00:00:00 Introductions. Grams started working for U.S. Geological Survey (USGS) at the Grand Canyon Monitoring and Research Center (GCMRC) in 2008. His involvement with Colorado River research in Grand Canyon goes back to 1991.

00:01:00 Grams was an undergraduate student at Middlebury College in Vermont. Jack Schmidt, then a professor there, taught a class on river management that was essentially a river trip through Grand Canyon.

00:02:00 Q: How did your career as a researcher evolve from that original trip? A: On the river trip were Schmidt, around 12 students, and river guide Tom Moody. The trip lasted about 22 days, meaning the group did a lot of camping and hiking. Afterward, Grams wrote his senior thesis on sediment issues on the Snake River in Hells Canyon.

00:03:00 The trip started Grams on his career of studying rivers below dams and his 30-year professional relationship with Schmidt. Q: What kind of research did you do as you pursued advanced degrees? A: His master's thesis was on sandbars, again inspired by his undergraduate river trip. Schmidt's dissertation research was on sandbars in Grand Canyon, but he wanted to expand that work to other rivers.

00:04:00 Grams' undergraduate research on the Snake River was part of that expansion. Even though most sediment is blocked by Glen Canyon Dam, the Colorado River in Grand Canyon receives some sediment from downstream tributaries. This is not true for the Snake River below Hells Canyon Dam. The study Schmidt and Grams did in the early 1990s is still consulted.

00:05:00 Schmidt moved to Utah State University and offered Grams master's thesis work on how Flaming Gorge Dam affected the Green River in Dinosaur National Monument.

00:06:00 Grams did his PhD work with Peter Wilcock at Johns Hopkins University, moving from the field-based work of his earlier studies to modeling and laboratory work.

00:07:00 The sediment transport study was applicable to Grand Canyon and partially funded by the Glen Canyon Dam Adaptive Management Program (GCDAMP). After completing his PhD, Grams took a postdoctoral position at Utah State University working on a project related to the U.S. Forest Service (USFS).

00:08:00 A job at GCMRC opened and Grams took it. Q: Tell us more about what you do here. A: Grams was hired for the physical science program manager position in 2008. GCMRC was structured differently then, with managers running separate programs. At its inception, GCMRC was envisioned to be a very small organization, with personnel managing outsourced research contracts.

00:09:00 When Grams was hired, GCMRC was pulling back from contract work, because it had proven to be problematic for ongoing studies. Grams managed the sediment and sandbar monitoring programs. Jack Schmidt became GCMRC Chief in 2011.

00:10:00 Schmidt prioritized in-house research. This shift made it possible for Grams to transition from program manager to research hydrologist. “So instead of sort of broadly overseeing programs, I manage a couple of research projects. So it’s a, somewhat of a semantic difference, but it is a real difference in terms of how the work gets done here.”

00:11:00 Q: You work at GCMRC, but much of the work you do informs decision-making for GCDAMP. What is your role in the program? A: GCMRC is commonly called the “science provider” for GCDAMP. Grams sees his role as providing the information needed to make resource management decisions.

00:12:00 Many people on GCDAMP either do not have science backgrounds, or do not specialize in the resources they are tasked to manage. A big part of GCDAMP scientists’ role is educating people on how resources interact, and how dam operations affect them. Q: Is your research agenda partly directed by questions and problems that GCDAMP participants pose to you?

00:13:00 A: Yes. The program has general goals. The goal for sediment in the Colorado River in Grand Canyon is to maintain or increase it for recreational, cultural, and biological or ecological purposes. Q: To recover sediment that has been lost since the dam was put in?

00:14:00 A: That is up for interpretation. GCDAMP participants would need to decide whether or not replicating a pre-dam condition is their goal. Grams could explain how current conditions compare with pre-dam conditions. That is not part of the current goals for sediment. Q: Are you in a position where you can choose some of your own research projects and generate the science that you think is valuable, but also responsible for helping develop a knowledge base to support decision-making in GCDAMP? Are you juggling those two together?

