

Budget Ad Hoc Group Triennial Work Plan Process FY 2025-2027

Chair: Erik Skeie

Charge: The Budget Ad Hoc Group (BAHG) will work with the Bureau of Reclamation (Reclamation) and Grand Canyon Monitoring and Research Center (GCMRC) to develop an annual budget recommendation for TWG consideration. This is to include an initial budget recommendation during the spring Technical Work Group meeting and a final recommendation during the summer TWG meeting.

Members: Mark Anderson, Cliff Barrett, Richard Begay, Rob Billerbeck, Rod Buchanan, Carrie Cannon, Shane Capron, Colleen Cunningham, Kurt Dongoske, Sinjin Eberle, Craig Ellsworth, Buddy Fazio, Mel Fegler, Charlie Ferrentelli, Michelle Garrison, Dani Greene, Sarah Haas, Jeremy Hammen, Brian Hines, Leslie James, Carliane Johnson, Kristen Johnson, Theresa Johnson, Dan Leavitt, Jakob Maase, Ryan Mann, Betsy Morgan, Jessica Neuwerth, Jess Newton, Ronda Newton, Christina Noftsker, Emily Omana, Bill Persons, Sara Price, Shana Rapoport, Ben Reeder, Andrew Schultz, Seth Shanahan, Bart Stevens, Larry Stevens, Jack Stewart, William Stewart, Jim Stroger, Deborah Williams, Emily Young, Jamescita Peshlakai, Erik Stanfield.

Invited technical advisors: Drew Eppheimer, Helen Fairley, Emily Palmquist, Heather Patno, Nick Williams, Charles Yackulic, Andrew Schultz.

The BAHG has held five meetings between the January 2024 Annual Reporting meeting and the February 2024 Adaptive Management Work Group Meeting. The purpose of these meetings was to allow the BAHG to provide feedback directly to the GCMRC as they develop the Initial Draft of the Triennial Work Plan (TWP). Reclamation's portion of the TWP will be discussed further in future meetings.

The following information is a summary of the GCMRC Projects that were presented to the BAHG for inclusion in the FY 2025-2027 TWP, and the BAHG Feedback. Please note that budget numbers are from the FY24 Budget, and are only present to give a general idea of previous costs. In the case of Project L: Overflight Remote Sensing, the budget from FY 21 when the flight was conducted has also been included. Also attached to this summary are the notes from each BAHG Call.

General BAHG Feedback: The BAHG encouraged GCMRC to think of how these Projects relate into the larger picture of LTEMP and the ecosystem as a whole. GCMRC should clearly define how their Projects relate to LTEMP and management decisions. The BAHG also requests that Reclamation conduct a priority exercise with the Projects in the Initial Draft of the TWP similar to previous work. The BAHG will also undergo its own prioritization exercise after the Initial Draft of the TWP is developed.

Project A: Streamflow, Water Quality, and Sediment Transport and Budgeting in the Colorado River Ecosystem (FY24 \$1,249,606)

This project collects the physical data that directly link dam operations to the downstream Colorado River; all other GCDAMP-funded projects use these data to link dam operations to their resources of interest. The data collected by this project are used to implement the High-Flow Experiment (HFE) Protocol (i.e., trigger and design HFE hydrographs), to evaluate the reach-scale sand mass-balance response to the HFE Protocol, and to evaluate the downstream effects of releases conducted under the Long-Term Experimental and Management Plan (LTEMP) Environmental Impact Statement (EIS; [LTEMP](#)). Full Description on page 80 of the [FY21-23 TWP](#).

- A.1 Stream gaging and hydrologic analyses
- A.2 Continuous water-quality parameters
- A.3 Sediment transport and budgeting

BAHG Feedback: The BAHG suggested moving the Database and Website management into Project K in order to streamline the TWP. There was an additional suggestion to analyze duration and extent of clear water flow, and what consequences that may have on the ecosystem.

Project B: Sandbar and Sediment Storage Monitoring and Research (FY24 \$1,010,030)

The purposes of this project are to: 1) track the effects of individual HFEs on sandbars and campsites), 2) monitor the cumulative effect of successive HFEs and intervening dam operations on sandbars and sand conservation, 3) investigate the interactions between dam operations, sand transport, and channel dynamics, and 4) develop and apply predictive models for streamflow and sandbar changes that can be used for evaluating dam operations scenarios. It directly relates to the LTEMP Record of Decision (ROD; [LTEMP](#)) to "increase and retain fine sediment volume, area, and distribution...for ecological, cultural, and recreational purposes." Full Description on page 106 of the [FY21-23 TWP](#).

- B.1 Sandbar and campsite monitoring with topographic surveys and remote cameras
- B.2 Bathymetric and topographic mapping for monitoring long-term trends in sediment storage
- B.3 Control network and survey support
- B.4 Sediment and sandbar modeling

BAHG Feedback: There was no additional feedback from the BAHG.

Project C: Riparian Vegetation Monitoring and Research (FY24 \$339,147)

The purpose of this project is to monitor the status and trends of riparian vegetation, examine mechanisms behind trends in riparian vegetation change as they relate to LTEMP flows, and apply existing and new knowledge to LTEMP vegetation management. The four elements of this project assess riparian vegetation status in the Colorado River Ecosystem (CRE), test mechanisms by which flow regime impacts species of interest, synthesize data to anticipate changes to vegetation, and assist nonflow management actions directed by the LTEMP. Full Description on page 135 of the [FY21-23 TWP](#).

- C.1 Ground-based riparian vegetation monitoring
- C.2 Determining hydrological tolerances and management tools for plant species of interest
- C.3 Predictive models and synthesis
- C.4 Vegetation management decision support

BAHG Feedback: The BAHG was supportive of moving towards a habitat based approach. There was also a suggestion to develop a wildlife habitat metric, and to look at wildlife habitat based on ecological functional groups.

Project D: Effects of Dam Operations and Vegetation Management for Archaeological Sites (FY24 \$331,622)

The LTEMP goal for Archaeological and Cultural Resources is to 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. Project D monitors and quantifies changes in the physical condition of river corridor archaeological sites in Grand Canyon as a function of ongoing and experimental dam operations and vegetation management actions of the LTEMP ROD ([LTEMP](#)), in keeping with the mandates of the Grand Canyon Protection Act (GCPA) and consistent with the monitoring plan developed in 2015 and Reclamation's 2017 Historic Preservation Plan. Description on page 164 of the [FY21-23 TWP](#).

- D.1 Dam operations, vegetation management, archaeological sites
- D.2 Monitoring landscape-scale ecosystem change with repeat photography
- D.3 Cultural Program History

NEW PROJECT IDEAS

1. Evaluate rock art site condition using LiDAR and photogrammetry (Reclamation)
2. Pilot study to evaluate potential to extract cultural and ecological information from Colorado River deposits using eDNA and pollen (Reclamation TWP)
3. GCMRC – NPS collaboration on formal analysis of archeological site monitoring data (Reclamation TWP)
4. Explore utility of existing system-wide changes in high elevation sand deposits
5. Model river sand transport and high-elevation deposition

BAHG Feedback: The BAHG asked GCMRC to consider whether some of these items have gone from experimental to management actions, and who should ultimately take ownership of any management actions. There was also concern expressed about Zuni being unable to connect with their ancestors if their sites are buried.

Project E: Controls on Ecosystem Productivity: Nutrients, Flow, and Temperature (FY24 \$293,152)

This project aims to disentangle some of these drivers by combining the highly resolved long-term information about riverine turbidity, silt and clay concentrations, solar inputs, discharge, and gross primary productivity via continuous oxygen and temperature measurements— data that are collected as parts of the Interagency Lake Powell Water Quality Monitoring project. Project E is designed to capture and link changes in productivity to changes in bottom-up drivers such as light, flow, and nutrients and to further develop links between these bottom-up drivers and higher trophic levels. Full Description on page 189 of the [FY21-23 TWP](#).

- E.1 Phosphorus budgeting in the Colorado River
- E.2 Rates and composition of primary producers in the Colorado River
- E.3 Productivity at higher trophic levels

BAHG Feedback: The BAHG suggested GCMRC look into developing a controlled experimental area downstream of the dam. There was also a suggestion to use bioenergetics in E.3 to determine how piscivorous warm water invasive fish species are, and better determine how much of a threat they pose to native fish species.

Project F: Aquatic Invertebrate Ecology (FY24 \$686,647)

The primary focus of Project F is continuation of long-term food base monitoring needed to track ecosystem response to “Bug Flows” and other LTEMP experiments. Additionally, this project supports other projects within the TWP such as: Project E, Project G, and Project H. Full Description on page 214 of the [FY21-23 TWP](#).

- F.1 Aquatic invertebrate monitoring in Marble and Grand Canyons
 - F.2 Aquatic invertebrate monitoring in Glen Canyon
 - F.3 Invertebrate Monitoring in Tributaries
 - F.4 Fish diet studies
- Additional Work: USGS/NPS Water Quality Partnership (Funded outside of AMP)

BAHG Feedback: The BAHG suggested using the eDNA collected in this project to detect/determine cause of human pathogens. The BAHG also asked if GCMRC foresaw any Bug Flow replicates occurring in the upcoming TWP, GCMRC stated the link between bug flows and humpback chub growth/survival has not been established, and further replicates may help determine if such a link exists.

Project G: Humpback Chub Population Dynamics throughout the Colorado River Ecosystem (FY24 \$1,594,535)

This project is mandated by the [2016 Biological Opinion](#) associated with the [LTEMP](#), while focusing research on improving our understanding of abundance and the drivers of humpback chub population dynamics throughout the lower CRE. Full Description on page 231 of the [FY21-23 TWP](#).

- G.1 Humpback chub population modeling
- G.2 Annual spring/fall HBC abundance estimates in the lower 13.6 km of the LCR
- G.3 Juvenile chub monitoring near the LCR confluence (JCM-East)
- G.4 Remote PIT-tag array monitoring in the LCR
- G.5 Monitoring humpback chub aggregation relative abundance and distribution
- G.6 Juvenile chub monitoring - West (JCM-West)
- G.7 Chute Falls translocations

NEW PROJECTS

1. HBC Exploration above Blue Springs
2. Expanding PIT antenna detections throughout Grand Canyon
3. Close-kin mark0recapture of HBC
4. LCR HBC population – vulnerability to climate change and drought

BAHG Feedback: The BAHG suggested including a means to monitor HBC response to actions in the LTEMP SEIS. There was an additional suggestion to examine whether or not bioenergetics from Project E could be used to look at carrying capacity of HBC in lower Western Grand Canyon. GCMRC was also asked to consider whether or not the Paria is suitable for HBC, and what would happen to the HBC populations in WGC should Lake Meade ever refill.

