

Summary of Scientific Advisory Panel (SAP) Meeting

April 15, 2005

The first meeting of the SAP was held by video and phone conference call on April 15, 2005. Below is an edited transcript of the comments and discussion by the SAP members and other participants. The participants included the following:

Gary Parker, Univ. of Minnesota, SAP Member (video link from Minneapolis, MN)
Peter Wilcock, Johns Hopkins Univ., SAP Member (video link from Baltimore, MD)
Kris Vyverberg, Fish and Game, SAP Member (video link Berkeley, CA)
Tom Lisle, US Forest Service, SAP Member (phone link from Arcata, CA)
Scott McBain, McBain & Trush, SAP Member (phone link from Arcata, CA)
Yantao Cui, Stillwater Sciences (video link from Berkeley, CA)
Scott Dusterhoff, Stillwater Sciences (video link from Berkeley, CA)
John Wooster, Stillwater Sciences (video link from Berkeley, CA)
Bill Dietrich, UC Berkeley (video link from Berkeley, CA)
Jeremy Venditti, UC Berkeley (video link from Berkeley, CA)
Christian Braudrick, UC Berkeley (video link from Berkeley, CA)
Peter Nelson, UC Berkeley (video link from Berkeley, CA)
Leonard Sklar, SFSU (video link from Berkeley, CA)
Glen Leverich, SFSU/Stillwater Sciences (video link from Berkeley, CA)

1. Overview presentation by Leonard Sklar

[see attached PowerPoint Presentation]

2. Gravel Augmentation presentation by Jeremy Venditti

[see attached PowerPoint presentation]

3. Gravel Augmentation Discussion

Gary Parker:

- Make sure to extend your experimental results using numerical models.
- You should also review the experiments of Wong who showed that the thickness of the active layer is function of shields number.
- Keep in mind that your use of a hydrograph does not represent the effect of tributaries downstream
- The effect you are looking for may be only weakly influenced by how much sediment you feed
- Why exclude sand? Sand may not scale as bad as you may be thinking.
- As you design your Mini-Helley Smith bedload samplers, you should consider several things
 - o Bakigaudi's conversion data
 - o Kristin Bunte's samplers, her measured increase in flux with shear stress matched theory better than standard Helley Smith samplers

- Make sure to use downstream sediment trap results to calibrate samplers

Bill Dietrich:

- It is essential to be able to see the bed when taking bedload samples
- These measurements within the flume are critical, can't rely only on downstream sediment trap

Peter Wilcock's comments

- I've worked with Kristin Bunte, she has obtained good data, but she has worked primarily in a range of very small transport rates
- Need to sample many grains, not just one or two, to get a reliable estimate of flux
- I agree with Gary's comment, Helley Smith will only work for very high transport rates
- I also agree that sand can be scaled, although the Reynolds number for sand on a gravel bed not such a simple matter.
- I suggest that we develop coordinated experiments in the main channel at Saint Anthony Falls Laboratory (SAFL) [at University of Minnesota, Minneapolis], in which we can use sand. The main channel at SAFL has one year of support for gravel transport experiments. We can use these to test lateral, "3D" scaling; it will be better using the 9 foot width rather than your 3 foot wide channel.
- A key question is the spatial extent of the response you expect. Does fine gravel all just build one bar, or does it go to the next bend, or does it all just smear out downstream?
- Your experimental variable of grain diameter ratio (augmented grain size divided by the armored bed grain size) is not sufficient. You also must take into account the transport stage. Really you need three axes to your plot, grain diameter ratio, transport stage, and sediment supply rate.
- You should use paint to make colored sediments for your pulses of augmented sediments.
- I recommend finding field analogs, for example the Trinity River might work well. Ideally you would have an allied field study.

Yantao Cui:

- Lateral variation in grain size will be the key response, this needs to be documented well.
- At a model scale of only 1:3 or 1:4 the flow will be very deep relative to width, you may not see a strong lateral response

Bill Dietrich:

- What we plan to do is start first with suppressed topography, in order to focus on grain-grain mechanics. First we can get at the fundamental processes, for example the fine grains mobilizing the coarse grains, and the coarse grains stopping the motion of the other coarse grains. After those experiments we

will then go on to larger width to depth ratio. Does the SAP think this is the right thing to do?

Gary Parker's comment:

- You have a very good plan. I would do it that way too.

