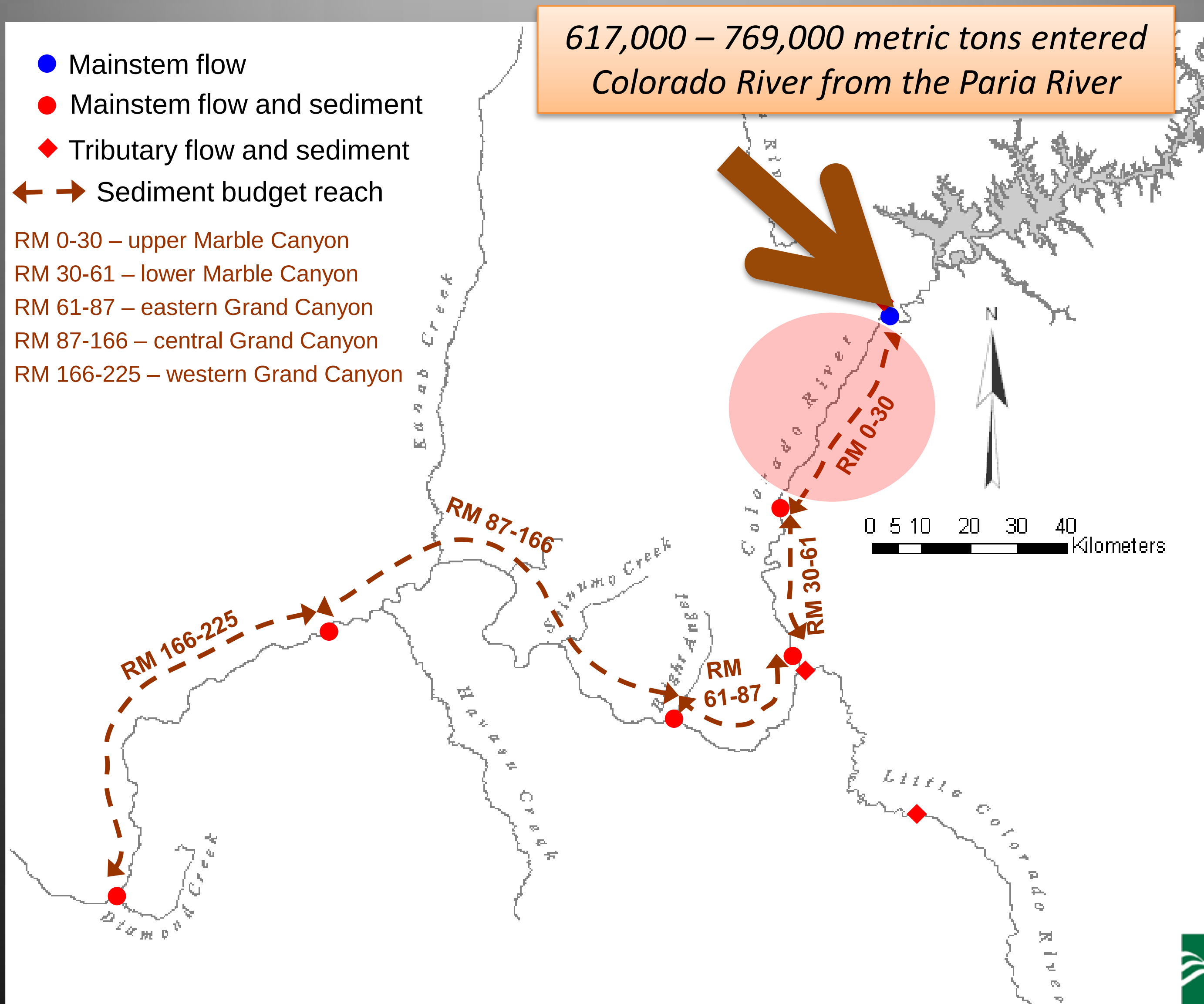
During the accounting period immediately before the HFE (July 1 and November 17, 2012) …



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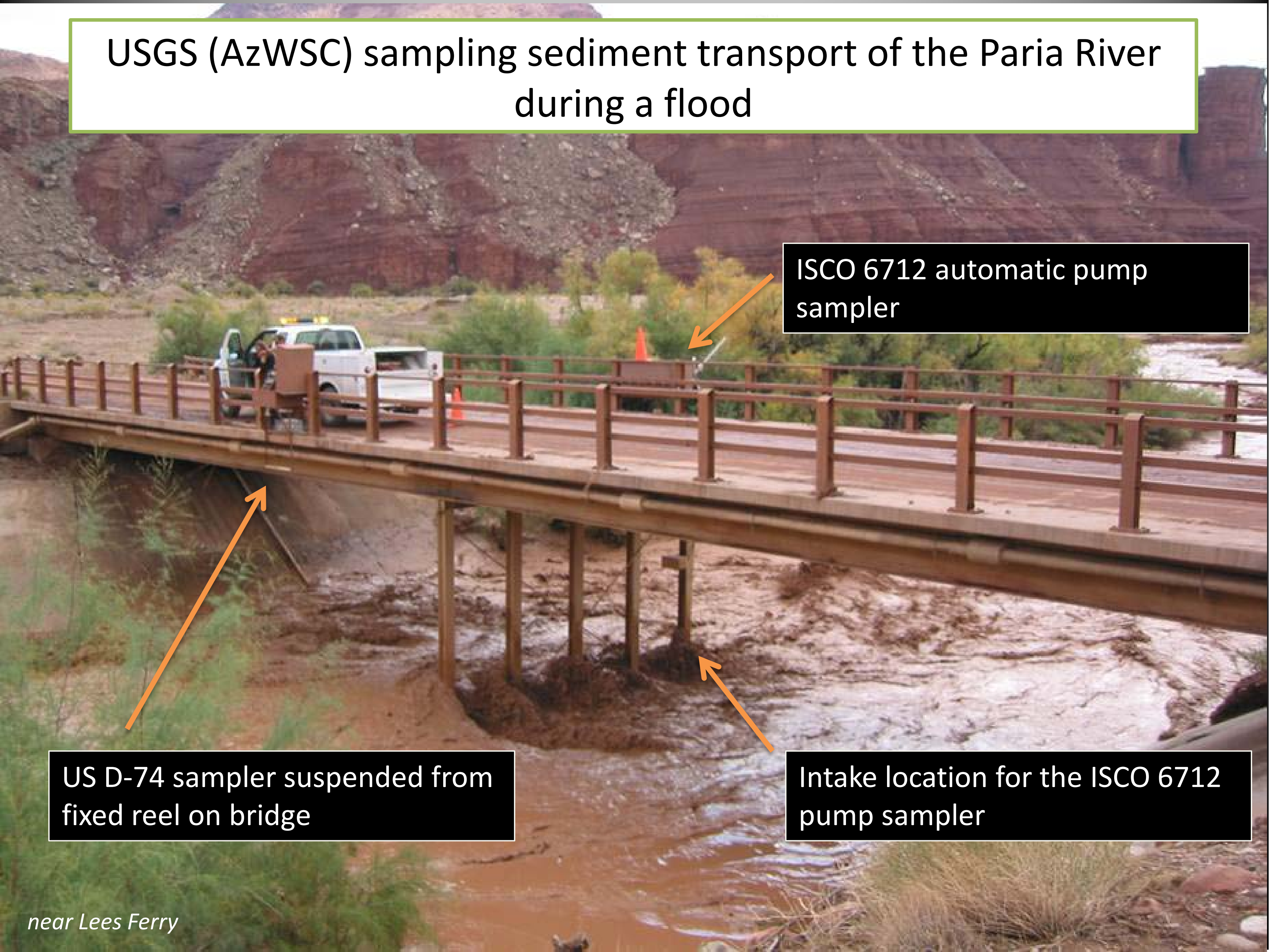
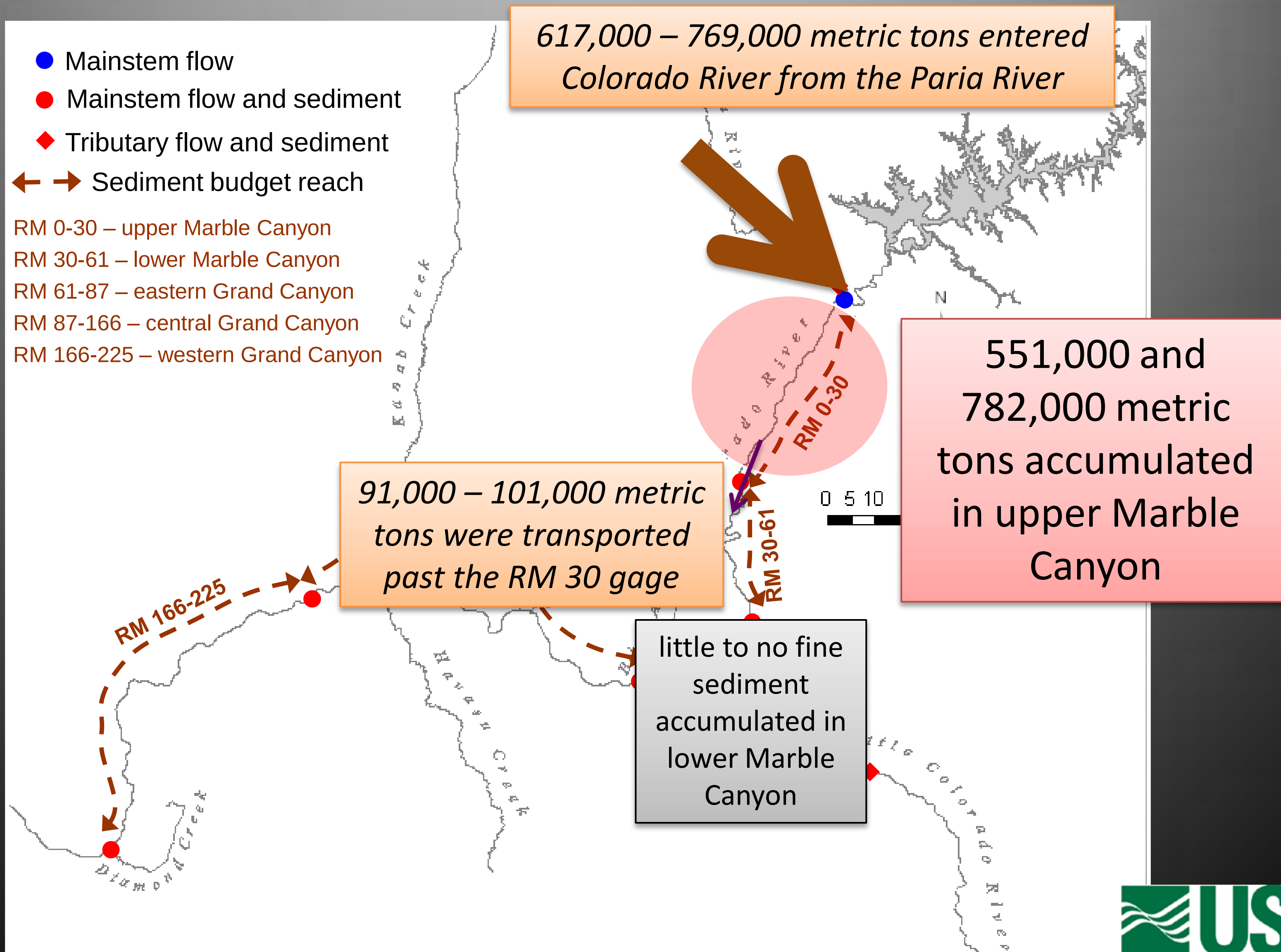


