Evaluating the Frequency of Triggered Spring High Flow Experiments (HFE's) Assumed in the Long-Term Experimental and Management Plan

Presentation to Glen Canyon Dam Adaptive Management Program, Technical Working Group
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Building sandbars with HFEs

Sand Budget for 2008 HFE in Upper Marble Canyon

- *HFEs transfer sand from channel and low-elevation parts of eddies to sandbars along channel margins*
- *Cause net export of sand*

Data from: https://www.gcmrc.gov/discharge_qw_sediment

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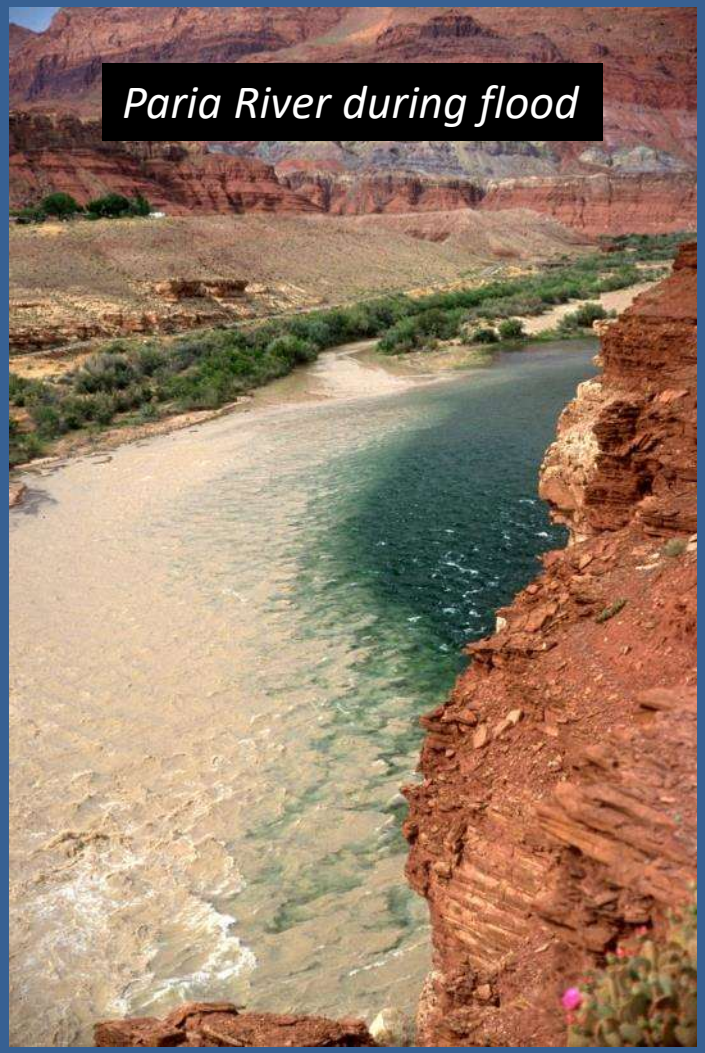
Basic concept of HFE protocol in LTEMP: Balance sand export during HFEs with Paria Sand inputs



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Transport at RM 61
(downstream end of Marble Canyon)

$$Sand_{Paria} + Sand_{small\ tribs} = Sand_{export\ at\ 61\ mi}$$

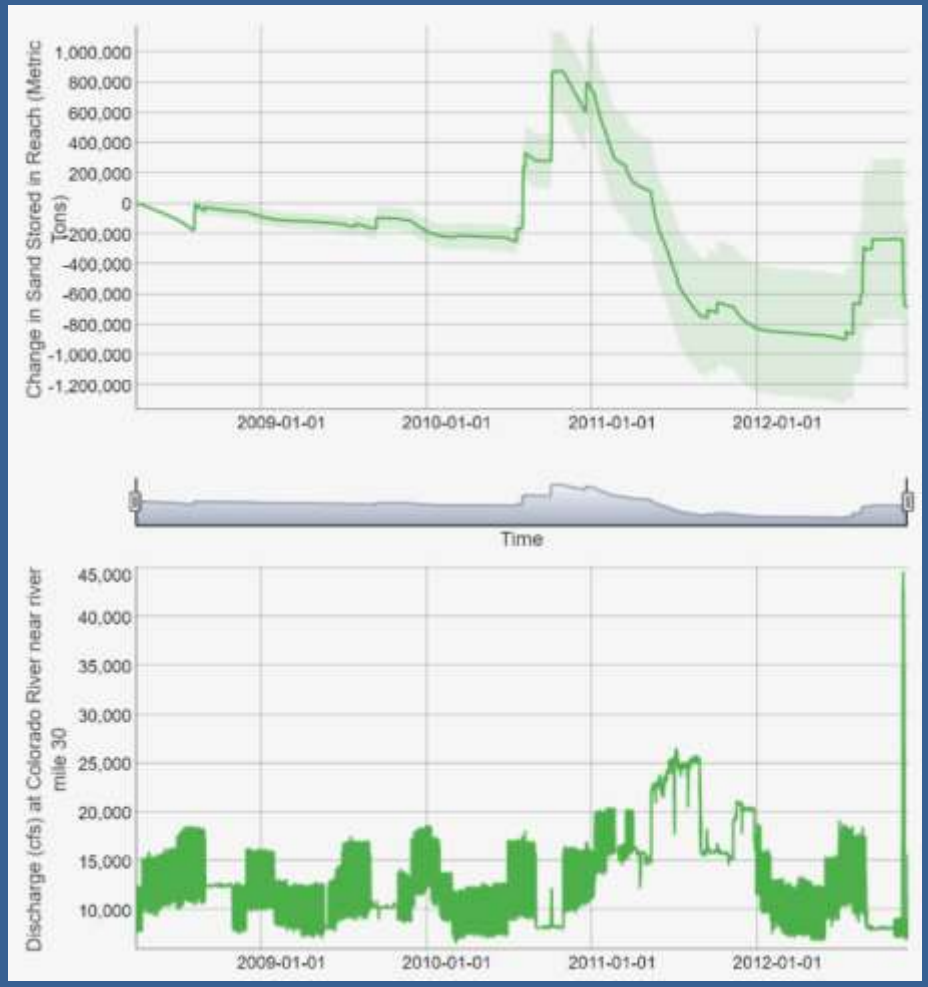
USGS

Sand accounting periods

Accomplish sand budget balance with absolute (long-term) sand accounting or relative (short-term) sand accounting?

