During the accounting period immediately before the HFE (July 1 and November 17, 2012)...

617,000 – 769,000 metric tons entered Colorado River from the Paria River
USGS (AzWSC) sampling sediment transport of the Paria River during a flood

US D-74 sampler suspended from fixed reel on bridge

ISCO 6712 automatic pump sampler

Intake location for the ISCO 6712 pump sampler

near Lees Ferry
During the accounting period immediately before the HFE (July 1 and November 17, 2012)...

- **Mainstem flow**
- **Mainstem flow and sediment**
- **Tributary flow and sediment**

**Sediment budget reach**
- RM 0-30 – upper Marble Canyon
- RM 30-61 – lower Marble Canyon
- RM 61-87 – eastern Grand Canyon
- RM 87-166 – central Grand Canyon
- RM 166-225 – western Grand Canyon

**617,000 – 769,000 metric tons entered Colorado River from the Paria River**

**551,000 and 782,000 metric tons accumulated in upper Marble Canyon**

**91,000 – 101,000 metric tons were transported past the RM 30 gage**

Little to no fine sediment accumulated in lower Marble Canyon.
During the accounting period immediately before the HFE (July 1 and November 17, 2012) ...
Motorized boat equipped for the collection of suspended-sediment data at tagline at River Mile 30.

Location of the 30-mile sampling tagline

Boat deployment for the US D-77 bag-type and US D-96 suspended-sediment samplers
Instrumentation and site appearance at the River Mile 30 sediment-transport gage.

Configuration of instruments. The rock wall behind the instruments is used to camouflage the station.

Site appearance from river level. View is downstream. Site is concealed behind the rock wall.
Mount for the 2-MHz Acoustic Doppler Profiler (ADP) at the River Mile 30 sediment-monitoring gage.

Underwater photo of ADP instrument head (USGS diver for scale)

Radio-modem antenna

Camouflaged mount and radio modem antenna.
Most sand was delivered to Colorado River before September 1.

Cumulative sand delivery to the Colorado River:
- Discharge, in cubic feet per second
- Mass, in metric tons

- Paria River at Lees Ferry
- upper range of estimate: 769,000
- lower range of estimate: 617,000
Water

Cumulative amount of sand transported past RM30 gage

Sand mass balance in upper Marble Canyon

782,000
551,000
Water

Cumulative amount of sand transported past RM30 gage

Sand mass balance in upper Marble Canyon

782,000
551,000
477,000
212,000
Between July 1 and December 1, 2012...

- **Mainstem flow**
- **Mainstem flow and sediment**
- **Tributary flow and sediment**
- **Sediment budget reach**

RM 0-30 – upper Marble Canyon
RM 30-61 – lower Marble Canyon
RM 61-87 – eastern Grand Canyon
RM 87-166 – central Grand Canyon
RM 166-225 – western Grand Canyon

**617,000 – 769,000 metric tons entered Colorado River from the Paria River**

**212,000 and 477,000 metric tons remained in upper Marble Canyon**

**400,000 – 445,000 metric tons were transported past the RM 30 gage**

little to no fine sediment accumulated in lower Marble Canyon
Suspended-sand concentration on Day One at RM30 and at RM61 was lower than in 2008 (no surprise) and in 2004 (surprise). Suspended sand transport at Diamond Creek (RM225) was higher than ever observed (surprise).

*Our working hypothesis is that floods with higher sand concentrations result in greater rates of sand deposition in eddies.*

Implications – the fine sediment delivered from the Paria River did not greatly increase the concentration of sand in transport in middle and lower Marble Canyon. High concentrations of fine sediment at Diamond Creek were likely due to mobilization of fine sediment that had accumulated in west-central Grand Canyon during equalization flows.
Long-term sand mass-balance context: The 2004 and 2008 floods were conducted when there was mass balance surplus. The sand that entered before the 2012 flood did not offset the large losses that had occurred in 2011.

<table>
<thead>
<tr>
<th>Period of budget</th>
<th>Upper Marble Canyon</th>
<th>Lower Marble Canyon</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2002 - pre2004 flood</td>
<td>330,000 ± 194,000</td>
<td>-280,000 ± 110,000</td>
</tr>
<tr>
<td>pre2004 flood – pre2008 flood</td>
<td>900,000 ± 640,000</td>
<td>290,000 ± 350,000</td>
</tr>
<tr>
<td>pre2008 flood – pre2012 flood</td>
<td>-1,500,000 ± 620,000</td>
<td>-12,000 ± 430,000</td>
</tr>
<tr>
<td></td>
<td>(mostly during May-August 2011)</td>
<td></td>
</tr>
<tr>
<td>July 2012 – pre2012 flood</td>
<td>670,000 ± 120,000</td>
<td>18,000 ± 15,000</td>
</tr>
<tr>
<td>during 2012 flood</td>
<td>-320,000 ± 13,000</td>
<td>-78,000 ± 36,000</td>
</tr>
</tbody>
</table>

Running totals (July 2002 to indicated date) (these values have very large uncertainty)

sand mass, in metric tons
Deposition of sand in eddies occurs wherever there is a large decrease in flow strength, flow enters an area previously depleted of sand, or where the flow enters an area where the bed sand is much coarser than what is in transport.

Implication: the same amount of deposition can occur in places even if the concentrations of sand in transport are less in those eddies where there is a large influence of changes in hydraulics.
Examples of eddy sandbars that increased in area and volume

RM 2.5 L

11/18/2012

11/24/2012

GCMRC automated camera program

RM 8 L

11/18/2012

11/24/2012
RM 9 L

11/18/2012

11/24/2012

RM 16 L

11/18/2012

11/24/2012

GCMRC automated camera program
Grand Canyon River Guides Adopt-a-Beach program

RM 29.4 L

Apr 2008

Oct 2010

Dec 2012
Examples of eddy sandbars where there was no substantial change in size or volume.
Example of eddy sandbar where there was a decrease in size and volume
A majority of photographed sandbars increased in area

• **Summary of evaluations at 33 sites for 2012**
  Substantial gain (deposition): 18 sandbars (55%)
  No substantial change: 12 sandbars (36%)
  Substantial loss (erosion): 3 sandbars (9%)

• **Downstream trends**
  – All sites between RM 0 and RM 32 increased
  – Downstream from RM 32, ~even proportional split between sites of noticeable gain and no change; a few sites had noticeable losses

- **15 sites with cameras present during all 4 events**
  - In each year, a few sites did better, a few not as well, *no notable temporal patterns*, too few sites to make any general conclusions

- **26 sites with cameras present in 2008 and 2012**
  - 4 sandbars larger in 2012 (3 upstream from RM 32)
  - 7 sandbars smaller in 2012
  - 15 sandbars about the same in 2012

*Implication: the amount of bar building not as directly linked with sand concentrations as hypothesized*
What is the effect of changing the hydrograph of the high flow?
Our evidence is anecdotal, because we surveyed such few sites

- Bar volume largest in 1996, area above 8,000 ft³/s stage, largest in 2012
Long-term average size of sand deposits along the channel margin depends on how much deposition occurs during each flood, how much erosion occurs between each flood, and how frequently the floods occur.
Long-term average size of sand deposits along the channel margin depends on how much deposition occurs during each flood, how much erosion occurs between each flood, and how frequently the floods occur.

We are learning more about how intervening operations preconditioned some of the sediment transport attributes of this flood.
Conclusions

• Concentrations of suspended sand less than anticipated, due to equalization flows, but ...

• 2012 flood resulted in sandbar building, similar to observations in previous controlled floods

• Bar building not as widespread as 2008