River Geomorphology Videos
LRRD YouTube Playlist
January 2018

Description of clips and teaching notes

Steve Gough

Little River Research & Design
550 N. University Ave.
Carbondale, IL 62901
618-529-7423 fax 618-529-0927
www.emriver.com
info@emriver.com

The clips are intended for use by instructors to demonstrate river geomorphology.

This project was supported and supervised by the Missouri Department of Conservation. The U.S. Environmental Protection Agency Region VII, through the Missouri Department of Natural Resources, has provided partial funding Under Section 319 of the Clean Water Act.

Videography, post production work, and moving graphics were done by Steve Gough. Mike Covell of SIU-Carbondale provided technical guidance. Kimi Artita and Jesse Riechman of LRRD assisted with many aspects of this project, including research on the behavior of the Emriver model.

Please contact us at info@emriver.com with questions. Please cite these videos as:

Gough, S. 2007. River geomorphology videos. DVD. Little River Research & Design, Carbondale, IL; www.emriver.com.

Map and Aerial clips (note there is no audio in these clips)

1
Grand River remeandering aerial photo sequence with graphics.

A sequence of eight aerial photos running from 1939 to 1996 show the remeandering of a reach that appears as a straight, probably recently channelized reach in 1939. The location is six miles north of Grant City, Missouri. An animated blue line traces the channel changes.

Note the vegetated bars left behind as meander loops grow. You can also note the severely incised tributaries (though these are best seen in a flyover— video 5, a detailed flyover of the 1996 aerial). Note also the extreme channel shifts from 1983 to 1996, especially in the northern end of the frame.

Note also that there appears to have been rechannelization of some reaches, and I suspect bank armoring, especially where the farm structures are threatened, just west of “1951” in the photo.

2
Thompson River channelization 7.5’ map flyover with slope change graphics.

Flyover of a segment of the Thompson River from the Brimson, Missouri USGS 7.5’ quad, which is based on 1981 aerial photography. The highlighted reach is about 2 miles north of Brimson. Dashed lines on the map show the former channel location.

At 0:19 the flyover stops and graphics appear that show the old and new channels. Though it appears the channelized reach has remeandered somewhat, I don’t know this for sure, so the remeandered length is used for the analysis. The reaches are graphically straightened out and placed on a graph which shows the relative change in channel slope. The channelized reach is 5.2 ft./mile; the original mapped channel was about 3ft/mile, about half the new slope.

After the pause and graphics, the flyover resumes to show the rest of the quad, on which you can see even more severe reductions in channel length.

3
Medicine Creek channelization near Chula, Missouri; 7.5' map flyover.

This short clip shows a simple flyover of the Chula, Missouri USGS 7.5' map showing the channelization of Medicine Creek near Chula in Livingston County; north-central Missouri. The map was made from 1980 aerial photographs. The dashed lines running alongside the channel are levees. Note the green hatch showing forest inside the levees, and the extreme change in channel length (from channelization) of reaches shown towards the end of the clip.

4
Map to Emriver remeandering, Grand River, Missouri-Iowa.

This clip uses the Grand River site appearing in other clips. It opens with a flyover of the Blockton USGS 7.5' map (from 1975 photography—map edited in 1981). The site is six miles north of Grant City, Missouri. The Missouri-Iowa line is at the north end of this reach—the heavy dashed line just to the right of the word "River" is the state line.

We next see a flyover of a 1996 aerial of this site. North is at left, flow is left to right. The curved road bend at bottom is Highway F. Note farm structures and a very deep gully at the top of the photo. I strongly suspect the distorted bend near these houses is due to bank armoring done to protect them.

This view is joined by a shot of the Emriver model showing development of a meandering form and fluvial features from simple, straight channel. Note the strong similarities between these real-world meanders and other features and those in the Emriver model.

5
Flyover of 1996 aerial, Grand River, Missouri-Iowa.

This clip shows a segment of the Grand River used elsewhere in these clips—a flyover of the 1996 aerial. In this view you can clearly see the post-channelization development of meander bends, point bars and terrace surfaces as the channel has evolved, and also the severe incision of tributaries. Many gullies enter the channel—a result of incision after this reach was channelized prior to 1939.