Kris Vyverberg:

- I would like to return to the issue of sand. There's a failure within restoration community to appreciate finer part of distribution and it's value to benthic community. For example there is the issue of whether to wash or not wash gravel. We need to get the community to look at total grain size distribution and size the sediment augmentation to compliment what's already there.
- We need to think in terms of the needs of the total ecosystem, not just the fish. For example, when we collected local gravel and put in egg baskets, we inadvertently washed the gravel. In this case predation was much greater. Eggs start in clean gravel naturally but receive fines during incubation. Crawfish and other macroinvertebrates got into egg baskets, but were not there in natural redds.

Tom Lisle:

- Where in the channel will you evaluate responses?
- What is the longitudinal approach?

Jeremy Venditti:

- We plan to take images along the channel; this will allow us to look at longitudinal response.

Tom Lisle:

- How do you scale the length of the flume, how does it compare to the field?

Yantao Cui:

- Sediment continuity is the key. As long as you maintain continuity then a shorter flume can represent near and far field responses.

Scott McBain:

- I'd like to go back to talking about the dominant management concerns in the field. For example, we haven't yet talked about sediment routing in bedrock rivers, where bedrock is both confining and composes the bed. An example is Clear Creek, but also there are many other examples in the Sierra Nevada. In these channels a key management question is how much gravel do we add? What is benefit of alluviations? This is often a key issue in FERC re-licensing of dams in bedrock canyon rivers.
- Another issue is the effect of multiple insertion points. If you think of Jeremy [Venditti]'s slide of downstream propagation of sediment waves, it might be better to spread out the sediment injection over multiple sites. When do you

do that or keep focused in on one site. Obviously permitting, cost, etc. favors using only one site.

- Then there's the issue of the effect of different grain size inputs for given transport rate. An increase in transport rate requires an increase in supply to maintain bed elevation. This requires that you add more coarse sediment than you might have otherwise.
- To model bigger floods and associated sediment supply, you should consider the integrated effects of a hydrograph.
- As for field studies, Clear Creek is a good one. The Trinity River restoration hasn't started yet, but that means we have opportunity to influence the experiment design. The Trinity has high flows "hard wired". In contrast, there's the Tuolumne River, which has no control on high flows, but there is lots of gravel going in there in the coming years.

Kris Vyverberg:

- For field sites you might also consider the American River, where very little augmentation has been done, but lots of substrate sampling has been done to date. Also our working relationship with Bureau [of Reclamation] is very good, they would be willing to release flows as needed, within reason.

4. Channel and Floodplain Reconstruction presentation by Christian Braudrick [See attached PowerPoint presentation]

5. Channel and Floodplain Reconstruction discussion

Gary Parker:

- This is a great plan; I think it's going to work.
- Be careful not to bury the alfalfa sprouts.
- You might consider hiring Michal Tal as a consultant; she has a wealth of experience working with sprouts.

Peter Wilcock:

- How many experiments do you plan to run, how many is reasonable?

Christian Braudrick:

- It takes a week for the sprouts to grow. Given that constrain we think we can run between 10 and 15 experiments with a variable hydrograph.

Gary Parker:

- You should look back at the experiments of Schumm and Khan. Their channels were not very sinuous. Their substrate was probably too cohesive. Make sure you do something different from that.

Peter Wilcock:

- Reds Wolman did experiments in the 1950s that may never have been published. He used corn starch, which has some cohesive properties.

Tom Lisle:

- Watanabe in Japan also did some relevant experiments. He looked at bar dimensions with different flows. He found that variable flows changed the regularity of bars. So that confirms that the transport curve matters. Construction of bars at lower flows will only happen if you have sediment in transport.

6. Dam Removal presentation by Yantao Cui

[see attached PowerPoint Presentation]

7. Dam Removal discussion

Gary Parker:

- I'm concerned that if you're thinking too narrowly about Clear Creek and the Saeltzer dam case, and in general thinking about steep mountain streams, that the signal is so damped that the downstream response will be minor. It would be helpful to work with ecologists to define thresholds and response that you are ultimately concerned with
- I agree that the material in reservoir deposit should very much matter. You should look at the grain size distribution as measured in deposits behind real dams. Several examples from California you might consider include: Inglebright dam (Noah Snyder has data); Musseter Dam on the Carmel river, or San Clemente dam. You might also talk to Ned Andrews; he's done some coring on the Matilija dam project.

Peter Wilcock:

- What are the principal concerns in your expected downstream response? They are very similar to the gravel augmentation case. In both cases the key uncertainties have to do with lateral variation, and fines content of the bed.