Project H: Salmonid Research and Monitoring (FY24 \$511,247)

Rainbow trout were an important component in the development of LTEMP for GCD operations, and thus were a major consideration in the flow decisions in the selected alternative in the LTEMP ROD. This study focuses on how experimental flows will influence recruitment, growth, survival, and dispersal of rainbow trout in Glen and Marble canyons. Full Description on page 257 of the [FY21-23 TWP](#).

- H.1 Rainbow trout monitoring in Glen Canyon
- H.2 Experimental flow assessment of trout recruitment
- ~~H.3 Brown Trout Early Life Stage Survey in Glen Canyon~~
- H.4 Salmonid modeling

BAHG Feedback: There was no additional feedback from the BAHG.

Project I: Non-Native Fish Monitoring and Research (FY24 \$655,278)

Maintaining self-sustaining native fish populations within the Colorado River and minimizing the presence and expansion of aquatic invasive species are two specific resource goals outlined in the [LTEMP](#) and associated [2016 Biological Opinion](#) for the operation of Glen Canyon Dam. These two resource goals are closely linked together in that introduced warm-water fish are largely incompatible with Colorado River native fish and pose a direct risk to native species like the Humpback Chub. This project will help to monitor those risks. Full Description on page 291 of the [FY21-23 TWP](#).

- I.1 System-wide native fish and invasive aquatic species monitoring
- I.2 Invasion and colonization dynamics of warm-water invasive fish
- ~~I.3 Impacts of channel catfish on native fish in the LCR~~

NEW PROJECT IDEAS:

1. Smallmouth bass
 - a. Modeling population dynamics
 - b. Reproduction
 - c. Laboratory studies
2. Other non-native fish
3. Lake Powell entrainment
4. Emerging Threats

BAHG Feedback: The BAHG suggested entrainment be included in the population dynamics model moving forward. The BAHG also suggested a Project Element to allow for GCMRC involvement in discussion and review of actions from Invasive Fish Species Below Glen Canyon Dam: A Strategic Plan to Prevent, Detect and Respond developed by the Smallmouth Bass Ad Hoc Group. Additionally, the BAHG would like GCMRC to ensure Project I is equipped to monitor/analyze data from any actions in the LTEMP SEIS. Additionally, there was a request that GCMRC to develop a reporting method that combines all findings from the various agencies on invasive species to keep the AMWG and TWG up to date on the statues of non-native fish detections in the system.

Project J: Socioeconomic Research (FY24 \$217,529)

Project J contains research elements that collect and integrate socioeconomic information with data and predictive models from ongoing long-term physical and biological monitoring and research led by the USGS GCMRC. The project elements improve the ability of GCDAMP resource managers and stakeholders to evaluate management actions and prioritize monitoring and research. The proposed project elements address the LTEMP research and monitoring related to humpback chub, sediment, and invasive fish, ~~and hydropower~~, as specified in Section 4. Full Description on page 291 of the [FY21-23 TWP](#).

- J.1 Predictive models for adaptive management
- J.2 Brown trout incentivized harvest

NEW PROJECT IDEAS:

1. Recreation project element
 - a. Develop modeling capabilities for recreation metrics
 - b. Examine regional economic impact of recreation spending under different future hydrology
2. Integrated modeling project
 - a. Continue to develop predictive model capabilities to integrate socio-economic, biological, and physical

- resource capabilities.
- b. Focus on value of information (ie. Linking research to management actions)
- c. Report on and further develop modeling capabilities for reporting on hydropower metrics
- 3. Tribal Project element
 - a. Collaborate with interested tribal partners to design and implement a framework for monitoring and integration of Tribal knowledge of cultural benefits into GCDAMP

BAHG Feedback: There is concern with inclusion of hydropower monitoring, analysis and metrics, particularly as the Socio-economic Ad Hoc Group recommended moving Project N to Reclamation. There was BAHG support for the remaining proposed elements.

Project K: Geospatial Science, Data Management, and Technology (FY24 \$503,453)

This project provides high-level support to GCDAMP-funded science efforts in the disciplines of geospatial science, data management, database administration, and emerging information technologies. Full Description on page 326 of the [FY21-23 TWP](#).

- K.1 Enterprise GIS, geospatial analysis, and processing
- K.2 Data management and database administration
- K.3 Remote monitoring and advanced technology support

BAHG Feedback: The BAHG suggested potentially expanding geospatial data collection to support Tribal research efforts.

Project L: Overflight Remote Sensing in Support of GCDAMP and LTEMP (FY21 \$897,350, FY24 \$312,349)

This project seeks to acquire and analyze high-resolution multispectral imagery and digital surface models (DSM) of the Colorado River and riparian area from the forebay of Glen Canyon Dam downstream to Lake Mead, and along the major tributaries to the Colorado River. Data derived from the 2021 and previous overflights are used either directly or indirectly by every science project to address every resource goal of the LTEMP. Full Description on page 346 of the [FY21-23 TWP](#).

- L.1 Overflight remote sensing
 - NEW PROJECT IDEAS:**
 - 1. Overflight mission to include LiDAR
 - 2. Overflight mission to include multispectral imagery

BAHG Feedback: There was concern about increased price if the flights include LiDAR and multispectral imagery, GCMRC was encouraged to look at ways to save money or cost share, specifically if there is opportunity to cost share with the USGS 3DEP Program.

Project M: Leadership, Management, and Support (FY24 \$1,337,333)

The Leadership, Management, and Support budget covers salaries for a budget analyst, librarian, a part-time library assistant, three members of the logistics support staff, as well as leadership and management personnel for GCMRC. Full Description on page 359 of the [FY21-23 TWP](#).

- M.1 Leadership, management, and support
- M.2 Logistics staff
- M.3 IT

BAHG Feedback: There was no additional feedback from the BAHG.

Project N: Hydropower Monitoring and Research (FY24 \$29,574)

The LTEMP states that the objective of the hydropower and energy resource goal is to, “maintain or increase GCD 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.” Project N will identify, coordinate, and collaborate with external partners on monitoring and research opportunities associated with operational experiments at GCD designed to meet hydropower and energy resource objectives, as stated in the LTEMP EIS and its ROD, and guided by the memorandum (Guidance Memo) from the Secretary's Designee, dated August 14, 2019. Full Description on page 360 of the [FY21-23 TWP](#).

N.1 Hydropower monitoring and research (\$29,574)

BAHG Feedback: The Socioeconomic Ad Hoc Group recommended moving this Project to the Bureau of Reclamation's Power Office. The BAHG was supportive of this recommendation, but will need additional information on what exactly this would mean in terms of budget and the project work.

NEW PROJECT: Other Native Fish

This project is tied to the LTEMP Goal to maintain self-sustaining native fish species populations and their habitats in their natural ranges on the Colorado River and its tributaries. The idea is to separate other native fish from Project I. The project seeks to understand size and distribution in the mainstem and tributaries, estimate native fish demographic rates and environmental drivers, understand predation, and improve predictive modeling to inform management actions (dam ops., barriers, etc.).

1. System Wide native fish monitoring
2. Analyze existing data – Bluehead, Flannelmouth, Razorback suckers & Speckled Dace
3. New technology-pilot study: acoustic tags with “predation sensors”

BAHG Feedback: There was no additional feedback from the BAHG.

Resource Goals found in section A-2 of the [LTEMP](#).

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.
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 GCNRA and reduce or eliminate downstream trout migration consistent with NPS fish management and 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.

BAHG Call #1

The purpose of this call was to walk through all of the GCMRC and BOR TWP Projects and get feedback from BAHG Members on what information they would like from GCMRC at the February BAHG Calls.

- **General Thoughts**

- Larry Stevens: low flows and hot summers, relational question: would it be a good idea to pay attention to human health and bacteria as it relates to warming conditions
- Rob Billerbeck:
 - Potential for low flows with the SEIS and 6.0, we should look at all resources and all projects are considering 6.0 year
- Christina Noftsker: budget estimates for all of projects
- Craig Ellsworth: Would be helpful to take a moment to see what data that's being collected is being used for management decisions
 - IF we are not using data, is it time to transition away from that data?
- Larry Stevens: third party external review
- Kurt Dogonske: Does the sampling have an impact on the aquatic life we are monitoring?
- Review all projects to make sure appropriate relationships are drawn
- Jim Stroger: could we shift collection dates to ensure times that are less stressful for fish?
- Leslie James: Take a general look to all references of GCPA, getting into authorities of these descriptions might not be appropriate. Just make sure it's consistent.
 - Jeremy Hammen: Will get rid of references as it is just adding confusion at this point
- Colleen Cunnigham: Is there a way for GCMRC to shows us how these projects relate to each other? Some project components seem duplicative
- Clarity on how monitoring operational changes fits into TWP, whether that is exclusively Experimental Fund or if it needs to be it's own project after LTEMP SEIS
- Larry Stevens: don't seem to be very clear about the role of this program in fostering improved ecological conditions
 - Not sure where such a discussion would take place
 - What do we want to achieve in terms of ecosystem health?
- Christina Noftsker: would like to see more climate change considerations included in research projects.

Project Specific Dsicussions

- Project A:
 - Website and database currently unsupported, GCMRC working to hire staff
 - How is this website/database related to Project K efforts, and does it make sense for Project K support the website/database management?
 - Deb Williams:
 - Understanding what the total budget might be looking like, and what the budget request is for these specific projects?
 - David Ward:
 - Project A database and website, what exactly is not supported?

- Is that stuff contracted out and not being supported on web servers, what portion is the part that's not supported?
 - Andrew: Having hard time getting people to post and maintain the data on the website
 - What has been decided is that the process will be internalized
 - Hoping to bring computer scientist in to internalize that process
 - Rob Billerbeck: bread and butter for a lot of other resources
 - Craig Ellsworth: also going to be a couple of other places to collect water quality (12 mile slough)
 - Would that potentially come in on this project or one of the fish projects?
 - Bill Persons: 2nd bacteriology, would AZ Department of Water Quality help?
 - Project B:
 - Looking to improve predictive modeling
 - Rob B: another key for understanding what happens in sediment
 - Larry Stevens: keep supported
 - Christina Noftsker: with HFE protocol change, will the budget change or remain similar based on the new protocol?
 - Project C:
 - Two new proposed analyses
 - Analysis of vegetation as wildlife habitat (in C.1)
 - Phragmites research (in C.4)
 - Modified analysis
 - Greenhouse to include analysis on what would happen if Powell goes below power pool
 - Larry Stevens: shift from vegetation to habitat monitoring might be large for this program, does the staff know what that means?
 - See more fleshing out as to how they would take this topic on
 - Greenhouse experiments: can be interesting as basic science, but conducting in field is the way to do them
 - Might be better framed as field experiments
 - Rob Billerbeck: agree with Larry statements
 - Support new additions
 - Rod Buchanan: is this vegetation in the water or outside of the water?
 - Emily Palmquist: vegetation on the shoreline
 - Rod: might have an interest at some point knowing if veg in water is changing
 - Deb Williams: phragmites study, what is the why behind that?
 - Emily Palmquist: Possibility that we have the non-native lineage
 - Want to identify whether or not it is native, genetic tests in the region
 - Deb Williams: is there a management implication?
 - Emily: Right now it's just whether or not non-native exists
 - Management action needs close coordination w/ tribal partners
 - Project D:
 - Consider new vegetation experimental activities to achieve LTEMP Goals
 - What exactly does GCMRC mean by this?