USGS (AzWSC) sampling sediment transport of the Paria River during a flood
ISCO 6712 automatic pump sampler
US D-74 sampler suspended from fixed reel on bridge
Intake location for the ISCO 6712 pump sampler
near Lees Ferry

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



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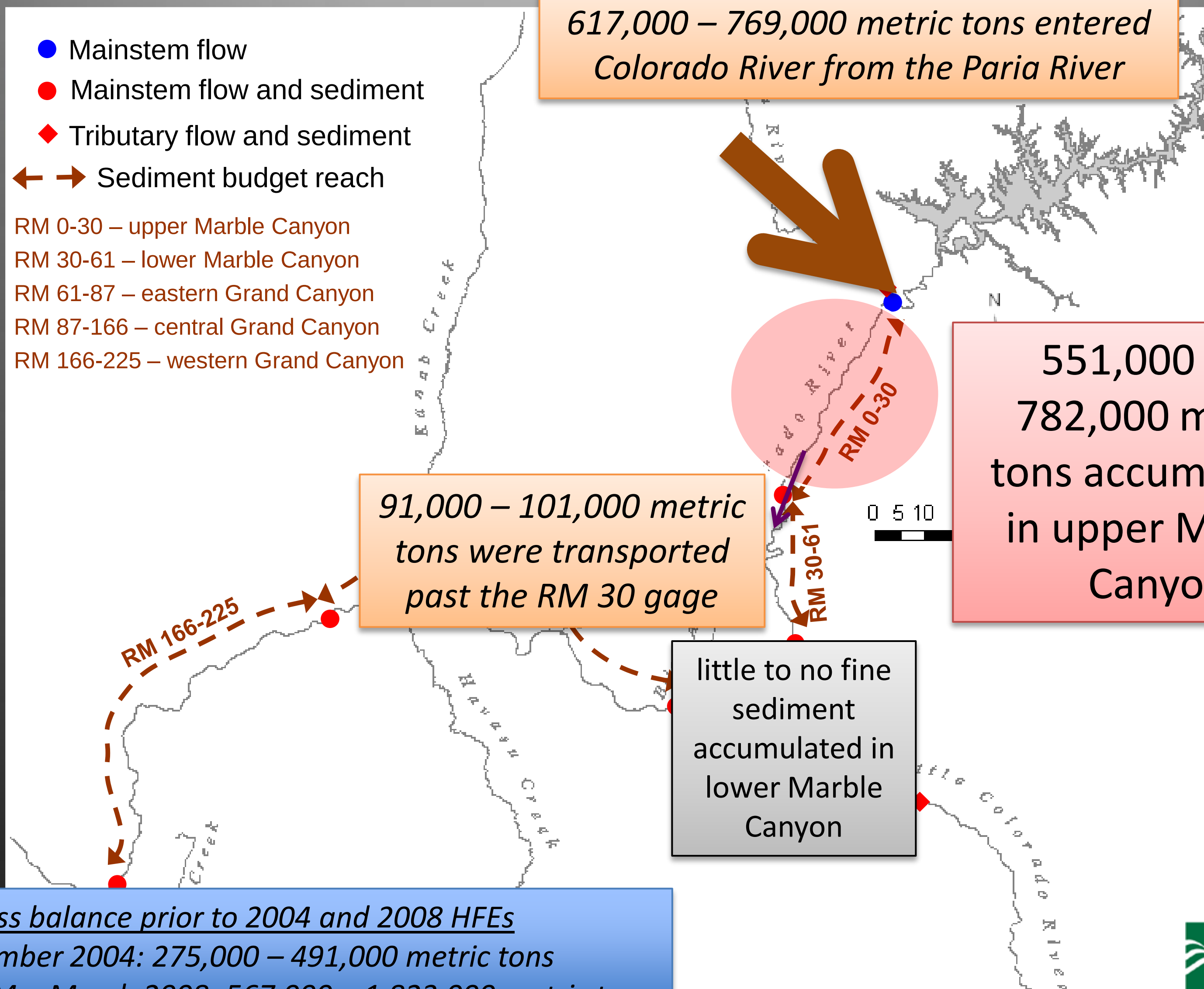
During the accounting period immediately before the HFE (July 1 and November 17, 2012) …



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

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

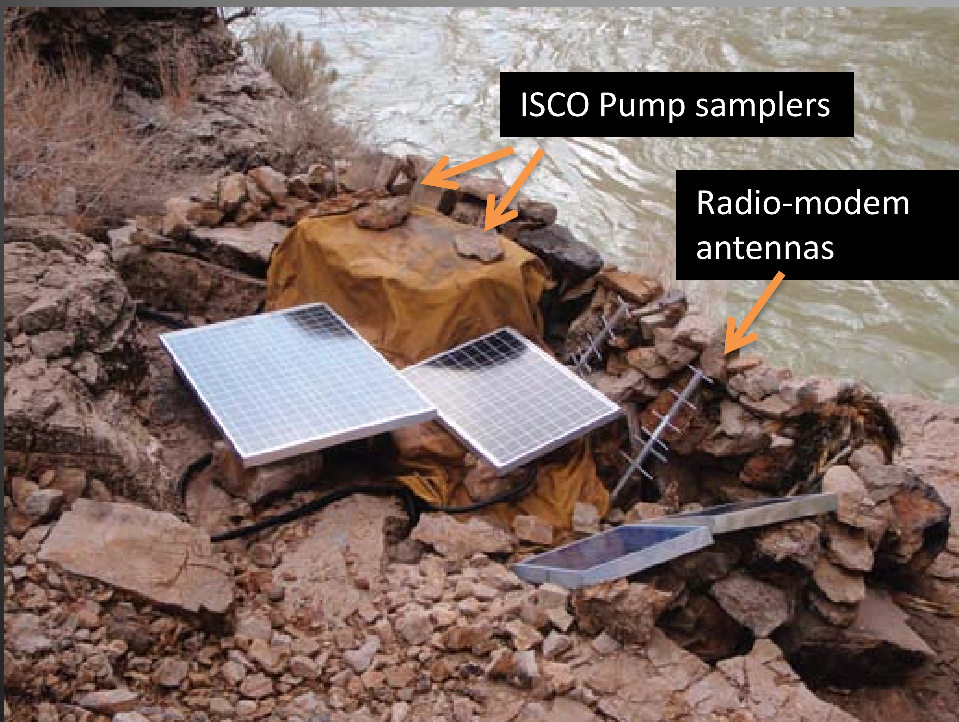
__Mass balance prior to 2004 and 2008 HFEs__