Yantao Cui:

- Another field example worth considering is the Klamath River dam removal projects. In that case cohesive sediments are present. Understanding cohesive sediments could be worked into goals for this project.

Peter Wilcock:

- The grain size of sediment in the reservoir is one variable to consider. As in gravel augmentation you have sand versus gravel. But another key question is how do you make lateral topographic variability?
- Again it's a question of how well can you overlap with the gravel augmentation experiments.
- This is another example of how we should make a larger master plan for experiments at multiple facilities.

Tom Lisle:

- We know from previous work that the sediment wave thins and changes transport rate as you move downstream. The scale of concern is the bar scale, in terms of sediment transport from bar to bar. We found that the two dimensional response dominated the picture. This leads to the suggestion, which might really be pie in sky, that you could combine dam removal with the alfalfa approach for modeling small unconfined channels. This way you could get large downstream distances.

Gary Parker:

- I would like to make one summary comment. You have a very exciting plan, nice facilities; your chances of success are very good.

8. Meeting conclusion

Attachment 1: Introductory Presentation

Physical Modeling Experiments to Guide River Restoration Projects

Gravel
Augmentation



Dam
Removal



Channel and
Floodplain Redesign



Stillwater Sciences
University of California Berkeley
San Francisco State University

(National Center for Earth-Surface Dynamics)

Scientific Advisory Panel (SAP)

- Tom Lisle (*USFS - Redwood Sciences Lab.*)
- Scott McBain (*McBain and Trush*)
- Gary Parker (*Universities of Illinois, Minnesota*)
- Kris Vyverberg (*California Fish and Game*)
- Peter Wilcock (*Johns Hopkins University*)

Principal Investigators Project Management

- Bill Dietrich (*University of California Berkeley*)
- Frank Ligon (*Stillwater Sciences*)
- Leonard Sklar (*San Francisco State University*)
- Scott Dusterhoff (*Stillwater Sciences*)
- Craig Fixler (*Stillwater Sciences*)

Scientific Teams

Gravel Augmentation

Jeremy Venditti (*U.C. Berkeley*)
– Jessica Fadde (*SFSU / Stillwater Sciences*)

Channel and Floodplain Redesign

Christian Braudrick (*U.C. Berkeley*)
– Glen Leverich (*SFSU / Stillwater Sciences*)

Dam Removal

Yantao Cui (*Stillwater Sciences*)
– John Wooster (*Stillwater Sciences*)

Additional Researchers

– Aleksandra Wyzga (*U.C. Santa Barbara*)
– Peter Nelson (*U.C. Berkeley*)

Today's Agenda

- 5 mins Intro (*Scott / Leonard*)
- 15 mins Gravel Augmentation (*Jeremy*)
- 30 mins Discussion
- 10 mins Channel-Floodplain (*Christian*)
- 30 mins Discussion
- 10 mins Dam Removal (*Yantao*)
- 20 mins Discussion
- 5 mins Wrap-up

Questions for the SAP

- Are we asking the right science questions?
- Will answers to these questions be useful to restoration practitioners?
- Are there other important processes or alternative hypotheses we should consider?
- Can our experimental design or techniques be improved?

Dear SAP...

(A sneak preview)

- **Gravel Augmentation**
 - Can fine gravel mobilize static armor?
 - Can fine sand be scaled as model gravel?
- **Channel and Floodplain Redesign**
 - How wide and long a floodplain basin do we need?
 - How to create cohesive yet erodible banks?
 - How to measure topography in a wide basin?
- **Dam Removal**
 - Do the details of reservoir erosion dynamics really matter to downstream reaches?
 - Can reservoirs be modeled in narrow flumes?

Thoughts to keep in mind...

- **Basic science research with near-term management impact**
- **Project must have significant results by September 2006**
- **Focus on California rivers below dams**
 - *Gravel Bedded*
 - *Fish-driven management concerns*
- **Gravel Augmentation and Dam Removal share the same flume, will alternate**

Attachment 2: Gravel Augmentation Presentation

Discussion: Gravel Augmentation

1. Goals of gravel augmentation projects
2. Testable hypotheses
3. Experimental apparatus
4. Proposed experimental program
5. Hypothesized outcomes
6. Proposed method to optimize variables for augmentation