6
Aerial view of Cape Girardeau, Missouri showing the Mississippi River and concrete channels.

The view zooms in on Cape Girardeau, Missouri showing the Mississippi River and a tributary. As the view moves northwest, you can see very large (and expensive) concrete trapezoidal channels. The aerial is a 1996 color infrared. Note that there appears to be no serious erosion where the concrete channel meets that natural meandering channel. This is because this reach is strongly influenced by the Mississippi River, and tends to be depositional.

Emriver model clips (note there is no audio in these clips)

7
Emriver channelization, large meanders, packed sediment.

This is a time-lapsed Emriver channelization demonstration in which a meander loop is cut off. In this case the channel length between two points is more than halved, so slope would increase by a factor of 2+. The playback speed varies and is noted on the video.

Note the relative stability of the system before channelization, in which a small amount of sediment is moving through the reach, but there is little bank erosion and by one definition—sediment in = sediment out—the system is very stable. A moving circle and the words “uniform bedload transport” illustrate this.

After the channelization note bank failures both up and downstream, and that the channel slowly reestablishes a meandering form so that its overall length is about the same as before the channelization. Graphics show how bedload transport greatly increases due to incision and bank erosion upstream of and within the reach.

During the remeandering process, note that there is a net export of sediment—you can see this by visually comparing sediment movement into the reach versus that out of it.

Near the end of the clip (2:17), transect graphics appear. These show the wide, unstable nature of the channelized reach versus the narrow, more stable upstream reach.

8
Emriver channelization, narrow meanders, packed sediment.

Same as video 7, except that meander belt is narrower, and the post-channelization effects are not quite so pronounced.

Just after the channelization, note the greatly increased velocities in the channelization reach. Dye pulses released just before and after the straightening is done help you see the relative velocities and depths.

Note the bar/terrace that forms at the upstream end of the channel reach that is cut off, indicating incision of the channelized reach.

In this demonstration, the downstream reach shows more of a tendency to braid than in video 7.

9
Headcut in a straight channel.

Sediment is removed from the lower end of a straight reach causing one or more headcuts to travel upstream. The first headcut is emphasized with an arrow that fades as the headcut becomes indistinct. As the incision progresses the channel begins to meander and form bars/terraces and the channel evolves.. Use the pause control in this short clip to take your time looking at these forms.

Good short illustration of headcutting, incision, and subsequent channel evolution.

10
Effects of piping channels on downstream reaches.

This clip shows the effects of channel piping on downstream reaches. The effects of converting natural channels to rectangular or trapezoidal concrete channels are very similar.

The clip opens with about 20 seconds of a vertical view of the scour hole at the end of a pipe. Next we see an unmodified channel in which a pipe is placed. Note the relative stability and continuity of sediment transport (sediment entering the reach = sediment leaving) before the pipe is added. The pipe has a much higher slope and also a narrower, smoother (hydraulically) cross section, so flow leaving it has a relatively high velocity. This flow is also free of sediment. Discharge is not changed during this demonstration.

You can see a scour hole form after the pipe is added, and erosion of the reach downstream. This accurately shows effects we see in the field. Note small terraces forming on the channel margins that indicate incision.

The pipe is then removed, and the channel reforms a stable form in which sediment continuity is maintained. Note the remeandering.

11
Tributary incision caused by main channel incision.

This clip shows how headcutting and incision in a main channel influences a smaller tributary. Sediment is removed from the larger channel (here using an aspirator, out of the frame to the right) causing it to incise. The headcutting and incision affect both the main channel and the smaller tributary. Dye pulses show velocity and relative depth. Note how incision is indicated by the formation of terraces in both channels.

This has many applications to real world problems. This demonstration shows how tributaries are influenced by vertical instability such as that caused by channelization. We can compare this with the large gullies and tributary incision seen in the aerial photos of the channelized Grand River in video 1.