July 1 to November 2004: 275,000 – 491,000 metric tons

December 2004 – March 2008: 567,000 – 1,823,000 metric tons

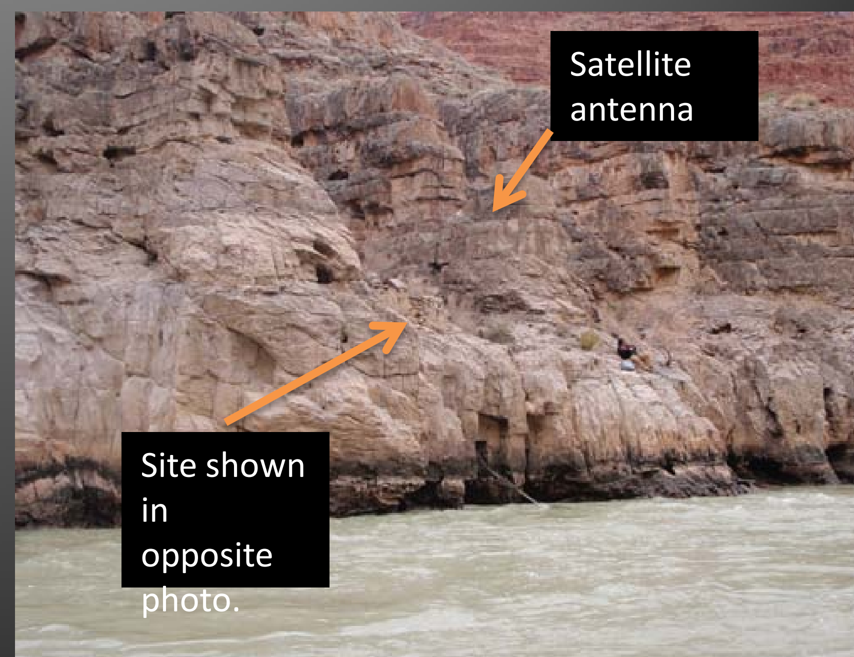
Motorized boat equipped for the collection of suspended-sediment data at tagline at River Mile 30.

Instrumentation and site appearance at the River Mile 30 sediment-transport gage.



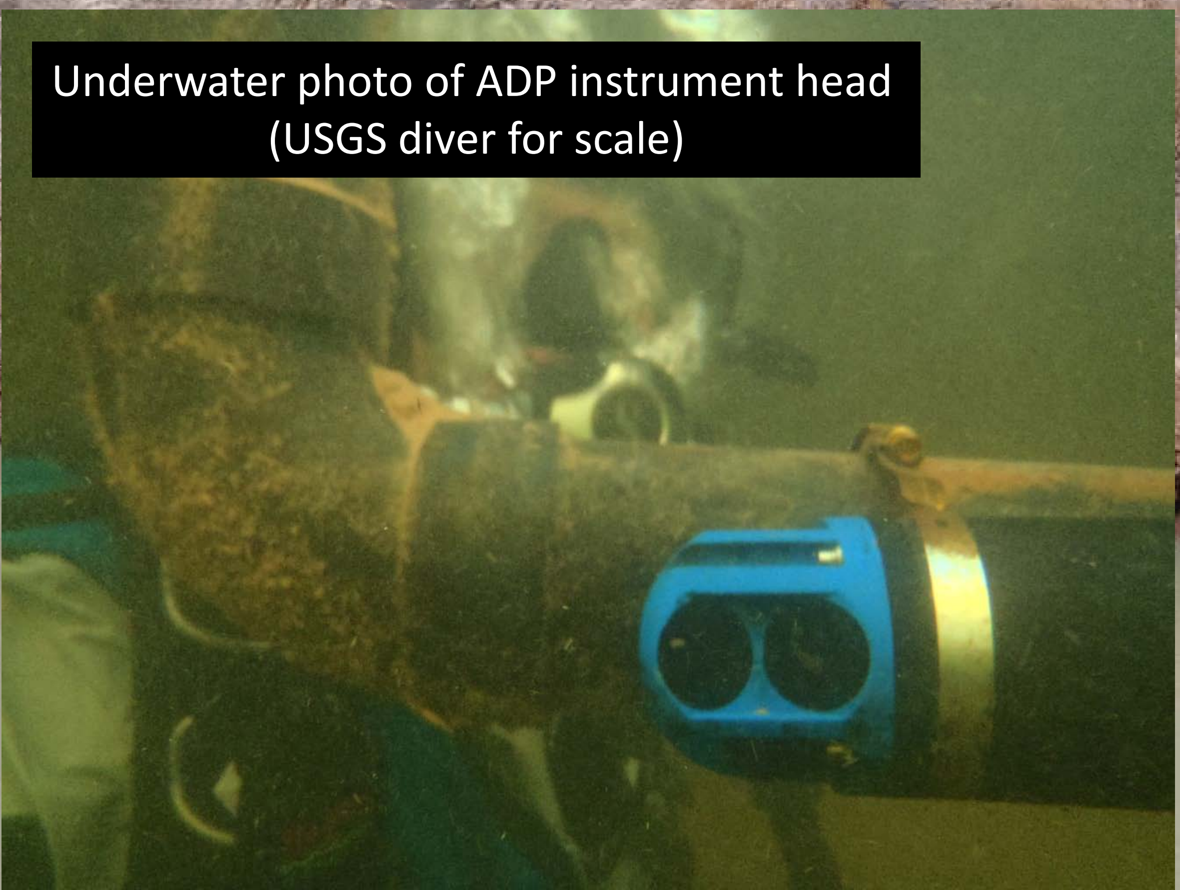
Configuration of instruments. The rock wall behind the instruments is used to camouflage the station.

Site appearance from river level. View is downstream. Site is concealed behind the rock wall.