- Problems with absolute or “long-term” accounting:
  - Lack accurate measurements of total sand storage
  - Uncertainty in sand budgets accumulates over time (several years)

We monitor the sand budget for long-term trends in storage, but use relative accounting for HFE planning.



2008 to 2012 sand budget for Upper Marble Canyon

Data from: https://www.gcmrc.gov/discharge_qw_sediment

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Sand accounting periods

Short-term relative sand accounting:

- Distinct Spring and Fall accounting periods:
  - Can design HFE to "use" only recent sand inputs.
  - HFEs are implemented when storage in Upper Marble Canyon is highest
  - Simple decision process
- One annual accounting period
  - Would likely end up with more sand export before implementing HFE
  - Would need decision process for deciding whether to implement HFE in Fall or Spring

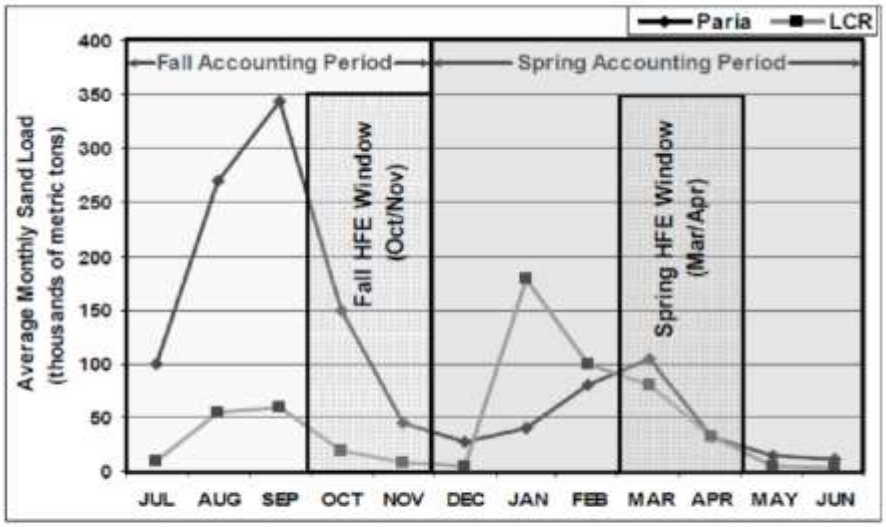

FIGURE P-1 Average Monthly Sand Load from the Paria River and Little Colorado River Showing the Fall and Spring HFE Accounting Periods and Implementation Windows

Plot from LTEMP EIS, Appendix P

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Sand accounting periods

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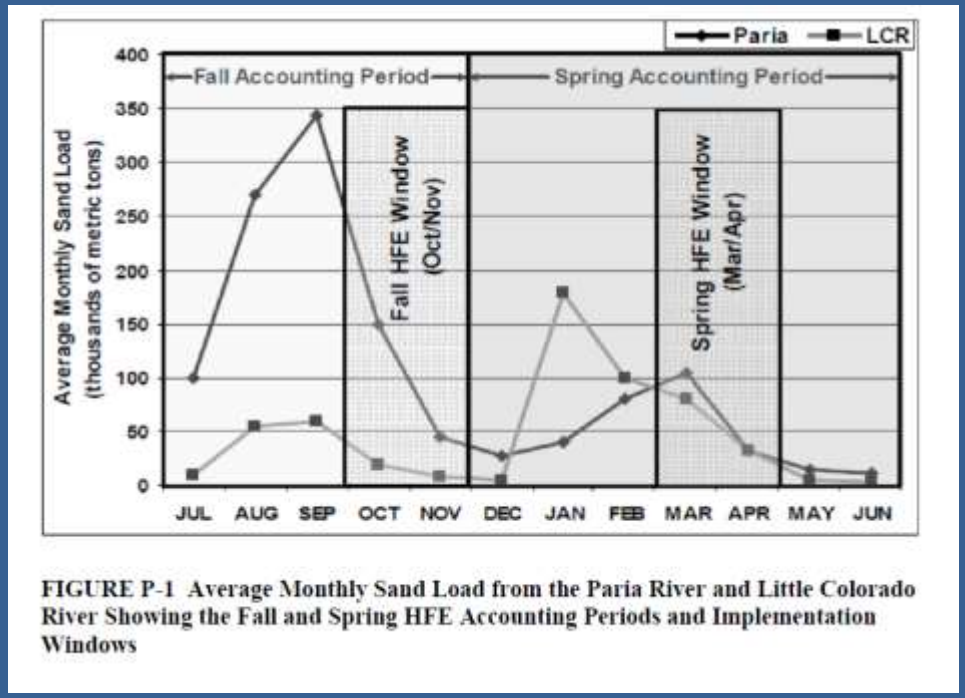

FIGURE P-1 Average Monthly Sand Load from the Paria River and Little Colorado River Showing the Fall and Spring HFE Accounting Periods and Implementation Windows

Plot from LTEMP EIS, Appendix P

Spring HFE's have been avoided since 2008:

"… sediment-triggered spring HFEs would be implemented after an initial 2-year delay in order to … address concerns raised by the apparent positive response of trout to the 2008 spring HFE (Korman et al. 2011; Melis et al. 2011)."