12
Incision, bend erosion, and tragic tractor loss.

Doomed tractor. A little fun. Base level is lowered by removing sediment downstream, causing headcutting and incision through a bend (headcut is brief, but visible), and tractor falls in as bank fails. Sediment was packed in this run, which caused banks to significantly undercut before failure. Time lapsed. Note video lights dimming when aspirator (used to removed sediment and induce headcutting/incision) is turned on.

13
Headcutting, incision and bank instability in a bend, closeup with graphics.

In this close-up view, incision is induced by removing sediment with an aspirator, and a clearly visible headcut, denoted by a moving arrow, moves through a bend. Banks then become unstable and collapse. Note the small terrace that forms on the inside of the bend at left.

14
Oblique bend incision, view upstream, closeup.

This clip shows incision and bend erosion from a downstream-looking-upstream viewpoint. As the channel incises, note severe bank erosion, cantilever failure, and formation of bars and terraces as the channel moves downward and laterally. At the end of the clip, note the scrolls left behind on the bar as the bank at left moves to the left and toward the viewer.

These features may be compared to real-world bars left behind in other remeandering systems shown here, including those in video 48.

15
Meander development in a straight channel.

A straight channel is formed in the Emriver model (video 25 shows part of the process by which this was done). Speed is x10. After flow begins, the channel slowly forms regular meanders and point bars. Note how the meanders tend to migrate in a downstream direction. The meander bends also expand the meander belt width until about 0:34, when they cease to move outward and migrate only in a downstream direction. Geomorphologists would argue that the channel reaches a point of stability then as sediment inputs to the reach match outputs and the reach no longer has net erosion. You can see this by observing sediment movement into versus out of the reach.

Other clips in the series use this clip to compare real-world remeandering reaches with those seen in the Emriver model, including video 4.

16
Floodplain wetland draining caused channel incision.

This clip shows a vertical view of a small wetland being drained as the channel near it incises and the water table elevation drops. Note the formation of a sequence of terraces as the channel incises. Here incision was caused by removal of sediment downstream using an aspirator. Speed is x10.

17
Wetland draining caused by incision, oblique upstream view.

Here the view is upstream. A clearly-defined headcut moves up through the channel, the water table is lowered as the channel incises, and the floodplain wetland becomes dry. Note formation of small terraces on both sides of the channel as it incises.

18
Floodplain wetland draining caused channel incision, #2.

This clip is very similar to video 16, with additional terrace development as the channel incises and the wetland drains.

19
Wetland draining caused by incision, formation of a connecting channel, and floodplain pit capture.

This is a very interesting clip, at least for a geomorphologist. As it begins, you can see the hands of a young civil engineer preparing the run. Next an aspirator is used to remove sediment (downstream, out of the frame) causing the channel to incise.   As it erodes its bank near the wetland depression, it briefly touches the depression and a small channel forms between the two. The main channel then quickly migrates in the opposite direction, but flow from the wetland (which is replenished through groundwater) through the small channel keeps it open, and it remains connected to the main channel.

As the main channel incises further, it forms a series of terraces on both banks. Some of these are eroded and new ones are formed. The channel connecting the wetland to the main channel also incises, following the vertical drop in the main channel.

At the very end of the run, the main channel captures the wetland depression. This process is very similar to the pit capture that can occur when channels migrate into and capture pits left from floodplain sand and gravel mining. Note the severe disruption in sediment transport continuity. Unfortunately, this unplanned event happened at the very end of our videotape and what you see here was all we were able to record.

20
Grade control structures.

This clip shows a basic demonstration of the use of grade control structures to manage energy and control vertical stability in a channel. Two rock grade controls are placed in the channel. Dye shows relative velocity and depth. Note the relatively low velocity upstream of the grade control at left (the upstream-most). The structures are then removed. Note how velocity becomes uniformly high throughout the reach (rather than low above the grade control structures and high over them.) Immediately the sediment transport rate increases overall and becomes uniformly distributed throughout the reach as the channel seeks a new equilibrium condition.