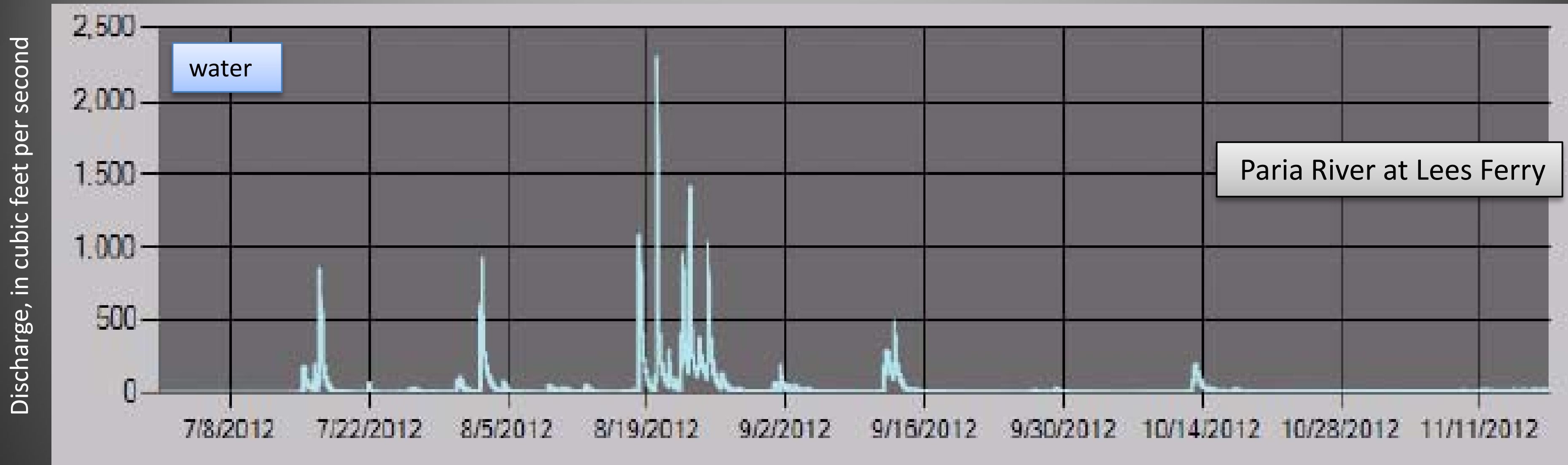


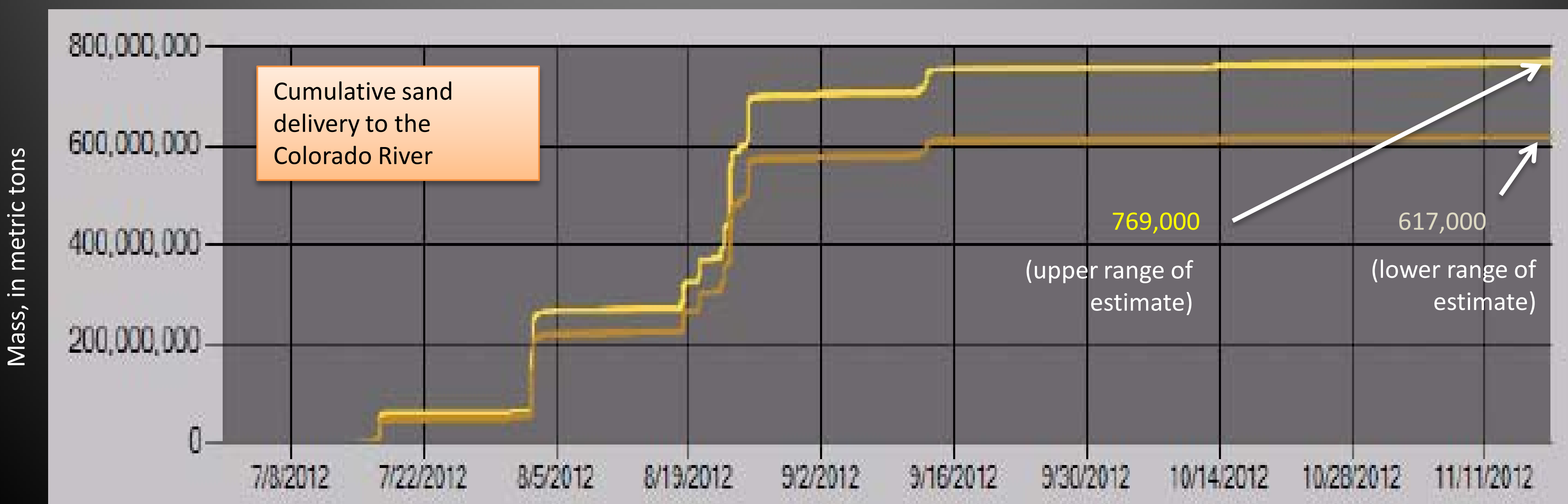
Mount for the 2-MHz Acoustic Doppler Profiler (ADP) at the River Mile 30 sediment-monitoring gage.

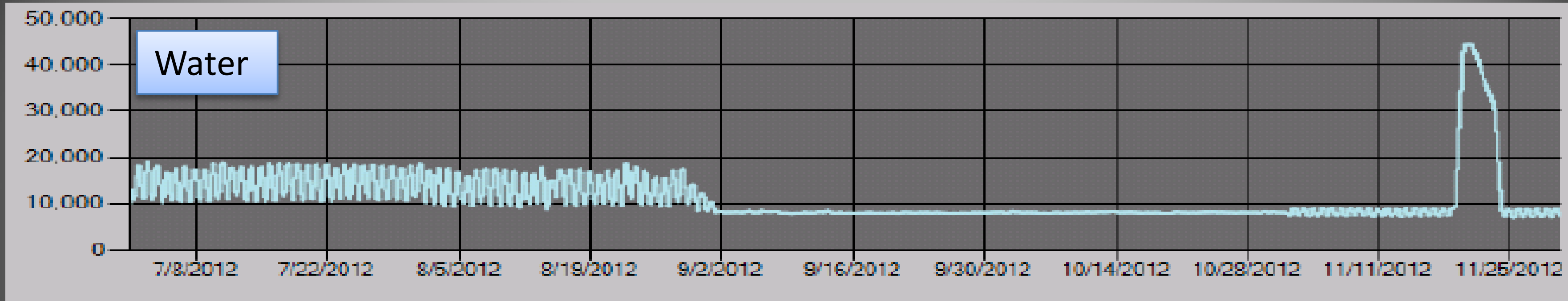
Camouflaged mount and radio modem antenna.

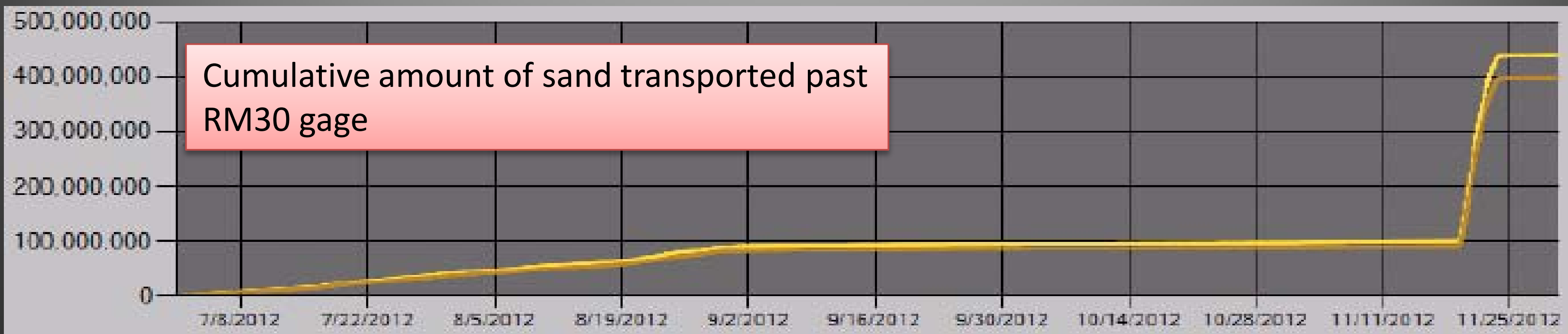


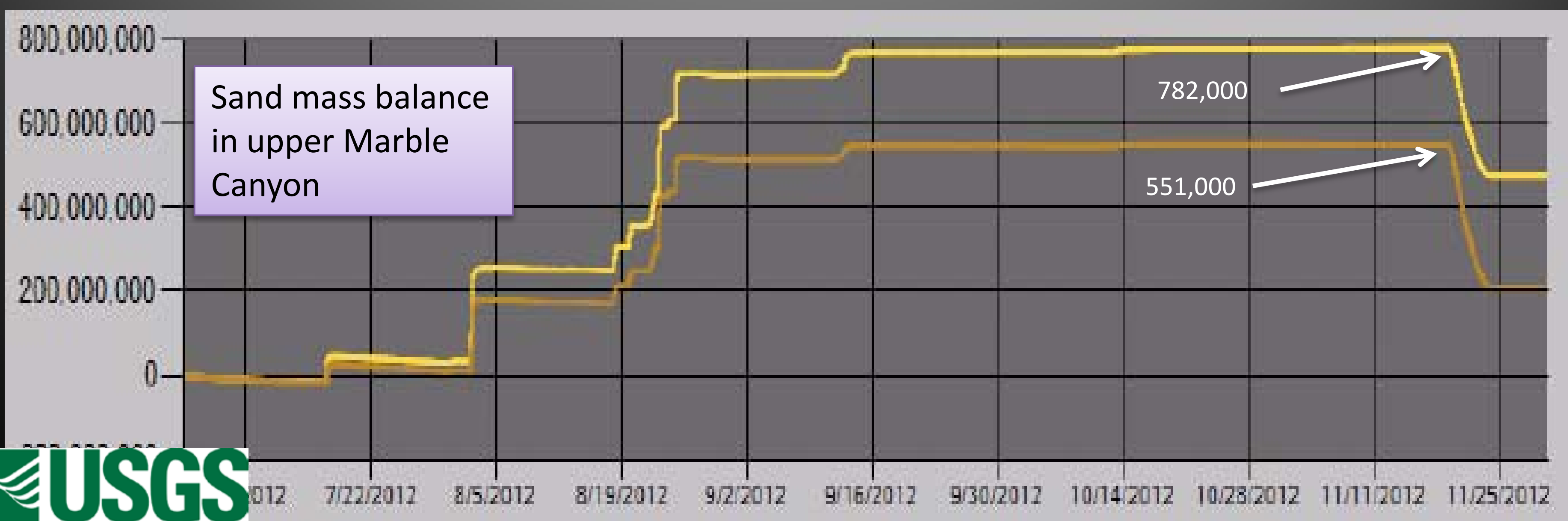
Most sand was delivered to Colorado River before September 1