Physical modeling experiments to guide river restoration projects

Goals of gravel augmentation projects

Producing of beneficial effects on rivers for salmon spawning and rearing

1. Local addition of fine material for spawning
2. Mobilize existing coarse surface sediment
 1. Restores benthic ecology
 2. Releases fines from the subsurface
 3. Restore spawnable gravel sizes
3. Build bar topography and habitat diversity
4. Channel-scale restoration / change
 - a. Downstream length scale of streambed fining
 - b. Temporal persistence of streambed fining

Physical modeling experiments to guide river restoration projects

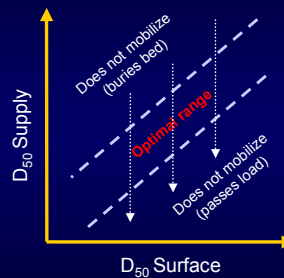
Testable Hypotheses

1. Finer bed-load can be used to mobilize a portion of an immobile or weakly mobile armored surface layer.
 - a. Coarse surface mobilization will result in exchange between the subsurface-surface and, ultimately, release sand and silt trapped in subsurface.
 - b. Effects of augmentation will be partly expressed by lateral variation in surface sediment texture and transport.
2. There are characteristic response functions that define the length and time scales of the grain size change.

Scales = f (Volume and g.s. added, duration of addition, number of additions)
3. For a fixed total volume of gravel added, there is an optimal frequency etc. of gravel additions (smaller, more frequent additions are best).

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Hypothesized outcome #1: Mobilization by finer sediment

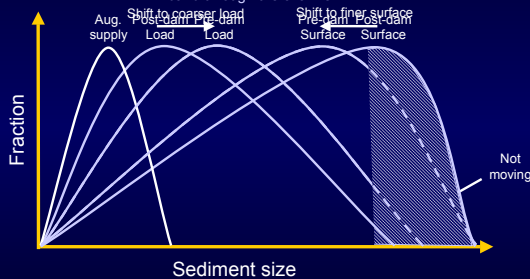


Our first experimental set is designed to examine mobilization in response to a progressively finer augmentation.

Physical modeling experiments to guide river restoration projects

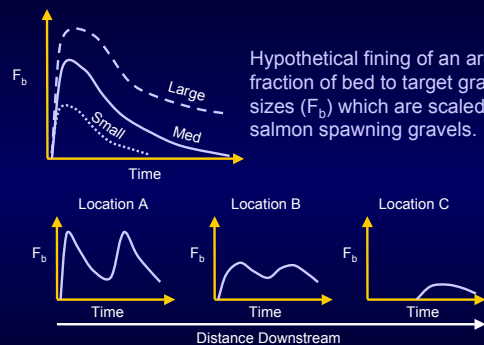
Hypothesized o/c #1 (cont.): Mobilization by finer sediment

Consider the coarse surface armor grains sediment supply and water discharge and augmented supply of fine material forms sediment armor grains for coarse grains and the band through the channel.



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Hypothesized o/c #2: Characteristic response functions

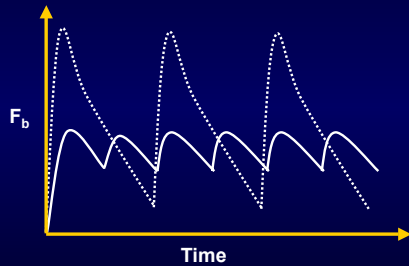


Hypothetical fining of an areal fraction of bed to target grain sizes (F_b) which are scaled salmon spawning gravels.

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Hypothesized outcome #3: Optimal Frequency

We hypothesize that there is an optimal frequency that will encourage a sustained fining of bed surface materials and minimal variability in grain-size at a location.



Physical modeling experiments to guide river restoration projects

Experimental Phases

I. Expression of along-stream topographic variability

Suppress bar development so we can focus on mechanics of grain-grain interactions that occur when augmented gravel interacts with resident coarse surface material. Flume is assumed to be a slice through a river channel with any reasonable width.

II. Expression of along-stream and lateral topographic variability

Encouraging alternate bar development to understand role of lateral variability in sediment sorting, texture and transport on grain-grain interactions. Flume is treated as a channel with bankfull width = flume width

III. Scaled channel with banks and some expressed sinuosity

Attempting to understand impact of augmentation on channel plan-form. Scaling to follow Yantao's application of Parker's [2003] dimensionless bankfull scaling for the dam removal experiments.

