Paul Hirt:  **Paul Grams:** 

Paul Hirt

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This is Paul Hirt and Jen Sweeney of Arizona State University interviewing Paul Grams at the Grand Canyon Monitoring and Research Center [GCMRC] in Flagstaff, Arizona on January 24, 2020.Thank you for joining us today, Paul.

Paul Grams

00:00:17

Happy to be here.

Paul Hirt

00:00:18

Um, start out by telling us your name and spell it for us please, and who you work for, and the years that you've been involved in Grand Canyon research.

Paul Grams

00:00:28

Uh, yeah. Well, my name is Paul Grams, uh, P-a-u-l G-r-a-m-s. Um, I've been, uh, working at USGS [U.S.Geological Survey] here, at GCMRC. I started twelve years– I started in January 2008. Um, just a couple months before the 2008 High Flow Experiment [HFE], which I'm sure we'll talk about. Um, but my involvement actually dates back to January of 1991, when I, uh, went on a wintertime river trip as a undergraduate student.

Paul Hirt

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With uh, which professors, and to do what kind of research?

Paul Grams

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That was (Pause) again, that was a wintertime trip. I was an undergraduate at Middlebury College in Vermont. I had already taken one geomorphology class from Jack Schmidt. And he offered, this was the second time he did it, he was a professor at Middlebury at the time, and he offered, uh, a winter term– Middlebury was on a, on a kind of winter term schedule where they had a January term that students could just do one class. And so he offered a January term class that was essentially a Colorado River trip, uh, studying, you know, the, the, the issues on river management and–connected with studying the issues on river management in Grand Canyon. And so I took that as a, I guess I was a (Pause) a junior or a senior. I can't quite remember. (Pause)

Paul Hirt

00:02:02

How did your–

Paul Grams

00:02:03

And, Middlebury–

Paul Hirt

00:02:03

Career as a researcher evolve from that original trip? I assume you fell in love with the Grand Canyon?

Paul Grams

00:02:09

Well, it was a great trip. There was about, oh, probably about twelve students, uh, Jack, a river guide named Tom Moody, who was very instrumental in, uh, the early part of the program. Um, and a couple other, uh, friends of Jack's on the trip. And we did a twen– I think it was a twenty-one, twenty-two-day trip, which is a very long trip with a motor rig, which means, you know, lots of, lots of time, uh, camping, lots of time to do hikes. It was, uh, it was a great experience, and we got to see a lot of sites on that trip. Um, and then after that trip, I went on and did a undergraduate thesis working with Jack as my advisor, studying, uh, sediment-related issues on the Snake River in Hells Canyon. So, um, so that was really the start of the–that trip kind of set me on the course toward studying rivers and, uh, studying, especially studying rivers downstream from dams, and it was the beginning of what is that, uh, you know, getting (laughs) uh, thirty-year, getting close to a thirty-year working relationship with, with Jack, on studying rivers.And so, working with him still today on both the Colorado River and throughout the [Colorado River] Basin.

Paul Hirt

00:03:28

So you have both a master's and a PhD. You specialized in river geomorphology. Um, you want to talk a little bit about the, uh, research that you continued to do as you went after those advanced degrees?

Paul Grams

00:03:42

Um, yeah, I did a undergraduate degree in geology, and again, that was, I did a master's thesis on, uh, looking at sandbars. You know, we, that river trip we did in Grand Canyon, we surveyed a few sandbars that Jack had studied. You know, Jack did his, his dissertation research in Grand Canyon in the 1980s, and so this wasn't too long after that. And so we went back to his study sites, surveyed a few sandbars, but, uh, he was at that time, you know, thinking more broadly than Grand Canyon, and we got some people interested in studying, uh, sandbars on the Snake River in Hells Canyon. So I did a little part of that as an undergraduate thesis. Um, looked at– and Hells Canyon is a place where, um, you know, in Grand Canyon we have the sediment-rich tributaries below the dam, that we can talk about more, but, that supply a lot of sediment, that make, uh, make it possible to sustain the sandbars in Grand Canyon. Whereas on the Snake River, there's very little tributaries downstream. So it was a case where there was extreme sandbar erosion caused by the upstream dam, and so we documented that. And, um, today, uh, it was kind of a very low-profile study at the time, but there are still people up at, managing, uh, Hells Canyon Dam who, who refer back to that work and are dealing with, you know, the effects of Hells Canyon Dam on the sandbars downstream. Um, but then after that I, uh, took a year or two off and then, uh, was living in Utah. And Jack by that time had moved from Vermont to Utah State University, and he, and–kind of his interest in looking at other river systems or other parts of the Colorado River Basin, um, had gotten a project with the National Park Service to look at how Flaming Gorge Dam had affected the Green River in Dinosaur National Monument. And so he, uh, offered that to me as a master's thesis project. So I spent, uh, you know, a mas–three years or so, working on that project, and, uh, and that was, uh, essentially evolved, involved looking at how, um, the dam operations, the, you know, the building of Flaming Gorge Dam had changed the downstream river system. First in Dinosaur, and then we expanded it a little bit to include, uh, the whole river from Flaming Gorge Dam down through, to the Vernal, Utah area. And, uh–.

Paul Hirt

00:06:13

Beautiful country.

Paul Grams

00:06:14

I finished that up, and, uh, wasn't quite sure what I was going to do next, but continued working on rivers with Jack and, uh, at Utah State for a couple of years as sort of a research associate. Then decided I wanted to go ahead and do a, pursue a PhD. And I got in touch with a professor at Johns Hopkins named Peter Wilcock, who is somebody I had met a few times and is a colleague of Jack's, and, um, decided to go work with him to do something just a little bit different, and did something that was more of a (Pause) less of a field-based study and more of a modeling and laboratory-based study. So I did, uh, experiments in a laboratory flume, and modeling work. And, but that was related to Grand Canyon. It was with the, it was, um, partially funded by the Glen Canyon Dam Adaptive Management Program, and it was looking at controls on sand entrainment and sand transport, and coarse–bedded river systems. But with laboratory experiments.

Paul Hirt

00:07:16

Can you explain the word “entrainment?”

Paul Grams

00:07:19

Oh, the (Pause) the picking up of sand from the bed of the river by the water. So the process by which water is picking up the sand and carrying it in suspension. And so–.

Paul Hirt

00:07:31

So you did your PhD, um, uh, doing research again on sediment transport, essentially, and–.

Paul Grams

00:07:37

Essentially sediment transport, yeah.

Paul Hirt

00:07:40

In Grand Canyon. And when you finished that PhD, is that when you got hired here at Grand Canyon Monitoring and Research Center?

Paul Grams

00:07:46

Not immediately, although I just did a couple–year postdoc position, um, at Utah State University. So the PhD was at Johns Hopkins, then moved back to Utah where I lived for a long time. Did a couple of years there at a postdoc working on, uh, looking at streams (Pause) mountain streams in the forest, for the, a [U.S.] Forest Service-related project. But then this job came up and, uh, took that.

Paul Hirt

00:08:13

All right. And this job is what? Tell us a little bit more about what you do here.

Paul Grams

00:08:16

So– (Speaking simultaneously). Um (Pause) I was hired–now this is a bit of the program and evolution of GCMRC is, um, I was hired as a program manager, which was the physical science program manager position, in 2008. Um, and at that time the structure of GCMRC was a little bit different than it is now. At that time we were structured a little bit more as a (Pause) with managers of a few different programs. Um, and, [Unintelligible] when, uh, there's been some evolution in terms of how GCMRC has functioned since it was started. There was, I think, some uncertainty or even an idea that GCMRC might be a very small organization, and most of the work would be contracted out or done through cooperative agreements with universities, and

GCMRC would be a small number of managers that managed those contracts. And I was hired at a point where it's maybe in between that where there was quite a bit of work done in-house because, you know, there's things that are ongoing, so the idea of always contracting out, I think, kind of immediately became problematic. But at any rate, I was hired as a–one of those program managers, and did that job for a couple of years. And in that capacity, I, I um, managed the, uh, sediment monitoring program that's continuing now, um, and the sandbar monitoring program. Um, but more as a manager. And then, after a couple of years, and this is–Jack Schmidt comes into the story again here. He was hired as chief in (Pause) 2012? '11? (Laughs) I don't remember the year. But he was, um, hired as the Chief, and he felt that we should have more of a research focus in-house, and he made it possible for me to transition my position from a quote-unquote program manager into a research scientist. So, my title now is a research hydrologist. And, so instead of sort of broadly overseeing programs, I manage a couple of research projects. So it's a, uh, a somewhat of a semantic difference, but it is a real difference in terms of how the work gets done here. [P.H.: Mm-hmm] Um, because instead of just managing projects– so David Topping, who's, comes over to my, colleague co-equal, he manages the suspended sediment transport monitoring and measuring program, and I was nominally overseeing that as a program manager. Well now he's just managing his project, and then I have the sandbar project that I just manage. And work on as a researcher, not just as a manager.