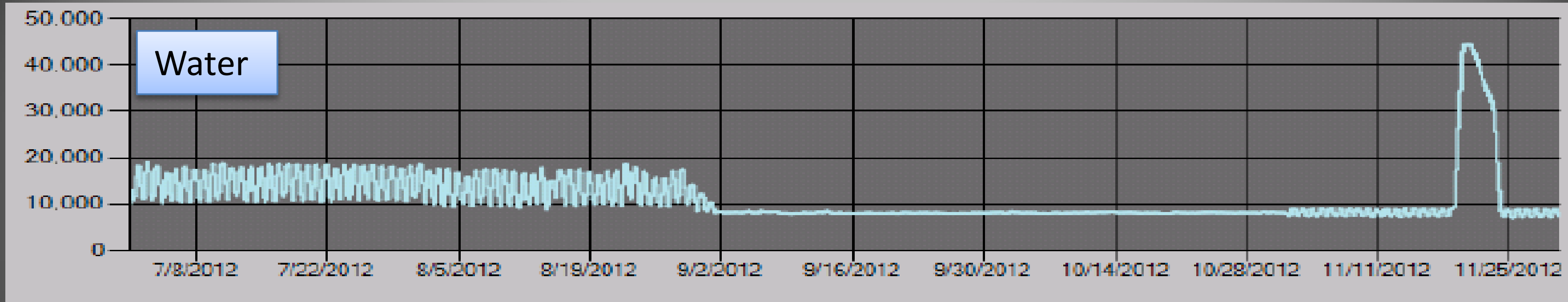


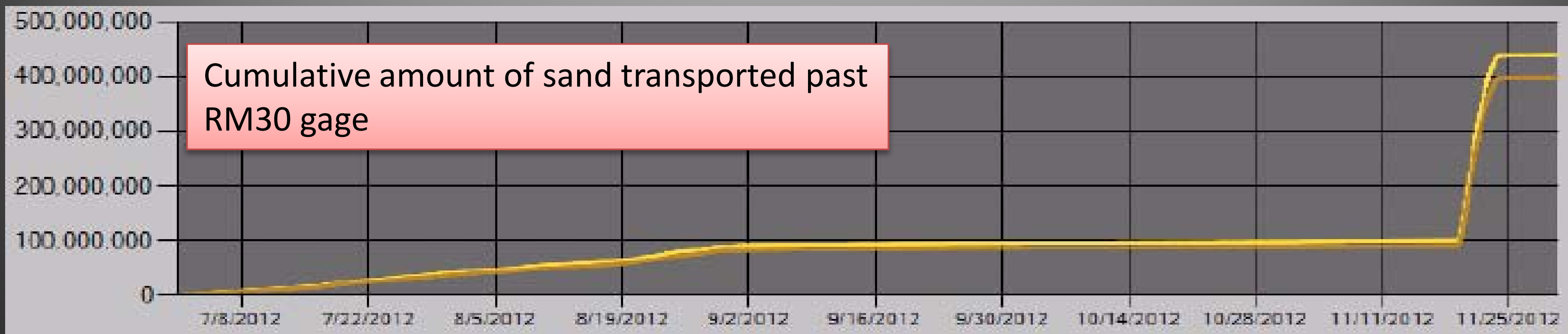


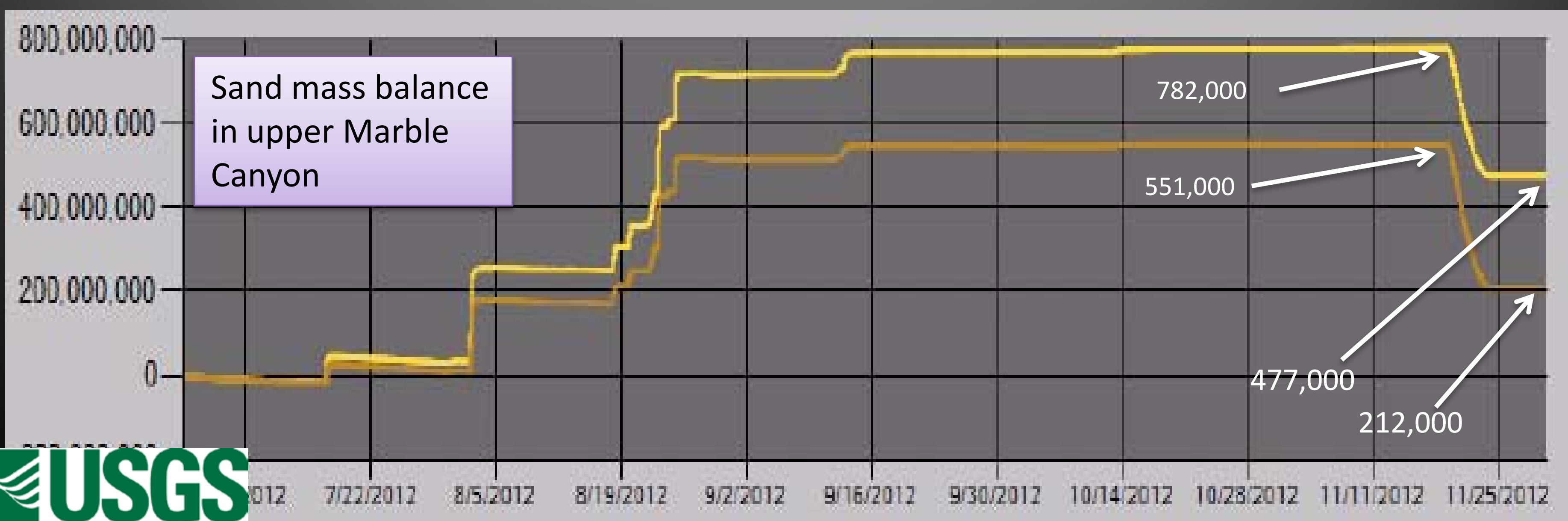

Water
50,000
40,000
30,000
20,000
10,000
0
7/8/2012
7/22/2012
8/5/2012
8/19/2012
9/2/2012
9/16/2012
9/30/2012
10/14/2012
10/28/2012
11/11/2012
11/25/2012


Cumulative amount of sand transported past RM30 gage
500,000,000
400,000,000
300,000,000
200,000,000
100,000,000
0
7/8/2012
7/22/2012
8/5/2012
8/19/2012
9/2/2012
9/16/2012
9/30/2012
10/14/2012
10/28/2012
11/11/2012
11/25/2012


Sand mass balance in upper Marble Canyon
782,000
551,000
800,000,000
600,000,000
400,000,000
200,000,000
0
7/22/2012
8/5/2012
8/19/2012
9/2/2012
9/16/2012
9/30/2012
10/14/2012
10/28/2012
11/11/2012
11/25/2012







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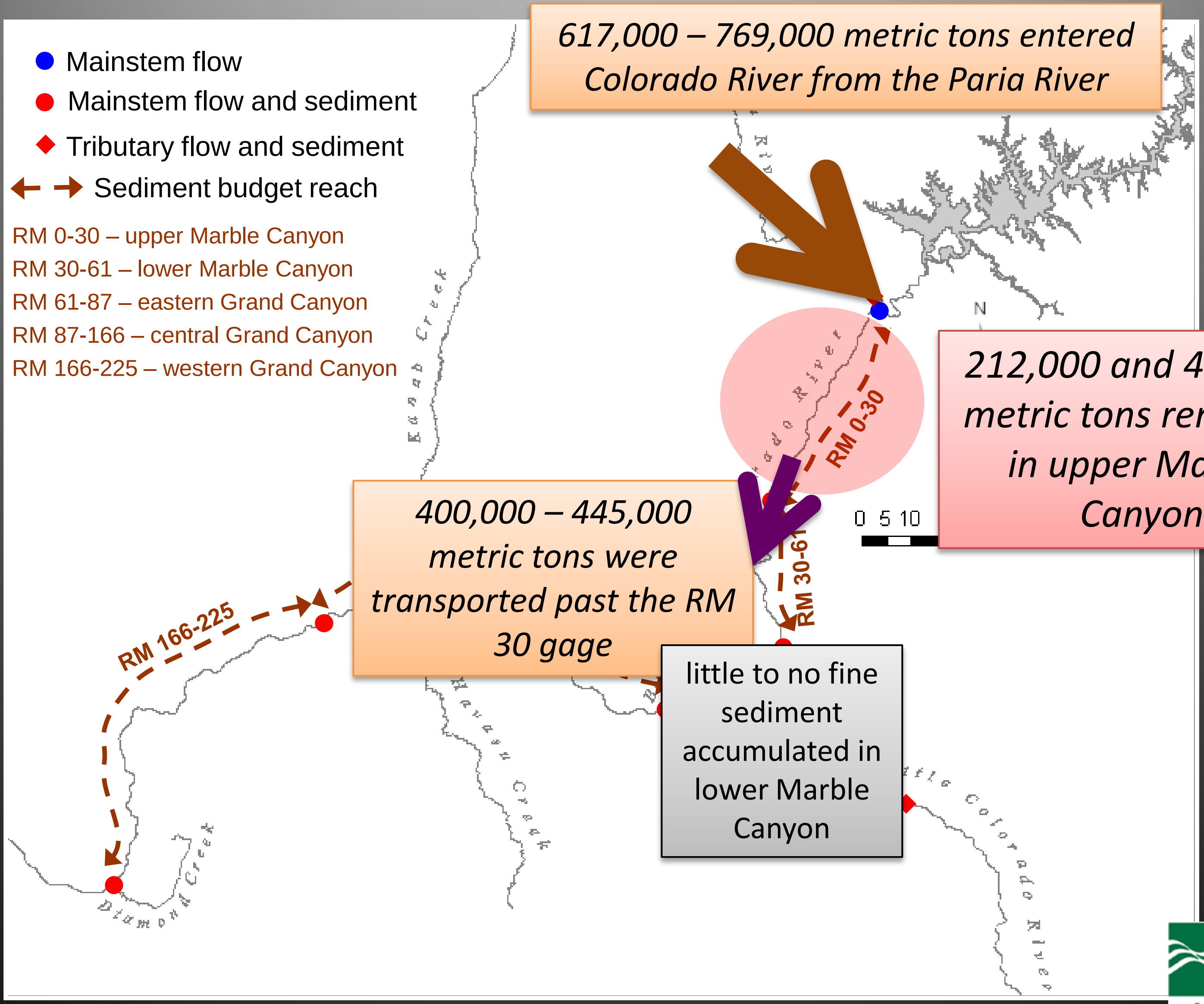
Between July 1 and December 1, 2012 …