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Experimental Apparatus

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Model Sediment Scaling

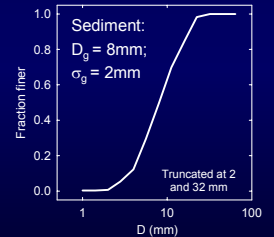
Spawnable gravel (Kondolf and Wolman, 1993): $D_{50surf} = 22$ mm; 50% of obs. between 14 – 35mm

Problem (prototype) channels in Central Valley: $D_{90surf} > 128$ mm; $D_{50surf} > 32$ mm

Model sediment size is scaled based on the following constraints:

1. Flume apparatus can handle gravel with $D < 32$ mm
2. Want to avoid using sand
3. Want to work as close to the 1:1 scale as possible

Above conditions and constraints suggest a model sediment scale of 1:3 or 1:4



Physical modeling experiments to guide river restoration projects

Proposed experimental procedure

All experiments will follow the procedure below:

1. Establish equilibrium sediment transport along flume (supply = transport)
2. Turn off supply to enhance developed of armored layer
3. Reintroduce supply as an analog to augmentation

Initial conditions for experiments

Plan to use 3 steady flows and transport stages in each phase of experiments that correspond to:

Phase I*

	Static Armor	Mobile Armor	Washed out Armor
Q (m ³ /s)	0.05	0.15	0.25
S (%)	0.5	0.5	0.5
τ/τ_c	0.7	1.2 (~bf)	1.6
Armor	1.9	1.5	1.3

*see end of file for graphs that show how these values were chosen for Phase I & II

Initial conditions for experiments (cont.)

Phase II

	Static Armor	Mobile Armor	Washed out Armor
Q (m ³ /s)	0.02	0.05	0.05
S (%)	1	1	1.5
τ/τ_c	0.7	1.2 (~bf)	1.6
Armor	1.9	1.5	1.3

Phase III (TBA)

Hydrographs

In addition to the steady flows, we intend to implement a run using multiple timed hydrographs that step through each flow stage above (i.e. low-medium-high-medium-low flow).

The timing and how to implement a sediment supply variation to match the hydrograph is under consideration.

Gravel augmentation optimization scheme

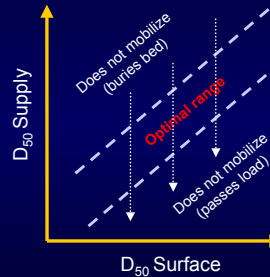
Ultimately our goal is to provide guidelines on how to go about choosing grain size, volume, duration and frequency for an augmentation project.

With this in mind we plan to conduct the experiments by optimizing a new variable at each stage.

Physical modeling experiments to guide river restoration projects

Proposed method for optimizing variables

1) Grain-size of augmented sediment

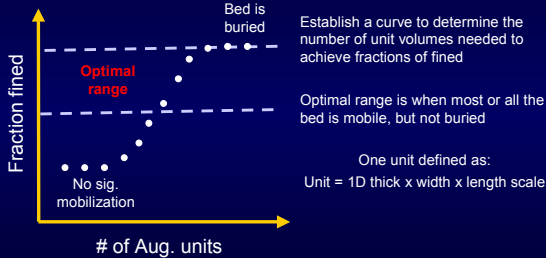


Beginning with the three flow and transport stages, determine the ratio of supply to surface sizes that enhance coarse surface mobility.

Physical modeling experiments to guide river restoration projects

Proposed method for optimizing variables

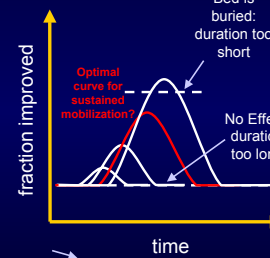
2) Augmentation volumes



Physical modeling experiments to guide river restoration projects

Proposed method for optimizing variables

3) Augmentation Duration



Identify an optimal duration over which to provide a given volume.

Must prevent: burial of coarse sediment and downstream migrating slugs of sediment which can destroy channel (e.g. Clear Creek).

Must encourage: sustained mobilization

In field: Duration = time to exhaust an augmentation cone.