- Would more like to get to all 40 sites on the three year cycle
- Rob Billerbeck: what we saw was a large number of sites moving out of type 1
 - Project to help identify where veg management occurs to help Aeolian transport
 - Good result to see that not 100% of veg needs to be removed
- Craig Ellsworth: there could be cross over with previous project, are there certain types of riparian veg species that would better allow wildlife habitat and Aeolian process?
- Kurt Dongoske: has there been any thought given to transplanting veg that has been removed on top of the sites to keep the sand in place as protection for arch site?
 - Joel Sanky: looking into that
- Kurt Dongoske: project talks about national register integrity, only identifies location. Would like to see the other integrity qualifiers more discussed
 - These sites are vital for zuni to see and interact with
 - Burial is fine for integrity, but affecting Zuni ability to interact with cultural identity
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- Project E:
 - GPP modeling linked with Project A
 - E.3 trying to get E.3 analysis done this summer
 - Larry Stevens: core to understanding how ecosystem works
 - Kinds of things that need to be done with careful field experiments
 - Having Lees Ferry as site could be game changer
 - Big question
- Project F:
 - Make invertebrate drift sample timing the same as fish monitoring
 - Will this affect the budget?
 - Want to continue bat monitoring
 - How does bat monitoring help decision making?
 - Christina Noftsker: Was there a question about whether or not bug flows would be attempted, was it no?
 - Jeremy: not at the process yet to determine whether or not we would do that again. Will be discussed in a larger context in the coming months
 - Bill Persons: also want to know why we're looking at bats
 - Well suited to citizen science
 - Personally would be more interested in monitoring benthic community not always in the drift over bats
 - Had been done in the past
 - Does monitoring the benthic community help us with trophic levels?
 - Craig Ellsworth: important to continue the monitoring regardless of whether or not bugflow occurs
 - Need a good way to analyze that data statistically
 - Look at data streams used to make those kind of decisions
 - Haven't seen drift data report in a while
 - Monitoring trout might be a better use of time than drift (trout are better drift catchers than drift net)

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- Project G:
 - Bill Persons: David Ward finding humpback chub further upstream in LCR than we've sampled raises questions
 - Would it be worth mark recapture?
 - Larry Stevens: we need to understand whether or not chub could exist in paria, and why/why not
 - Jim Stroger: agree with looking at upper reaches of LCR
 - Important to see situations with non-natives up there as well
 - Deb Williams: G.6 WGC should monitoring be a little more wide or broad in WGC?
 - Ryan Mann: a lot of the monitoring programs are not duplicative, JCM west is fixed site with intended purpose of understanding dynamics by mark recapture
- Project H:
 - Proposal to discontinue H.3
 - Fish ultrasounds
 - We have a general idea now that BRNT are "Spawning Capable" in Nov. and RBT in Jan, why is additional sampling necessary for decision making?
 - David Ward: DO trends didn't show up in trout populations, would like to make sure we are really keeping track of DO (either here or in water quality sections)
 - Ryan Mann: second this comment, add that monitoring DO is important but need to understand DO dynamics within 5 miles of dam
 - Larry Stevens: is it possible to aerate turbines?
 - Jeremy Hammen: Small review a couple of years ago
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- Project I:
 - Looking to expand parasite monitoring in I.1
 - Addition of SMB modeling
 - Addition of using sonic tags to better understand predation of native fish
 - Links to SBAHG Work
 - Larry Stevens: questions remain about comparable life history model for fish species
 - Do we have enough data to model response to warming temps in the system?
 - Dan Leavitt: would be valuable to get a sense of where we are on the invasion curve for warm water species
 - Critical to budgeting
 - Colleen Cunningham: can we get enough information in I.1 for species response to flow changes to control invasive. If not, that is something that should be considered. Need to be collecting the data to know whether or not it's working.
 - Kim Dibble: it's mostly monitoring by AZGFD, not really about making conclusions about that
 - Systemwide monitoring looking at broad trends, harder to assess direct response
 - Bill Persons: highlights tension b/w research and management
 - Feeling is we need to remove SMB, but if we want to learn about the species we would want to pit tag them

- At the stage where we feel like we have to do something that does not include research
 - Colleen: if we are doing operational changes, we need to be doing the research to show effectiveness (is that here or somewhere else?)
 - Deb Williams: agree that we should be monitoring effectiveness of these flow changes
 - Craig Ellsworth: echoing those last two comments
 - This demonstrates are lack of nimbleness to adjust
 - Would like to see a SMB specific element in this project
 - Why focus on channel catfish if no SMB?
 - David Ward: we kind of know now about channel cats, and it might be time to swap out that project and swap it out for SMB
 - Emily Young: great point to think more forward especially as final year is new operational guidelines
 - SMB monitoring and analyses
 - Rob Billerbeck: I.2 might be the way to address SMB as green sunfish are also a threat
 - Kim Dibble: maybe use some eDNA to look at channel cat diet
 - There had only been 10 or 12 SMB detected before the previous workplan, catfish were considered more of a threat. Things have shifted in the system and GCMRC will address that moving forward
 - Craig Ellsworth: study ways to reduce entrainment or generate ideas of how to reduce
- Project J:
 - Lucas suggested breaking up into specific goals and developing reporting metrics for recreation
 - Potential for Project J to be an integrated model (ask Leslie more about this)
 - Leslie James: recommend that the reference in this write up to hydropower be pulled from J and that hydropower work be included as BOR responsibility
 - Deb Williams: don't want to see the model for hydropower go away, it might need more collaboration
 - Leslie James: not sure that revenues are one of the key metrics so there might be some disconnect
 - Something that the SEAHG will be discussing
 - Rob Billerbeck: Lucas' presentation was a clear method to understand, this program should have a clear metric for hydropower
 - Lucas Bair: SEAHG is 2/1
- Project K:
 - Clarity on whether or not this is meant to be the one stop shop for all GCMRC data
 - If not, would that be beneficial?
 - Colleen Cunningham: yes, we should get some clarity
 - Deb Williams: how does K relate to Project A and their website challenges?
 - Maybe some relation to project L
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- Project L:
 - Would like to see inclusion, potential for May 2026 overflight
 - Discussion of including LiDAR collection

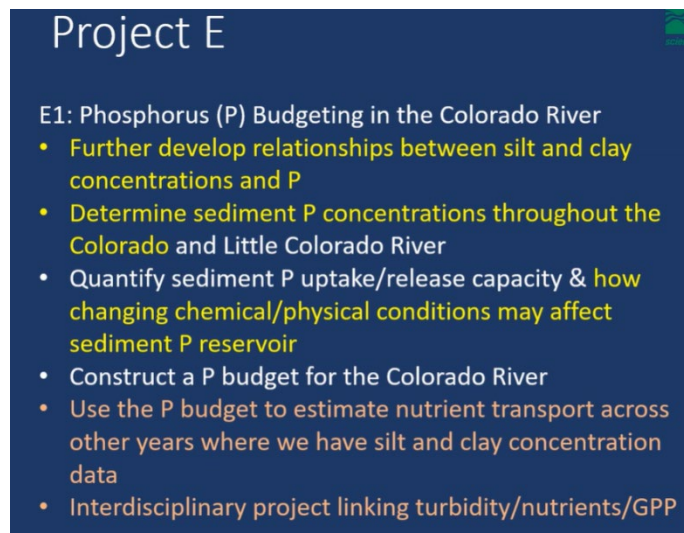
- How beneficial would this be for the other projects?
 - Christina Noftsker: when we get cost estimates, would we get a breakdown of LiDAR vs. not
 - Deb Williams: very costly, the more data we can snag all at once the better
 - Would be good to understand why the 3-4 yr timeline is a thing
 -
 - Project M:
 - Not sure how/if we can provide comment on it
 -
 - Project N:
 - SEAHG
 - Jeremy Hammen: were discussions on what was produced in N might fit potential new project for screening tools in Project J
 - Craig Ellsworth: have issue with developing hydropower tools that have not been reviewed, many assumptions that have come up
 - Need to get those assumptions discussed
 - Table of Projects:
 - Colleen Cunningham: this table could also help us cross walk information and dates regarding project overlap
 - Table type of format to help visualize and resolve potential duplicative efforts
 - Some visualization that would answer whether or not there is duplicative efforts
 - Might also help answer how much stress is being put on the fish if we knew when they were occurring and by what groups in some sort of table or matrix
 - Craig Ellsworth: frequency would be helpful (what is current frequency, what frequency do we need to answer these questions?)
 - Bill Persons: duplicative efforts are a concern as not sure what and when is being done
 -
 - BOR:
 - Kurt Dongoske: a lot of these projects are tied to BOR PA, would like to hear from Reclamation on where they think they stand in terms of that agreement

BAHG Call #2: Foodbase, Nutrients, Water Quality

- **Project E: Controls on Ecosystem Productivity: Nutrients, Flow, and Temperature (FY24 \$293,152)**

- This project aims to disentangle some of these drivers by combining the highly resolved long-term information about riverine turbidity, silt and clay concentrations, solar inputs, discharge, and gross primary productivity via continuous oxygen and temperature measurements— data that are collected as parts of the Interagency Lake Powell Water Quality Monitoring project. Project E is designed to capture and link changes in productivity to changes in bottom-up drivers such as light, flow, and nutrients and to further develop links between these bottom-up drivers and higher trophic levels. Full Description on page 189 of the FY21-23 TWP.