21
Logjams forming at the transition from a straight to meandering reach.

(Note—video 34 logjam clip is longer and in some ways superior to this clip) This clip shows how logjams tend to form where straight, channelized reaches flow into meandering reaches. In this example, we see small simulated trees and logs flow quickly down a narrow, relatively deep straightened reach into a meandering channel. Graphics show the cross sections at a transect in each reach. The wood is effectively moved through the deeper, faster-flowing straight reach, but tends to hang up in the meandering reach, which is wider and shallower. Wood also hangs up on the banks as the channel bends. As some wood is trapped, other wood piles up on it.

22
Logjams forming at the transition from a straight to meandering reach-no graphics.

This clip is identical to video 21 except that the graphics showing relative channel cross section have been omitted.

23
Cantilever bank failure.

This clip shows a closeup of bank failure in an incising channel. Here the media in the Emriver has been compacted so that it is more cohesive. This cohesion allows for significant undercutting before classic cantilever failure occurs. Note how the failed material is gradually removed by flow, and how series of point bars/terraces form opposite the failing banks as the channel incises.

24
Classic channelization, closeup, unconsolidated media

A very fast-paced (speed is x 15) demonstration with unpacked sediment and loosely-formed meanders. Here we see a clear increase in velocity and sediment transport in the channelized reach. Note the disparities in sediment transport between the channelized reach and that upstream—clearly there is net erosion in the straightened reach. As the reach adjusts, you can barely discern bedload movement at the upstream end of the visible channel, but there is clearly a lot of sediment leaving the channelized reach, most of which appears to be eroded from the migrating bend just upstream of the straightened reach.

Note the relative stability of the bend that forms at the immediate upstream end of the channelization and the next upstream bend, which moves very little during the clip.

As the reach slowly remeanders and begins to resemble the starting sinuosity, sediment transport continuity is restored (though it doesn't quite get back to a completely stable condition in this clip).

25
Emriver channelization setup sequence.

That's right, in 10 seconds you can see how the channelization video sequences are set up. First the sediment is consolidated with a cypress board, then the meander path is marked out and excavated. Then flow is routed through the reach until it reaches equilibrium sediment transport, and is ready to be straightened.

26
Oblique view of channel reaming with house props.

An oblique upstream view of channel reaming with house props. The channel is "reamed" and straightened by pushing bed material from the center to both banks. As flow resumes, the channel remeanders, removing the material it put there in the first place. At the very end of the clip the well-built house at lower left finally succumbs to bank erosion.

27
Vertical view of channel reaming at 10x speed.

The clip opens with a self-formed channel best described as braided. Flow is stopped and the channel is “reamed” by forming a central straight channel with banks made of the bed materials. When flow resumes the channel immediately remeanders and eventually removes most of the bed materials pushed against the banks.

28
Vertical view of channel reaming at 20x speed.

Exactly the same as video 27 but at 20x, for a shorter run time.

29
Vertical view of inchannel mining and bar pit capture with graphics.

Early in the clip the channel thalweg is mined, producing a strong headcut (denoted by an arrow) that migrates upstream. As sediment continuity is disrupted we see incision downstream of the pit as well. As the clip progresses, not the formation of terraces on the point bar at bottom left. At 0:47 a pit is excavated in the large terrace/bar at the center of the frame. As the channel captures this pit, we again see a headcut migrate upstream and further incision. As the channel adjusts, note that the surfaces at the bottom center of the frame, which were formerly at bed level, become terraces as the main channel incises. At the end of the clip the channel is forming a new equilibrium form within terraces on each side.

30
Vertical view of inchannel mining with strong incision and headcut response.

A very good example of channel incision up and downstream of a radical inchannel gravel mining operation. The clip opens with a marginally braided self-formed channel flowing within sets of paired terraces. A scoop is used to create a large pit in the channel, causing a strong headcut to form. As this headcut moves past upstream cutbanks, they collapse. Note also another well-defined headcut forms after the sediment from this collapse is removed. We then see very distinct incision downstream of the pit. Upstream, note that the sediment entering the frame at left appears to be much smaller than that entering the mined pit, and that this material is being eroded from channel bed and banks.