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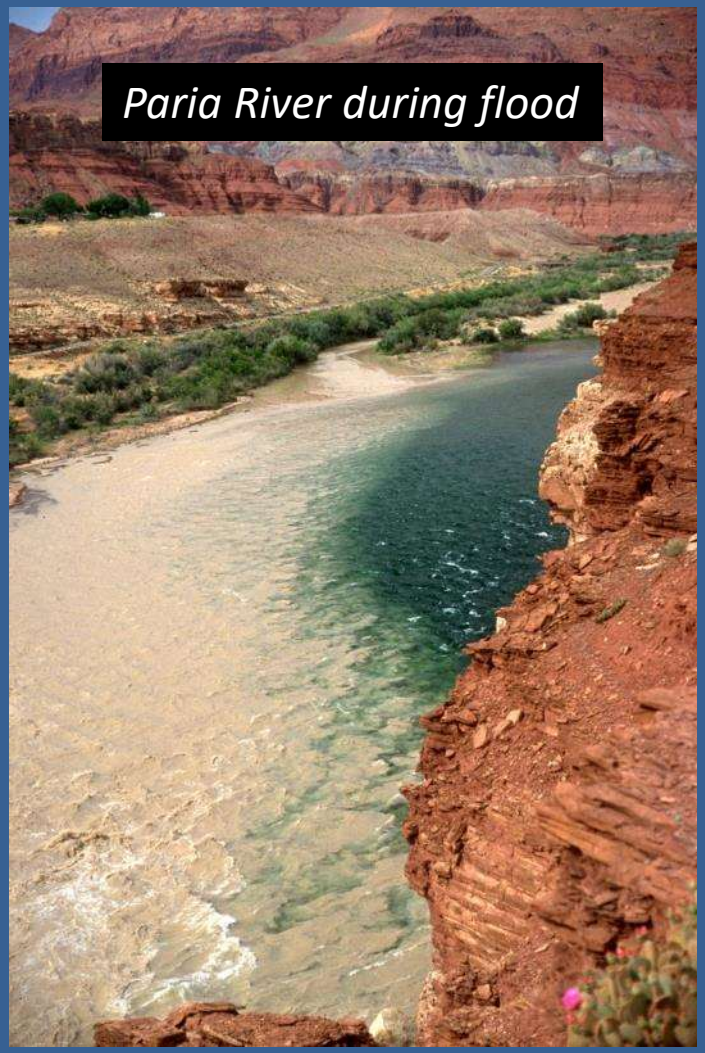
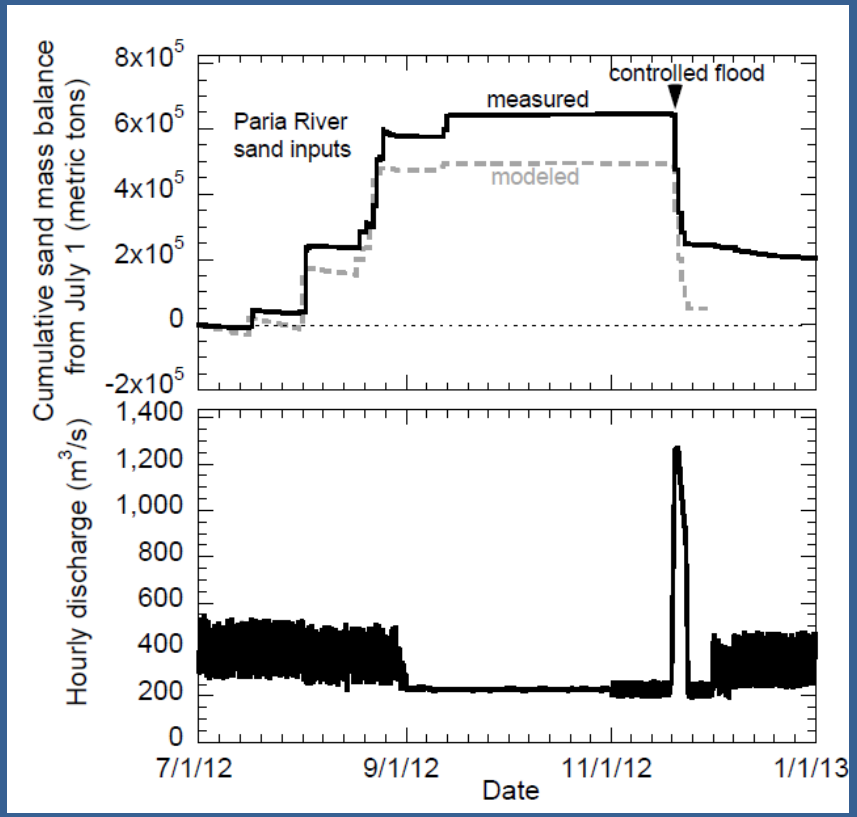
Basic concept of HFE protocol in LTEMP: Balance sand export during HFEs with Paria Sand inputs





Data from: https://www.gcmrc.gov/discharge_qw_sediment

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Frequency of Spring HFEs

As estimated in LTEMP

- Simulations designed to represent the full range of historical conditions:
  - 21 hydrologic traces
  - 3 sediment traces (low, median, high)

➢ May be sufficient sediment input to trigger Spring HFEs in “26% of the years in the LTEMP period”

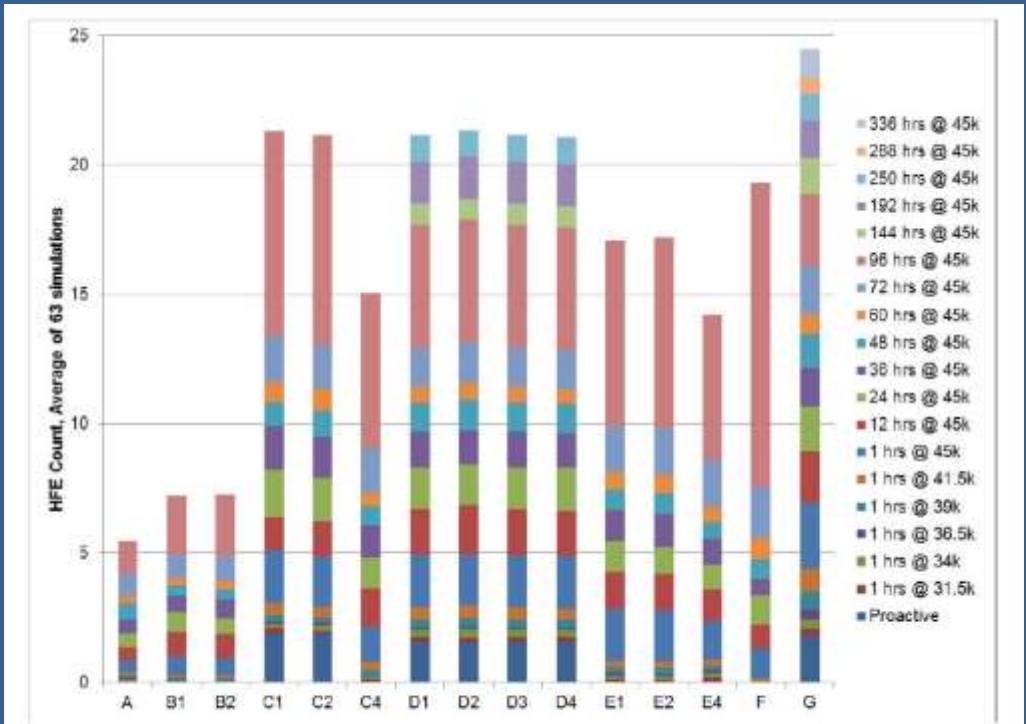

FIGURE E-8 Average Sediment and Hydrology Triggered HFE Count by Type for Each Long-Term Strategy (long-term strategies C3, E3, E5, and E6 by definition have no HFEs)