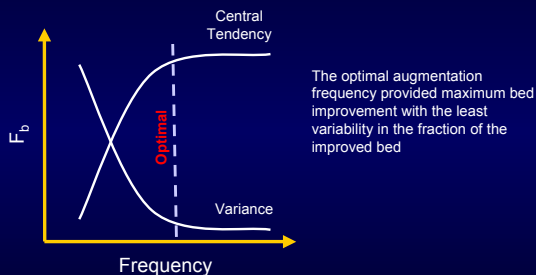
In flume: Duration = supply time

Hold volume constant and vary time over which it is fed (vary supply rate)

Physical modeling experiments to guide river restoration projects

Proposed method for optimizing variables

4) Augmentation Frequency

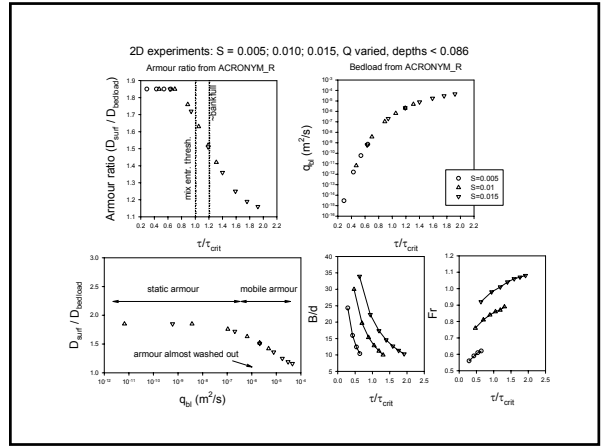
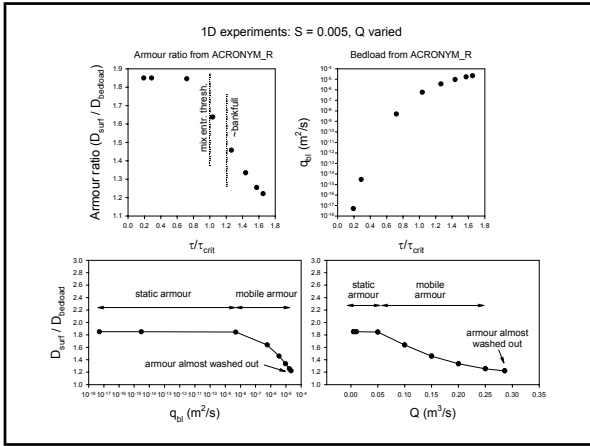


Physical modeling experiments to guide river restoration projects

Measurement Capabilities

1. Laser Scanning of gravel surface with flume drained (high res.)
2. Echo-sounding of bed while flume is running (low res.)
3. Water surface profiles
4. Imaging (6 MP still camera / 1.3 MP high speed camera)
5. Velocity profiles (Acoustic Doppler Velocimeter)
6. Time dependent relative density (porosity) measurements with measurements of infiltration and exhumation of fine sediments
7. High res. bedload transport measurements with periodic g.s. samples
8. Local sediment transport measurements (w/ mini Helley-Smith)
9. Conventional surface sampling and subsurface sampling

Physical modeling experiments to guide river restoration projects



Attachment 3: Channel and Floodplain Redesign Presentation

Channel & Floodplain Reconstruction Goals:

- Create a self-formed, gravel-bedded, meandering channel in a flume (*create the blue lab rat*)
- Develop a physical understanding of controls on channel geometry in streams by varying slope, grain size, sediment feed rate, discharge in the flume



Restoration Goals

- Guide restoration of channels and floodplains in gravel-bed rivers.
 - Rebuilding channels that have been heavily disturbed to their former geometry
 - Designing "mini me" channels and floodplains that are at dynamic equilibrium under a new hydrologic regime

A. January 1996



B. June 1997



From Kondolf et al. (2001)

Hypotheses

- A key parameter controlling channel size is the ratio of flow strength to bank strength
 - If the banks are too weak relative to flow strength, the channel braids
 - if the banks are too strong relative to flow strength, the bed is static
- Meandering channels require that sediment is able to accrete onto the inside bank of bars. This may require:
 - A variable hydrograph
 - Fine sediment
 - Vegetation

Why do laboratory channels braid?



from Eaton and Church (2004)

Approach

Depth and grain size assessment

- Maximize grain size, while allowing enough room in the basin for the channel to migrate
- Ensure that channel dimensions are reasonable (using methods outlined in Parker et al. (2003))
- $\tau^*/\tau^*_{crit} \approx 1.5$ at bankfull flow (assuming all stress is bed stress)

Initial conditions

- Initial B/H ≈ 20
- Initial bend in channel, allowed to propagate downstream
- Alfalfa sprouts distributed evenly along entire floodplain

Approach (con't)

Experiments

- Systematically vary discharge, slope, vegetation density, and sediment feed rate until the rat turns blue
- Seed bars following each flood event
- feed bedload and suspended load separately