31
Oblique view of mine pit capture with house and loader props.

The clip opens with a tight oblique view of a self-formed channel with houses on either side. A small pit is excavated in a bar. As the channel captures the pit, incision occurs. Note how the lowering of the thalweg elevation causes the large bar at left to become emergent and less active, but at the expense of erosion of the bank at right.

This large bar is then mined. When the channel captures this pit, a distinct headcut forms and migrates upstream. The poor little creek is then subjected to a large inchannel excavation, which causes further incision and a massive bank collapse upstream.

32
Vertical view of headcutting both upstream and downstream of an inchannel mine pit.

This clip has good examples of bank instability caused by incision above an inchannel mine and also the rarely seen (at least in these models) distinct headcutting *downstream* of the mine pit. The clip opens with a low flow rate, which is increased as it progresses. The downstream headcutting, which is indicated by graphics at about 0:47, occurs after the pit is excavated a second time.

33
Oblique view of the effects of “bar pushing.”

Here a point bar is pushed to the opposite cutbank (a landowner technique frequently seen in the Ozarks) in an attempt to protect it from erosion. Just as with inchannel gravel mining, we see upstream incision and, eventually, the channel returns to its previous state after the upstream banks are heavily eroded.

34
Logjam formation at the transition from straight to meandering channel with graphics.

This clip is an improved version of videos 21 and 22. This clip shows how logjams tend to form where straight, channelized reaches transition to meandering planform--this typically occurs when channelized reaches join unchannelized ones. In this example, we see small simulated trees and logs flow quickly down a narrow, relatively deep straightened reach into a meandering channel. Graphics show the cross sections at a transect in each reach. The wood is effectively moved through the deeper, faster-flowing straight reach, but tends to hang up in the meandering reach, which is wider and shallower. Wood also hangs up on the banks as the channel bends. As some wood is trapped, other wood piles up on it.

And it’s not your imagination; this clip is somewhat marred by occasional vibration of the camera mount.

35
Closeup oblique comic shot of house falling into river.

A little fun. Severe channel incision cause a house to fall into the river.

36
Exploding bulldozer LRRD promo clip.

We won’t spoil the fun, you’ll have to watch this clip yourself. Pyrotechnics by Steve Gough.

37
Oblique view of the effects of inchannel gravel mining with props.

Here we have a very good low oblique view of the effects of excavating a pit in a river channel, including both upstream and downstream incision. Note the formation of terraces on the bar at right, especially after the second excavation. This clips also demonstrates the interruption of sediment transport continuity, and what can happen to infrastructure (in this case a house) near incising channels.

2D Flume clips (note there is no sound on these clips)

38
Flume – flow over low head dam, wide shot, with sediment

As the clip opens, we see a blue low head dam above which sediment has been deposited. The bed is at equilibrium with flow—bedload is moving, but the bed is at equilibrium—there is neither net erosion nor deposition. Shallow, fast flow goes over this sediment and the dam, and a hydraulic jump (i.e. flow goes from supercritical to subcritical) below the dam.

Note the thin layer of bedload moving above the dam, the scour below the dam, and then gradually increasing depth of bedload farther downstream.

As the clip progresses the downstream gate is lowered and stage rises, drowning the hydraulic jump. As depth increases over the dam and passes the point at which critical flow occurs, we see subcritical flow throughout, and a deeper layer of bedload is deposited. A short jump in time shows a dune/slipface moving from left to right as the sediment is deposited so that a new equilibrium depth is established at which bedload can be transported.

The slipface moves past the dam, which now has no effect on hydraulics, and into the scour hole downstream.

As the gate is raised, stage drops, sediment below the dam is quickly scoured out, and we return to the condition seen at the beginning of the clip.

39
Flume – Box culvert or bridge interaction with flow and sediment transport.

The clip shows a longitudinal section of channel as it might appear if sliced down the center of the channel through a box culvert, span bridge, or large culvert. Discharge (Q) remains constant throughout this demonstration.