Paul Hirt

00:11:16

So you work for the U.S.Geological Survey here at GCMRC. Um, but much of the work that you're doing goes to inform decision-making for the Glen Canyon Dam Adaptive Management Program. Can you talk a little bit about how you see your role as a researcher at GCMRC in the larger environment of the Adaptive Management Program? What's your role in the Adaptive Management Program?

Paul Grams

00:11:32

Well, I mean, I th–you know, I mean, I think simply our role as, I think every, as people generally call it, is to be the science provider, the information provider, so. I do see it as (Pause) giving them the information they seek to make management decisions, um, and trying to–and uh, and, also, I think a big part of the role is (Pause) because they do this as, you know, non-specialists, [Unintelligible] at least, or non-, most of them non-science, I mean, a lot of them have science backgrounds, but some of them don't. And if there's, if they do have a science background, it could be in any area. So a big part of our role is educators on the science we do, and on how the [eco]system works, and connecting that with whatever resource or, um, whether it's a biological resource, a species of fish, or whether it's the, the sediment or the sandbars themselves, how those are related to the work we do. Or how (Pause) they are aff–how they are changing, or how they are being affected by the dam operations or other factors that (Pause) might cause changes in those resources.

Paul Hirt

00:12:53

So does, does your research, is your research agenda, your personal one and GCMRC's larger constellation of research, um, is it partly directed by questions and problems that the Adaptive Management Program, uh, participants pose to you? Do–can they come to you and say, "We need to know more about X so we can make a decision about Y?" Is that–.

Paul Grams

00:13:19

Yeah, and it, it happens on, you know, with a program that's gone on for so long, I mean, they'd have some general goals. Um, they, you know, sometimes it would be nice if the goals could be more specific, but that's difficult in the political and in the, in the context. But, uh, you know, so for sediment, they have a goal that's something like to, to uh, maintain or increase sediment, um (Pause) throughout the Colorado River in Grand Canyon for recreational, um, cultural, and biological, or ecological, purposes. So–.

Paul Hirt

00:13:58

And that's recovering sediment that has been lost since the dam was put in, right?

Paul Grams

00:14:02

That would be, uh, I think that would be up to interpretation in reading that.I mean the, the goal is really–they, they've written, they've spent quite a bit of time and it's, it's, uh, "to maintain or increase." So, uh, when it comes to saying, "Do we want to bring back to a, restoring to a pre-dam condition?" that's something that they would, that different stakeholders might have different opinions about. Um, when it– what we try to do on, in those situations is tell them, "Okay, here's what it used to look like here, here's what we have relative to a pre-damned condition." It's up to them to decide whether that's the goal or not. They have not–um, they have not declared that (Pause) I mean, having a pre-dam condition as a goal would be pretty difficult to achieve, and they haven't, they haven't set that goal. Specifically.

Paul Hirt

00:14:52

So some of your work, um, you know, I'm at a university and there's uh, academic freedom in a sense, where I could choose to research anything I wanted to research as long as I could find some financial support. Are you sort of in-between that, where you can choose some of your own research projects and generate the science that you think is valuable, but also you're responsible for helping develop a knowledge base to support decision-making in the Adaptive Management Program? Are you juggling those two together?

Paul Grams

00:15:20

We do juggle those. I mean we are free to um, do research on any–just like an academic, if we can bring in funding for other research, we are free to work on that. And so I, we do have, some of us don't, some of us at, at GCMRC work only in Grand Canyon, and some have some other, a few other outside projects. I have a couple other non-Grand Canyon projects that funding comes in for, and I work on separately from Grand Canyon. So, we are free to do that as, uh, as scientists. Um, within Grand Canyon if we're using, you know, our (Pause) Adaptive Management Program funding, we try to keep it to things that are tied to the program, and are directly relevant, we have a work plan process where we do that.So, within that, if, um, to, I guess maintain some level of (Pause) there are certain things that, you know, we monitor, uh, sandbars in the same way every, every year and we've done it for thirty years. That doesn't create a high-impact journal article publication each year, because it's kind of an ongoing data series of the same thing. So, when it comes to, um, maybe adding a little bit of innovative science to that, we try to bring in new technology at times. So, evaluate different methods to, to monitor what is of interest to the stakeholders, but doing it in new ways, we've evaluated use of, you know, um, the sandbar surveys that we do, um, were started by, uh, the group at Northern Arizona University, in (Pause) the early 1990s, and, using methods at the time, and those have evolved a little bit, um, traditional survey methods. So we've evolved–we've explored, uh, bringing in more modern or (Pause) new technology and things like that. So that's some of the ways we, uh, are doing the work for the Adaptive Management Program, but also keeping it current, and scientifically relevant.

Paul Hirt

00:17:23

Mm-hmm, great. So, um, one last question about the relationship between GCMRC and the Adaptive Management Program, and then I want to drill down into the science of sedimentation a little bit more. [P.G.: Okay.] What is your sense of what the relationship is, and I know it's changed over time, you've only been here since 2008, but how do you see that relationship, besides you're a science provider? Is there anything more you can say about that?

Paul Grams

00:17:56

I think it, I mean it's, it's (Whispers) this is really, um (Pause) we (Pause) beyond being the science provider, um (Pause) I think it's a source of stability for the program. Um, there are–I mean, there are stakeholders that have been around for a long time, um, and there are new stakeholders. Um, and so it kind of brings back to that–kind of comes back to that education side of it, I mean we–that's one thing I try to keep in mind now. I think when I started twelve years ago, a majority of the stakeholders were people who had been involved in the program since the beginning. And uh (Pause) so maybe the education aspect wasn't quite the same then. But we're in a stage now where a lot of the original stakeholders, there's a lot of turnover, people retiring, new people coming in. So I think, uh, providing that kind of continuity and education to make it possible for new stakeholders, or ones that are less familiar and have, probably have less time to actually come up to speed, you know, don't– we now have a, I mean, if you added up the publications and the, the amount of literature and what's been written and (Pause) not written or is in gray literature on the Colorado River and Grand Canyon, there's nobody that could get through that in (Laughs) in ten years, let alone, you know, if they're just starting out as a new stakeholder, it's kind of overwhelming. So I think distilling what's, you know, important to–within each area that we work in for them is, I think, one important thing we provide.

Paul Hirt

00:19:40

Yeah, are there specific documents in which you do that distillation?

Paul Grams

00:19:45

Ah (Pause) you know, that's a good question. I, uh, I mean we do, our work plan is on a three-year cycle, so each time we write a work plan that has, um, some of that in it, I don't know if I can say that it's, uh, if we would write those intentionally with–as a, as a kind of a broad overview, but those are provided in that, in our reports. But no, I, I think it happens when we interact with them, mostly at meetings, and give our presentations on our project updates that we try, I try to do that kind of a thing.

Paul Hirt

00:20:19

I bring that up because a little bit later I'm going to ask you a question about key reports or documents that, um, should be preserved for the historical record that provide, sort of, summaries of important developments or important research, and so, um, keep that in the back of your mind and we'll come back to it a little bit later. Um, so what have we learned about sediment and the Grand Canyon and the role of the dam in shaping, you know, that sediment transport, and sediment load, and sediment deposition since 1991, when you were first down there?

Paul Grams

00:20:53

Oh boy, since 1991. Um, there's been a lot since 1991. At that period it was, uh, just when, um (Pause) there was the push to really, um, constrain dam operations from extreme fluctuations on a daily basis. So, from the 1960s up until 1990, '91, the dam was operated primarily for hydropower generation. So, daily fluctuations from lows of around 5,000 cubic feet per second [cfs] to highs of around 30,000 cubic feet per second on a daily basis. That was, that's probably the extreme range, but I think it typically fluctuated from around five or six [thousand] up to 25,000 cfs, which is very high–the, a pre-dam average flood was around, um, eighty-five or 90,000 cubic feet per second. 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. And so that was a source of (Pause) a mechanism of sand erosion. I mean, the sand bar deposits are inherently unstable, but the dam did two things, it, uh, it blocked all upstream sediment from the whole Colorado River Basin from entering Grand Canyon, and then it changed the flow regime. And so those two things resulted in erosion with the, the clear water, high fluctuating flows, but then the lack of replenishment, because the Upper [Colorado River] Basin, um, sediment, uh, delivery was gone. So those two things contribute to a big decline in sandbars, and in the '90s, that was the point at which they had seen that. They had seen the potential, um, by the, there was a, uh, unintentional floods that occurred in 1983 and '84, and they saw, wow, even in this, in a system that's been so (Pause) impacted, the sandbars could recover, because those floods did build sandbars on the banks of the river, and they saw that. And then they saw that they were eroding again.