Estimated number of HFEs to occur during 20-year implementation of LTEMP
(“D” was selected alternative)

Plot from LTEMP EIS, Appendix E

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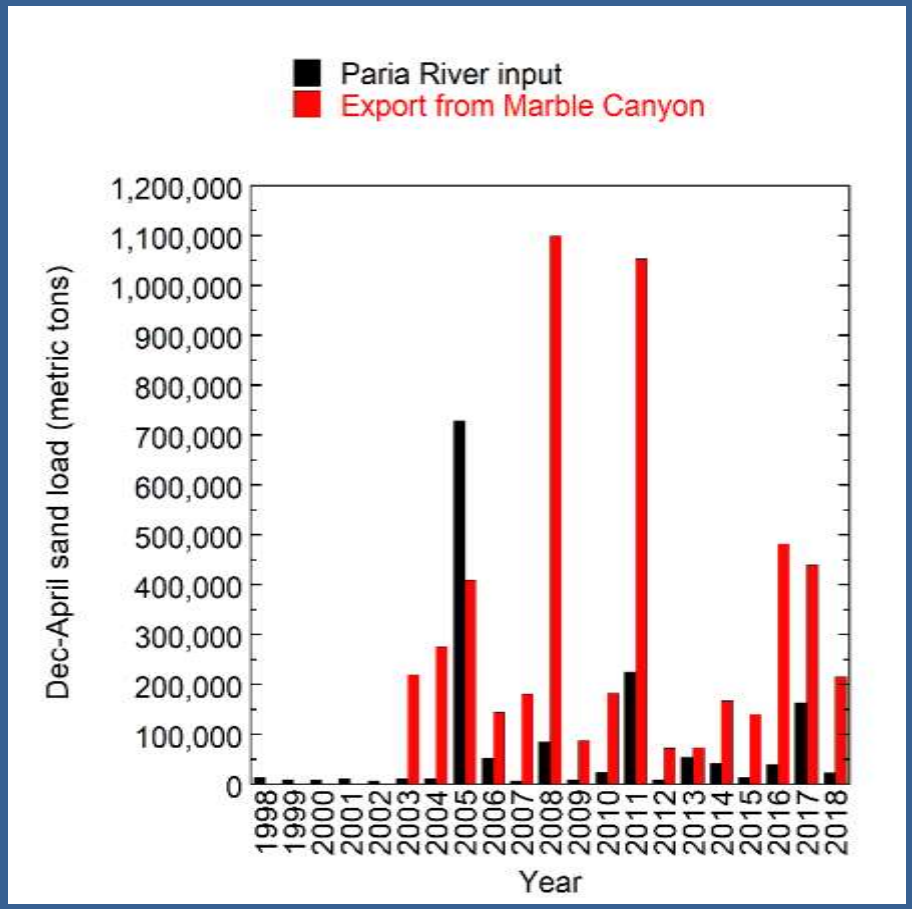
Frequency of Spring HFEs

Based on observations of past 20 years:

- Compare December – April Paria sand inputs with December to April sand export from Marble Canyon
- ➢ May have been sufficient sediment input to trigger Spring HFE: “Once since 1998”



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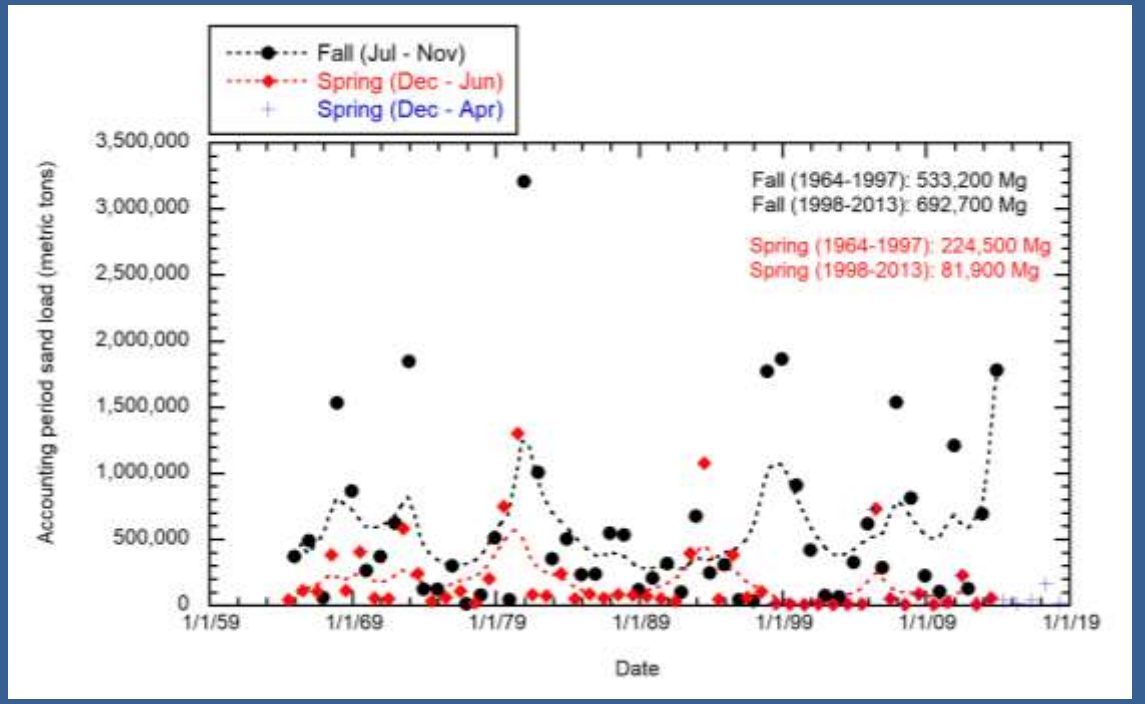
Frequency of Spring HFEs

Why the difference?

