Thanks to CREDA/UAMPS representatives for taking the time to carefully review our FY2015 Annual Report to the Bureau of Reclamation. Responses from GCMRC are provided after each question in **bold**.

Scott VanderKooi – January 27, 2016

GCMRC ANNUAL REPORT – FY 15

CREDA/UAMPS INITIAL QUESTIONS/COMMENTS – January 13, 2016

1) Project 2, page 9, how did the GCMRC sampling compare with the Utah & AZ Water Science Centers sampling? Were they compared for calibration?

   Response: All sampling done by all USGS science centers involved in this project are conducted using the same USGS methods.

2) Project 2: This project mentions water quality as an included parameter; however, this is a very limited data set including only physical measurements. Are there efforts to track chemical quality of water as it transits the canyon, e.g. nitrogen, phosphorus, etc.? If so, where do these values appear and what are the trends?

   Response: Episodic chemical and nutrient samples are collected by the USGS (these are funded from other sources) but no efforts have been made to track how the chemistry of the water or nutrient loads change through the canyon.

3) Project 2: How does any relationship between turbidity and suspended solids change during transit spatially and temporally? What are the implications to sight-feeding predators (trout) and algae of any change in the relationship between turbidity and suspended solids?

   Response: For the sake of brevity here, we direct you to the 2014 publication by Voichick and Topping (available at: https://pubs.er.usgs.gov/publication/sir20145097) and the 2015 publication by Hall and others (available at: http://onlinelibrary.wiley.com/doi/10.1002/lno.10031/abstract) for responses to these questions.

4) Project 3: Do the sandbar volume data provide any help in determining differences in volume due to down ramp rates? If not, what project does this?

   Response: The annual sandbar monitoring does not isolate the effect of ramp rates. Higher rates of erosion have been observed to be associated with higher average releases (Hazel et al., 2010). However, we have completed experimental studies to specifically examine the effect of downramp rate on sandbar erosion (Alvarez and Schmeeckle, 2012). This study concluded that downramp rate, by itself, did not significantly affect erosion rates. Erosion amount and rate were controlled by the range of fluctuations and the number or frequency of fluctuations (i.e. more fluctuating cycles per day would be expected to cause more erosion).

5) Project 3: What is the spatial trend of sandbar volume relative to HFEs, i.e. throughout the canyon?

Response: Deposition has occurred at sandbars throughout Marble and Grand Canyons. Some differences among reaches and research into sandbar variability will be discussed at annual reporting meeting.

6) Project 3: Is this project capable of distinguishing sandbar volume changes due to dam operations following an HFE from changes due to other factors, e.g., campers, upgradient flow, etc.?

Response: See answer to question 4, above.

7) Project 3: Are there plans to develop sandbar data for the rest of the river corridor commensurate with those collected in Marble Canyon?

Response: There are more sites in Marble Canyon, but there are monitoring sites throughout the river corridor. Data from throughout the river corridor will be discussed at annual reporting meeting.

8) Project 3, page 13, 1st full paragraph, "vegetation expansion is responsible for net long-term decline in open areas". Same paragraph," post-HFE erosion decreases in campsite areas" Is this due to ramping or is it due to weather erosion?

Response: Most erosion of sandbars results from erosion by the Colorado River. Erosion by local hillslope runoff is important at a few sites.

9) Project 3, page 13, 2nd full paragraph weather stations are available to determine erosionary effects of weather pre & post storms as a possible cause to erosion. Scour should have occurred similarly for increased sandbars proportionally unless the delta of flow is buffered due to checks in the river. To have 50% of the sand bars maintain their increase after 3 months makes me believe it may be something different than scour due to ramping. This could also be caused by flooding from side channels causing localized flow changes. It might be good to ask for a pattern of which sandbars maintain vs. erode in relation to location in the system.

Response: Downstream variability in sandbar response and causes for variability in sandbar behavior are being researched (see Grams and Mueller talks at annual reporting meeting).

10) Project 3, page 15, 2nd full paragraph, why is an unsupervised classification method being used?