Paul Grams

00:23:12

And so I think that sparked the idea with, uh, the sediment– senior sediment scientists at the time, you know, Jack Schmidt, Ned Andrews, um, Bob Webb, uh (Pause) I'm sure others, Tim

Randall at the Bureau of Reclamation, I think, was involved. Um, I was a, I was an undergraduate student so, I was sitting at the outside ring of the campfire when they were having those discussions on that river trip in, in, uh, 1991, about, well, what would, if we did a, um, an intentional flood release from the dam. Would that do the same thing as those floods in the 1980s? And so that was, I think that was a big turning point, was just the (Pause) the idea, and the follow-through that happened at that time, to, to give it a try with that first experimental flood that they did in 1996. So it, I think that idea came about, and I'm sure if you've, uh, you'd need to check with some of those guys on ex–when, exactly, they came up with the idea, but it was around that time and then, um, it took a few years for it to gain traction and to get the (Pause) the political will to do it behind it. But, by the time that happened in 1996, that was a big turning point then, and (Pause) and, uh, that provided the demonstration that yes, you could use the dam to raise the river to build sandbars. Because the real problem with the, the situation with the sandbars are those two things, the lack of a flood to build them, and then you need the supply to do it. So there's just, 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. And those are the two things we study is, what is (Pause) what the floods do, what the flows do to building the bars, but then is there enough supply of the sand such that those floods can actually do it? Because if there isn't enough supply, then the floods will eventually cause net erosion. If there's enough background storage that uh, you could do a few of these floods, and expect them to build sandbars. It's kind of like a deficit spending situation, are you (Pause) are you using that last bit in your bank account to build some sandbars, and then going to run out? Or are you, can–do you have a, auto-deposit system going that's putting sand back in. So.

Paul Hirt

00:25:42

Now, you mentioned, um, 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. Not too many. Would you explain what and where they are, and a little bit about how you monitor those to determine when a High Flow Experiment is appropriate?

Paul Grams

00:26:06

Yeah. Um, you know, and that, those are critical. And that's, and that is what makes it possible to do this in Grand Canyon, to manage the system for both the hydropower interests and for sandbars and for recreational interests, is that we have tributaries that do supply a lot of sediment.And the first of those is the Paria River. Um, it drains a big, big portion of Southern Utah. It comes into the Colorado River just at Lees Ferry, about fifteen miles downstream from Glen Canyon Dam. So, really relatively soon, down–near downstream from the dam, is a tributary that supplies a lot of sediment. Um, not a lot in context to what the pre-dam average loads were, something on the order of maybe five-ish percent [P.H.: Wow] of what would have gone by Lees Ferry, uh, without the dam, is what the Paria delivers on average. But the, but because it's just one tributary you're dealing with, you know, the, and (Pause) and its sediment delivery events are triggered by very unpredictable, uh, summer monsoon-type thunderstorm events. So, when that sediment comes in, it's predictable in the sense that it happens in the late summer, early fall, sometime July through September each year. But you have years when nothing happens and–which occurred last year. And then you have years that you get a lot of, uh, monsoonal activity and a lot of thunderstorms and a lot of sediment delivery. Um, but that's the source of sediment, the source of resupply, the (Pause) the replenishment of the bank account, the sediment bank account that allows us to, um, use flood releases from the dam to rebuild sandbars.

Paul Grams

00:27:56

And, uh, the way we do it is by (Pause) measuring, uh, the stream flow, and sediment concentrations, on the Paria River. So, it's a river that almost dries up, it's usually got a little bit of a trickle of water in it, but when a flood happens and we know when a flood's happening by, simply by watching the weather or we have upstream gauges that tell us when the flood's coming downstream, but when we know of flood's coming downstream, um, a team of hydrologists from this office get in their trucks and drive out to Lees Ferry, and start sampling. And they measure the, the flow and the sediment concentrations. And then we start analyzing those data, and (Pause) calculating how much sediment is coming in from the Paria River. And we do that every year. And um, and then, this (Pause) process is written up into a protocol that is a document produced by the Bureau of Reclamation for how the controlled floods will be designed.And so we monitor those sediment inputs, and once we've gotten a few, we, um, the data get published, they actually go to our website. Um, but they also go to the Bureau of Reclamation and then they use those data in a model that es–that predicts, given that amount of sediment, what will happen to that sediment with or without a high flow. Um, the idea here isn't–it, this is all, I think the banking–the bank account analogy is the correct one, because what we're trying to do is keep the sediment bank account in, um, Marble Canyon, which is the reach of the river between Lees Ferry and sixty miles downstream where the next major tributary comes in, and I'll, can talk about that more in a minute, but we're focused mainly on the Paria River. We try to keep the sediment bank account in that reach, on an annual basis, to be balanced, to–so that what goes in is about the same as what goes out. And what goes in is the sediment from the Paria River and what goes out is what the Colorado River transport out, downstream, sixty miles downstream from where the Paria River comes in. And we measure that as well. We have a measurement program that measures that. But we also have models that can predict how much will go out at the downstream end.

Paul Grams

00:30:24

And so once we have, uh, some data on how much sediment has come in from the Paria River, so maybe the Paria River has, uh, some storms in August and we get some data on that, by the end of August and early September. We give that data to the Bureau of Reclamation, and they run this model and say, "Okay, we've had, um, 500,000 tons of sand come in from the Paria River. If we do normal dam operations, no High F–no flood, um, about a hundred thousand tons of that sand will go out. That means there's four hundred thousand tons left in the bank account to work with." So then they re-run the model putting in a flood. And they put in a flood, and the protocol that they've written allows for a flood to be up to (Pause) is it sixty or ninety-six hours? I can't remember. One of those two. A certain duration at the capacity of the power plant plus the bypass tubes. So that gets us to about forty-four to 45,000 cubic feet per second, um, flow rate that they could release from the dam for a flood. So they run a model with that flood, 45,000 cfs for sixty hours, and then see what happens to the bank account of sediment. And if that causes all the sediment to go out and drive it negative, they decide that flood's too big. And they rerun the model with the smaller flood. But if that model predicts, "Gee, you can run that big flood and the balance is at zero or above," they say, "Well that's it. We can do it." And then that's what they schedule for the fall.

Paul Hirt

00:32:05

So there's a High Flow Experimental, um, flood each fall, depending on whether the sediment is there for it?

Paul Grams

00:32:12

Exactly. Just following that, that step-by-step process, if there’s enough sediment from the Paria that you can run a flood but keep your Marble Canyon sand bank account balance above zero, you can do it.

Paul Hirt

00:32:26

All right.

Paul Grams

00:32:27

Um, if it drives it negative, you reduce the size of that flood to a minimum of, I think, twenty-four hours, and at power plant capacity. So they run this model iteratively with progressively smaller floods, to find the one that fits. And if nothing fits, then they don’t do one at all. And that’s what happened last year, that the sediment inputs were so low that, I don’t even know if they bothered (Pause) they probably ran the model and, but (Pause) the balance was already negative without even having a flood, so. And that’s what happens if you don’t have any Paria sediment inputs.

Paul Hirt

00:33:00

So do you think, before you turn to the Little Colorado River, because I know that’s your next example, um, do you think that, um, 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? I mean, how close to predicting, you know, the outcome that you want are the models working?

Paul Grams

00:33:26

The models ah– this is the, this main model is a model written by, uh (Pause) Scott Wright, who worked, he's still a USGS employee, but he worked at, uh, GCMRC up until just before I left. Um, now he's with the California Water Science Center, and, [written] by Scott, and Dave Topping, who is still here. And um, it's a, it's a model for predicting sand transport in the river based on, uh, the sediment supply conditions and flow rate, and it works pretty well. And so, when we test the model performance by redo–in this scenario, the predictive mode, but then we can, after we've actually done the flood and everything, we can compare the measurements, the field data and do a (Pause) do an after-the-fact assessment of how the model performed, predicted relative to what actually happened. And, um, when we've done those comparisons, the model predictions tend to be off by a little bit, but on the order of 10, 15, 20 percent or something. Um, which with the, the objectives of this, you know, the model isn't designed and doesn't predict what happens to each individual sandbar. It's not designed to do that, and it doesn't do that. But what it does do is predict this, predict what's going to happen to the sediment bank account. And it does that closely enough that we can use it as this management tool. So, um, I mean, and I think it's a good example of where the science really has produced something for man–for the managers at a useful scale. I mean, people, at the same time, have spent efforts–have not–spent quite a bit of effort trying to do much more precise and finely resolved models. That maybe would predict what every sandbar does. But those never got finished (Laughs) because they're very complicated, very finicky and difficult to–difficult. Um, and required a lot of, lot of input data, and constant evaluation. Whereas this model is pretty robust, quite simple. Um, and it does what the, what the managers really need, which is a tool to, to tell them, you know, whether or not to do a flood and about how big it should be. And if it's off by a few percent, it doesn't matter that much. And it, and it looks like it's been off in the realm where they tend to be a little more conservative, which is good. That the models predicted maybe a little more erosion that has ended–than what has ended up happening. So our (Pause) sediment balance ends up being a little bit positive.