Test Flume

- Adjustable slope 3.7 m wide X 6.1 m long
- Pump Capacity 0.4-8.0 l/s
- Bedload and suspended load fed separately



Current channel conditions

- Valley slope = 0.01
- 50-cm wide sinuous walls that contain the channel and the floodplain
- Initial channel dimensions=2.5 cm deep X 25 cm wide
- Q_{bf} =0.67 l/s
- Q_s =16.6 kg/hr
- D_{50} =0.9 mm



What we've done so far

- Conducted tests without fines and without sprouts
 - *the channel braided*
- Conducted sinuous fixed wall tests with a variable hydrograph without cohesive sediment or sprouts
 - *channel geometry adjusted as discharge adjusted*
- Conducted sinuous fixed wall tests with a variable hydrograph with sprouts and sporadic fines
 - we created bars and trapped fine sediment and bank erosion was caused by bar growth



What we've done so far

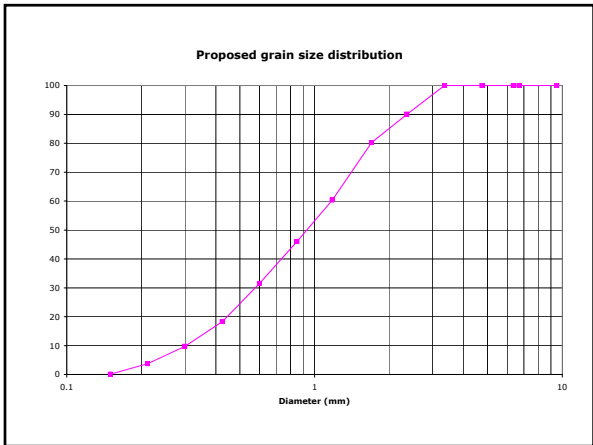
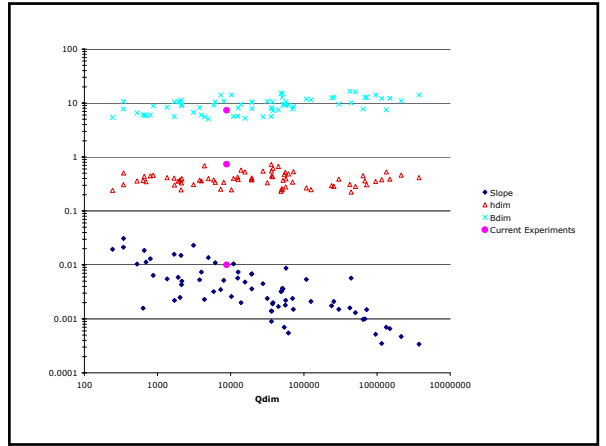
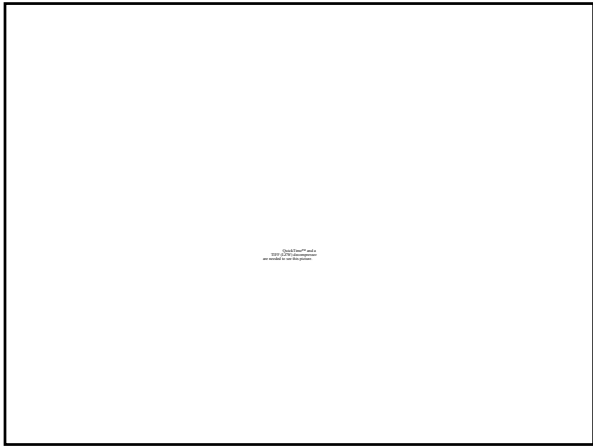


What we're doing now

- Remove the sinuous walls
- Fill the basin with sediment with a distribution the same as the coarse sediment feed
 - no cohesive sediment in banks
- Planting sprouts along the floodplain (and waiting for them to grow)
- Carve a channel with an initial bend

Preliminary future plans

- Construct larger basin
- Increase channel width and length based on results of initial experiments
- Modify approach based on initial experiments and input from the Advisory Panel



Attachment4: Dam Removal Presentation

Dam Removal Experiments

Preliminary Study Plan

Motivations* for Hypothesis #1

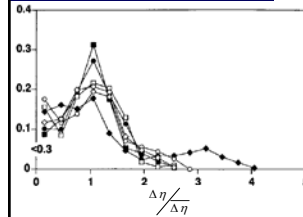
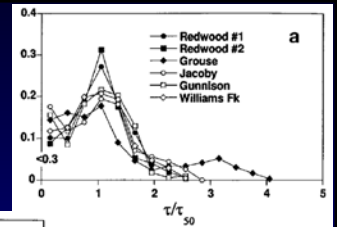
- One-dimensional numerical model will be the primary numerical tool in the near future for sediment transport simulation following dam removal, which is accurate at reach-average level at best;
- Need two-dimensional interpretation of one-dimensional results so that we can apply the reach-average results to a habitat scale.