00:15:00 A: We do juggle those. GCMRC scientists are free to do other research if they can secure funding. GCDAMP funding is used for research that is relevant to the program.

00:16:00 GCMRC scientists look for ways to innovate on long-term projects by applying new methods or technologies.

00:17:00 The long-term monitoring work important to GCDAMP needs to be kept current and scientifically relevant. Q: I know the relationship between GCMRC and GCDAMP has changed over time. You've only been here since 2008, but how do you see that relationship, besides being a science provider? A: Being the science provider makes GCMRC a source of stability for the program.

00:18:00 GCMRC's education role will provide continuity as new stakeholders replace people who have been with GCDAMP since its inception.

00:19:00 There is an overwhelming amount of scientific literature available on the Colorado River and Grand Canyon. Distilling the results of the best science is "one important thing we provide." Q: Are there specific documents in which you do that distillation? A: The GCMRC Triennial Work Plans contain some of it.

00:20:00 Most of the information gets conveyed at Adaptive Management Work Group (AMWG) and Technical Work Group (TWG) meetings. Q: What have we learned about the role of the dam in sediment transport, load, and deposition since 1991, when you were first in Grand Canyon?

00:21:00 A: From the 1960s to the early 1990s, the dam was operated primarily for hydropower generation. There were daily fluctuations from around 5,000 cubic feet per second (cfs) to 25,000 or 30,000 cfs. The pre-dam average seasonal flood was 85,000 or 90,000 cfs. "So that's fluctuating from essentially, not turning the river off, but turning it way down low, to a third of an annual flood each day."

00:22:00 The dam exacerbated the inherent instability of sandbar deposits. It blocked sediment delivery from the entire Colorado River Basin, and increased the erosive capabilities of the Colorado River in Grand Canyon. The floods of 1983 and 1984 showed that sandbars could be rebuilt under the right conditions.

00:23:00 On the 1991 river trip, Grams listened while sediment experts like Jack Schmidt, Ned Andrews, Bob Webb, and Tim Randall discussed the possibility of an intentional flood release from the dam.

00:24:00 The idea led to the first High Flow Experiment (HFE) in 1996. It was a turning point in sediment management in Grand Canyon. "It's a pretty simple process, we just need two things. You need the water to move the sand around, but then you need the sand there to begin with."

00:25:00 Floods will cause net erosion without adequate sand supply. Q: When Glen Canyon Dam went in, it cut off the flow of sediment from all of the upstream tributaries. There are still a few downstream tributaries below Glen Canyon Dam. Would you explain what and where they are, and how you monitor those to determine when an HFE is appropriate?

00:26:00 A: It is the tributaries that make it possible to manage the system for both hydropower and recreational interests. The Paria River, which drains a big part of southern Utah, joins the Colorado River 15 miles downstream from the dam at Lees Ferry. What the Paria delivers is about 5% of the sediment that would have gone by Lees Ferry without the dam.

00:27:00 The Paria's sediment delivery events are triggered by unpredictable thunderstorms from July through September. Some years there is a lot of storm activity, and some years none at all. Tributary flows replenish the sediment "bank account" needed for HFEs to build sandbars.

00:28:00 Scientists watch the weather and monitor upstream gauges on the Paria River. When they know a flood is coming downstream they go to Lees Ferry to sample the flow and sediment concentrations, using those data to calculate how much sediment to expect. The data collection process is part of the U.S. Bureau of Reclamation (USBR) HFE protocol.

00:29:00 The annual data are published by GCMRC and used in USBR models that predict what will happen with and without HFEs. Managers try to maintain the sediment account in Marble Canyon, the 60-mile reach between Lees Ferry and the next major tributary (the Little Colorado River), so that the amount coming in is about equal to what goes out.

00:30:00 Scientists use both predictive models and measuring programs to monitor the sediment going out the downstream end of the reach.

00:31:00 USBR notes how much sediment is in the account and runs models to determine whether to do an HFE in the fall, and if so how many hours the flow should last.