Paul Hirt

00:36:04

Which is better [Unintelligible].

Paul Grams

00:36:05

So it's erring on the side of, of holding back a little bit.

Paul Hirt

00:36:09

So the second tributary (Laughter) that, uh, contributes sediment?

Paul Grams

00:36:14

Is the Little Colorado River. Um, and that is about, uh, sixty miles downstream from Lees Ferry. It, uh (Pause) at the time, and that's been, that's something we're learning a lot about right now, and, um, uh, a couple of my colleagues here have recently completed a study of the Little Colorado River Basin, to better understand what's gone on in that river basin, but, um (Pause) it was considered to be about equal in si–in the amount of sediment delivery to the Paria River. Um, it's looking like recently the amount of sediment contributed by the Little Colorado River has declined, um, is less, and uh, and it's also less predictable. It's a little bit, um, the monsoon storms, although they happen in the Little Colorado River Basin, a lot of those storms don't, they don't necessarily all make it down to the mouth, delivering sediment to the Colorado River. Um, and so as a supplier of sediment, it's a little less reliable now than the, than the upstream Paria River is. Um, and because of its location further downstream, um, we've focused management on the Paria River and the upstream reach, because it's the reach in the greatest amount of sediment deficit. And because the system's large, it's also a bit of, okay, we need to constrain–confine the problem a little bit to make it manageable. And that's been, sort of, the manageable thing is to tackle, to run the protocol around the Paria River and Marble Canyon. And then we monitor the effects for the whole system. So we, there's a bit of um (Pause) manage it for the, for the upstream segment and then (Pause) monitoring downstream, hoping that it can, it performs well down there, too.

Paul Hirt

00:38:06

So, when we have a high flow event, you get both erosion and deposition, depending on what kind of flow there is, how much sediment there is, where, you know, which beach we're talking about, which reach. Um, and your goal as I understand it, then, in designing these HFEs, High Flow Experiments, is to maximize the deposition to do Beach Building Flows, as they used to be called, and minimize beach erosion, because you're trying to build sediment on the shore, on the beaches. Um, there's, a number of the people that we've interviewed have suggested that the HFEs are not working, and there's as much erosion or more than sediment. I think it's probably changed over time and you're the expert who can probably answer that question for us. Have, have you gotten better at being able to figure out how to make the HFEs deposit more than, than they erode? (Pause).

Paul Grams

00:39:07

Well, we can't control what they do. Um (Laughs). [P.H.: Right.] You open the dam, uh, but what the, the reality is, I mean the HFE–every time we've done one they have resulted in more deposition of sandbars than erosion. So the HFEs themselves do cause sandbar deposition.Um, they're–.

Paul Hirt

00:39:34

In the upper reach, I assume you're talking about–you mean the whole river?

Paul Grams

00:39:36

I actually, no, the whole river.

Paul Hirt

00:39:37

Whole river.

Paul Grams

00:39:38

And we've seen this now, we've, we've done enough of them that, um, there may be sites that get smaller, but by and large, probably two thirds of the sites we monitor, at least, get larger with H–each HFE. Um, a few get smaller, but that would be a pretty small percentage, and a few don't change much. Uh, but most of them, uh, get bigger.I think what (Pause) what a lot of people see and what we, you know, honestly do have to, we do tell them, is that a lot of these, the bars then begin eroding again immediately. Um, or, or within several months. Um, so that by the time you're, maybe a year later, uh, a lot of the sites are back to where they started. Um, and so (Pause) that is, uh, (Pause) really part of the process. I mean, these are (Pause) unstable sandbars in a, in a river with fluctuating flows, in a river that's constantly changing. Um, in the pre-dam system, the bars weren't stable, they would be, the river would deposit huge sandbars and they'd erode. Um, I think, in some sense, the objective is for the bars to erode. Um, if you didn't intend for the bar to erode, there's no point in, in building them.I mean, it's a dynamic system, and the erosion is part of the process that, I think, we should be managing for. Um (Pause) because, without the erosion, then they become locked in and stable, and so one of the other issues that's going on, and you've probably talked to people about it, is the vegetation encroachment. Well, some of these bars that are the most active, which means that they get big and then they erode, those are bars where the vegetation hasn't become established, and can be large sandbars. And, so another way to look at it is, by doing the HFEs, we have bars that are larger for (Pause) 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. Um, and that we have to recognize that we're managing for a dynamic system, and not a static, like, the bars are perfect and they will be this way all the time. Ahh.

Paul Hirt

00:41:56

That's an excellent explanation (Grams laughs), I appreciate that. Yeah. We had a recent interview with somebody who was suggesting that, um, the beaches haven't changed that much, and once you create a beach, it'll be there for a hundred years. And that was different than anything I'd ever heard from anybody else before.Um, does, does the research support that assertion, or not?

Paul Grams

00:42:19

Well, you know, and (Pause) the dam has helped with that. There are things that have been there for a hundred years now, because the dam doesn't, the flows don't get high enough to erode them. [P.H.: To erode them] So, but we're not going to build those beaches either, because the dam doesn't get high enough to build it.

Paul Hirt

00:42:37

You mean, the floods don't get high to build them.

Paul Grams

00:42:38

Right. The floods, I'm sorry, yeah. The floods don't get–the floods released from the dam don't get high enough to build bars that would be up high. So, there are portions of sandbars now that are completely overgrown with vegetation, locked in place, and will not change unless, you know, all hell breaks loose and, and we get snow all winter and, and they fill the reservoir and have to release, you know, floods like they did in the 1980s. [P.H.: Right] Um, but until that happens, there are things that won't change. Um, so what we're managing with the HFEs are a portion of the sandbars that are dynamic, that do change.

Paul Hirt

00:43:17

Great.

Paul Grams

00:43:17

Um, and those, uh, the ones that are static, that the HFEs don't affect, tend to be the ones that are stabilized by vegetation. And, then there are the portions that are, um, the active bars that the HFEs do rebuild. Um, you know, one of the other things I, you know, remi–that I point out when we're talking about what the HFEs do on the sandbars, is that a lot of the places are affected by smaller-scale processes, like, uh, hillslope runoff, that are, that cuts gullies across the sandbars. Um (Pause) even small tributaries that form and erode a big gully in some of the campsites and sandbars. And then the HFEs can come along and repair those gullies and fill it in and, basically, create a new sandbar that might not be all that much bigger than the bar that was there before, but it's been, essentially (Pause) renovated.

Paul Hirt

00:44:13

One of the other, um, complaints we've heard from people we've interviewed, um, in, uh, involve, um, the fact that the HFEs are bringing a lot of sediment from the riverbed itself farther to–down to the lower river, and where it gets close to Lake Mead and the flow is slower, it drops that sediment. And so places like Diamond Creek, where the Hualapai Tribe has a river running operation, they're talking about sediment, you know, making it difficult for their business operations.

Paul Grams

00:44:48

Right, right.

Paul Hirt

00:44:49

Um (Pause) is there truth to the argument that the HFEs are causing problems for people in the lower river, and what might be done about that?

Paul Grams

00:45:01

Well, we could, I mean that, um, so what–I think what's going on with that, is that the (Pause) they are in the part of the river, this is essentially the part of the river that has sometimes been underwater in Lake Mead. So it's the transition from the Colorado River to Lake Mead. So it's the segment of the canyon that has the opposite problem from most of Grand Canyon. [P.H.: Right] Most of Grand Canyon is in sediment deficit, because, as I said, the dam blocks 90 percent of what was (Pause) entered before the dam was built. And so it's a condition of, of lack of sediment. Well, the sediment that we do have, is going downstream, and all of it goes to Lake Mead. And so they're in the, they're in the realm, uh, the zone of sediment deficit, that area is, essentially, a river delta. So it's in aggradi–aggrading system and um, all the flows transport the sediment downstream. Um, one thing we've seen, when we look at the years with and without HFEs, it, it doesn't really matter whether or not we do an HFE–or the, the, uh, an HFE doesn't really affect the total amount of sediment that goes past, um, say, Diamond Creek, which is our downstream gauging station, which is um, you know, two hundred and twenty-five miles downstream from Lees Ferry, about thirty, or maybe thirty, forty miles upstream from the, from the reach of maybe sediment accumulation that the Hualapai are concerned about. But, about the same amount of sediment goes past that point, whether or not we do an HFE.Because what the HFE does, it doesn't, it doesn't really change the total amount of sediment that gets carried downstream, it changes the timing of when that occurs. Um, because the Paria's deliver a lot of sediment, it's relatively fine, it accumulates on the bed of the river. And then we do an HFE, and that picks up the sediment, and deposits and sandbars, and moves them downstream.