Response: "unsupervised" means that the classification is done with an automated computer program. There is still ground truthing and inspection of how well it works. This is the most efficient way to classify imagery when possible. Because the images are high quality, the method works well for vegetation.

11) Project 3, page 15, 3rd full paragraph, why is something being manually edited?

Response: Sand is more difficult to classify with strictly automated methods. Manual editing is done to ensure accuracy.

12) Project 3, page 18, 1st full paragraph, this is another example of stable beach increases for 6 months of duration.

Response: Downstream variability in sandbar response and causes for variability in sandbar behavior are being researched (see Grams and Mueller talks at annual reporting meeting).

13) Project 3, page 19, 2nd full paragraph, how about comparing storage locations against each other over time? That would make it easier to facilitate discussion about management choices of WHICH beaches should be prioritized, to the extent possible. As river bed/bottom scours, mean surface elevation drops because flow equals area times velocity.

Response: We are investigating causes of spatial variability in sandbar response (Erich Mueller talk at annual reporting meeting). Scour of sand from the river bed does not typically result in a commensurate drop in water surface elevation in Grand Canyon. Water surface elevations are determined by the bed at channel controls, which in Grand Canyon are the rapids with very coarse bed material that does not frequently change. Thus, scour of sand from the bed would typically be compensated by decrease in mean velocity to maintain continuity.

14) Project 3, page 20, A.4, "bedload contributes more to total load than previously thought", meaning sediment on floor is causing a higher surface elevation, increasing erosion along the river's edge. We have asked in various forums about the possibility of looking at non-flow related tools to improve camping beaches. Please consider the potential of using a suction dredge to blow sand up on beaches. Has this been considered in the past?

Response: Bedload will be discussed at meeting. See above response on relation between bed scour (or aggradation) on water surface elevations. I'm not aware of the history of discussion on dredging as a potential management action. Whether or not this would be a desirable action would have to be a subject for discussion among stakeholders.

15) Project 4, How does dam operations affect archeological sites that should have been built above the food stage 45K cfs. Aeolian transport would have provided protection to historical sites long before dam was installed.

Response: There are two key components of the aeolian transport equation: wind (prevailing direction and intensity) and sediment (supply). The former is not affected by dam operations but the latter is affected. Dam operations affect sediment supply in terms of where sand gets deposited, how much sand is deposited, the elevation of those deposits, and so forth. Dam operations also affect vegetation growth patterns, which in turn influence both the availability of sand for transport and whether it can be transported from one location to another (i.e., vegetation can form a barrier to aeolian transport of sediment). If a site was formerly protected by wind-blown sand but the source of that sand is diminished, either because sand bars are not being replenished or increased vegetation hinders movement of sand by wind, the site will progressively erode over time at rates faster than would be the case if the sediment supply to the site was maintained.

What about investigating wind patterns from weather stations in the canyon to determine Aeolian transport effects?

Response: Monitoring weather parameters in relation to sediment supply and examining how these factors interact to affect archaeological site condition is an important component of Project 4. We currently have four weather stations deployed throughout the canyon specifically for this purpose.

16) Project 4, page 32, top of the page, I read this to say there really isn't anything different pre & post dam on Aeolian transport, this conflicts with Section 5, second bullet point #3 in the section below (same page).

Response: This conclusion is premature and probably incorrect. We know that not all river-derived sand (RDS) comes directly from channel margin deposits or from sand bars below the 45k flow elevation; much river-derived sand was also derived from deposits of pre-dam floods at higher elevations. Therefore it is not surprising that not all mapped RDS units are necessarily larger or more active when located adjacent to channel segments with high ratios of MCS to MCV. We do believe, however, that vegetation plays an important role in determining whether sand is transported from the active channel to higher elevations (where most archaeological sites occur). In project 4, we are examining the relationships between sediment supply and vegetation as they affect the condition of archaeological sites from a variety of different angles. It is premature to draw any broad conclusion about these relationships at this early stage of the study.