00:32:00 Q: There's an HFE each fall, depending on whether adequate sediment is there? A: Yes. The model is run with progressively smaller floods, to find the one that fits, and if nothing fits there is no HFE. Sediment inputs from the Paria River were so low last year [2019] that Grams is not sure USBR ran the model.

00:33:00 Q: Do you think that those models are working, or are they constantly having to be updated because what you expect to happen based on the modeling doesn't happen? A: Scott Wright and Dave Topping of USGS wrote the main model. Model performance is tested by comparing its predictions to what actually happened as a result of the HFE.

00:34:00 The model predictions tend to be off by 10-20%, but the model is not designed to predict what happens to each individual sandbar. It predicts what will happen to the sediment bank account, which it does well enough to be a good management tool.

00:35:00 There have been efforts to develop a predictive model for the state of individual sandbars, but none have been completed because they are complicated and hard to use. The sediment bank account model is simple and effective in comparison.

00:36:00 The Little Colorado River is the second tributary below the dam that contributes sediment. Based on recent studies, the amount of sediment contributed by the Little Colorado has declined and is less predictable.

00:37:00 The Little Colorado River is a less reliable sediment supplier than the Paria River is. The sediment management protocol focuses on the reach through Marble Canyon just below the Paria because it has the greatest sediment deficit. The effects of HFEs and sediment transport farther downstream are monitored somewhat less robustly.

00:038:00 Q: A number of people we've interviewed have suggested that HFEs are not working, that they cause as much erosion as deposition. I think it's probably changed over time, and you're the expert who can answer that question for us. Have you gotten better at figuring out how to make the HFEs deposit more than they erode?

00:39:00 A: "Every time we've done one they have resulted in more deposition of sandbars than erosion." Q: In the upper reach, or the whole river? A: The whole river. About two thirds of monitored sandbars get larger with each HFE. The rest either get smaller or do not change.

00:40:00 A lot of sandbars begin eroding again right away after the initial deposition, so that within a year they may be back to where they started. The river and the sandbars are dynamic. "In the pre-dam system, the bars weren't stable…the river would deposit huge sandbars and they'd erode. I think, in some sense, the objective is for the bars to erode. If you didn't intend for the bar to erode, there's no point in building them."

00:41:00 Vegetation encroachment is a problem on sandbars that are not active. "Another way to look at it is, by doing the HFEs, we have bars that are larger for a good fraction of the year than they would be without the HFEs. So they don't immediately erode to nothing, they're there for people to use for a good chunk of the year."

00:42:00 Q: We had a recent interview with somebody who suggested that the beaches haven't changed that much, and once you create a beach it'll be there for a hundred years [Robert Lynch interview]. That was different than anything I heard from anybody else. Does the research support that assertion? A: The dam prevents some high areas from changing, because floods do not get high enough to either erode or build them. But sandbars that are stable get covered with vegetation over time. Only something on the scale of the early 1980s floods would affect them.

00:43:00 Other erosion phenomena also affect sandbars. Hill slope runoff often cuts gullies across them, which HFEs can repair.

00:44:00 Q: Another criticism we've heard is that HFEs bring sediment into the lower river, where flows are slower, and it collects around Diamond Creek. The Hualapai Tribe says the sediment makes it difficult for their river running operation there. Is there truth to the argument that HFEs are causing problems for people in the lower river, and what might be done about that?

00:45:00 A: That is the transition area between the Colorado River and Lake Mead. Sometimes that part of the river is under the lake waters. All of the sediment that enters the river below the dam eventually goes into Lake Mead. That area is essentially a river delta.

00:46:00 Diamond Creek is the downstream gauging station for measuring sediment. The same amount of sediment goes past it, whether or not an HFE is done. HFEs only affect when the sediment is carried, not the total amount that is carried. The sediment delivered by the Paria River is fine, and accumulates on the bottom of the Colorado River. HFEs move that sediment downstream.

00:47:00 Removal of the fine sediment leaves the riverbed more coarse, lowering sediment transport rates after an HFE. If an HFE is not done in a given year, the fine sediment gets transported later, by the high fluctuating flows resulting from increased hydropower generation in the winter.