Paul Grams

00:47:05

And it also coarsens the, the bed of the river at the same time. So as that sediment is (Pause) picked up in the high flows, they coarsen the bed of the river, so then after an HFE, you get relatively lower transport rates than before. [P.H.: Ohh] If you don't do an HFE, you've still got all that fine sediment there, but w–then we go into the winter season of high power plant operations to generate electricity, and so those high fluctuating flows, instead, they transport the sand downstream. So, whether we do an HFE to move the sand, or do high power plant operations in the winter, the sand's going to go downstream, and it's going to go to Lake Mead either way. So, it's not so much a question of the volume that's going into this reach where they're having the navigation issues, it's the timing, and the flows, that cause its redistribution. And so, (Pause) so it doesn't mean that they don't have a– that there isn't a problem there, and HFEs could have a role in determining the–or the, the relative distribution of that sediment. Um, it's possible that the HFEs make it better than it would be without the HFEs. Um, it could be even worse. Um, and so that is something we (Pause) haven't studied in detail down there, but it's something that I actually, uh, proposed a project in the last work plan to work on this issue, but the budgets were tight and that one didn't quite get through. We'll put it again this time. But, um, the idea there would be to look at, at how, um, the sediment in that reach, how the distribution of the sediment is affected by different dam operations. Um, there is a problem there, because it is going to be a zone of sediment accu– just like the upstream reaches is a zone of deficit no matter what we do, there's a zone of sediment accumulation no matter what we do. Um, and it's not just affected by, um, by dam operations. It's also affected by the fact that it's, it's cutting down into the former Lake Mead delta. You know, the, Lake Mead has now dropped a lot. And so the river is, is (Pause) incising into the, uh (Pause)–.

Paul Hirt

00:49:27

Accumulation of sediment.

Paul Grams

00:49:28

The accumulated sediment, so, um (Pause) yeah. It's a difficult problem, um, in terms of (Pause) of how to, whether or not it's even possible to, to (Pause) find, uh, an operation scenario that would help create them, uh, help create their nav–improve their navigation channel, is really what it's about. It's, it's tricky, you know. These are the things that engineers deal with on the big rivers, where they're trying to get barges upstream and downstream, but they end up doing things like building a, building wing dikes and groynes and things that, that, that concentrate the stream flow into the center of a river channel. But those are big engineering works. But those are the, those are the kinds of things that are done to deal with those problems.

Paul Hirt

00:50:13

I did a river trip through Grand Canyon last year, my very first one, last summer, we went all the way to, um, was that Hayden Ferry, or some–.

Paul Grams

00:50:22

Pearce Ferry.

Paul Hirt

00:50:22

Pearce Ferry, right. And, um, it was rather eerie floating through that stretch below Diamond Creek and above Pearce Ferry where you're incised down in, in the river beneath these giant plateaus of sediment that are constantly, um, falling into the river. And there was a, one point, when we were floating through this stretch of river and the plateau of sediment was probably a couple of hundred feet high, and a, a wind, a gust of wind, set off a collapse of a piece of it. And, and more and more, it's like a, uh, an avalanche of snow on a steep mountain slope. [P.G.: Yeah] It just came pouring down and hit the water and sent a, a blast of dusty water and wind across the river, right into one of our boats. It was, um, it was dangerous!

Paul Grams

00:51:14

And you saw–and you were there on one trip, in one year, and saw that. And I've, when I've been down there, I've seen that. So that's something that is happening constantly and so, uh, it's, it's entirely possible that the amount of sediment, uh, falling into the river off of those high cut banks from the form– that was the bed of Lake Mead–.

Paul Hirt

00:51:34

Former Lake Mead, right.

Paul Grams

00:51:35

Um, is (Pause) is an equal contributor to the, to the navigation problem down there.

Paul Hirt

00:51:43

Yeah. We actually got stuck at one point. We couldn't figure out which way to get around. There was a–.

Paul Grams

00:51:47

And that, that–.

Paul Hirt

00:51:47

Very wide river and a big sandbar. We didn't know whether to go ahead. We took the wrong path and we had to drag our, our raft.

Paul Grams

00:51:53

And that's the problem that they're talking about. So it's a legitimate pr–it's a serious problem that they have. Um, it's not going to be a, an easy solution.

Paul Hirt

00:52:02

Yeah. So, were you part of the effort to create that phenomenal website that USGS has, that shows before and after pictures from the High Flow Experiments? There's a website that USGS has, did you help to develop that, and can you tell us a little bit about that?

Paul Grams

00:52:20

Well, thanks (Laughs). Yeah, no, that's, that's our website. Um, uh, I can't take credit for doing the technical side, but that's my project in terms of, of the, collecting those images and making it happen, getting them on there. That's one of the things that my project does. And so, um (Pause) where that came about was, um, actually when I first started, uh (Pause) um, there's a long history of using cameras at our, uh, monitoring sites. That goes back to the early days when they were first starting these sites in the 1990s, the scientists at the time recognized pretty quickly that they were collecting data (Pause) you know, even if they were doing trips. A couple, you know, there were years when they were doing several river trips a few months apart, but even, even with that level of frequency visiting monitoring sites, they recognized a lot was happening when they weren't there. And so they put up, at that time, it was, um, analog, old film cameras [P.H.: Right], just, just handheld, uh, um, small, um, little point-and-shoot film cameras that had a intervalometer that they could put on them, that would, I think the most they could do is set the intervalometer to take a picture every twenty-four hours. Set it up in a, they put it in a little ammo cam with a window and hit "go." Whatever time they did it was when it took the first picture, and then twenty-four hours thereafter till the roll of film was gone. So they would at least get something, they'd, maybe, they would get, uh, twenty-four days or, if they had, uh, thirty- six days' worth of, of images from a site. And they, they kept those going on and off from, in the 1990s and 2000s. And then by–when I started in 2008, uh, a colleague in, um, a different, uh, USGS branch here, had developed a, uh, a digital system. And we started putting those in in, uh, 2008 for the 2008 High Flow Experiment. And, uh, they worked great, were very reliable. So we decided to, um, put them at every, all of our monitoring sites, so it–.

Paul Hirt

00:54:28

And you can, you get hundreds and hundreds of pictures, with one of those (speaking simultaneously).

Paul Grams

00:54:30

Yep. So between 2008 and 2012 is when we expanded to putting–getting one at every one of our sites, and we program them to take, um, actually where they're taking five pictures a day, because we want to get, um, well because, memory card space now is, is cheap, so why not take enough pictures? And then by doing that we get a range of flows and lighting conditions. So then we can pick from the photos it takes, which ones have the best combination of river flow level and lighting. And then we pick the one–from those, we pick some and put on the website for seeing what the HFEs do.

Paul Hirt

00:55:09

Our younger readers are probably going to want to know what we mean by "roll of film" (laughter). Um, how could somebody find that, uh, what's the easiest way for somebody to find that website? Because it really is remarkable. You can look at these different beaches, and you get a picture before the High Flow Experiment, and then during, and then after. And really see how those flows alter, uh, the morphology of the river.

Paul Grams

00:55:34

Yeah.It’s just on our website, www dot GCMRC dot gov slash sandbar [www.gcmrc.gov/sandbar].

Paul Hirt

00:55:52

Slash sandbar. (Grams laughs.) Okay.

Paul Grams

00:55:43

It’s a redirect now. I don’t think it’s, that’s the actual site, they’ve changed– the government has kicked us around a bit in terms of how our websites are set up, but that still works.

Paul Hirt

00:55:52

Yeah.I would like to get a permanent link for that, um, to link to our website, because that’s something that I dreamed of doing. Because I love re- photography. It’s one of my most interesting ways of documenting change over time, is re-photography. My colleague at ASU, Mark Klett, did some of the best and most interesting re-photography work on the Grand Canyon decades ago. And when I saw what you guys had done, I thought, “Okay, well I don’t have to do that now.” It’s really a remarkable resource, so thank you for putting it together.

Paul Grams

00:56:22

Yeah. And uh, no, thanks for that. And, um, we also, in addition to just those paired or the ser–the time series photos at each site, we also have a site, um, uh, kind of a collaborative effort with the Grand Canyon River Guides association. So, they started a program back, I think they started it with the 1996, uh, controlled flood, and they call it the Adopt-a-Beach program, and this is where, um, river guides volunteer to take a camera and take repeat pictures of, of, of their favorite campsite or beach. And they do it throughout a season. And then we put those, we also put those photos on a website, they're not (Pause) they're not–like, our remote cameras are at fixed locations, so there are perfect matches from one to the next. [P.H.: Right] These are more, you know, the guide gets–picks a spot and takes a photo there and kind of approximately–.

Paul Hirt

00:57:12

Next year that spot's underwater, so–.