- E.1 Phosphorus budgeting in the Colorado River (FY24 \$106,169)



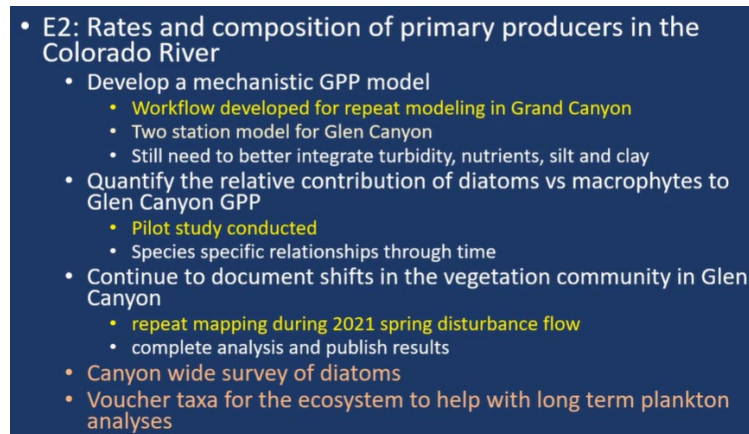
Project E

E1: Phosphorus (P) Budgeting in the Colorado River

- Further develop relationships between silt and clay concentrations and P
- Determine sediment P concentrations throughout the Colorado and Little Colorado River
- Quantify sediment P uptake/release capacity & how changing chemical/physical conditions may affect sediment P reservoir
- Construct a P budget for the Colorado River
- Use the P budget to estimate nutrient transport across other years where we have silt and clay concentration data
- Interdisciplinary project linking turbidity/nutrients/GPP

- Construct phosphorus (P) budget
 - Extending that to GPP model

- E.2 Rates and composition of primary producers in the Colorado River (FY24 \$94,945)



E2: Rates and composition of primary producers in the Colorado River

- Develop a mechanistic GPP model
 - Workflow developed for repeat modeling in Grand Canyon
 - Two station model for Glen Canyon
 - Still need to better integrate turbidity, nutrients, silt and clay
- Quantify the relative contribution of diatoms vs macrophytes to Glen Canyon GPP
 - Pilot study conducted
 - Species specific relationships through time
- Continue to document shifts in the vegetation community in Glen Canyon
 - repeat mapping during 2021 spring disturbance flow
 - complete analysis and publish results
- Canyon wide survey of diatoms
- Voucher taxa for the ecosystem to help with long term plankton analyses

- E.3 Productivity at higher trophic levels (FY24 \$92,038)

- E3: Fish Metabolism & Ecosystem Models

- Measure standard and active metabolic rates of native fishers under laboratory conditions
- Integrate data in ecosystem models
 - Ecosystem model in Glen Canyon (Yard et al. 2023)
 - Goal to do this in Grand Canyon

- Need new equipment to measure metabolism of fish
- Basis of fish model (bioenergetics)
- A lot of fish biomass in Western Grand Canyon
 - Expect that food will become the limiting factor
- Building on food web work that was done in the past
- **Discussion:**
- Project E Started from thinking of how things related to WQ and the ecosystem
 - Jim Strogon: are you at the point to say that P is too low and might require supplementing, or would further research be needed?
 - Charles Yackulic: P is often limiting
 - Downstream P becomes less a factor, that's why we want to go downstream
 - Limits productivity in Lees Ferry
 - GCMRC focuses more on finding out what is happening in the trends and why, as opposed to management action
 - Have evidence to show that it is limiting and low
 - If you were to add P, big question of how to get it to stay available as sediment lowers P availability
 - Bridget Deemer: incubations collected sediment from Pearce Ferry and Paria, both incubations show P limitations
 - There will be questions about how much P would be needed below the dam
 - Chrsitina Noftsker: E.2, when you mentioned you want to do mapping, was a repeat of something, or are you proposing to do more?
 - Kim Dibble: started in 2016 matching TRGD segments to make links to RBT abundance and growth
 - Idea is to generate deep learning model w/ imagery
 - Do Glen Canyon for now, moving downstream won't happen until solid progress has been made upstream
 - Repeat sampling every 3-5 years (if not included in this Work Plan, it should be in the next one)
 - CY: one thing to note is that the field work doesn't take long, analysis is the hiccup
 - Craig Ellsworth: there might be openness to have experimental area downstream of dam
 - BD: tried two work plans ago to have experimental stream
 - Looking at warming water on macrophytes
 - Water was warmed too much through pipeline, so they couldn't run the experiments

- If there is an opportunity now to run experiments at banks or below dam it would be ideal
 - Bill Persons: tried to set up experimental streams below dam but had time maintaining water due to sump pumps, streams would sometimes go dry
 - Rob Billerbeck: For NPS definitely concerns about P fertilizing. For bioenergetics, I guess I'm wondering how the bioenergetics will help us with the big problems of the day - would it help us answer how well HBC and other natives will survive the warm water fish onslaught? Is that a necessary part of the models or what actionable info would be get from it?
 - CY: Bioenergetics of warmwater nonnative fish could help us understand how piscivorous they might be an what the impact of warmwater nonnatives populations of different sizes on native fish populations. Most of the information for warmwater nonnatives is well known. When it comes to questions of competition between native and nonnative species bioenergetics is a really useful tool.
- **Project F: Aquatic Invertebrate Ecology (FY24 \$686,647)**
 - The primary focus of Project F is continuation of long-term food base monitoring needed to track ecosystem response to “Bug Flows” and other LTEMP experiments. Additionally, this project supports other projects within the TWP such as: Project E, Project G, and Project H. Full Description on page 214 of the FY21-23 TWP.
 - F.1 Aquatic invertebrate monitoring in Marble and Grand Canyons (FY 24 \$358,497)
 - F.2 Aquatic invertebrate monitoring in Glen Canyon (FY 24 \$270,068)
 - Drift is the best way to model trout growth
 - F.3 invertebrate monitoring in tributaries (not funded since 2021)
 - F.4 Fish diet studies (FY 24 \$58,082)

Project F

- **F.1: Aquatic invertebrate monitoring in Grand Canyon**
 - Community science
 - eDNA
- **F.2: Aquatic invertebrate monitoring in Glen Canyon**
 - Monthly sampling of drift, sticky traps, light traps
- **F.3: Invertebrate monitoring in tributaries**
 - Only funded in FY21, suggest continuing in FY25-27 with eDNA
- **F.4: Fish diet studies**
 - Started in FY22, emphasis on fecal DNA
- **USGS/NPS Water Quality Partnership (funded outside AMP)**
 - Monitoring parasites and pathogens with eDNA
 - Emphasis on fish but open to adding human pathogens and parasites

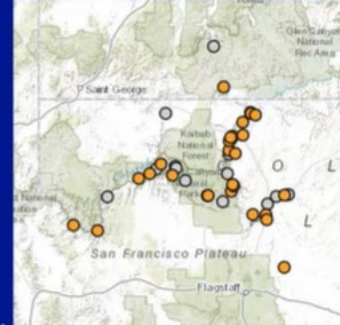
- **Discussion:**
 - Larry Stevens: is it possible to move from individual resource to habitat basis in the next couple of funding cycles

- Ted Kennedy: haven't thought much about that, would be interested in meeting to discuss further
 - Two work plans ago had a student looking at importance of aquatic vs. land fauna
 - Papers have not been published yet
 - LS: long time since we heard about birds in the canyon
 - CN: would it be possible to look for eDNA related to the human "toelio" outbreaks in the canyon?
 - TK: possibly, does anyone know what order or phylum it's from?
 - Viruses don't have DNA, they have RNA, so it might be possible to monitor norovirus using water sample collections
 - Will reach out to grad student
 - CE: is there additional bug flow experimenting you would like to see done, what's the next big thing?
 - TK: abundance of midges correlates strongly
 - Haven't made a link w/ chub growth and survival
 - Can see role for additional replicates of bug flows to see if that connection exists
- **Project A: Streamflow, Water Quality, and Sediment Transport and Budgeting in the Colorado River Ecosystem (FY24 \$1,249,606)**
 - This project collects the physical data that directly link dam operations to the downstream Colorado River; all other GCDAMP-funded projects use these data to link dam operations to their resources of interest. The data collected by this project are used to implement the High-Flow Experiment (HFE) Protocol (i.e., trigger and design HFE hydrographs), to evaluate the reach-scale sand mass-balance response to the HFE Protocol, and to evaluate the downstream effects of releases conducted under the Long-Term Experimental and Management Plan (LTEMP) Environmental Impact Statement (EIS; LTEMP). Full Description on page 80 of the FY21-23 TWP.
 - A.1 Stream gaging and hydrologic analyses (\$400,958)
 - A.2 Continuous water-quality parameters (\$137,334)
 -

Project A: Streamflow, Water Quality, and Sediment Transport and Budgeting in the Colorado River Ecosystem

Project A collects the physical data that directly link dam operations to all resources in the downstream Colorado River; data inform 10 LTEMP goals

- Element 1: Stream gaging
 - Stage
 - Discharge
- Element 2: Water quality
 - Water temperature
 - Salinity (specific conductance)
 - Turbidity
 - Dissolved Oxygen
- Element 3: Sediment transport and budgeting
 - Suspended- and bed-sediment data
 - Sediment loads (silt and clay loads and sand loads)
 - User-interactive sand budgets in 6 reaches from Lees Ferry to Lake Mead
- All elements
 - Database and website (currently UNSUPPORTED)



- This project is salary heavy
 - Only two river trips to maintain remote gaging stations in the canyon
 - HFE might have additional logistics to collect more data
-
- Discussion:
 - CN: would temp in the slough fit in A, or different project area?
 - DT: deciding whether or not slough fits in Project A or not
 - Had hallway conversations about how to streamline some of the data collection so it's not add on for other projects
 - DO sensor for GPP work halfway b/w dam and lees ferry that could become part of project A
 - Need to QA/QC data back to June 2023
 - In 25 this person might be able to take on more
 - Jim Strogon: is vandalism an issue on these sites?
 - David Topping: many years ago we had vandalism at LCR above the mouth
 - A couple others at outlying sites, but not a big problem here as with other sites
 - Betsy Morgan: how does the database/website effort differ from Project K?
 - Project K does not have an employee at the moment, looking for support
 - Data goes back to the 1990s
 - Hope in next TWP is to have someone in Project K take this on
 - Have to bring expertise in house w/ new position in Project K
 - Thomas Gushue (Project K): workflow for Project A data has followed a different path to other projects

- Didn't have capacity back then, but with new hire we would have a lot of crossover
- Bridget Deemer: having a database manager would help a lot of projects
 - David Topping: incredibly important to bring this expertise in-house
 - Could distribute cost of funding this position across a lot of different projects

BAHG Call #3: Humpback Chub/Native Fish, Rainbow Trout, & Vegetation (Projects C, G, H) 02/13/24

NOTE: All dollar values are from the FY24 Budget

- **Project C: Riparian Vegetation Monitoring and Research (\$339,147) Emily Palmquist**
 - The purpose of this project is to monitor the status and trends of riparian vegetation, examine mechanisms behind trends in riparian vegetation change as they relate to LTEMP flows, and apply existing and new knowledge to LTEMP vegetation management. The four elements of this project assess riparian vegetation status in the Colorado River Ecosystem (CRe), test mechanisms by which flow regime impacts species of interest, synthesize data to anticipate changes to vegetation, and assist nonflow management actions directed by the LTEMP. Full Description on page 135 of the FY21-23 TWP.