17) Project 4, page 32, last paragraph, how can there be a realistic comparison of photographic comparisons given the duration between when the first and last 2 sets were taken as well as the fact that they are from one perspective.

Response: Use of repeat photography to document ecological change is a well-established method that has been in use by scientists for well over a hundred years (a succinct description of this method and its history can be found at the following link: http://pubs.usgs.gov/fs/2007/3046/fs2007-3046.pdf). We are comparing images taken of the river corridor prior to the existence of the dam with current conditions. There are literally hundreds of views captured in the collection of photographs we are using for this study; many of them show both upstream and downstream views from the same position and many of the views are overlapping.

How much of this is due to vegetation infestation, or image distortion due to vegetation blocking views of the single perspective?

Response: The degree to which new vegetation growth covers formerly open aeolian source deposits or has created barriers that now hinder aeolian transport of sediment is one of the key questions we are trying to answer in this study. In terms of the "single perspective" issue, many of the images overlap one another (many views are also taken looking both upstream and down from the same position) so if a view of an area is blocked in one image, it is often visible in another. However, not every square inch of the river corridor has been photographed, so it is not possible to evaluate sediment source supply conditions at every site of interest; however, we expect to obtain a good representative sample using this approach.

18) Project 5, page 39, bottom of the page, Cloudy days affect algae (food base). Unless this project is going to get into weather modification, how is this relevant?

Response: This kind of perspective (cloud cover > hydropeaking) is valuable and absolutely critical to informed discussions about adaptive management experimentation.

19) Project 5: Foodbase data demonstrated that prey availability and size limit the maximum size of rainbow trout in Glen Canyon and drift data show that prey availability is playing a role in trout growth rates among sites and seasons. What is being proposed that hasn't already been studied?

Response: Prior studies have not explicitly evaluated how prey size affects maximum size of rainbow trout. Also, the model that was developed to evaluate effects of prey availability and size can be used to evaluate how trout size responds to different idealized prey scenarios. This is a useful tool for scientists and managers that did not previously exist.

20) Project 6.4: Fish community monitoring has attempted to track and record presence and abundance of native and nonnative fish; yet, we discovered a thriving population of green sunfish in the Lees Ferry reach. What factor or factors may have contributed to this apparent sudden influx of this nonnative warmwater fish? Are there efforts underway to determine if there is a relationship between use of HFEs which bypass generators and infuse large amounts of water and the sudden influx of the sunfish (and possibly other warmwater nonnatives) from Lake Powell? What is the seasonality of fish distributions in the Lake Powell forebay or the reservoir level changes that might be contributing to the introduction?

Response: The green sunfish population found in Glen Canyon in 2015 was detected because of the nonnative fish monitoring program currently in place. This detection allowed for quick action to eliminate this invasive species from the -12 mile slough. Green sunfish are quick to mature and highly fecund thus a few individuals can invade new areas and produce a large numbers of offspring quickly if conditions are favorable as they were in Glen Canyon. This seems a more likely scenario, as opposed to large numbers of green sunfish being passed through the dam, given that almost all individuals were found in one relatively discrete location rather than throughout Glen Canyon. Other species like walleye and striped bass get passed through the dam in small numbers and are detected in our monitoring. As described above, we believe this event was due to a small number of individuals finding the right habitat and conditions to reproduce and have high survival rates of young rather than a sudden influx of nonnatives. It should be noted, however, that low reservoir levels may allow more fish to be entrained and passed through the dam. There is not currently an effort to correlate HFEs with the detection of nonnative fishes in Glen Canyon. A number of factors make the turbines the more likely route of bypass of nonnative fishes rather than the jet tubes. The intakes for the jet tubes are deeper in the reservoir making conditions less favorable for fish to be entrained. Additionally, the duration of HFEs is short (96 h) and the volume of water bypassed by the jet tubes is small relative to that moved through the turbines during these events and throughout the remainder of the year. We are unaware of any monitoring of the seasonality of fish distributions in the Lake Powell forebay.

21) Project 8, page 62, section 8.1, did water temperatures result in lower harvest rates?