Paul Grams

00:57:14

Yeah, so there, but they show the same sites, and so the, that's also on our website to look at.

Paul Hirt

00:57:19

Great, great (Pause). Alright. Well, um, again, historians like to think about and evaluate change over time. And, um, so that's what I want to turn to for a minute, and ask you to reflect on how sediment research has changed over time. You've talked about what we do now and how we've perfected those processes to better predict outcomes, but can you give us a little historical sense if you can, about, you know, the questions we were asking early on versus the questions we're asking today, and what we've learned.

Paul Grams

00:57:58

Um… (Long pause) well I think what we've (Pause) a lot of the questions are similar. Um, but what we–I think we've learned about, um, you know, like I said, the, the basics of the, the sandbar management on one level are pretty simple, in the sense of it's the, it's, it's needing the flows to build a sandbar, and then it's–what's the supply condition? So, a big part of the initial focus was guessing what the supply condition was. What we do now is we actually measure it, and we're setting ourselves up to actually know what the supply condition is. So it's kind of the, the scientists working on this, um, when we first started, they recognized what the most important thing was, and that is how much sand is there, and, and then what does it take to use it to build sandbars and keep it there. But what we do now is we–but they had to rely on extremely sparse measurements and, um, essentially very simple modeling prediction guesses of what the supply conditions were. And their, their predictions varied greatly from the sand, you know, sand—"the sand's just accumulating on the bed of the river and we just need to run floods, and we'll be fine." Um, to underst–then, there is, then going the opposite direction, saying, "No, no, no, there's a downward spiral and there's almost no sand left, and the system is about to be completely reamed out." And I think what we've learned now is that there's a potential–at least under the conditions we've seen, so by, by going from the–or implementing this, um, this high flow protocol period, where we do the repeat high flows, we got pretty lucky in the timing of things. And we'll see how luck carries us into the future.

Paul Grams

00:59:53

But the luck we had is that, since 2012 when this started, we have had most years with good amounts of sand inputs from the Paria River, (Pause) um, average or above. And we have had approximately average dam release volumes. So those two things are the two key ingredients to what happens to the sand supply. You get–if dam release volumes are high, we get a lot of export. And that happened one–that happened in 2011, but since 2011, the release volumes have been at about an average amount that has allowed sand to either be maintained in the system or accumulate. So what I think we've really learned is that–and now that we can actually measure the sand budget, and we measure it by, are our measurements of sand transport in the river. And we measure it by actually going out and mapping the bed of the river, and then repeating that map of the bed of the river at a second point in time and looking at the difference and seeing how much has the bed of the river changed, and has the s– the sand storage supply in the bed of the river changed. And (Pause) so when, uh, twenty, thirty years ago, they were kind of assuming or guessing what the sand storage would do when we had a flood, or under different scenarios of annual volumes and tributary inputs, we're now in a position to actually measure what the bed of the river does, and see how that plays out. Um, and what we've seen is that it's in an approximate balance, under these conditions. So I think the, there was a big, you know, the, I mean, you, you asked about major turning points, I think, you know, that '96 flood was an–and what led up to it, was one major turning point.

Paul Grams

01:01:51

I think the next one was the recognition and then the, uh, the implementation of the idea of doing repeat high flows, which happened with the, the HFE protocol, which was implemented in 2012. So the idea that, instead of these high flows being, being ex–being one-off experiments that we did once in a while, it was turned into a, uh, an experiment that involved (Pause) doing it repeatedly year after year. And they called it a HFE, High Flow Experiment protocol. Th–um, and so it's not, uh, but the experiment isn't what each HFE does. The experiment is, what happens if we do this for ten or twenty years. [P.H.: Ahh.] And so that's what we're in the middle of, and, at this point in it, what I think we're learning is that if the conditions are right, it basically works. Um, but it's kind of a teeter-totter balance of, right now we're, uh (Pause) in this position where the inputs and the flow volumes have allowed it to work a–almost exactly as intended, as designed. Um, and so what the future holds is, really, it–it's almost, you get different answers, and I think it's more of a (Pause) um, almost a (Pause) a personal or a (Pause) it, the answer you get might reflect more on that person's disposition than on any basis in–because somebody who tends to be a little bit of a pessimist will say, "Look, we're, we're hinging this all on continued average inputs and bel–above average inputs, and, uh, average or below dam releases. Well, that's not likely. So the system is doomed," is one perspective. Because how can it, how can we have above average inputs and below average dam releases? Um, the, the flip side is, "Well, it's worked for close to ten years now, and so maybe, maybe these are the average conditions that we're going to have." Um, so really, the–and so that's kind of the big mystery, is what will happen with, you know, we've got expectations of what, what's the, (Pause) uh, the idea that, uh (Pause) flows will be average or below average might not be that ridiculous, because (Pause) predictions for the basin are for low runoff with climate change. [P.H.: Mm-hmm.] But, um, uh, what else scientifically is–let's see–.

Paul Hirt

01:04:28

Is there anything else that we need to know? I mean, you sound, it was really interesting to hear you say at the very beginning when people started proposing these High Flow, um, events, Experiments, um, they were guessing at what the results might be and didn't have the data to actually say, "Here's the likely outcome, based on what we've measured before," so you had to spend years and years and years, advocating for something that was a guess, and then monitoring the outcomes to refine your predictions and models to the point where now you're saying, after, maybe, I don't know, what is this, uh, twenty years–.

Paul Grams

01:05:05

Mm hmm.

Paul Hirt

01:05:05

Of experiments, now you're saying the model is pretty robust. Um, it has only about 15 percent error in it, for the most part it's been working well for ten years, and we get the outcome we're looking for every time we do this [P.G.: Right] because we've been able to refine what we know, and how to manage these things. That's pretty great. So somebody might say, "Well, have we learned everything we need to learn?"

Paul Grams

01:05:31

Uh, have we learned everything we need to learn.

Paul Hirt

01:05:33

Can we stop studying sediment now and move on to something else?

Paul Grams

01:05:37

You know, it depends on what they, what their next, what their objective is [P.H.: mm-hmm], really. I mean, if, uh, we were comfortable with, um, (Pause) if we're comfortable with everything as they are, and are confident in (Pause) in what the Paria River's going to do in the future, or what the, um (Pause) river flows would be, that, that might be an argument. Um, I don't, you know, I mean, what–part of what the program is interested in is, is monitoring, you know, the (Pause) results into the future.

Paul Hirt

01:06:08

Grand Canyon Monitoring and Research Center (speaking simultaneously).

Paul Grams

01:06:10

Yeah, so. So there's that aspect of it is like, it's keeping track of what the system is doing and continuing to verify that things are happening. Um (Pause) so–.

Paul Hirt

01:06:21

Are there any big questions or knowledge gaps in, in, uh, sediment flow that, um, you wish we could throw some money at to understand better?

Paul Grams

01:06:29

Well, there's, uh, probably, um (Pause) uh, the (Pause) the areas that we are working in on that are, the–you mentioned the issue of, of navigation downstream, so that's one area where there's kind of a resource or a, or a, I guess a management problem or issue that they're interested in that we don't really understand or– And so that would be an area of research to do to, to learn something new about how the system's working, that might be of interest. Um, in terms of the, um, the sandbars themselves, uh, one thing we've been looking at, or continue to look at is interactions between the sandbars and vegetation. So, the role that different vegetation types play in either, uh, essentially, accelerating sandbar deposition or, or sandbar stabilization. So, if they, um, and that could be applied towards management if they want to start removing vegetation, or changing the vegetation community in some way to improve the, or change the way the sandbars look or change how people can use the sandbars is one thing. Um, the other thing that's come up that's of interest is, uh, and is, I guess in th–that would maybe be in the realm of fine-tuning how the HFEs work is, is whether we can, uh (Pause) by using HFEs of different magnitudes, we can cause deposition to occur in different places. And that's a, um–or whether by changing the shape of the HFE hydrographs, if you look, if you go to our website and look at the HFE, um, hydrographs, the flow releases from the dam, they all have a pretty similar shape where the water goes straight up, you know, they increase the releases very quickly, it's flat at the peak of the HFE, and then they turn it off and it's, essentially, straight down. And, um, so there's questions about whether if we had different, uh, rates of, like, downramp rate, so lowered the releases slower, could we have bars that had a different shape? So, some of the river guides are interested in bars that might have a lower slope or something like that.