- Simulations included Paria River sand inputs since 1963
- Fall (summer) sand inputs from Paria have been relatively consistent
- Spring (winter) sand inputs were at least 3 times greater between 1964 and 1997 than between 1998 and present
- ➢ Winter sand inputs are not consistent

Maybe we'll see a return to larger winter floods, or maybe there has been a shift in winter precipitation…



- *Black circles (summer/fall inputs) and red diamonds (winter/spring inputs) are data used in LTEMP*
- *Blue "+" are 1998 2018 data we looked at (same)*

Data from: https://www.gcmrc.gov/discharge_qw_sediment

USGS

HFE Design

April 24, 2018

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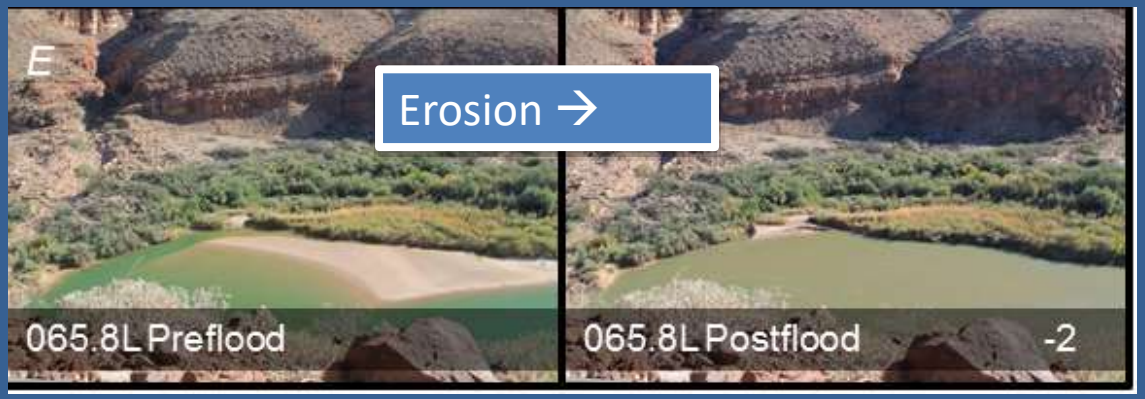
U.S. Department of Interior
U.S. Geological Survey

Types of sandbar response to HFEs

~ 50-60% of sites

~ 30-40% of sites



~ 10% of sites

Grams et al. (2018)

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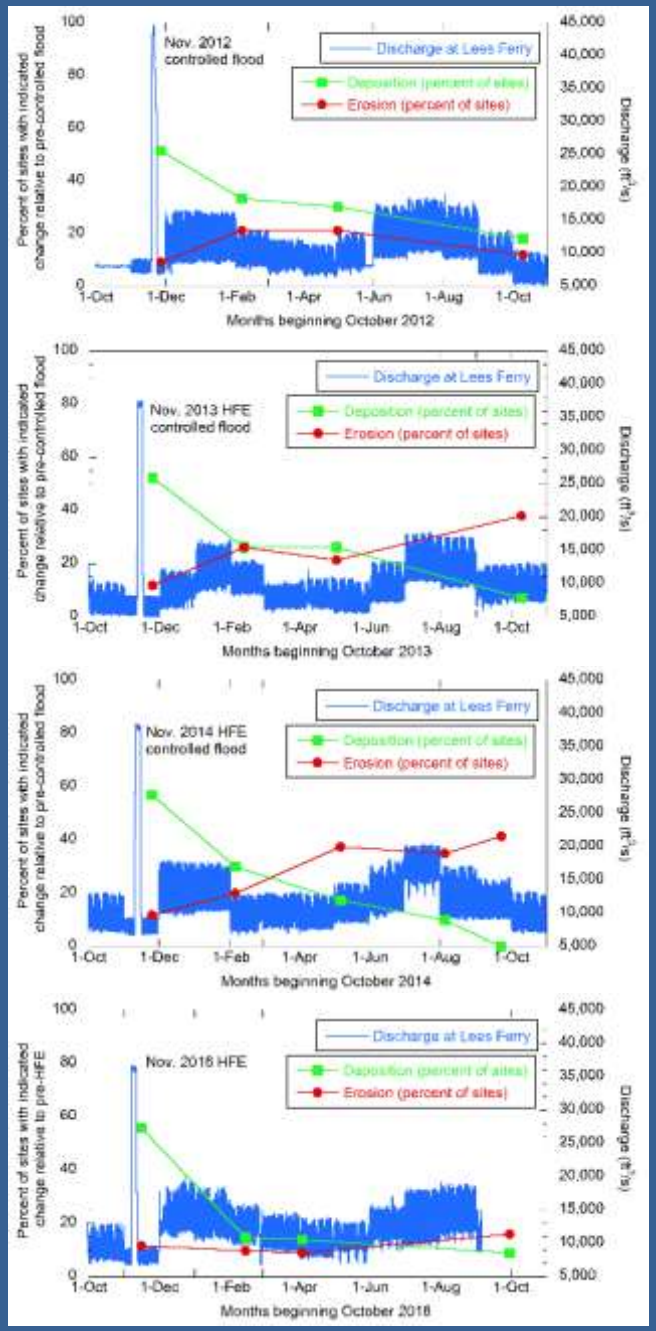
Erosion of HFE deposit

Most sandbars erode near pre-HFE size within 6 to 12 months.