Project Elements in FY21-23 TWP

C.1: Ground-based riparian vegetation monitoring

- Annual data collection
- Analysis of vegetation as wildlife habitat

C.2: Determining hydrological tolerances and management tools for plant species of interest

- Greenhouse experiments on daily fluctuating flows

C.3: Predictive models and synthesis

- Flows that would push plant communities toward metric goals
- Use existing data to explore changes in dominant species impacts on the rest of the community
- Flow/vegetation/sediment modeling

C.4: Vegetation management decision support

- Consult on vegetation removals/plantings
- Phragmites research

Continue
Discontinue
Modify
New



- C.1 Ground-based riparian vegetation monitoring (\$169,062)
 - Adding analysis of vegetation as wildlife habitat
 - In response to not addressing wildlife habitat part of LTEMP goal
 - Using first part of workplan to develop monitoring and research/questions
-
- C.2 Determining hydrological tolerances and management tools for plant species of interest (\$12,012)
 - Anticipating first year as growing the plants and acquiring needed equipment
 - Considering if there is a way to combine this with field experiments
- C.3 Predictive models and synthesis (\$143,022)
 - Want to dig into what change in bacarus and tamarisk will do to broader vegetation diversity

- Half a page and a half of workshopping for ideas for flow/veg/sediment modeling, trying to figure out where to put this in the workplan (interdisciplinary studies)
- C.4 Vegetation management decision support (\$15,051)
 - Adding Phragmites research
 - Genotype for invasive vs. native phragmites
 - Would need to talk about what the broader group would like to do IF the non-native lineage is present in the canyon
 -
- **Discussion**
 - Larry Stevens: historical perspective: vegetation has transitioned from tamarisk dominated to wasteland of habitat
 - All in favor of habitat approach
 - Challenge in this system is NPS “conserve natural state”
 - No consensus on what exactly that means
 - Need NPS fully on board for any management actions recommended from GCDAMP
 - EP: would it be useful in habitat studies to think of questions along the lines of “What will the habitat be if we leave things the way they are vs. what would it be if plant communities are altered?”
 - LS: imagery might be a way to broach that subject, status quo, invasive species, non-native phragmites
 -
 - Seth Shanahan: don’t see aerial mapping, is that because ground is more useful?
 - EP: imagery still important, ground based gives info in the interim
 - Aerial is good at looking at landscape changes in large areas
 - Ground based better @ shorter term scale changes
 - Aerial in imagery project
 - SS: focus on wildlife and partnering w/ Navajo, will that be BOR of GCMRC?
 - Bird data on BOR side
 - Coordinating efforts for bird data with BOR
 - SS: should be a metric for wildlife habitat
 - EP: can add that component
 - Dan Leavitt: wildlife habitat is a large concept: would challenge to think of it like native veg and look at functional groups
 - Leverage data to further our current understanding
 - Value in answering questions
 - EP: discussed a lot of concepts at this point, haven’t gone into how wildlife side is being handled right now
 - Do like the idea of thinking about functional groups
 - DL: it’ll be a long iterative process
 - Christina Noftsker: were cottonwoods present pre-dam?

- EP: yes, there were in pockets, goodings willow was more common than Fremont cottonwood

- **Project G: Humpback Chub Population Dynamics throughout the Colorado River Ecosystem (\$1,594,535) Maria Dzul (Jewell)**

- This project is mandated by the 2016 Biological Opinion associated with the LTEMP, while focusing research on improving our understanding of abundance and the drivers of humpback chub population dynamics throughout the lower CRE. Full Description on page 231 of the FY21-23 TWP.

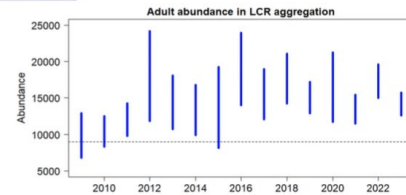
- G.1 Humpback chub population modeling (\$150,929)

G.1: HBC population modeling

- HBC abundance required by 2016 BiOp
- All project elements require models!



Adult abundances in the LCR aggregation are above the trigger



Preliminary Information - Subject to Revision. Not for Citation or Distribution.



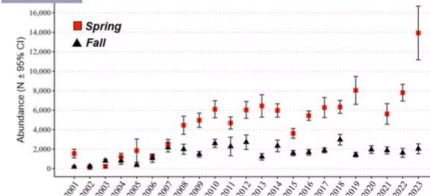
- G.2 Annual spring/fall HBC abundance estimates in the lower 13.6 km of the LCR (\$526,083)

G.2 Annual spring/fall HBC abundance estimates in the lower 13.6 km of the Little Colorado River (LCR)

- 4 trips per year (2 in spring, 2 in fall) - ongoing since 2000
- HBC abundance required by 2016 BiOp



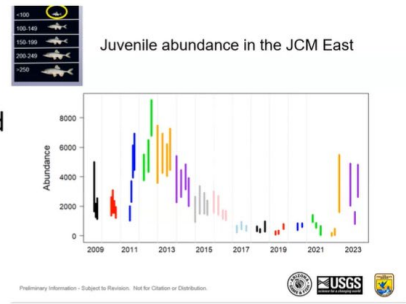
Fall adult (≥ 200 mm) abundance of LCR resident HBC in 2023 is stable in recent years



- G.3 Juvenile chub monitoring near the LCR confluence (JCM-East) (\$530,907)

G.3. Juvenile HBC monitoring near the LCR confluence

- Includes 3 trips per year to a fixed site (JCM-East site) near LCR confluence and LCR trip in July
- Estimate survival, growth, movement
- Required for 2016 BiOp
- Focus on age-0 lifestage



G.4 Remote PIT-tag array monitoring in the LCR (\$75,569)

Adding PIT antenna detections can improve population models without requiring additional fish handling

-improve precision on abundances (Dzul et al. 2022)

Does receive some external funding (BoR)

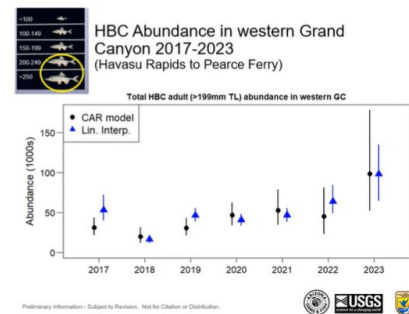
Provide better inference on migration because physical sampling can miss fish

-Dzul et al. *Accepted*, Dzul et al. 2021, Dzul et al. 2018

G.5 Monitoring humpback chub aggregation relative abundance and distribution (\$210,348)

- Estimate HBC abundance in western Grand Canyon
- Some mark-recap
- Spatially widespread

• WANTED: one extra trip to get updated information about HBC capture probabilities

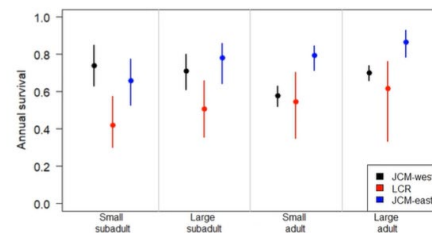


G.6 Juvenile chub monitoring - West (JCM-West) (\$0)

Includes 3 trips per year to a fixed site (JCM-West site) in western Grand Canyon

Estimate survival, growth, movement

Key uncertainties : Is adult survival lower in western Grand Canyon? Is lower adult survival due to warmer water temperatures?



G.7 Chute Falls translocations (\$100,699)

- Not seeing elimination of any project elements

New projects?

- HBC exploration above Blue Springs?
- Expanding PIT antenna detections throughout Grand Canyon
 - Help determine true survival of HBC in western Grand Canyon
- Close-kin mark-recapture of HBC
 - Determine N_{eff} (effective breeding size)
 - Validation of tool
 - Increase cost-effectiveness?
- LCR HBC population – vulnerability to climate change and drought
 - Years without floods could be very bad for age-0 HBC
 - Implications for Chute Falls translocations
-
-
- **Discussion**
 - Brian Hines: for new pit tag detection, are you looking at mobile or more self contained methods?
 - MD: looking at something more portable, especially if they are going on other projects
 - Something to deploy overnight
 - Hoping to add to trips that are already going out
 - Seth Shanahan: with submission of SEIS, are there components that reflect on Maria's workplan that we should know about?
 - Bill Stewart: what is being proposed is covered in terms of triggers
 - SS: would be good to know what needs to be done vs. what we want to be done
 - Larry Stevens: is Paria suitable for HBC, if so, how?
 - Do we have enough data?
 - MD: if river continues to warm, HBC could expand and get to Paria on their own
 - Could try to analyze translocation more formally if people are interested
 - LS: in WGC, how much attention are you paying to tributary miles?
 - MD: USFWS might know better for tribs
 - Not specifically looking for spawning activity
 - LS: Big increase in WGC has happened in low lake levels, if lake were to refill, what are issues surrounding that? Or is that population kind of sacrificial?
 - KD: Haven't walked through that scenario before
 - DL: BOR Separated Glen Canyon Dam portion from Hoover Dam under SEIS, little premature to talk about end results as nothing is signed

Potential Changes to Project Elements

H.1: Rainbow Trout Monitoring in Glen Canyon (Arizona Game and Fish Department; AZGFD)

- Electrofishing (AZGD)
- Creel survey/Citizen science

H.2: Experimental Flow Assessment of Trout Recruitment (TRGD Project)

- Mark-recapture trips
- Reproductive status

H.3: Brown trout early life stage studies (BTELSS)

H.4: Salmonid Modeling

- Causal hypotheses (revisit Brown Trout report – Runge, et al. 2018)
- Incorporate incentivized harvest into Brown Trout modeling
- Trout population dynamics/forecasting
- Predictive capabilities for decision-making: recruitment/outmigration

Continue
Discontinue
Modify



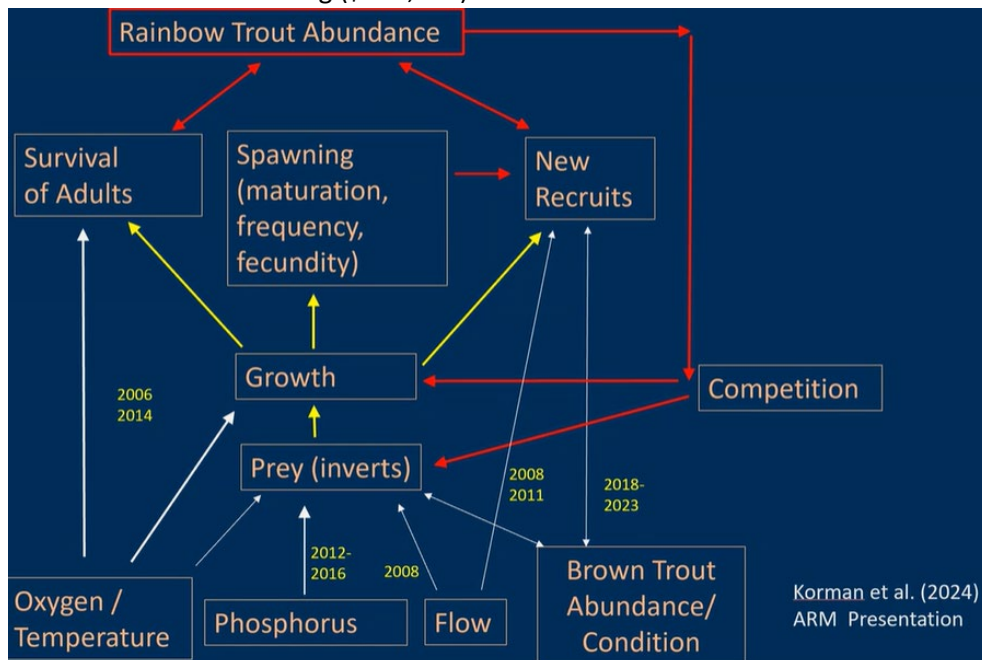
○

- Rainbow trout monitoring in Glen Canyon (\$123,760)

LTEMP Goal – Rainbow Trout Fishery:

- “Achieve a healthy high-quality recreational rainbow trout fishery in GCNRA and reduce or eliminate downstream trout migration consistent with NPS fish management and ESA compliance.”