00:48:00 It is possible that HFEs actually help the sediment situation in the area that concerns the Hualapai by pushing it farther downstream in the higher, faster flows. Grams has proposed research on how different dam operations affect distribution of sediment in the reach just upstream from Lake Mead. Just as the area close to Glen Canyon Dam is inevitably a zone of sediment deficit, the area near Lake Mead is a zone of accrual.

00:49:00 Lake Mead is now so low that the Colorado River is cutting into the sediment accumulated at the delta area. Grams does not know if there is a dam operation scenario that would improve the navigation channel used by the Hualapai. Engineers typically address such issues with structures that concentrate water flow in order to maintain a deeper river channel.

00:50:00 Q: I did a river trip through Grand Canyon last year, and it was eerie floating through the incised area between Diamond Creek and Pearce Ferry. A piece of the sand plateau above the river collapsed like an avalanche and poured into the river.

00:51:00 A: That is happening constantly. A lot of sediment falls into the river from the high cut banks that used to be the bed of Lake Mead, and is probably contributing to the navigation problem. It is a legitimate problem without an easy solution.

00:52:00 Q: Were you part of the effort to create the USGS website that shows before and after pictures from the HFEs? Can you tell us a little bit about that? A: One of the things Grams' research project does is collect those images. Cameras have been used at the monitoring sites since the 1990s.

00:53:00 Scientists realized they were missing a lot of what was happening at the monitoring sites between river trips. They set up film cameras with intervalometers that took a photograph every 24 hours.

00:54:00 GCMRC set up a digital camera system at some of the sites in time to monitor the effects of the 2008 HFE. All of the monitoring sites were upgraded to the digital camera system between 2008 and 2012. Each camera takes five photographs a day, enabling the team to choose the best combination of flow level and lighting for images added to the website.

00:55:00 Q: What's the easiest way for somebody to find that website? Because it really is remarkable. A: It is on the GCMRC website. [U.S. Geological Survey. "Grand Canyon Monitoring and Research Center Sandbar Monitoring Sites Remote Camera Photographs." https://grandcanyon.usgs.gov/gisapps/sandbarphotoviewer/RemoteCameraTimeSeri es.html.]

00:56:00 Q: Rephotography is one of the most interesting ways of documenting change over time. A: GCMRC has also collaborated with Grand Canyon River Guides (GCRG) on the CGRG Adopt-a-Beach repeat photography program. [U.S. Geological Survey. "Grand Canyon Monitoring and Research Center Sandbar Monitoring Sites Adopt-A-Beach Photographs." https://grandcanyon.usgs.gov/gisapps/adopt-a-beach/index.html.]

00:57:00 Q: How has sediment research changed over time? Can you give us a sense of the questions being asked early on versus the questions being asked today, and what we've learned?

00:58:00 A: A lot of the questions are similar. The basics of sandbar management, flows and sediment supply, are pretty simple. Scientists initially guessed at sediment supply, and now it can be measured better.

00:59:00 Based on sparse measurements and simple modeling, predictions could vary greatly. Grams calls it "luck" that, since 2012, sand inputs from the Paria River have been average or above.

01:00:00 Dam release volumes since 2012 have been average. High release volumes result in greater sediment transport. Scientists can now measure how much sand has accumulated by mapping the riverbed at designated times.

01:01:00 The guesswork of 20 or 30 years ago contrasts greatly with the current ability to map the riverbed and measure how flooding affects sand storage. So the 1996 HFE was a major turning point for GCDAMP. Another turning point was the 2012 implementation of annual high flows as part of the HFE protocol.

01:02:00 HFEs were previously one-off experiments. Now they are done as part of a long-term study. "The experiment isn't what each HFE does. The experiment is, what happens if we do this for ten or twenty years." Conditions since 2012 "have allowed HFEs to work almost exactly as intended, as designed."