HFE Response: 2012 to 2017



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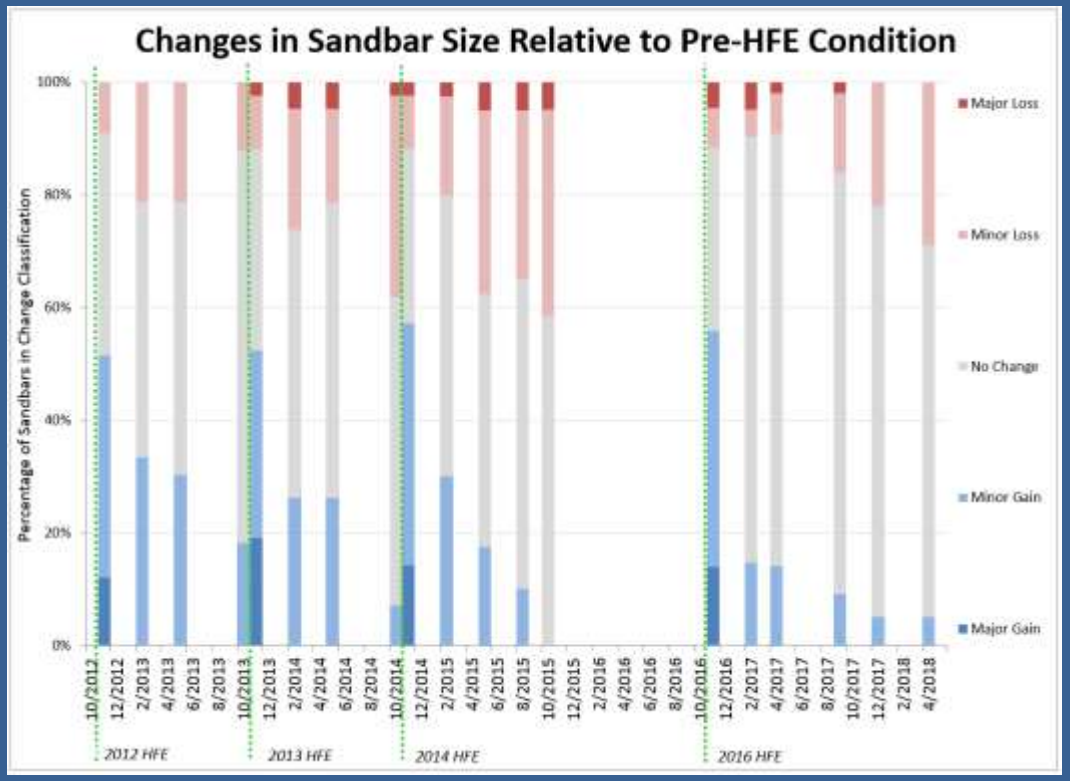
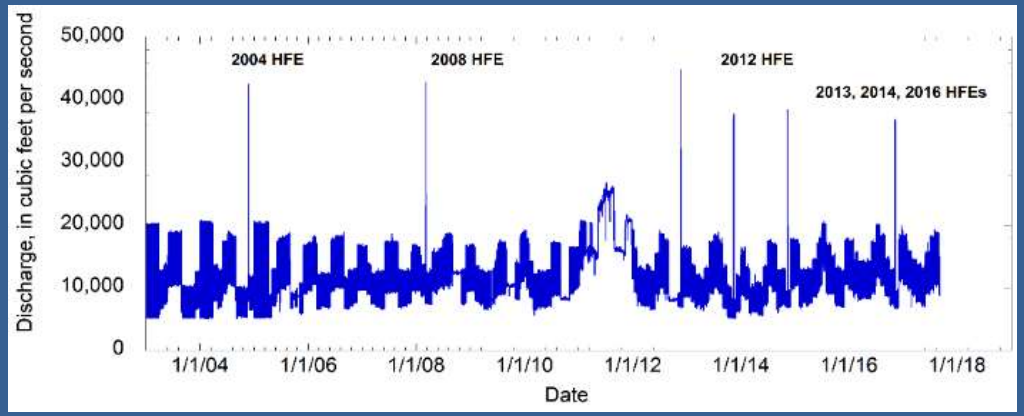
Grams et al. (2018)

HFE Response: 2012 to 2017



Unpublished data, do not cite



Data from: https://www.gcmrc.gov/discharge_qw_sediment

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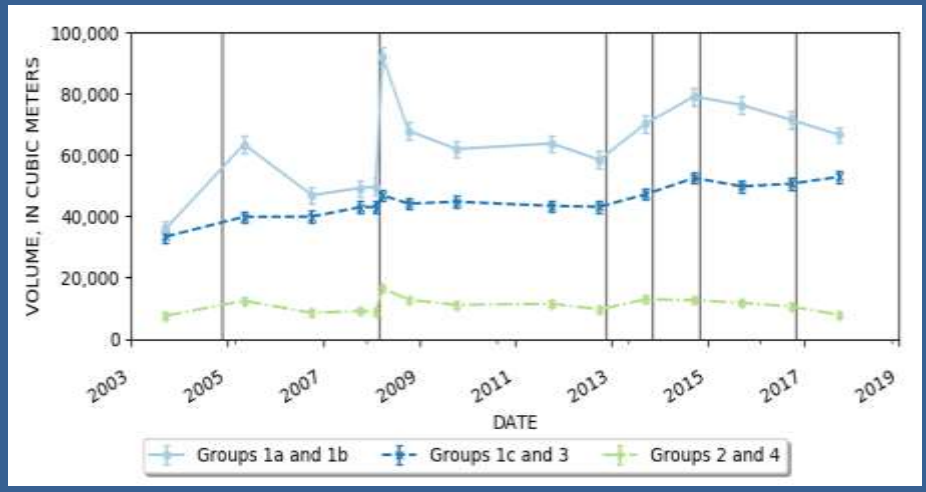
Sandbar monitoring

New analysis of sandbar trends based on grouping of bars by morphology and average response

- Groups 1a and 1b:
  - relatively large and mostly open bare sandbars
  - Strongest response to HFEs
- Groups 1c and 3:
  - heavily vegetated bars
  - Less dynamic around HFEs, tend to accumulate over time
- Groups 2 and 4:
  - Mostly smaller bars adjacent to debris fans (don't project into eddy)
  - Tend to be most stable
  - HFEs still improve condition by filling gullies and burying/removing debris



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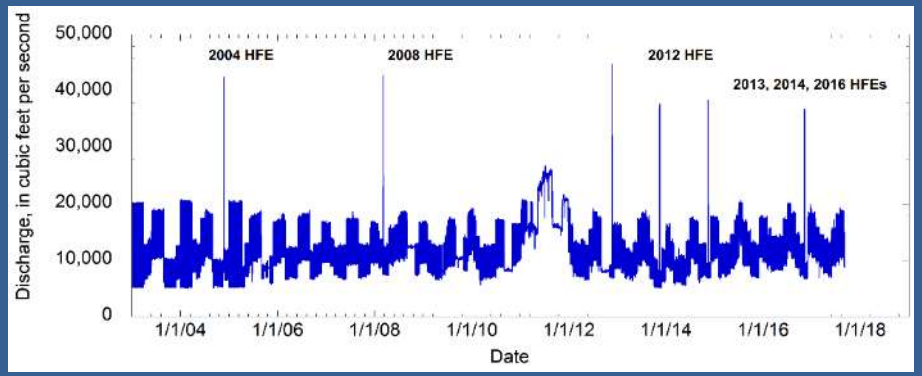