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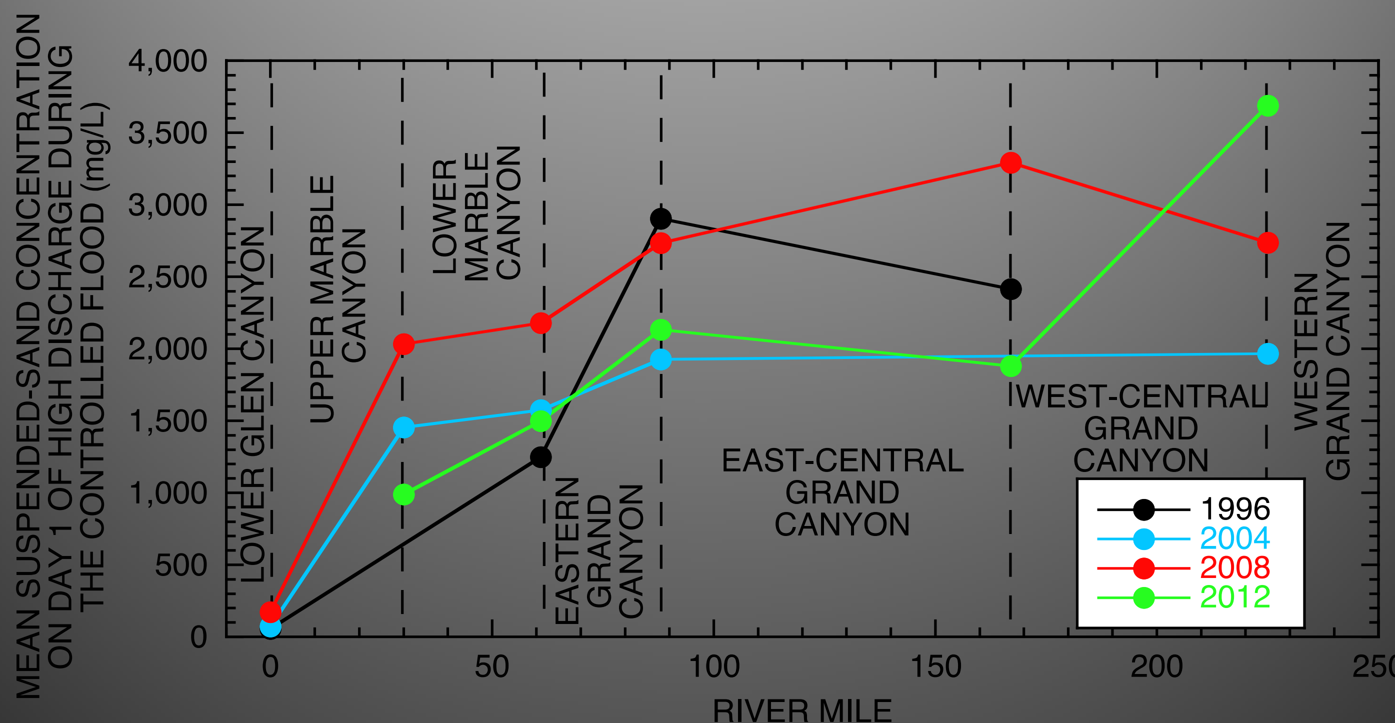
Suspended-sand concentration on Day One at RM30 and at RM61 was lower than in 2008 (no surprise) and in 2004 (surprise). Suspended sand transport at Diamond Creek (RM225) was higher than ever observed (surprise).

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

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(after Topping and others, 2010)

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.*

Period of budget	Upper Marble Canyon	Lower Marble Canyon
July 2002 - pre2004 flood	**330,000 ± 194,000** +330,000	**-280,000 ± 110,000** -280,000
pre2004 flood – pre2008 flood	**900,000 ± 640,000** +1,230,000	**290,000 ± 350,000** +10,000
pre2008 flood – pre2012 flood	**-1,500,000 ± 620,000** *(mostly during May-August 2011)*	**-12,000 ± 430,000**
July 2012 – pre2012 flood	**670,000 ± 120,000** -270,000	**18,000 ± 15,000** -2,000
during 2012 flood	**-320,000 ± 13,000** -590,000	**-78,000 ± 36,000** -80,000

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

sand mass, in metric tons

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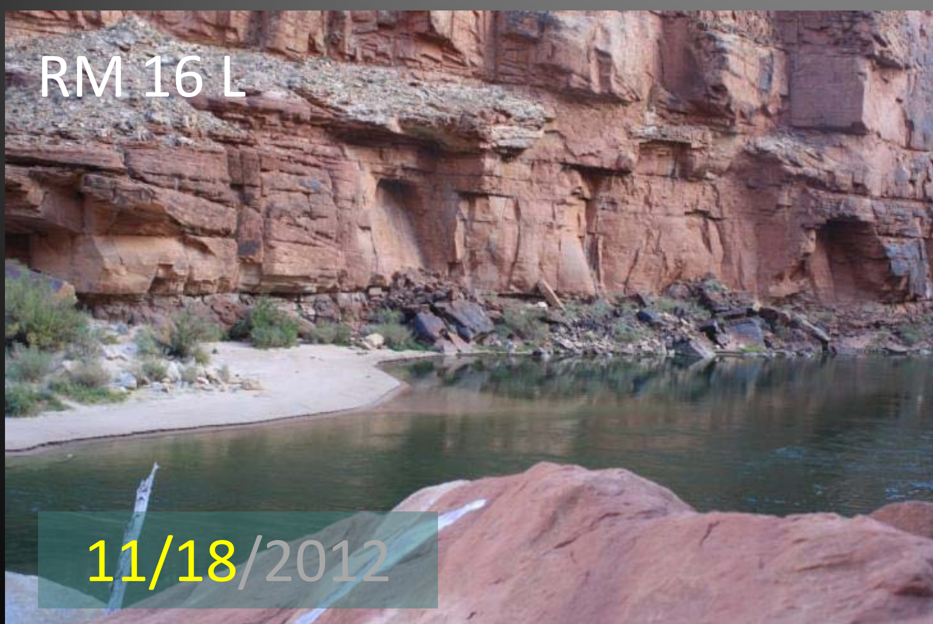
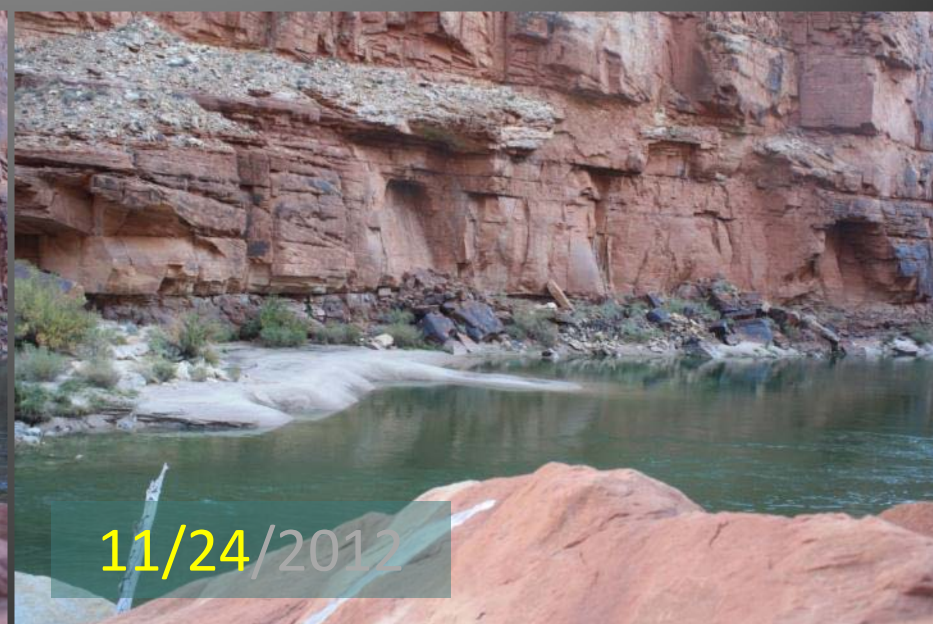
- Deposition of sand in eddies occurs wherever there is a large decrease in flow strength, flow enters an area previously depleted of sand, or where the flow enters an area where the bed sand is much coarser than what is in transport