Paul Grams

01:08:52

Um, what's another thing? Um, the other thing that there, uh, is, is in terms of, um, the (Pause) um, scientifically, there's quite, a (Pause) quite a bit we could still understand about, there are, um, I think you mentioned earlier that, you know, there are (Pause) the HFEs don't cause every sandbar to respond the same, so there are some bars there, there are some bars that erode with HFEs or under different conditions, while some build. And we don't, we still don't, um (Pause) understand exactly why that is, for some sites. We know it has something to do with the channel conditions probably, or the hydraulics being different at different sites. And so scientifically, that's something we're looking at and trying to explain why some eddies, some sandbar areas, some eddies where the sandbars occur, behave differently than others. Um, and I think that can help with management. I think, uh, it's, you know, I think it's, it's at, uh, a finer level than, than just: okay, we've got the HFE protocol that generally builds sandbars. Now we're going to look at how we can optimize it or, or what we could do to improve, more broadly improve conditions. So those are some of the other things we're looking at. Um, but when it comes to, um, we're going to be starting working on our, writing up our new (Pause) next three-year work plan in the next few months here, and so our project will, you know, we've got our, our regular sandbar monitoring, which is seeing what each HFE does and what the long-term trends are at the sandbar monitoring sites. And that involves surveying the sites and collecting those photos. So that, um (Pause) is primarily a monitoring effort. And then we do these repeat maps of the riverbed, which is, you know, okay, over the long terms, are we maintaining the sand, the sand mass balance? And that is contributing to really determining whether or not, uh, what is, what are the chances that they can keep doing this, um, using the HFE protocol, um, successfully, or whether they should be doing floods more frequently. You know, if sand's accumulating and things that it's possible to show, well you actually have plenty of (Pause) degrees of freedom here and you could be doing floods more liberally, or you should hold back, because the sand is, is (Pause) supply is diminishing, which means, not just holding back on HFEs but considering what other operations might be needed to maintain sand storage, if that's what they want to do.

Paul Hirt

01:11:36

I'm glad you mentioned that riverbed mapping. That's one of the things that Jen and I, um, found when looking at some of your, uh, previous, uh, published research. Um, could you talk briefly about how you map the, s–you know, subsurface of the water, the riverbed itself, which is, you know, several feet to twenty or thirty feet below the surface. You can't see it, when you're floating down the river, you can't see the riverbed [P.G.: Right], for the most part. Um, but we need to know how much sediment is down there and, and where it's deposited. And so you've, um, helped to sort of innovate ways of mapping the sediment. And you said earlier in our interview, that it's like 80 percent or more of the sediment in the river is underwater in the river channel.

Paul Grams

01:12:25

Yeah. 80 to 90 percent.

Paul Hirt

01:12:26

Eighty or ninety percent (Speaking simultaneously).

Paul Grams

01:12:26

Of, of the sediment that's moved by the, I mean [P.H.: mm-hmm], it takes the water to move it, so the sediment that water is moving is underwater by definition. And so it's only that little bit between, you know (Pause) if you happen to be on the river when it's flowing at 10,000 cubic feet per second, it's only that bit between, that, where the water, the river gets at ten thousand and up to maybe the high flow stage of thirty-five to forty thousand. So there's, there's that window there of where the sediment gets deposited by the high flows, but that's a small slice of the sand in the system that, most of the sediment is in, um, there's deep pools in the center of the channel, and then there's deep pools in the eddies. The big kind of–.

Paul Hirt

01:13:07

Pools of sediment, you mean.

Paul Grams

01:13:08

Yeah. Big pools of sediment there and, and so we mapped those, um, and (Pause) people started doing it, uh, as soon as the technology became available, using sonar.

Paul Hirt

01:13:19

Sonar.

Paul Grams

01:13:19

So we use, uh, sonar instruments. So those are acoustic instruments, they generate a ping, a pulse of sound, that, uh, is generated by an instrument that's in the water that we hang off (Pause) you know, suspend from the front of the boat, um, into the river. And, uh, it sends a ping down, that,

that sound bounces off the bed of the river, comes back to the instrument, and the instrument knows when it sent it and it measures the time it took for it to travel, and calculates the distance, and uses that to come up with, uh, measurements of depth. But the instruments are actually sophisticated enough that it doesn't send down one ping, in one beam, it sends down, uh, up to, I think around, our instrument does five hundred and twelve beams in a swath. So, just by driving the center of the channel, you can actually measure depth, um, across a large portion of the riverbed as you're driving. So in a, in kind of a swath as you drive down the channel. So we can, um, drive these boats with these, uh, these multi-beam sonar instruments up and down the channel in a section of river, and then make a topogra–essentially, a topographic map, but it's a bathymetric map of the bed of the river.

Paul Hirt

01:14:37

And do–are those available on the web somewhere? Can somebody go and look at those maps?

Paul Grams

01:14:42

Yeah. Yeah. We have two different ways, we have the, a map viewer on our website that, you kind of have to look around for it, but it's on the GCMRC website, um, that has the one for (Pause) right now, I think the only one that's on there is from Lees Ferry to–or from the dam to Lees Ferry. But that's something you can toggle around and view. And then we've got publications with the, you can download the maps, um, for other segments of the river. And–.

Paul Hirt

01:15:11

So that's an example of a critical resource that we didn't know anything about, because we couldn't see it, and hadn't measured it, 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.

Paul Grams

01:15:36

Right.

Paul Hirt

01:15:37

Yes?

Paul Grams

01:15:37

Yeah, no, that's the idea.

Paul Hirt

01:15:40

That's how science works.

Paul Grams

01:15:40

(Laughs) That's how it works. And so back in, uh (Pause) when, in the early period, when they had a need for a stream flow model, uh, to predict, um, just water surface elevations at different flows throughout the canyon. And so they did that by, um, they did a river trip in the 1980s where they measured a channel cross-section every mile or two, and used that to develop a stream flow model, which is very coarse. And then the rest of it, they had to, they had to interpolate between those cross-sections and make up what the bed of the river looked like. But so now what we've done is collected enough data that they can do a model based on real measurements of what the riverbed is. (Pause) [P.H.: And–] So scientifically that, then that's another next step, is developing models for stream flow for the, based on our measured channel geometry.

Paul Hirt

01:16:35

Was the funding for that, um, riverbed mapping, uh, did it come from the Glen Canyon Dam Adaptive Management Program, or was this some other grant or independent research?

Paul Grams

01:16:45

No, it's all been from the Adaptive Management Program.

Paul Hirt

01:16:46

Okay, all right. Um, do you have any sense of what percentage of the research that's funded here at GCMRC comes from the Adaptive Management Program? (Pause) Is it a small fraction, or half, or a majority, any idea?

Paul Grams

01:17:02

No, all of it.

Paul Hirt

01:17:04

All of your fund–well, you said you have several other projects–.

Paul Grams

01:17:06

Oh, I have a couple other projects–.

Paul Hirt

01:17:08

From other grants that are–.

Paul Grams

01:17:08

Oh, that–but when you talk GCMRC I'm thinking, um, so I, I'd say (Pause) and the non-Grand Canyon work has been relatively recent and is only a few of us. Um, you know, for myself it's, you know, probably I've had maybe a couple of years where it's been, maybe, I've had (Pause) maybe up to 25 or 30 percent non-Grand Canyon work. [P.H.: Okay.] Now I'm back to probably more like 90 percent Grand Canyon work. So–.

Paul Hirt

01:17:37

Grand Canyon work funded by–.

Paul Grams

01:17:39

Funded by the Adaptive Management Program. And so, um (Pause) and I think, and there are, most of the people here are 100 percent on the, on the Adaptive Management Program.

Paul Hirt

01:17:51

Okay. (Speaking simultaneously) So then, with that as a background–.

Paul Grams

01:17:51

At the center as a whole, it's probably on, you know, 90, 95 percent Adaptive Management Program.

Paul Hirt

01:17:58

That's very significant. So with that as a background, um, stepping back a little bit again, away from the specific research, um, how well do you think the effort, um, to link the research done here at GCMRC with decision-making, policy decisions and dam operation decisions (Pause) that's the goal, is to have science to support decision-making. But sometimes it's difficult [P.G.: Yeah] to make that connection. So just, you know, tell us what you think about that process. How has it gone? Has it changed much over time? Is it, uh, fulfilling or frustrating?

Paul Grams

01:18:41

Um, I think it's, I mean (Pause) from my perspective, I think it's, I think it functions (Pause) pretty well. Um, we have a reasonable dialogue with the stakeholders. Um, we (Long pause) I think, you know, I think it does vary. Uh, depending on who you talk to and things have cycles. But, um (Pause) from my perspective, the system, the (Pause) setup, uh, it depends on how you, (Pause) see the objectives, but 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, it's accomplishing what it was meant to. (Long pause) I think that, uh (Long pause) I'm trying to think, you know (Pause). I mean, I'm pretty proud of how the sediment program has worked, in the sense that we've been able to, and you know, this–a lot of these contributions came from the work that was done before I came here in terms of just setting up the idea of, of doing the (Pause) the high flows and, um, and the way we do the monitoring, and have the, the monitoring set up. But I think it's a pretty good example of how (Pause) both some basic science, but a lot of applied science, has been, directed directly towards management problems, and it's been used to guide it. And, with, with, with quite a bit of back-and-forth in terms of, of doing experiments and then, um (Pause) scientists, you know, writing up publications on what happened, and then the managers doing something different. I mean, the response isn't always immediate lit–isn't always immediate, and it takes time, you know, the, doing the, the HFE protocol document, I mean, if people started saying, "Well, we need to do high flows more frequently than just having," you know, every, what would, what would it have been, you know, almost eight years between them or something. Um (Pause) and that discussion started immediately (Pause) was sort of going on when I started in 2008, and it took until 2012 for that to be implemented, but it did happen.