Data from: https://www.gcmrc.gov/discharge_qw_sediment

Mueller et al. (2018); unpublished data, do not cite

USGS

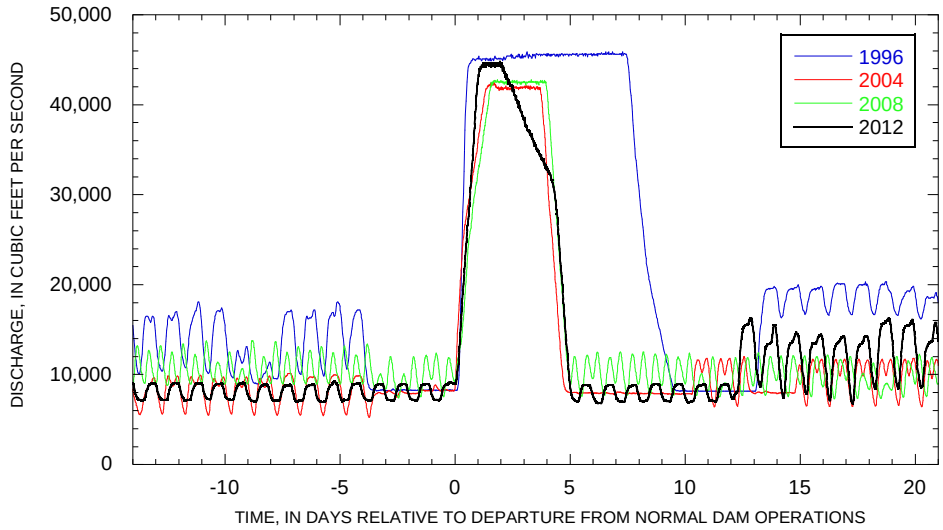
HFE Design Experiments

- Extended duration HFEs
  - Up to 8-10 days (compared to 4 days as currently implemented)
  - Only if there is "enough" sand
  - If enough sand, could build larger and more numerous bars
  - LTEMP simulations estimated conditions might occur 5 times in 20 years, LTEMP ROD allows 4 implementations

1996 HFE was 8 days, but was not designed to match recent sand inputs

Makes sense to test when conditions occur.

- Monitoring needed for comparison with other HFEs
  - Monitoring sand concentration
  - Sandbar monitoring at all sites with complete surveys
  - Daily surveys at selected sites to measure changes in deposition rates during HFE



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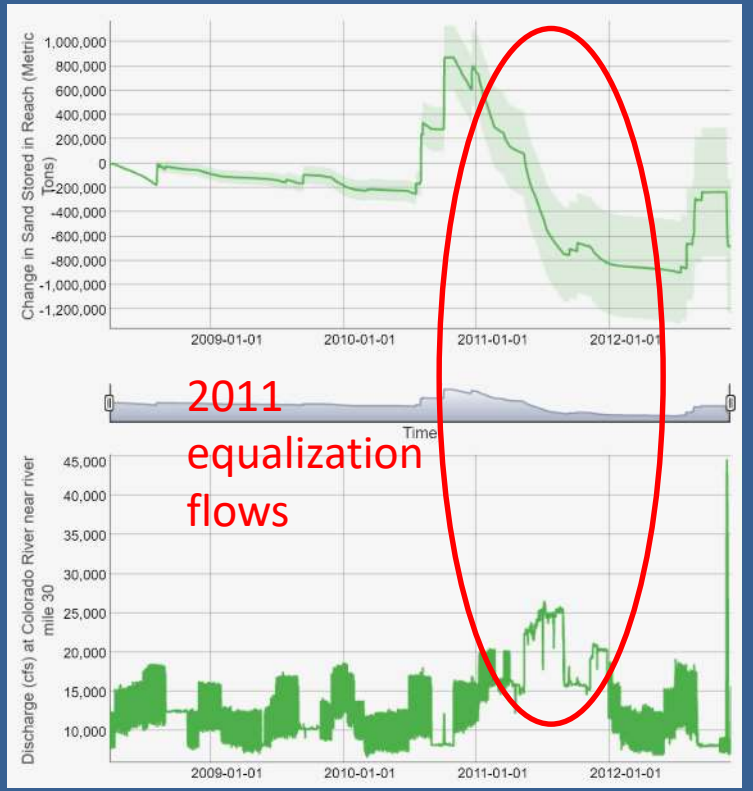
HFE Design Experiments

- Proactive HFEs
  - Spring HFE released regardless of sand trigger in advance of summer equalization flows
  - Goal is to create some high-elevation sand deposits in advance of erosion that will occur during sustained high releases.
  - LTEMP simulations estimated conditions might occur twice in 20 years



Makes sense to test when conditions occur.

Conditions in 2011 "inspired" idea for proactive Spring HFE – large sand inputs during previous fall followed by equalization flows