Response: We were not entirely sure if this was referencing the correct section. Section 8.1 is about efficacy and impacts of trout removal at Bright Angel Creek. We did have a lower catch

of brown trout and rainbows at the Bright Angel Creek inflow during the Feb. 2015 sampling efforts, but it is difficult to link that to water temperatures. It is likely that the reduced catch rates were the result of turbid water conditions during the sampling period. It does appear, from the AZGFD catch-per-unit effort data, that trout populations in the area around Bright Angel Creek have seen a recent reduction, but the reason for that is unknown. It could be the result of the Park Service removal efforts within Bright Angel Creek or due to mainstem water temperatures or other factors. We don't believe we can establish a cause and effect relationship at this point.

22) Project 9.6: Is this project intended to determine turbidity levels that may constrain trout populations and if so, is this really a new idea? Has this been assessed previously? What kind of literature review was made to ascertain this before starting? Will there be a separate analysis of total suspended solids constraints on trout? Also, what is meant by "constrain rainbow trout populations?" If numbers are found, how will these be extrapolated to conditions now occurring in the CRE?

Response: These are really good questions. There is a significant body of literature indicating that turbidity can exclude rainbow trout from river systems. What is interesting is that the levels of turbidity reported in the literature are relatively low, <50 NTU, compared to the Colorado River. So the question then becomes how long does the turbidity need to persist to impact rainbow trout to the extent that it has the potential to effects populations. This is the question we are attempting to answer with our laboratory studies. Once durations and magnitudes of turbidity are found in the laboratory we can use that information to look at the turbidity record and see if we can link turbidity to trout population fluctuations in the mainstem to evaluate it as a fish management tool.

23) Project 9.8: Trout growth in various tailwaters may also be a function of which trout strain exists and been studied at the respective tailwater. This factor should be considered when modeling bioenergetics.

Response: We attempted to evaluate the growth of various strains of rainbow trout compared to Lee's Ferry rainbow trout in the last workplan. Unfortunately we discovered that we do not have adequate facilities to hold large fish for long enough to thoroughly evaluate this question. The data that we did collect indicates very little difference in growth among strains at small sizes and that food limitations likely overshadow any strain differences.

24) Project 9.10: How will population dynamics from 2014 to 2015 be considered when assessing effects of HFEs on trout condition? What new ground will be broken with these results that don't already exist in the literature?

Response: Question 1: The rainbow trout population in Glen Canyon is not a static population, but rather one that is very dynamic annually with varying densities, size-structure, age-structure, growth, and survival. Therefore, difference observed in the trout response across different HFE treatments may be independent of flow or alternatively confounded because of the characteristics of the population at that time. In order to test whether or not there is a flow effect requires a combination of flow replication across years as well as contrasts made between years that do not have accompanying flow treatments.

Question 2: There is very little information in the current literature to make inferences about the seasonal effects related to fall experimental flows on trout population. To date there are results published on two spring flows and one fall flow; however, the biological response of trout to these seasonal flows were very different. Because of these seasonal differences in flow response it has required additional replication as well as a control to make comparisons. The reason for the continuation of this project (9.10) was there have been no years since the NO fall-marking study was initiated (2012-2014) that there hasn't been a corresponding HFE conducted. Alternatively, when there have been no HFE there has been no extensive fish study in place to make inferences in trout response. As stated continuing this study will increase the likelihood of having at least one year where flows weren't conducted in order to make a comparison with and without HFE.

25) Project 10.2: It is now apparent that native fish dominate the fish community downstream of the LCR yet this area receives disproportionately less attention than upstream of the LCR. Should this project attempt to learn what conditions exist downstream of the LCR and compare this with areas upstream to see why?

Response: Project 10.2 is using an across disciplinarian approach to better understand the physical factors that may be limiting the distribution and abundance of non-native fish particularly trout. This study is not meant to be a native fish habitat study.

Perhaps greater emphasis on maintaining the lower river's fish community conditions could be a future goal.