Paul Grams

01:21:05

And so, I think (Pause) there's frustration with, now that they've implemented the, the newest, the latest version of management, the Long-Term Experiment [Experimental] and Management Plan, they call it the LTEMP, which, um, sets the operating regime. I think, you know, there's, there's uh, one of the things that with the, where the high flow protocol has a little bit of a, I don't know, problem, an issue right now, is that there's a kind of a growing, uh, interest in having high flows occur in the spring. And the high flow protocol is all about maximizing the use of the Paria River to do things in the fall, because the Paria River contributes sediment in the late summer, um, and it makes sense in terms of capitalizing on those Paria sand inputs to do, uh, the high flows in the fall. And that at the time the protocol was written, spring fl–high flows were uh, um (Pause) the, the biologists were recommending ag–recommending against spring high flows because of a perceived impact on the, on the trout and the chub. And you know, the, the fish aren't my area of expertise, but I, you know, the science there at the time was, the spring high flows were stimulating the trout population, causing the trout population to increase and, and too many trout was a bit of a threat to the chub, because they might start preying on the chub or competing with the chub and cause the chub population to decline. And so spring high flows were (Pause) the idea was we should avoid those. And so it all fit together for this, this high flow protocol focused on the, uh, the fall. The high flow protocol does allow for spring high flows, but it requires the sediment trigger in the spring. Which are unlikely to occur. And so they haven't occurred, there hasn't been any sediment-triggered spring high flows.

Paul Grams

01:23:00

And so, there is some frustration now because, well, now it–the idea is that, well, maybe a spring high flow actually would be good for the biology. There's less concern about the trout-chub interaction, I think. But nevertheless there is interest in spring high flows, but (Pause) but we're in this little bit of a, uh, a trap, where the protocol makes them happen in the fall. Um, so there's some frustration with that, in terms of how the system is working, how the Adaptive Management Program is working. And there's some idea that, well the, there should be, uh, some flexibility to adjust how that works to make a high flow more likely to occur in the spring, and (Pause) I think that's probably going to happen, but, you know, we're kind of working through that process. And so that–and then that's another reason why, uh, where the continued interaction and involvement is important. Because these things, a [Unintelligible] you know, the learning keeps changing a little bit and ideas evolve, and (Pause) we've got to adjust.

Paul Hirt

01:24:00

Mm-hmm. Are there good reasons that things take so much time? You're saying one of the frustrations is how long it took to get the, um, high flow, the HFE, uh, protocol in place for an annual event. Um, but, should people interpret that as, you know, the typical problem of a bureaucracy? Or sh–or, can we, you know, shine a better light on that and say, "Well, that's how long it took us to do the groundwork, and come to a consensus, and know what we were doing was the right thing to do." What's your feeling about that? Is it just frustrating delays, or is there a good explanation for why it takes so long?

Paul Grams

01:24:43

Oh, I, I think, I think it's more towards the, I think there is a (Pause) in most cases there's a, a decent explanation. Sometimes, you know, where that bridge, where that transition is from, you know, enough time to involve everybody so that everybody is involved in the decision process and, and gets to contribute, um, versus something that just, uh, becomes (Pause) bureaucratic delays. It's hard to know where the (laughs) what the difference is there (laughter), but, but it does take time. So, I didn't consider the, I thought the, um, the amount of time it took for that, uh, HFE protocol, which was a few years, made sense.I mean that, it was, you know, lots of, lots of discussions about how it was set up and (Pause) including, um, different parties in, in the process.

Paul Hirt

01:25:35

Can you think of, um, based on your experience over the years, can you think of any ways that, um, we might improve the relationship between, um, science and policy? Get the results of research, um, to be more useful and more effective in shaping policy decisions?

Paul Grams

01:25:56

Well, I think, and I don't know how realistic it is. I mean, I think one of the things that has helped with this program is, where you have, uh, a system set up for, uh, a structure where, um (Pause) a group of (Pause) of both, uh, the decision-makers and stakeholders, um, interact with, uh, the scientists, repeatedly over periods of many years. So you build up relationships. And people build up some understanding of a system. And now, I mean that works here, where you have, um, a big resource, a big dam, you know, Glen Canyon Dam, which is of interest to a lot of people and, and the Grand Canyon National Park, which is a big focal point. Um, I don't know how many different systems or problems this model can be successfully applied to, but I think that really does help, and I think applying that where, um, to other problems would, would be useful.I mean, because I think that's, I think that's a big part of what works, is when you get, um, uh, people who are involved over long periods of time.

Paul Hirt

01:27:07

Um, climate change. What's, uh, how is climate change affecting the work that you do, um, affecting the questions you ask, affecting the, um, decision- making environment of the Adaptive Management Program?

Paul Grams

01:27:22

Well, it's, you know, I'd say that it's something people have been, had in the back of their minds for a while, and I think, uh, in terms of actually impacting what we do, it's probably only just starting to creep in. Um, I mean, certainly the issues of, of drought and the potential for longer periods of drought has been a issue that has, uh, that the water managers have been thinking about, and are now doing more about. Um, it impacts, it does have a potential– certainly there's a lot of potential impacts on the resources in Grand Canyon and our program. Um (Pause) I'm trying to think, um, I think we're, in terms of the scientists here, aren't studying climate change predictions per se so much, although recently there has been some of that, and there's, and I don't know if you've talked to anybody who's, who's done that work, but there's been some, some work on temperature modeling, uh, throughout the Colorado River system, including Grand Canyon.

Paul Hirt

01:28:30

Who’s doing that work?

Paul Grams

01:28:31

Uh, that’s w–Jack Schmidt was involved in it. But, but, um, Kim Dibble, who’s in the building here, is the lead on it. Her, um, Kim and Charles Yackulic.

Paul Hirt

01:28:41

D-i-b-b-l-e?

Paul Grams

01:28:43

Yeah.

Paul Hirt

01:28:44

And Charles–?

Paul Grams

01:28:45

Yackulic.

Paul Hirt

01:28:46

How do you spell that?

Paul Grams

01:28:47

Y-a-c-k- (Pause).

Paul Hirt

01:28:49

[Whispers – Unintelligible] (Laughter).

Paul Grams

01:28:52

I can spell it, I can write it down and send it to you–.

Paul Hirt

01:28:53

We'll look it up. Send it to us later.

Paul Grams

01:28:54

Yeah, um–.

Paul Hirt

01:28:55

Yeah, they might be, um, interesting to interview them [Unintelligible].

Paul Grams

01:28:58

Yeah. And so they, they've looked at, you know, how, um (Pause) climate change scenarios might affect river temperatures on the Colorado River Basin. Which is hugely important. And–.

Paul Hirt

01:29:10

Anybody looking at, um, dam operations and climate change?

Paul Grams

01:29:13

Yeah. Exact–no, it is–.

Paul Hirt

01:29:14

You mentioned that earlier–.

Paul Grams

01:29:15

That's part of the same question there [P.H.: Okay], is, is both climate change and um, dam operations on river temperatures.

Paul Hirt

01:29:23

Okay.

Paul Grams

01:30:52

Um (Pause) and so, the other thing that I'm looking at, not just for Grand Canyon, and it almost more applied to the whole–basin as a whole, is, you know, if, if river flows decline, what's the projected change on river channels? You know, we've seen chan–essentially, we see channel narrowing as a result of dams, because of a decrease in flood magnitudes, and we'd probably expect to see continued channel narrowing and channel simplification if peak flows and river flows continue to decline. So.That's sort of the hypothesis on that. That's something that, uh (Pause) to be looking at. Um, what else in the– you know, and then, and then the, the big impact here is, is how, um, managers decide to handle projections in the reality of climate change in, in managing the re–the reservoirs of the basin. And that's sort of above our (Pause) outside our realm of study here, you know, how, how the managers decide whether they're going to (Pause) keep, uh, do everything they can to keep, uh, both Lake Mead and Lake Powell operational, or if one of them is going to go down first or what. How, how they decide to handle that issue is, will have a big impact.And, and so part of what, um, we should be doing is, I guess, helping them think through, what are the impacts of either of those decisions on the river system?

Yeah, (Speaking simultaneously) that was [Unintelligible]–.

The automated transcript ended at the 1:30:52 minute mark; the audio file continues until the 1:38:54 minute mark.