At the beginning, the bridge opening is just barely passing flow without causing backwater. As the graphics indicate, sediment is then added to the system. The sediment raises stage somewhat, and backwater begins to appear. This further aggravates sediment transport upstream, stage rises further, and the bridge is overtopped.

As sediment is removed from the system, it returns to the beginning condition, in which the bridge easily passes the flow.

This demonstration shows how coarse bed sediment load can greatly influence hydraulics and bridges. This influence is not always apparent during the flood or after the event passes.

40
Flume – Low head dam installation effects on coarse sediment transport, medium shot

As the clip opens you see shallow flow with uniform bedmaterial transport throughout. A small low head wier or dam is installed. This produces deep subcritical flow above the dam and critical flow over it. Below the dam we see supercritical flow.

The deeper, low velocity flow above the dam cannot move the coarse bedload (Q = VA, and since A is greatly increased and Q is unchanged above the dam, V is greatly decreased) and we see deposition occur until depth is shallow enough (and A small enough) that the increase in V moved bedload again. Deposition occurs to the top of the dam.

When the dam is installed, we see a classic disruption in sediment transport continuity. Coarse transport essentially ceases through the dam until deposition builds a higher streambed. Sediment is blown out below the dam (often scoured to bedrock in the real world) This is the well known “hungry water” effect seen below dams.

At low-water crossings in the Missouri Ozarks, many of which are essentially low dams, we often see this condition, manifested as a wide, sediment-filled channel with low banks upstream of the bridge. This contrasts with a deep, scoured channel below, sometimes with high, unstable banks.

At the end of the demonstration, the downstream gate is lowered and a hydraulic jump appears which is then drowned as stage increases. The depositional dune and slipface then move past the dam. The gate is then raised somewhat, allowing a jump to reform and sediment is blown out below the dam.

41
Double low head dam removal and grade control demonstration.

Here we see a simple demonstration with two low head dams in place and active equilibrium bedload transport throughout-- i.e. sediment entering the reach = sediment leaving it, and there are no zones of net deposition or erosion.

The downstream (yellow) structure is then removed. The bed immediately adjusts by downcutting. The incision is effectively controlled by the upstream (blue) structure.

This shows how bedrock control or built structures can prevent incision and headcutting. In the St. Louis, Missouri area, for example, buried sanitary sewer lines and other utilities crossing streams often are exposed by incision in this manner and act as grade controls.

42
Flume – Headcutting after low head dam removal.

Here we see a low head dam with deposited sediment upstream and equilibrium sediment transport. The dam is removed, and the channel bed quickly establishes a new equilibrium slope by headcutting.

43
Hydraulics over a weir; no sediment in flume.

This clips shows basic hydraulics over a weir in the absence of bed material (though there is a small amount of material present in the flume). At the clip beginning dye is injected into flow upstream of the weir to show the transition from relatively deep, low velocity flow to critical and supercritical flow over the weir.

Below the dam, supercritical flow is much faster and shallower. As the downstream gate is closed, stage rises and hydraulic jump appears downstream. Here we can also see the loss of energy due to the jump by comparing the elevation of the water surface below the dam with that above the dam. This energy loss is one of the things that make grade control structures work—they act to dissipate the energy of flow at a point of our choosing.

Note the turbulence and reverse roller (the sort that is very dangerous to be caught in) below the weir.

44
Effects of slope increase in flume

This clip shows how velocity and sediment transport increase as the slope of the flume is made steeper. Applications include channel slope increases from gravel mining or channelization.

45
Headcut migration in the flume

Here a headcut (initiated in packed sediment by raising the flume's tailgate) moves through the length of the flume, leaving a steeper bed slope behind.

Field clips (note there is no sound in most of these clips)

46
High flow in a Missouri Bootheel Ditch

This clip shows the Little River Ditch #1 near Morehouse, Missouri on July 13, 2006 at the USGS gage site along US Highway 60. Discharge is 1,220 cfs (about twice the mean daily flow value) on the tail of a hydrograph that peaked at over 3,700 cfs four days earlier. Drainage area is 450 sq. miles. Note the very low velocities in this channelized, low slope system.