01:03:00 This almost perfect scenario divides people into camps. The more pessimistic will say it is unlikely that above-average sediment flows from the Paria will continue, so "the system is doomed." The optimistic view is that the conditions on the Paria that have persisted for almost 10 years may be the new normal.

01:04:00 What will happen is a mystery, although predictions are for lower runoff in the future due to climate change.

01:05:00 Q: The model is pretty robust, and we get the outcome we're going for every time we do this, we know how to manage these things. So somebody might say, "Well, have we learned everything we need to learn?" Can we stop studying sediment now and move on to something else? A: For stakeholders, it depends on what their next objective is, and how confident they are in what dam release flows and Paria River sediment will do in the future.

01:06:00 Currently, GCDAMP has an interest in monitoring results "into the future." Q: Are there any big questions or knowledge gaps in sediment flow that you wish we could throw some money at to understand better? A: Studying the navigation problem where the Colorado River transitions to Lake Mead could lead to new information on how the system works.

01:07:00 Another area for further study is how certain types of vegetation might stabilize sandbars or accelerate their erosion, and whether that can be applied to sandbar management.

01:08:00 "Fine-tuning" how HFEs work is another interest. It may be possible to change the magnitude or vary the hydrograph of HFEs to deposit sediment in different areas or change sandbar characteristics.

01:09:00 Scientists still do not know the fine points of why HFEs cause some sandbars to erode and others to enlarge. Optimizing the HFE protocol could help with management.

01:10:00 The core of Grams' project at GCMRC is long-term monitoring of HFE effects and the sediment supply. Monitoring is the basis for using the HFE protocol optimally.

01:11:00 Q: Could you talk briefly about how you map the riverbed? You've helped to innovate ways of mapping the sediment. And you said earlier in our interview, that 80% or more of the sediment in the river is underwater in the river channel.

01:12:00 A: Yes, 80 to 90%. A small amount of sediment is deposited above the 10,000 cfs mark by high flows. Most of the sediment accumulates in deep pools in the center of the channel and in eddies.

01:13:00 GCMRC scientists map the large pools of sediment using sonar. Users hang the instrument from the side of a boat. It generates pulses of sound that bounce off the bed of the river and return to the instrument, which calculates the distance the pulses traveled and measures the depth of the riverbed.

01:14:00 The multi-beam sonar instrument emits 512 pulses in a swath. "Just by driving the center of the channel, you can actually measure depth across a large portion of the riverbed." This creates a bathymetric map, essentially a topographic map of the riverbed. Some maps are available on the GCMRC website. [U.S. Geological Survey. "Sediment Storage in Grand Canyon." https://www.usgs.gov/centers/sbsc/science/sediment-storage-grand-canyon?qt-science_center_objects=0#qt-science_center_objects.]

01:15:00 Q: That's an example of a critical resource that we didn't know anything about, and you came up with a proposal to fund a project to map that sediment, and now you're monitoring how it changes over time so that you can be in a better position to determine the effects of different flow levels. A: Yes. In the 1980s, scientists wanted to predict water surface elevations at different flows throughout the canyon.

01:16:00 They did a river trip, measured a channel cross-section every mile or two, and interpolated between the cross-sections to develop a coarse stream flow model. With the new riverbed measurement data, a much more accurate stream flow model can now be developed. Q: Did funding for riverbed mapping come from GCDAMP? A: Yes.

01:17:00 All of the GCMRC research related to Grand Canyon is funded by GCDAMP. The projects funded by outside sources are not focused on Grand Canyon. 90 to 95% of work done at GCMRC is Grand Canyon research funded by GCDAMP.

01:18:00 Q: How well do you think the research done at GCMRC has been linked with decision-making, policy decisions and dam operation decisions? Has it changed much over time? Is it fulfilling or frustrating? A: It functions pretty well.

01:19:00 It depends on how people see the objectives. "I think there's probably a good balance. I don't know if anybody's perfectly happy with it, but I think most people feel that it's accomplishing what it was meant to." Grams is proud of how the sediment program has worked.