- Experimental flow assessment of trout recruitment (\$267,705)
- Brown Trout Early Life Stage Survey in Glen Canyon (\$0)
- Salmonid modeling (\$119,782)



Korman et al. (2024)
ARM Presentation

○

Discussion

- Emily Omana-Smith: in support

- Happy to see flow options
- **NEW PROJECT Other Native Fish**

New Research Project: Other Native Fish

- **LTEMP Goal:** “Maintain self-sustaining native fish species populations and their habitats in their natural ranges on the Colorado River and its tributaries.”
- **Projects:**
 - **Analyze existing data – Bluehead, Flannelmouth, Razorback suckers & Speckled Dace:**
 - Data: size, distribution, capture, and PIT-tag antennas – tributaries and mainstem
 - Estimate native fish demographic rates and understand environmental drivers
 - Improve predictive modeling – inform management actions (dam ops., barriers?)
 - **New technology-pilot study: acoustic tags with “predation sensors”**
 - Understand predation as source of mortality
 - Pilot study with juvenile/sub-adult native fish, rainbow trout(?)

○

○ **Discussion:**

- Would the Native Fish Element of Project I be moved into this New Project?
 - BH: it could be moved into this new project
 - Kim Dibble: that was the thought, try to separate native vs. non-native, trying to disentangle the species
 - Taking the data that would be collected in the other projects for modeling in this one to address the LTEMP Goal
- Larry Stevens: will life history models require additional sampling?
 - BH: speckled dace respond rapidly to management actions
 - Little more difficult to monitor in a quantitative way as they’re so small
 - BH: I realized I might not have answered all of Larry's questions: as far as additional sampling for "other native fish", I wouldn't plan much additional field work, but use data that is already being collected on the other trips. I plan to think more about this. Sorry about that Larry

- **Project L: Overflight Remote Sensing in Support of GCDAMP and LTEMP (\$312,349) (Joel Sankey, Thomas Gushue)**
 - This project seeks to acquire and analyze high-resolution multispectral imagery and digital surface models (DSM) of the Colorado River and riparian area from the forebay of Glen Canyon Dam downstream to Lake Mead, and along the major tributaries to the Colorado River. Data derived from the 2021 and previous overflights are used either directly or indirectly by every science project to address every resource goal of the LTEMP. Full Description on page 346 of the FY21-23 TWP.
 - Overflight remote sensing (\$312,349)

FY25-27 Science Elements: Project L

Continue
Discontinue
Modify
New

- **Map Colorado River ecosystem (river channel, sand, riparian vegetation) landcover changes and interpret relationships to dam operations and other factors**
 - Using remote sensing imagery acquired by Project L during the FY21-24 workplan and previously
- **Measure system-wide changes in high-elevation sand deposits**
 - Using remote sensing digital topography acquired by Project L during the FY21-24 workplan and previously
 - Collaboration with Projects A, B, C, and D
- **Flow/vegetation/sediment modeling**
 - Contribute landcover change observations for model calibration and validation
 - Collaboration with Projects A, B, C, and D
- **Overflight mission to acquire multispectral imagery**
 - Proposed for 2026
 - Similar to previous data acquisition in 2021
- **Overflight mission to acquire airborne lidar**
 - Proposed for 2026 in conjunction with imagery overflight

- - LiDAR would be very helpful for hydrologic modeling
- **Discussion:**
 - Seth Shanahan: could we get a sense of what the budget might look like for regular flight vs. w/ LiDAR? Are there ways to save on the budget?
 - Joel Sankey: preliminary conversations w/ contractor price is similar to previous years w/o LiDAR. Don't have a number right now on LiDAR, but will get back to you
 - Thomas Gushue: USGS 3DEP program, mission is to collect high resolution LiDAR, would try to coordinate w/ them and offset cost
 - SS: Imagery about \$500k, how or if we could save money? What information do we lose or gain by doing it this workplan or not?
 - JS: people use this imagery and map data in the field to collect their data, there were significant enough changes @ 8,000cfs that another imagery run would be worthwhile
 - TG: only data collection that spans the entire system
 - 2026 would give us a change detection from spring HFE

- Cost gets spread out across every project every year
 - JS: pushing the project off risks having those funds getting picked up by other projects
 - Betsy Morgan: how does the program distinguish which project bears costs since there is collaboration?
 - JS: try to make sure there is not a waste of money being spent by having redundant data collection across projects
 - Larry Stevens: probably the most important record of how the ecosystem changes
 - Running at 4-8 intervals is essential to many different resources
 - Christina Noftsker: 3DEP, does the program pay for the LiDAR if it can be dovetailed w/ 3DEP?
 - JS: Depends on the program, but idea is multiple partners come together to provide funding towards it
 - CN: in prior years, did other branches of the program pay for the imagery?
 - JS: a lot of work put into other ways to collect that imagery. Have settled on overflights due to advancement of sensors.
 - Save money on 2021 overflight
- **Project D: Effects of Dam Operations and Vegetation Management for Archaeological Sites (\$331,622) (Joel Sankey, Helen Fairley)**
 - The LTEMP goal for Archaeological and Cultural Resources is to 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. Project D monitors and quantifies changes in the physical condition of river corridor archaeological sites in Grand Canyon as a function of ongoing and experimental dam operations and vegetation management actions of the LTEMP ROD (LTEMP), in keeping with the mandates of the Grand Canyon Protection Act (GCPA) and consistent with the monitoring plan developed in 2015 and Reclamation's 2017 Historic Preservation Plan. Description on page 164 of the FY21-23 TWP.

Continue
Discontinue
Modify
New

FY25-27 Science Elements: Project D

- **Continue long-term monitoring of archaeological sites using lidar and site classifications (GCMRC TWP)**
 - Continue monitoring site sample according to established three-year rotational schedule
 - Evaluate mechanisms responsible for observed changes in site classifications (i.e., degradation in site preservation potential)
- **Continue compiling record of ecological changes affecting cultural landscape and archaeological site preservation using repeat photography (GCMRC TWP)**
- **Build on vegetation management study for archaeological site preservation (Reclamation TWP?)**
 - Continue experimental vegetation management study with NPS
 - Based on lessons learned in FY21-23, experiment with different vegetation removal strategies, plantings, and sediment capture using minimally invasive methods
 - Through collaboration with Hopi Tribe, NPS, and others, explore applicability of traditional dryland farming knowledge and soil management practices for achieving archaeological site preservation goals

FY25-27 Science Elements: Project D New Starts

- Evaluate rock art site condition using lidar and photogrammetry with guidance from the LTEMP Cultural PA Signatories, building from “Supai Man” pilot study undertaken in FY23 (Reclamation TWP)
- Pilot study to evaluate potential to extract cultural and ecological information from Colorado River deposits using eDNA and pollen (Reclamation TWP?)
- GCMRC-NPS collaboration on formal analysis of archaeological site monitoring data (Reclamation TWP?)
 - Examine relationship of NPS site condition and integrity assessments to GCMRC measured geomorphic and classification changes

FY25-27 Science Elements: Interdisciplinary

- Explore utility of existing remotely-sensed data for measuring system-wide changes in high-elevation sand deposits
- Model river sand transport and high-elevation sand deposition
 - With specific consideration to archaeological site preservation potential (Mendenhall Post-doctoral Fellow program)

- Dam operations, vegetation management, archaeological sites (\$294,846)

- Monitoring landscape-scale ecosystem change with repeat photography (\$36,776)
- Cultural Program History (\$0)
-
- **Discussion:**
 - Would Project L LiDAR allow for cost saving in the year it is collected?
 - Leslie James: What is the practical effect of moving some of this work over to Reclamation, what does that really mean? Moving some of GCMRC funds back to BOR?
 - Helen Fairley: some of these projects (like rock art) is more suited to PA as it has a broader scope than Dam Effects
 - Pilot study is one that had back and forth, part of PA but there has not been much effort to understand it
 - LJ: understand that, but why is some of this work still considered experimental as opposed to more management actions?
 - If management actions, where should the responsibility lie?
 - JS: Last work plan the Veg management had parallel projects w/ NPS, last TWP fit the work to evaluate those management actions
 - HF: in terms of veg management, looked at effects of veg management and how quickly it comes back and how sediment management actions effect sandbars
 - Rob Billerbeck: LiDAR stuff, we haven't had a lot of NPS discussion, yet
 - Looks useful at getting at how sites are changing
 - Knowing how much veg and how many sites are experiencing that encroachment was significant for NPS action
 - Learned we didn't have to remove as much veg as initially thought
 - Larry Stevens: think as big as possible at this point in the program
 - Why not spend some time in the next three years using historical photos to focus in on micro habitats to develop ecological understanding of vegetation states through time
 - HF: potential there, one of the challenges we face is "habitat for who?" and being more explicit about what we're talking about
 - Maybe some of these changes are benefiting some and not others
 - Repeat photography records haven't been used to their full potential
 - Potential for understanding sediment supply availability
 - LS: not suggesting fullscale habitat search, but would love to see the conversation to develop a plan for it
 - Would like to see planning to get at that broader perspective
 - Word "enhance" in GCPA difficult term for NPS, what do we want to the river corridor to look like?

and pose a direct risk to native species like the Humpback Chub. This project will help to monitor those risks. Full Description on page 291 of the FY21-23 TWP.

Project I: Warm-water Native and Nonnative Fish Monitoring and Research

LTEMP EIS Goal #5: Other Native Fish Species (separate project in next TWP)

-Maintain self-sustaining native fish species populations and their habitats in their natural ranges on the Colorado River and its tributaries.

LTEMP EIS Goal #10: Nonnative Invasive Species

-Minimize or reduce the presence and expansion of aquatic nonnative invasive species.