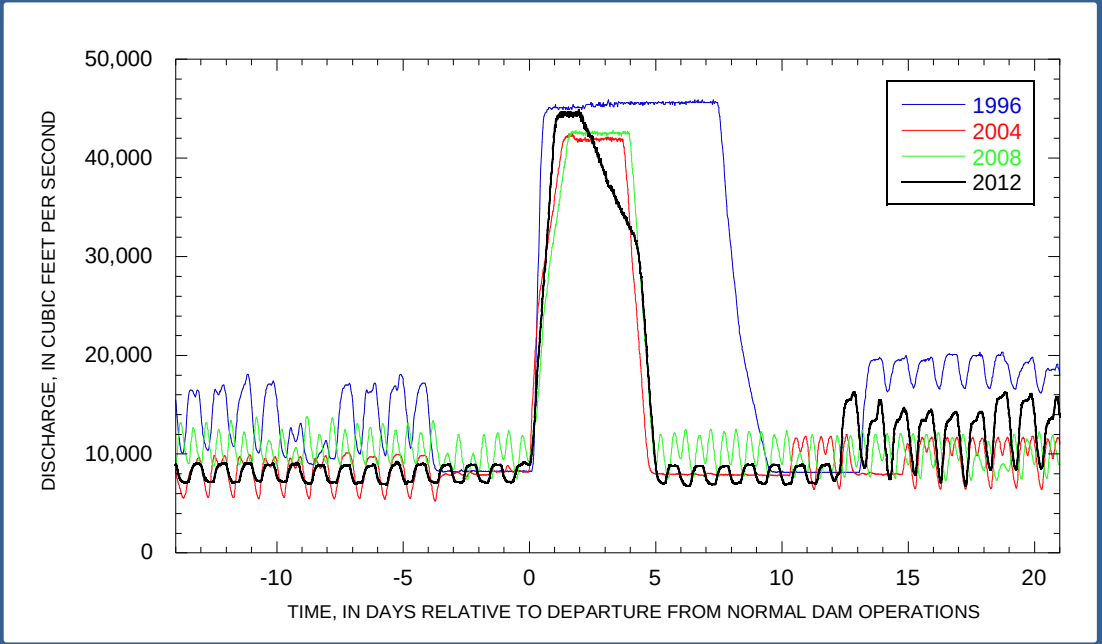
- Monitoring needed for comparison with other HFEs
  - Monitoring sand concentration
  - Sandbar monitoring at all sites with complete surveys
    - Compare deposition with other HFEs
    - Measure summer erosion (what is the size of bars following equalization compared to before the proactive HFE?)

Data from: https://www.gcmrc.gov/discharge_qw_sediment

USGS

HFE Design Experiments

- Changes to hydrograph shape (lower downramp rate)
  - Deposition at range of elevations, instead of focused at elevation of peak stage
  - Expected to produce sandbars that have lower slope on bar face
  - Tested in 2012
    - Limited monitoring indicated some bars did have lower slopes
    - Bars still eroded, but lack enough measurements to compare erosion rates.



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Since all releases above powerplant capacity count towards the HFE duration, lower downramp comes at expense duration of peak sand concentrations. Best experiment might be to follow a "regular" 96-hour HFE with slow downramp as part of extended duration HFE test.

- Monitoring needed for comparison with other HFEs
  - Sandbar monitoring at all sites with complete surveys
    - Compare deposition with other HFEs

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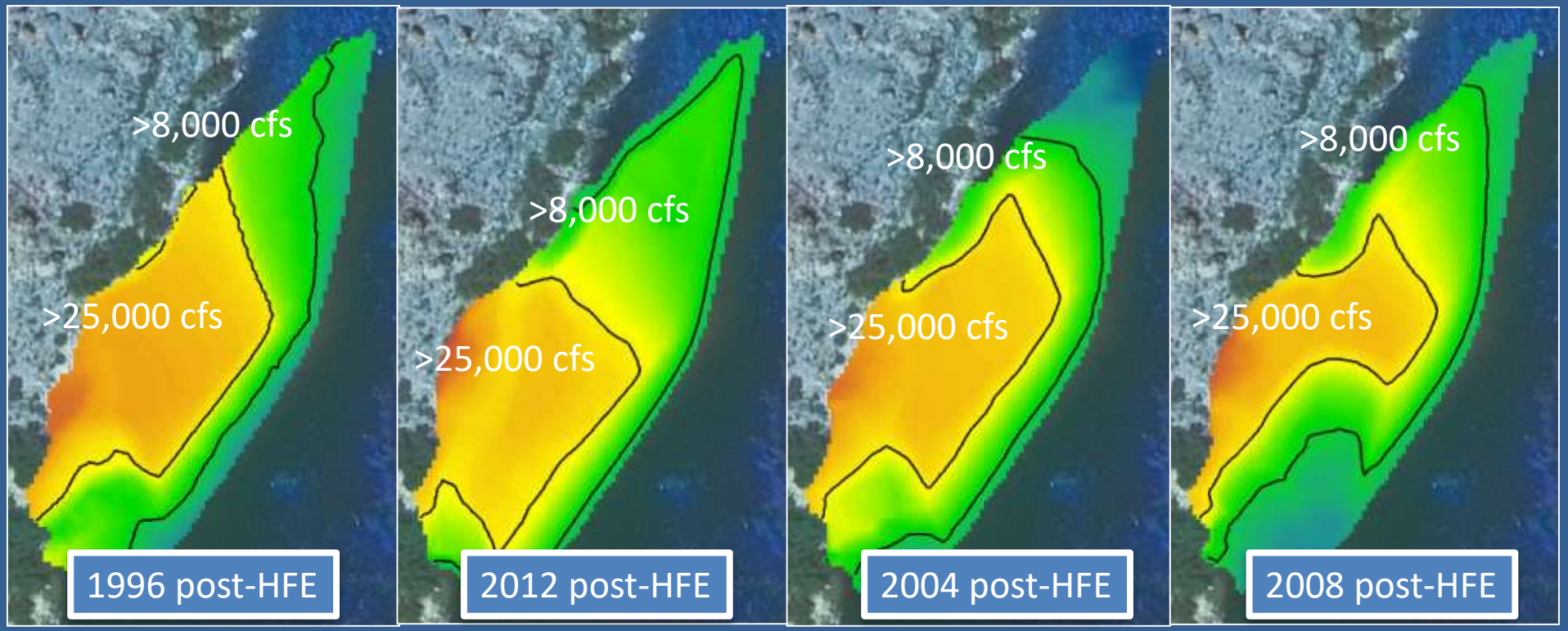
HFE Design Experiments



Surveys before and after 2012 HFE at 3 large reattachment bars

- *Bar volume largest in 1996 (highest discharge and longest duration), area above 8,000 cfs stage largest in 2012 (gradual downramp)*
- Slope from bar crest to 8,000 cfs level less steep than other floods

Unpublished data, do not cite

USGS

HFE Design Experiments

- Low-magnitude HFE (HFE at or near powerplant capacity of 31,500 cfs)
  - Not identified as “experiment” in LTEMP.
  - Allowed by HFE protocol
  - But they have not yet occurred

Is there interest in comparison with larger HFEs if a low-magnitude HFE does occur?

- Monitoring needed for comparison with other HFEs
  - Sandbar monitoring at all sites with complete surveys
    - Compare deposition with other HFEs

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