Elements K.1 and K.2 are specifically structured to provide the support needed to manage, analyze, and communicate these data and results. Element K.3 is focused on providing the tools and expertise for data collection and uploading.

One important topic not mentioned in this task is data maintenance and security. The document mentions that the existing GCMRC database currently contains >2.5 terabytes of spatial data. This is likely only a portion of the digital data created by GCMRC scientists. All this data needs to be managed in a manner that prevents loss over time (decades) and ensures it remains accessible when needed. The introduction to the Project suggests that, with the existing non-centralized structure for data management, this important task is no one's responsibility.

Project L

No general comments.

Project M

No general comments.