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

GCMRC automated camera program



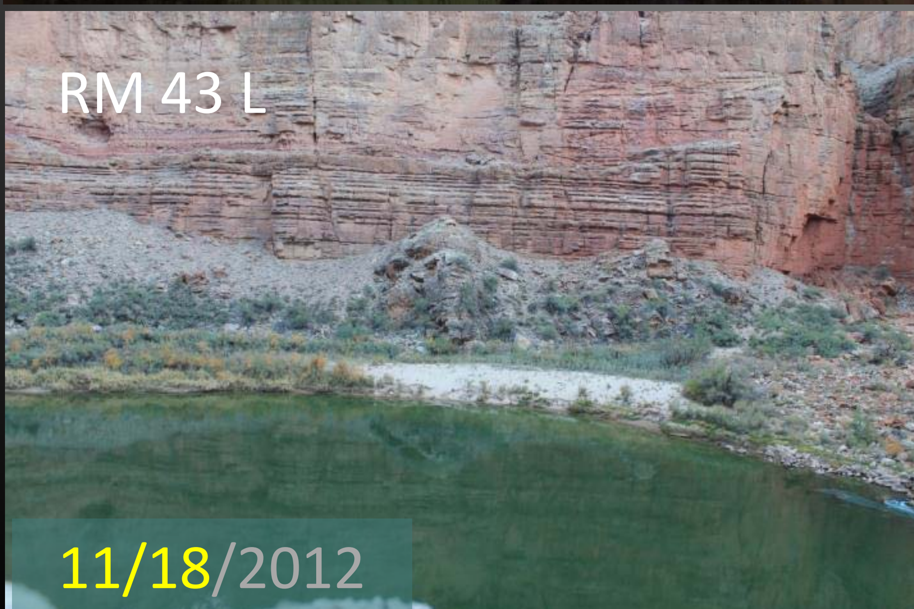


GCMRC automated camera program

RM 29.4 L

Grand Canyon River Guides Adopt-a-Beach program

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%)

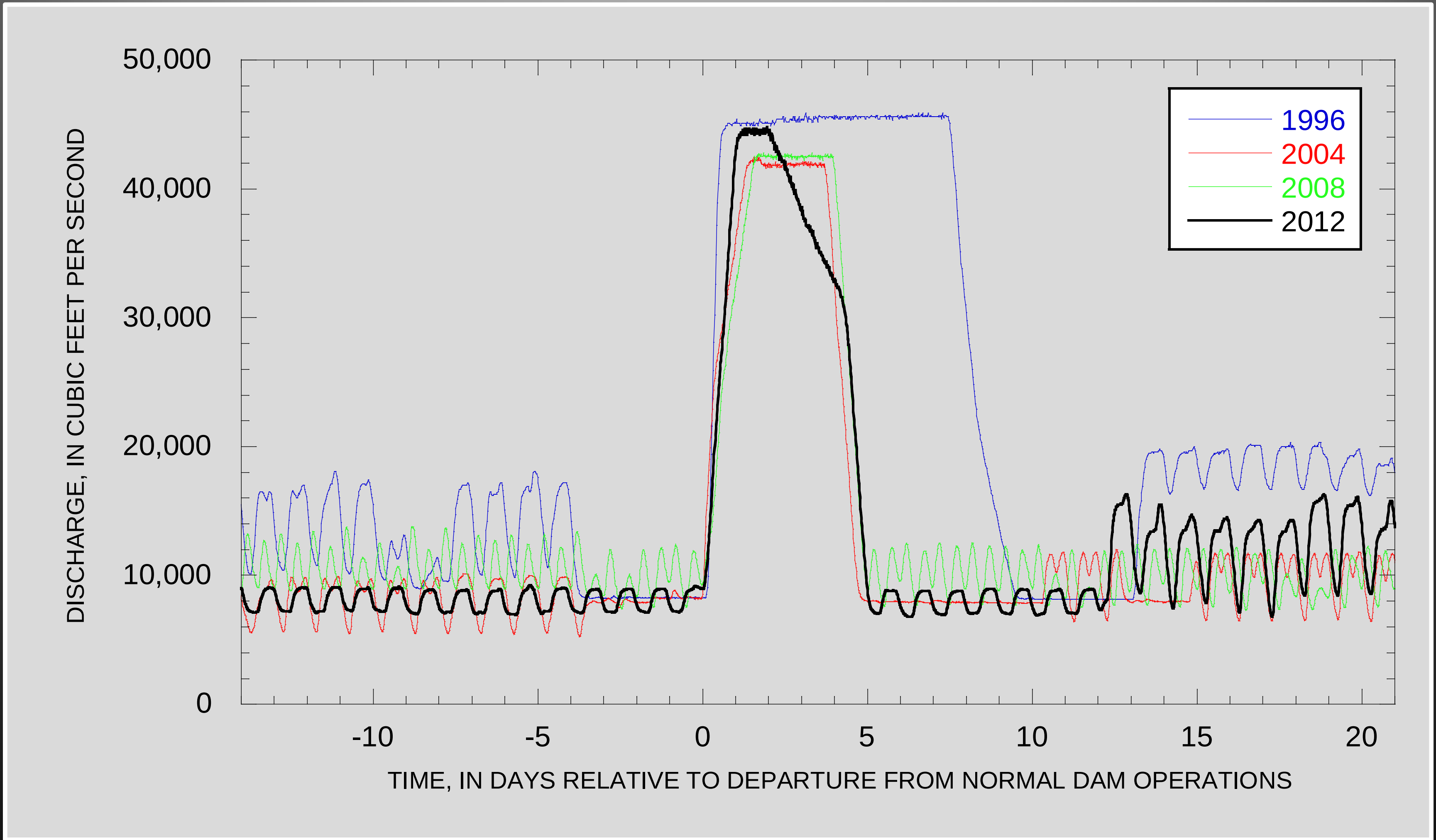
- Downstream trends
  - All sites between RM 0 and RM 32 increased
  - Downstream from RM 32, ~even proportional split between sites of noticeable gain and no change; a few sites had noticeable losses

Comparison of Response Among 4 Controlled Floods: 1996, 2004, 2008, 2012

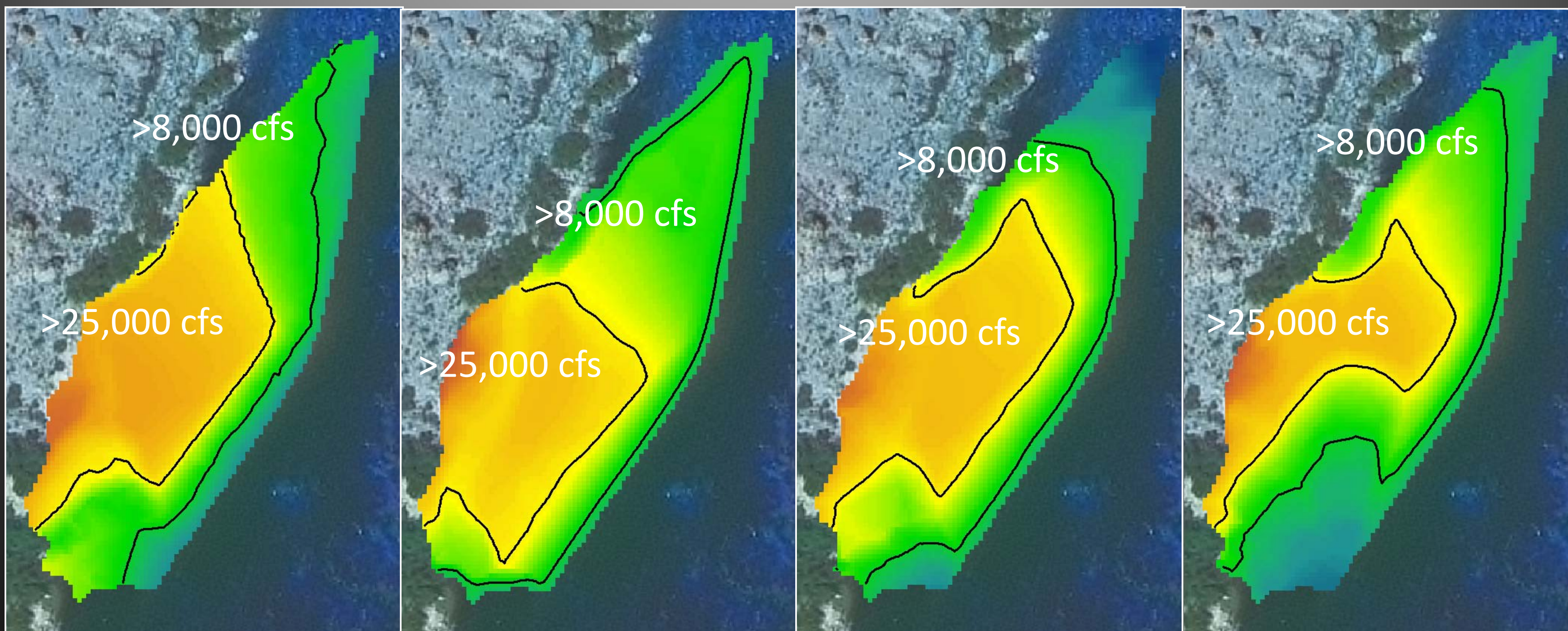
- 15 sites with cameras present <u>during all 4 events</u>
  - In each year, a few sites did better, a few not as well, ***no notable temporal patterns***, too few sites to make any general conclusions
- 26 sites with cameras present in <u>2008 and 2012</u>
  - 4 sandbars larger in 2012 (3 upstream from 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?