Response: Results from this study will not preclude this emphasis.

26) Project 12, page 96-97, the report doesn't appear to prioritize a consult with the tribes for culturally important vegetation as first.

Response: Not so. The February 2015 workshop was the start of project 12, and as part of that workshop, we discussed and collectively agreed on a list of plants to focus on for the pilot study.

It also identified species that were important to 3 or more tribes, but it did not present a breakdown of how important each species was. For example, one tribe may rely on a single plant for 100% of their ceremonies/medicine/etc., but it wouldn't have made the list if no other tribe valued it according to how this is presented. Is that an accurate interpretation of the information?

Response: Yes, this is an accurate understanding. We did not attempt to rank the relative importance of any particular plant species in terms of how it is valued by any given tribe, nor did we attempt to assess how a given plant was used traditionally. We view this information as the prerogative of each tribe to share, if they choose to do so. Instead, we focused on identifying a list of plants growing in the riparian zone that were traditionally used by three or more tribes, as indicated in tribal reports or existing published literature, with the aim of including an array of plants that had cultural value for multiple tribes.

27) Project 12, page 98, last paragraph, same issue with photographic record as before, time between samples and single perspective.

Response: I am not sure that I fully understand this question but will do my best to answer it. Use of repeat photography to document ecological change is a well-established method that has been in use by scientists for well over a hundred years (a succinct description of this method and its history can be found at the following link: http://pubs.usgs.gov/fs/2007/3046/fs2007-3046.pdf). We are comparing images taken of the river corridor prior to the existence of the dam with current conditions. There are literally hundreds of views captured in the collection of photographs we are using for this study; many of them show both upstream and downstream views from the same position and many of the views are overlapping. We examine matched images and the field notes of the ecologists and botanists who participated in the original photo matching to see what has changed. While comparison of just one or a few matched images may not be sufficient to reliably characterize landscape-scale changes, the cumulative information derived from comparing hundreds of matched images can provide a robust perspective on how plant species distribution and abundance has changed over time.

28) Project 12, page 99, what is the practical impact on HFE planning with the discovery of the 1923 USGS inscription?

Response: The inscription is located above the 45K flow level, in an obscure location, so there is no foreseeable impact in terms of HFE planning.

29) Project 13, please include narrative and costs associated with peer review coordination/economics work done for the LTEMP EIS?

Response: Lucas Bair, economist with GCMRC, coordinated and participated in the LTEMP power system and rate payer analysis external review. Lucas Bair also reviewed the economic elements of the LTEMP EIS prior to release of the public draft. The time associated with peer review coordination/economics work done for the LTEMP EIS was included in the total provided to Reclamation for work conducted from June 2014 to June 2015, a total of 128.

30) Project 1, page 113, what is the timing of the project's review/determination?

Response: The timing of this review has yet to be determined. Reclamation has placed funding for this project on hold pending an internal review. GCMRC will decide how to proceed once a determination regarding the future of this project has been reached.

31) General, it would be helpful to see a single table showing budget compared to actuals, along with beginning carryover amount and ending carryover amount.

Response: A table providing budgeted amounts, spending and amount over/under budget by project for FY2015 from our annual report is provided below.

Project	Budgeted Amount	Actual Spent	(Over)/Under Budget
1	$305,097	$136,627	$168,470
2	$1,245,886	$1,201,229	$44,657
3	$1,247,234	$1,210,990	$36,244
4	$331,256	$298,348	$32,908
5	$478,584	$464,985	$13,599
6	$549,829	$516,007	$33,822
7	$1,236,062	$1,133,300	$102,762
8	$139,789	$128,622	$11,167
9	$727,502	$675,121	$52,381
10	$146,018	$167,345	($21,327)
11	$426,585	$377,656	$48,929
12	$45,676	$23,758	$21,918
13	$173,511	$164,215	$9,296
14	$221,768	$210,678	$11,090
15	$954,412	$642,490	$311,922
16	$1,201,669	$1,247,971	($46,302)
Total	$9,430,878	$8,599,341	$831,537