Project Elements in FY21-23 TWP:

I.1: System-wide native fish and invasive species monitoring (continue)

I.2: Invasion and colonization dynamics of warm-water fish (modify)

I.3: Impacts of channel catfish on native fish in the LCR (discontinue)

- ~~System wide native fish and invasive aquatic species monitoring (\$357,743)~~
- Invasion and colonization dynamics of warm-water invasive fish (\$168,365)
- Impacts of channel catfish on native fish in the LCR (\$129,170)

New Research Project Ideas

▪ Smallmouth bass

▪ Modeling population dynamics

- Improving forecasting tools – incorporate dispersal, growth, recruitment, population growth rate
- Analyze data from multiple agencies for non-native fish to determine efficacy of removal actions and/or flow management actions

▪ Reproduction

- Use kinship genetic analysis to estimate number of nests and the role of local reproduction vs. entrainment
- Test efficacy of side scan sonar to locate nests
- Determine hatch dates of larval fish

▪ Laboratory studies

- Determine larval survival and growth under high turbidity conditions and varying temperatures
- What's in the diet? Food preferences of SMB in Lees Ferry (Project F?)

- Diet studies happening under Project F, not sure if it go under project I or not

New Research Project Ideas

- o
 - **Other non-native fish**

- Mark-recapture of GSF to determine efficacy of removals and vital rates
- Pit tag experiment in laboratory – tag shed/mortality rate for small fish
- Do literature review to inform development of walleye models
- Metrics- develop pipeline to analyze fish data in an occupancy framework
- Mini antenna citizen science pilot to detect fish

- o
 - **Lake Powell – Entrainment**

- Determining the efficacy of nets using paired eDNA samples
- Lake Powell eDNA study at depth to determine species that could be entrained

- o
 - **Emerging threats**

- Monitor fish disease and parasites associated with warming water
- Utilize tools like metabarcoding to monitor for new introductions of fish, crayfish, bivalves, gastropods, and other aquatic invasive species

- o
 - Would that fit more under project G?

- o **Discussion:**

- Jim Strogon: parasites, is there ultimately a management action that could mitigate, or is this just a study?
 - System-wide the parasites are coming in due to warming waters
 - o Need to monitor as it's in the BO
 - o If due to warming, there is potential management action to cool the water
 - JS: knowing about the parasites is all well and good, but can't think of management action for us
 - KD: management action would be related to temps
- Larry Stevens: how do we get to the big picture of fisheries? Maybe get bibliography of all information?
 - Is there strategy of life history model for these fish species?
 - o KD: would be a huge effort to get all of that data and information together on a resolution necessary for life history
 - Would need to think about it more
 - LS: Want to make sure there is a clear plan to move forward in the next TWP
- Craig Ellsworth: modeling population dynamics, would hope entrainment would be included in that model
 - Hope that there is temp monitoring being done in areas like the slough and other easily accessible areas to get idea of what's going on
 - Tucker trough (2nd bullet on "New Research Ideas" is a good idea

- KD: Jeff Arnold putting out two loggers in the slough next week, talked about temp and DO loggers, concern of losing those loggers due to activity in the slough
 - Looking at temps in vegetation beds
- Seth Shanahan: ideas from the non-native fish strategic plan. One idea is a discussion and review of fish actions on how they are at controlling non-natives, and any opportunities for off-ramping
 - Add project element that would allow GCMRC participation
 - KD: will touch base later to see what would work
- Shana Rapoport: could you give us detail on how the budget pertains to presenting the results, how do we aggregate all the information coming in from difference agencies?
 - Do we need to devote more funding to that kind of activity, or would another agency be more suited to being the data clearing house?
 - KD: use the ARM to relay science to stakeholders, are opportunities to present to TWG and AMWG periodically
 - Bill Stewart: a lot going on, and it's a mix of TWP and NPS actions
 - Glad to hear having some space in the TWP to better communicate these efforts
 - There is technical team focused just on folks doing the work in the river
 - KD: quantifying where we are in the invasion curve could be difficult, have been trying to figure out how to answer that question
 - Do have a web map for non-native fish mapping
 - BS: not available publicly yet
- Emily Young: since we're considering SMB flow options, does additional monitoring need to be included in this work plan, or would it be experimental fund?
 - Any additional research we want to see if we aren't able to have those flow options?
 - KD: modeling that was mentioned earlier might encompass some of that effort
 - As far as adding additional monitoring, we are monitoring Lee's Ferry a lot already (TRGD, NPS monitoring, AZGFD, etc.).
- Rob Billerbeck: relevant projects to what we're going through right now, appreciate Emily's comments on the LTEMP SEIS options
 - Maybe something b/w Lee's Ferry and LCR would be appropriate

BAHG Call #5 Notes

- **Project B: Sandbar and Sediment Storage Monitoring and Research (\$1,010,030) (Paul Grams and David Topping)**
 - The purposes of this project are to: 1) track the effects of individual HFEs on sandbars and campsites), 2) monitor the cumulative effect of successive HFEs and intervening dam operations on sandbars and sand conservation, 3) investigate the interactions between dam operations, sand transport, and channel dynamics, and 4) develop and apply predictive models for streamflow and sandbar changes that can be used for evaluating dam operations scenarios. It directly relates to the LTEMP Record of Decision (ROD; LTEMP) to “increase and retain fine sediment volume, area, and distribution...for ecological, cultural, and recreational purposes.” Full Description on page 106 of the FY21-23 TWP.

Project B: Sandbar and Sediment Storage Monitoring and Research (FY 2021-23)

- **Project Objectives**

- Track the effects of individual High Flow Experiments (HFEs) on sandbars – supports implementation of LTEMP.
- Monitor the cumulative effect of successive HFEs and intervening dam operations on sandbars and fine sediment in Glen, Marble, and Grand canyons – supports evaluation of LTEMP.
- Investigate and model interactions between dam operations, sand transport, and eddy sandbar dynamics – predictive modeling to support decision making.



- **Project Elements**

- B.1 Sandbar and campsite monitoring
- B.2 Bathymetric and topographic mapping for monitoring sandbars and fine sediment from Glen Canyon Dam to Pearce Ferry
- B.3 Control Network and Survey Support
- B.4 Sediment and Sandbar Modeling

- - Sandbar and campsite monitoring with topographic surveys and remote cameras (\$573,964)

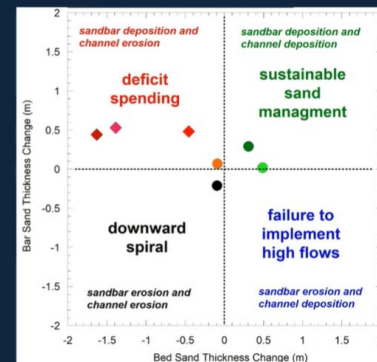
B.1 Sandbar monitoring for FY 2025 to 2027

- Continue annual sandbar monitoring – Consider replacing sites that are no longer sensitive to dam operations with other sites that may be more responsive.
- Maintain remote cameras – begin to update with new system.
- Investigate of the impact of HFE hydrograph shape on sandbar morphology – Implementing and studying an HFE with lower downramp rate is an LTEMP experiment that has not yet been conducted. Stakeholders may want to consider prioritizing this for the next work plan.
- Continue to investigate the interactions between sandbars and vegetation – Develop a coupled model for sandbar and vegetation change in cooperation with Project C. This information could be used to understand why some sites are more or less likely to have vegetation expansion and could also be used to choose sites for vegetation management.

- Bathymetric and topographic mapping for monitoring long-term trends in sediment storage (\$333,831)

B.2 Bathymetric and topographic mapping for monitoring sandbars and fine sediment from Glen Canyon Dam to Pearce Ferry for FY 2025 to 2027

- Sand-storage monitoring (channel mapping)
 - Upper Marble Canyon will be mapped May 2024.
 - Provide updated assessments for joint sandbar and sand storage response for Lower Marble Canyon and Eastern Grand Canyon – Two mapping trips in 3-year work plan.
 - Develop method for “synoptic” (one trip) assessment of sand storage for all of Grand Canyon (data to develop and test method will be collected on the regular channel mapping trips)
- Riverbed dynamics in Western Grand Canyon
 - Continue evaluation of riverbed response to dam operations in Western Grand Canyon – Develop a sediment budget for reach and study stability of Pearce Ferry Rapid (and what happens if rapid goes away).



Schmidt and Grams, 2011; Grams et al. 2018; and Preliminary results. Do not cite.

- Control network and survey support (\$102,235)

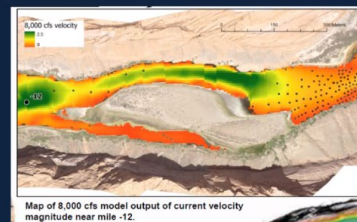
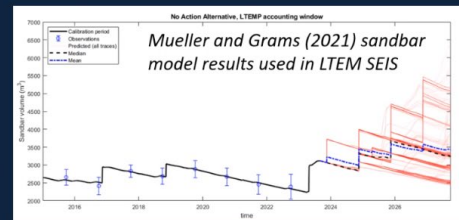
B.3 Control network and survey s

Objectives

- Ensure that geospatial data collected for AMP projects are accurately referenced, precisely defined, and can be reliably compared with past and future datasets
- Maintain integrity and accuracy for network of more than 2900 monumented control points that are referenced by:
 - > 9000 GNSS vectors
 - ~ 9000 classical survey measurements
- Support ground-based referencing for remote sensing missions
- Manage and maintain large inventory of survey equipment

B.4 Sediment and sandbar modeling for FY 2025 to 2027

- Needs for predictive modeling
 - Predictions of turbidity and fine sediment (mud) storage for fish habitat and nutrient dynamics – Continue work on fine sediment (mud) routing model
 - Improve sandbar modeling to better predict sandbar erosion – Improve sandbar model to include more sites and improve parameterization of erosion.
 - Predictions of flow depth and velocity for fish habitat in Marble Canyon – Develop two-dimensional streamflow models for Upper Marble Canyon and Lower Marble Canyon.