* Arguments made during the NCED dam removal workshop

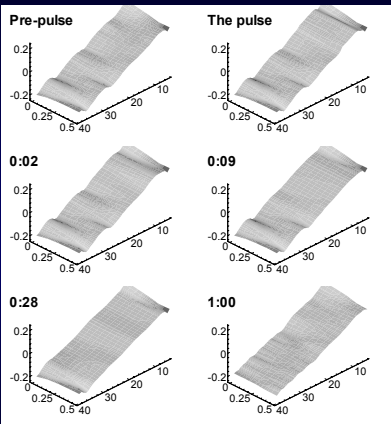
Hypothesis #1

- There is a general statistical relationship between aggradation at individual locations and reach-average aggradation;
- Parameters that may characterize this relationship include
 - reach-average sediment supply to equilibrium sediment transport rate ratio
 - reach average Shields stress
 - standard deviation of equilibrium topography
 - ...

Lisle et al. 2000 (WRR) →
The y-axis is fraction



← Is something like this possible?



What to do?

- Collect detailed aggradation data under different conditions (varying Q_s and Q_w);
- Analyze the data to find if any coherent statistic relation exists;
- Document and analyze the aggradation process to see if any other general conclusions can be made (filling of the pools, reduced complexity, potential braiding, etc.)

Relationship to Gravel Augmentation

- Data and results from this experiment can be used for gravel augmentation project;
- Certain data from gravel augmentation experiments may be used as part of the database in deriving the statistical relationship.

Motivation for Hypothesis #2

- Investigate the implications/interactions of erosion/sediment transport into stratified sand and gravel layer reservoir deposits
- To validate a hypothesis used in DREAM-2 model.
- Further investigate observations previously made in dam removal experiments (e.g., Cantelli in 2000 and Wooster 2001)

Hypothesis #2

- Erosion of reservoir deposit with naturally formed stratified gravel/sand layers will always preserve a gravel surface even when incision reaches the underlying sand layers, and thus, the erosion process is governed by the transport rate of gravel.
- Preservation of a gravel surface as you cut into the underlying sand layers within the reservoir deposit, leads to a system with an armored bed relative to the finer bank material. As observed in earlier flume runs this promotes over-widening of the channel, a transition to a multi-thread channel, and excavation of larger volumes of sediment than might have been predicted. We will test under hypothesis #2 what effects the mixed reservoir deposit has on channel development, and whether the varying erosional processes tested in hypothesis #2 really have any meaningful implications for reaches far downstream.

What to do?

- Feed gravel/sand mixture into impoundment to form stratified gravel/sand deposit;
- Core or slice the deposit to document its grain size distributions;
- Remove the barrier to start and document the dam removal process;
- Analyze data collected during the process;
- Simulate the deposition and erosion processes with a numerical model.

Motivation for Hypothesis #3

- Current dam removal studies have been focused too much on the erosion process in the reservoir deposit, which may not be very important to sedimentation processes further downstream of the dam under certain conditions.
- We are hoping to redirect the future research to focus more on the far downstream processes than the reservoir erosion process if this hypothesis is proven to be true.

Hypothesis #3

- In the case of (a) a non-cohesive reservoir sediment deposit; and (b) a channel bed downstream of the dam coarser than reservoir sediment deposit, the detailed reservoir erosion process is relatively unimportant to the long-term, far-downstream aggradation process.

* Most of dam removal cases on the west coast probably satisfy both (a) and (b)!

Why do we believe hypothesis #3 is true?

- Intuition - the interaction of the reservoir erosion process and the fan-delta deposition downstream of the dam controls the rate of sediment release to reaches further downstream;
- Results of some very early numerical experiments with accelerated reservoir erosion processes.

What to do

- Conduct experiments with and without artificially accelerated reservoir erosion processes;
- Systematic numerical experiments on different reservoir erosion processes or artificially accelerated erosion rates;
- Compare sediment out-flux time series of different processes.