01:20:00 It is a good example of directing applied science toward management problems, although sometimes managers do something different from what the science indicates. The HFE protocol is an example of how it takes a lot of negotiation and time to move management in a new direction.

01:21:00 GCDAMP recently implemented its latest version of management, the Long-Term Experimental and Management Plan (LTEMP). There is growing interest in having HFEs in the spring. They are usually done in the fall to capitalize on late-summer sediment deliveries from the Paria River. When the HFE protocol was first devised, biologists recommended against spring HFEs, thinking they would favor trout that prey on native fish.

01:22:00 The HFE protocol requires a sediment trigger for spring high flows. There have been no sediment-triggered spring HFEs.

01:23:00 Based on findings that a spring HFE might be good for the biology, some GCDAMP stakeholders want more flexibility in the HFE protocol. Changing management directions is a complex process, and the continued involvement of scientists is important. "The learning keeps changing a little bit and ideas evolve, and we've got to adjust."

01:24:00 Q: What's your feeling about that? Is it just frustrating delays, or is there a good explanation for why it takes so long? A: In most cases there's a decent explanation. An inclusive decision-making process where everyone gets to contribute takes time.

01:25:00 Q: Can you think of any ways that we might improve the relationship between science and policy? Get the results of research to be more useful and more effective in shaping policy decisions? A: That may not be completely realistic.

01:26:00 The structure of GCDAMP helps the science-policy relationship. It facilitates relationships among stakeholders, decision-makers, and scientists. The resources at stake in GCDAMP are big, and are of interest to a lot of people. Grams is not sure the GCDAMP framework can be successfully applied to other systems. GCDAMP also works well because people are involved over long periods of time.

01:27:00 Q: How is climate change affecting the work that you do, the questions you ask, and the decision-making environment of GCDAMP? A: It has been on participants' minds for a while, but has only recently become a part of management decisions. Water managers are feeling more urgency. The potential impacts on Grand Canyon and GCDAMP are obvious.

01:28:00 GCMRC is not doing climate change work per se, but Kim Dibble and Charles Yackulic are working on temperature modeling throughout the Colorado River system, including Grand Canyon.

01:29:00 Q: Is anybody looking at dam operations and climate change? A: That's part of the same question, the impact of both climate change and dam operations on river temperatures. Grams is also looking at the effects of declines in flows on river channels in the Colorado River Basin.

01:30:00 The big impact of climate change will be in how decision-makers manage Lake Powell and Lake Mead. Although that is outside GCMRC's realm of study, Grams feels its scientists should help managers think through the impacts of different decisions. That is part of what Dibbles' and Yackulic's study will do.

01:31:00 Q: Just in the last few years, it's become increasingly obvious that there is a chance we may not be able to keep those two reservoirs functioning. It's a remarkable new context for adaptive management and for the science that we need to do. A: Yes. Q: The value of GCDAMP and adaptive management as a management regime, do you think it's valuable to approach things in this way?

01:32:00 A: Yes. There are some firm constraints on this system. Climate change could cause big changes in operations, but until then Glen Canyon Dam operates in certain ways.

01:33:00 It is tied to mandated annual release volumes. Managers are "boxed in, in terms of what they can actually do." Within those constraints, they have decided to manage for a balance of resources. The GCDAMP framework is effective for that. "You get all the people with all their interests coming and sharing their perspectives and grievances, and you end up with…as much of a balance as there can be."

01:34:00 Q: So you think it should be continued, it's been worthwhile? A: Yes. Q: Is there anybody else that you haven't already mentioned that you think we should interview? A: Ted Melis.

01:35:00 Carol Fritzinger, retired GCMRC logistics coordinator.

01:36:00 Bob Webb. He worked on sediment for USGS, but not at GCMRC. He specializes in rephotography and wrote a book on the Stanton Expedition.

01:37:00 David Rubin did a lot of the early sediment work. David Topping, who works at GCMRC. Scott VanderKooi. Q: Any last thoughts you'd like to share? A: It's been a great privilege to do applied science that directly influences management decisions.

01:38:00 Not every scientist gets to do that, and in a context that people really care about.