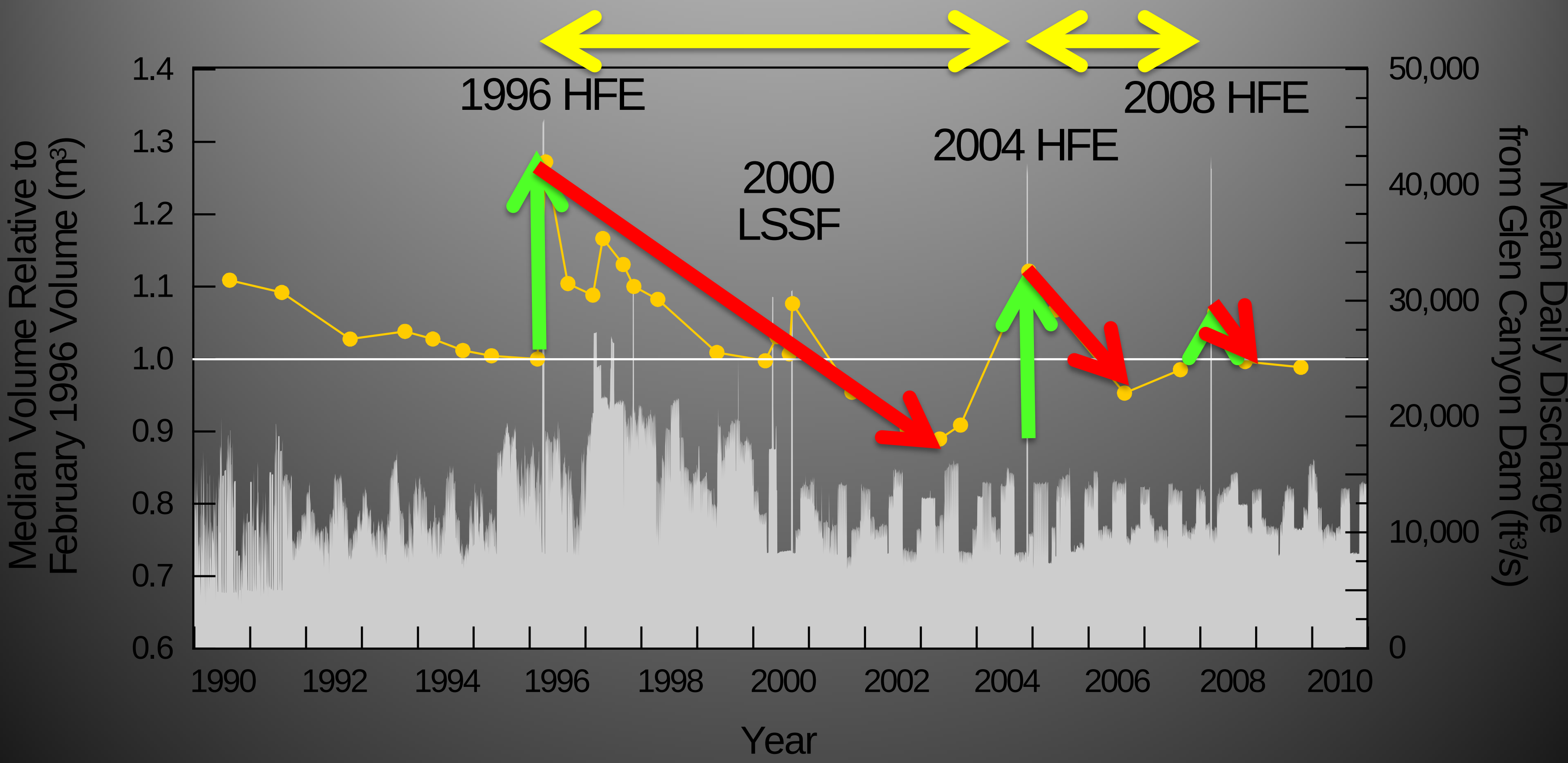
Our evidence is anecdotal, because we surveyed such few sites



1996 post-HFE 2012 post-HFE 2004 post-HFE 2008 post-HFE

- *Bar volume largest in 1996, area above 8,000 ft^3/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**



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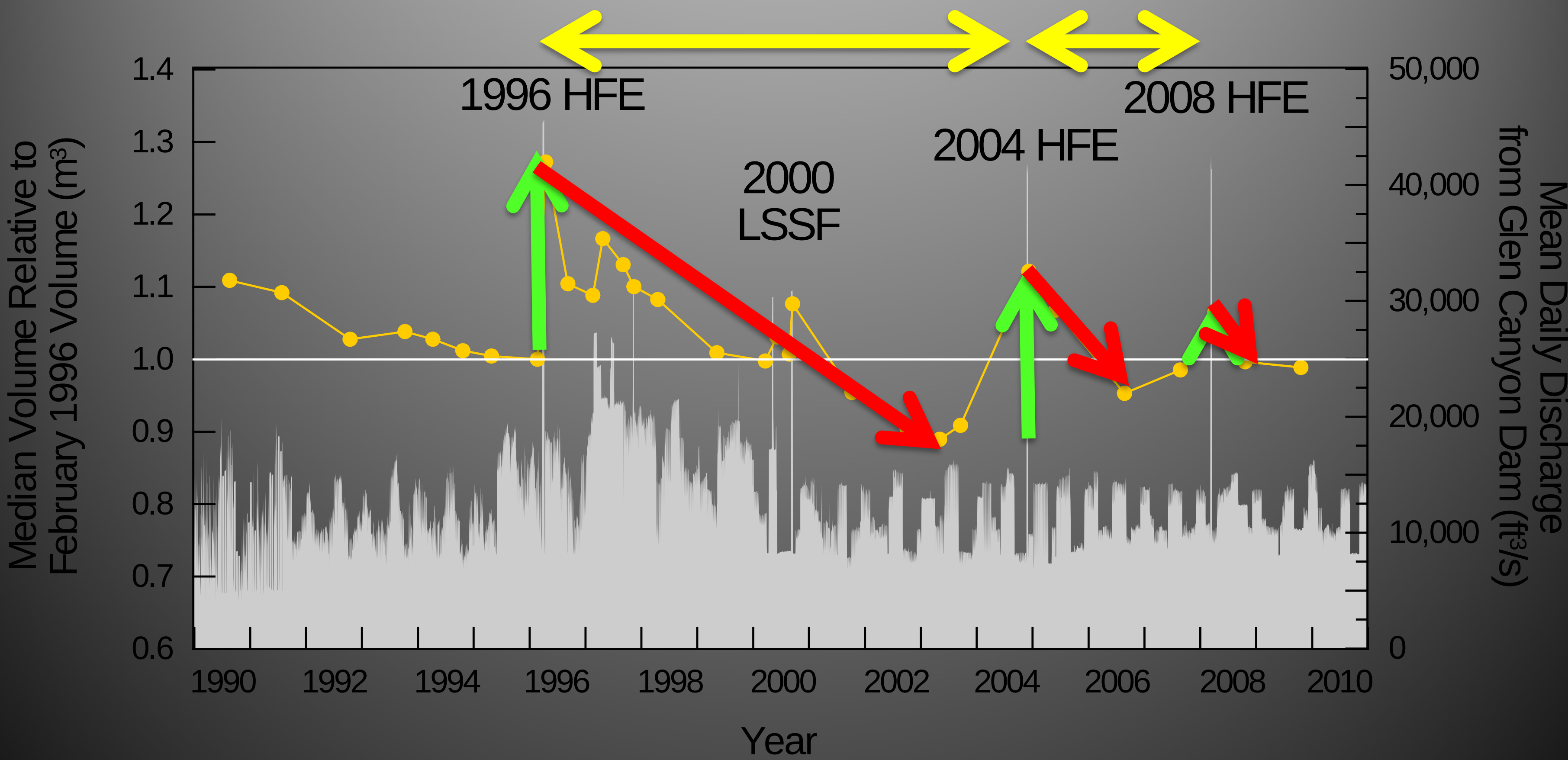
Long-term average size of sand deposits along the channel margin depends on **how much deposition occurs during each flood**, **how much erosion occurs between each flood**, and **how frequently the floods occur**



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

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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