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

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Building sandbars with HFEs

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

Sand Budget for 2008 HFE in Upper Marble Canyon

Data from: https://www.gcmrc.gov/discharge_qw_sediment
Basic concept of HFE protocol in LTEMP: Balance sand export during HFEs with Paria Sand inputs

Paria River during flood

Transport at RM 61 (downstream end of Marble Canyon)

\[ \text{Sand}_{\text{Paria}} + \text{Sand}_{\text{small tribs}} = \text{Sand}_{\text{export at 61 mi}} \]
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
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

Plot from LTEMP EIS, Appendix P
Sand accounting periods

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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)."
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
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”

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

Plot from LTEMP EIS, Appendix E
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”

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

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Types of sandbar response to HFEs

A. Deposition →
   119.4R Preflood
   119.4R Postflood +2
   ~ 50-60% of sites

C. No change →
   172.6L Preflood
   172.6L Postflood 0
   ~ 30-40% of sites

E. Erosion →
   065.8L Preflood
   065.8L Postflood -2
   ~ 10% of sites

Grams et al. (2018)
Most sandbars erode near pre-HFE size within 6 to 12 months.
HFE Response: 2012 to 2017

Unpublished data, do not cite

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

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

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 (2018); unpublished data, do not cite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

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

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

- 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

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

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

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