47
Gullying and headcuts on a contruction site during a storm

Here we see gullies formed in a clay-silt soil on a construction site during a storm.   Arrows indicate several small headcuts. Note the vertical drop and energy dissipation at these headcuts, which are migrating upstream, leaving an incised channel below them.

Though it is usually not as obvious, and the headcuts not so pronounced, this is exactly the means by which larger channels incise.

48
Remeandering of a small channelized stream.

As the camera pulls back in the beginning of this clip we see a small, meandering channel. As the graphics soon reveal, this channel was excavated as a wide, straight trapezoid about 10 years before this video was shot. The graphics show the remeandering process and also how the cross section has changed as terraces and point bars formed during the remeandering.

This channel is an unnamed tributary to Little Crab Orchard Creek near Parrish Elementary School in Carbondale, Illinois.

49
An urban concrete channel in flood.

This clip shows a rectangular concrete channel in Marion, Illinois during flood flows. This channel section shows more turbulence than most such engineered channels because large stormwater inflows enter just upstream.

These channels are dangerous for obvious reasons—note the chain link fence topped with barbed wire. These channels also have no environmental or aesthetic value—their only use is for floodwater conveyance. At the end of the clip we are looking upstream at a less turbulent section of the channel.

50
An urban concrete channel in flood at lowflow and flood.

This clip shows low flows in a rectangular concrete channel (the same reach as shown in video 49). Note the very uniform velocity distribution and lack of habitat or refugia for fish. Next we see the same reach during a flood. In a natural channel with a functioning floodplain, these flows would have a wide distribution of velocities and depths, but in this artificial channel, we see only deep, high velocity flow during a flood.

51
Underwater views of turbulence and fish.

This clip shows how woody structure and coarse bed material can form turbulence in channels, and fish interacting with that structure and with the camera operator, whom they like to trail because he stirs up the bed.

52

Underwater view; mobilization of bedmaterial by camera housing.

The camera is placed into shallow, high velocity flow in the Jacks Fork River in the Missouri Ozarks. The turbulence and changes in velocity distribution caused by the camera housing dislodge bed materials and cause them to move. If we could observe bedload movement during floods, it might look much like this.

53

Miller County road crew mining in Saline Creek, Missouri (with audio).

This clip shows the Miller County, Missouri road crew removing gravel from Saline Creek using BMP’s. Gravel naturally accumulates in this reach due to backwater from Lake of the Ozarks, and its removal does not cause channel incision. The crew is scraping a large bar (the scarps you see in the background are the original bar elevation). A well-maintained culvert allows trucks to cross the creek with no harm to water quality, as the over/underwater shots show. The gravel removed from this site is used on public roads.

54

Dusky shiners and other small fish in moderate velocity.

Dusky shiners (*Notropis cummingsae*) in moderate velocity over a gravel cobble bed in the Jacks Fork River (Missouri Ozarks). You can also see a whitetail shiner (*Cyprinella galactura*). The beautiful torquise color is typical of these Ozark Rivers.

55
Darters in a low velocity side channel, Jacks Fork River.

Darters darting on gravel and cobble-sized bed material in a low velocity side channel.

56
Orangespotted sunfish on nests.

Orangespotted sunfish (*Lepomis humilis*) over nests in low velocity habitat in the Jacks Fork River, Missouri. One fish's curiosity towards the camera is provoked because the flat housing port becomes a mirror at certain angles.

57
Smallmouth bass and dusky shiners and orangespotted sunfish in high velocity.

In this short clip a sunfish is using the camera housing for cover (perhaps as hydraulic refuge). In the background are dusky shiners and a smallmouth bass (*Micropterus dolomieu*). We did not measure velocity, but shooting this was very difficult, and I estimate it was approaching two feet per second.

58
Dusky shiners in side channel, view upstream.

Dusky shiners and the occasional darter in a low velocity side channel, view upstream.

59
Smallmouth bass and dusky shiners in high velocity

The same scene as video 57, but with the camera housing closer to the fish, which are interacting with the turbulence it causes.