Wright et al. (2024) flow model for Glen Canyon



○

○ Discussion:

- Craig Ellsworth: is anyone tracking how pearce ferry rapid is changing over time?
 - PG: we have started doing that, just as a casual add-on with a remote camera
 - Proposed to include in element B.2
 - Monitoring effect of rapid on water surface elevation

- Looking at river bed above and below rapid as well
 - CE: thinking of it in terms of fish passage/barrier
 - AZGFD monitoring fish movement directly (funded through NPS at Meade and USFWS)
 - Looking at extending that effort through BOR
 - Rob Billerbeck: NPS Support for both
 - Note that revising downslope of HFE is supported
 - Worthwhile and within intent of maximizing benefits of HFEs
 - Larry Stevens: work is critical to program
- **Project A: Streamflow, Water Quality, and Sediment Transport and Budgeting in the Colorado River Ecosystem (\$1,249,606)**
 - This project collects the physical data that directly link dam operations to the downstream Colorado River; all other GCDAMP-funded projects use these data to link dam operations to their resources of interest. The data collected by this project are used to implement the High-Flow Experiment (HFE) Protocol (i.e., trigger and design HFE hydrographs), to evaluate the reach-scale sand mass-balance response to the HFE Protocol, and to evaluate the downstream effects of releases conducted under the Long-Term Experimental and Management Plan (LTEMP) Environmental Impact Statement (EIS; LTEMP). Full Description on page 80 of the FY21-23 TWP.
 - A.3 Sediment transport and budgeting (\$711,314)
 - **Discussion:**
 - Larry Stevens: have we looked at duration and extent of clearwater flows?
 - DT: we did publish an analysis in 2014 showing duration, haven't done anything more recent, but do show turbidity on their sediment website
 - LS: is longer duration Clearwater flows more common, and what are the consequences of that?
 - DT: we have seen longer duration
 - Andrew Schultz: the web tool is incredibly important to the program, and it is cost effective and more efficient to internalize this position
 - Need to show we have financial support for it
 - Data work load has increased since those
- **Project J: Socioeconomic Research (\$217,529) (Lucas Bair)**
 - Project J contains research elements that collect and integrate socioeconomic information with data and predictive models from ongoing long-term physical and biological monitoring and research led by the USGS GCMRC. The project elements improve the ability of GCDAMP resource managers and stakeholders to evaluate management actions and prioritize monitoring and research. The proposed project elements address the LTEMP ROD resource goals related to humpback chub, sediment, invasive fish, and hydropower, as specified in Section 4. Full Description on page 291 of the FY21-23 TWP.

Project J: Socioeconomic Monitoring and Research

Recreation project element

- Continue with monitoring and research related to the brown trout incentivized harvest program.
- Develop modeling capabilities for recreation metrics.
- Regional economic impact of recreation spending under different future hydrology.
 - Partner with NPS and AZGFD to manage existing, and design and implement the collection of additional, recreation data important to the management of recreational resources considering low flows and other changing environmental and social conditions.
 - Design best practices for collaborative data collection including prioritizing the collection of data to inform management.

○

- Predictive models for adaptive management
- Brown trout incentivized harvest

Project J: Socioeconomic Monitoring and Research

Integrated modeling project element

- Continue to develop predictive screening model capabilities to integrate socio-economic, biological, and physical resource outcomes downstream of GCD.
- Focus on value of information (i.e., linking research to management) methods.
 - Example, nonnative fish control assessment (temporal and spatial aspects), similar to Bair et al. 2018 (<https://www.sciencedirect.com/science/article/pii/S0006320717312971>) and Donovan et al. 2019 (<https://escholarship.org/content/qt4vz9j7tj/qt4vz9j7tj.pdf>).
- Report on and further develop modeling capabilities for reporting on hydropower metrics.

▪

Project J: Socioeconomic Monitoring and Research

Tribal project element

- In collaboration with the interested tribal partners design and implement a framework for monitoring and integration of Tribal knowledge of cultural benefits into the Glen Canyon Dam Adaptive Management Program.
 - An example would be working with Tribes in the development, implementation and communication of monitoring programs.
 - This work will be based on the recent research by Hoelting et al. 2023 (<https://osf.io/preprints/socarxiv/v6fxs>) and Hoelting et al. 2024 (<https://doi.org/10.1016/j.ecoser.2023.101587>).

Discussion:

- Larry Stevens: is it your plan to get to a statement of overall economic tradeoffs from dam
 - LB: slowly moving towards that, but getting to that end point will be difficult
 - Some of that is being addressed in the integrated modeling, so making progress
 - Craig Ellsworth: have concerns w/ GCMRC developing hydropower metrics, non-starter for WAPA as a stakeholder
 - Leslie James: same as Craig
 - Can't approve w/ hydropower piece
 - Rob Billerbeck: NPS supports
 - Erik Stanfield: echo what Rob just said, specifically support for tribal component
 - Navajo feel strongly about exploring how to work together
 - Economics are best methods we have to do this
- **Project K: Geospatial Science, Data Management, and Technology (\$503,453) (Thomas Gushue)**
 - This project provides high-level support to GCDAMP-funded science efforts in the disciplines of geospatial science, data management, database administration, and emerging information technologies. Full Description on page 326 of the FY21-23 TWP.
 - Enterprise GIS, geospatial analysis, and processing (\$236,424)

K.1. Geospatial Data & Analysis, FY25-27

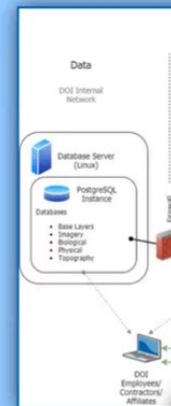
- Continued support to science projects
 - Aligning support with proposed elements for TWP
 - Many field support functions: Maps, GIS layers, Tools
 - Guidance on ArcGIS Pro, other software
- Expanding analysis and processing support
 - Use of Python programming
 - Training for staff and cooperators
 - Data Integration
- Expanding Access to Geospatial Content
 - Data Services
 - Online Maps
 - Integrated online content

-
- Data management and database administration (\$206,180)

K.2. Data Management (Geospatial and Non-spatial)

Enterprise GIS and Relational Databases

- Many project data sets now using enterprise environment
- Centrally managed computing resources, but separately maintained, resource-specific databases
- Spatial and Tabular use the same / similar platforms
- Allows for easier integration of different data sets
- Infrastructure as Code (IaC) - design and deploy relational database resources through code

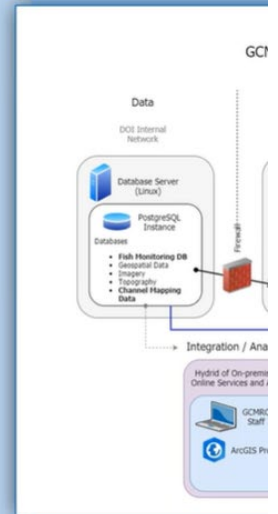


```
18 # CREATE DATABASES FROM TEMPLATES
19
20 # Create non-spatial databases
21 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
22 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
23 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
24 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
25 # END NON-SPATIAL
26
27 # Create spatial (non-vector) databases
28 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
29 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
30 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
31 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
32 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
33 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
34 psql -h $H -p $P -U $U -d postgres -c "CREATE DATABASE $db_name WITH OWNER = $db_owner TEMPLATE = template1;"
35 # END SPATIAL
```

K.2. Data Management – Relational Databases, FY25-27

- Continued support to relational databases
 - Fish Monitoring
 - Lake Powell Water Quality
 - Sandbar Monitoring
 - Riparian Vegetation
- Renewed / Expanded Support *
 - Fish Monitoring - redesign & improved workflows
 - Data Release & Development of online tools
- Tentative New Start for Project K *
 - Project A: Sediment monitoring database and website
 - Several HR actions required for this to happen

* These new or expanded efforts are **not** possible unless existing but vacant positions or new positions can be filled, and other HR actions finalized.



- Remote monitoring and advanced technology support (\$60,849)

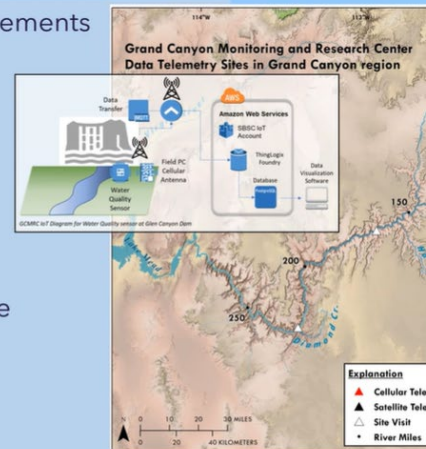
K.3. Data Telemetry / Field Engineering / Internet of Things (IoT)

Continued Support, Maintenance and Improvements

- Glen Canyon Dam IoT Field Site
- Little Colorado River IoT Site
- Sediment Monitoring / Gauging Stations
 - Low Earth Orbit (LEO) Satellites

Expanding Efforts for Connect Sensors

- Many potential sensors / sites to modernize
 - Sediment stations not connected yet
 - Sandbar monitoring cameras
 - Expected growth in sensors for all resources
- Collaborations with other USGS entities
 - Partnering with USGS Cloud Hosting Solutions (Subsidized \$)
 - Coordinating with Ecosystems Mission Area
 - + Co-developing a Community of Practice with USGS ACIO



Any use of trade, firm, or product name for descriptive purposes only an implied endorsement by the U.S. Government.

- Discussion:

- Erik Stanfield: conversation about doing large veg project on LCR
 - Is there a possibility to extend some of that geospatial data up the LCR?
 - TG: would love to be involved, if it's a huge lift
- **Project M: Leadership, Management, and Support (\$1,337,333) (Mark Anderson/Andrew Schultz)**
 - The Leadership, Management, and Support budget covers salaries for a budget analyst, librarian, a part-time library assistant, three members of the logistics support staff, as well as leadership and management personnel for GCMRC. Full Description on page 359 of the FY21-23 TWP.
 - Leadership, management, and support (\$900,014)
 - Logistics staff (\$360,619)
 - IT (\$76,700)
 - Haven't had both deputy and Chief on in a while, anticipating increase to logistics budget
 - **Discussion**
 -
- **Project N: Hydropower Monitoring and Research (\$29,574) Lucas Bair**
 - The LTEMP states that the objective of the hydropower and energy resource goal is to, "maintain or increase GCD 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." Project N will identify, coordinate, and collaborate with external partners on monitoring and research opportunities associated with operational experiments at GCD designed to meet hydropower and energy resource objectives, as stated in the LTEMP EIS and its ROD, and guided by the memorandum (Guidance Memo) from the Secretary's Designee, dated August 14, 2019. Full Description on page 360 of the FY21-23 TWP.
 - Hydropower monitoring and research
 - **Move Project N as written in previous TWP to BOR side**
 - Craig Ellsworth: work as written was not completed, thinks it's a good fit for BOR power office.
 - Open to working w/ GCMRC and show them in person how the models work and run
 - WAPA wants to be at table while model is being run
 - **Discussion:**
 - Andrew Schultz: elaborate on SEIS reference
 - CE: not sure if that is a topic for this call
 - Think there is some inaccuracy in data analysis
 - Christina Nofstker: NM support moving N to BOR side, and still support Lucas' work in recreation and tribal
 - Helen Fairley: before any decision is made history of Project N should be examined
 - Leslie James: don't want comments interpreted as denigrating/reducing socioeconomics in this program
 - Recommendation would help make the program more robust as a whole by providing wider collaborative net
- **General:**
 - Craig Ellsworth: need some help on how this program needs to prioritize

- Need to talk amongst ourselves and identify those priorities
- **Have BOR run their priorities exercise again**
- **Have Stakeholder Priorities as well**
 - LS: strongly second
 - How do we do that? Easy to rank in terms of our perspective