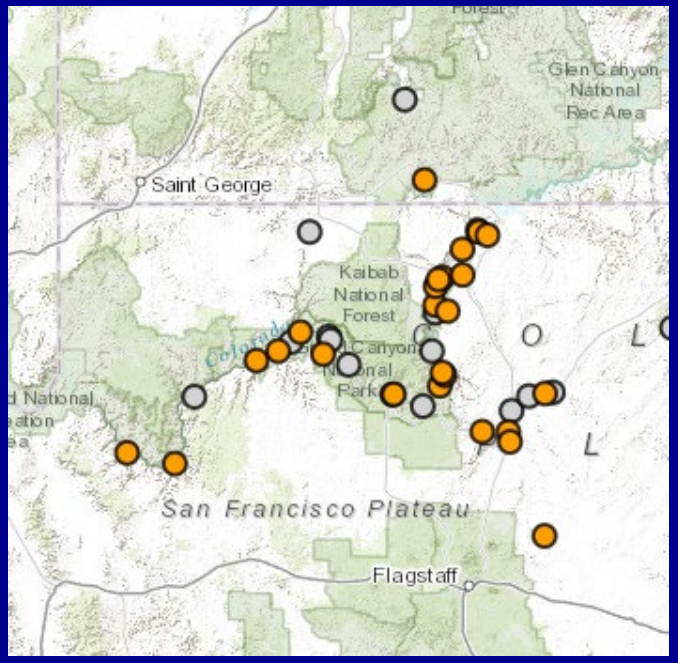
Project A: Streamflow, Water Quality, and Sediment Transport and Budgeting in the Colorado River Ecosystem

Project A collects the physical data that directly link dam operations to all resources in the downstream Colorado River; data inform 10 LTEMP goals



- Element 1: Stream gaging
  - Stage
  - Discharge
- Element 2: Water quality
  - Water temperature
  - Salinity (specific conductance)
  - Turbidity
  - Dissolved Oxygen
- Element 3: Sediment transport and budgeting
  - Suspended- and bed-sediment data
  - Sediment loads (silt and clay loads and sand loads)
  - User-interactive sand budgets in 6 reaches from Lees Ferry to Lake Mead

- All elements
  - Database and website (currently UNSUPPORTED)

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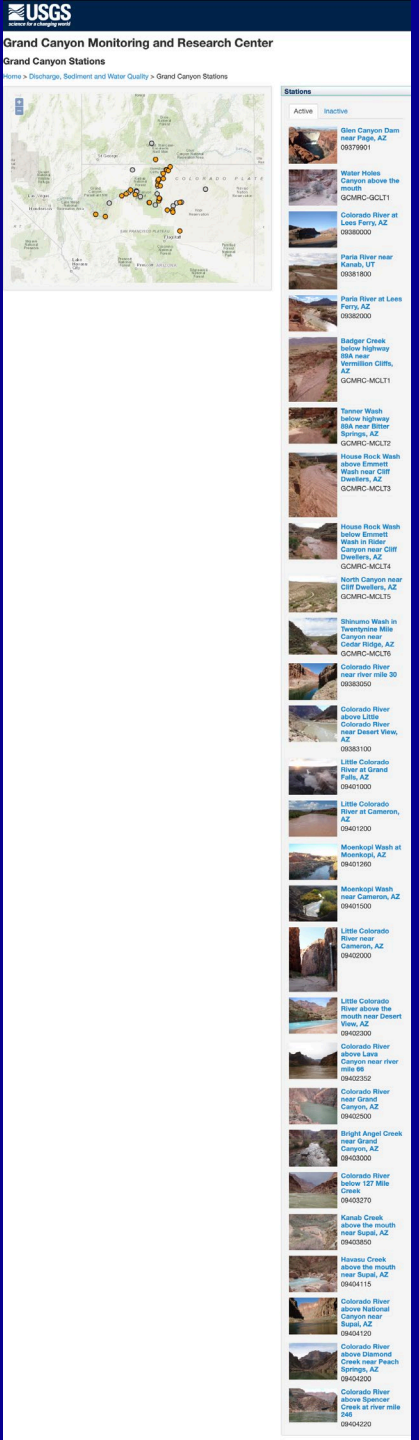

Major risk to GCDAMP remains unresolved

- Despite adequate GCDAMP funding, Project A's database and website have not had stable Computer Science support since 2019

- >30 million dollars of GCDAMP funding since 1990s for data that mostly exist only in this database and are available only through this website

- Database and website are breaking down

- Risk is loss of ability to relate resource changes to dam operations, inability to plan and evaluate HFEs, and loss of pre-dam and early syn-dam context (1921–1990s data are only available through website)

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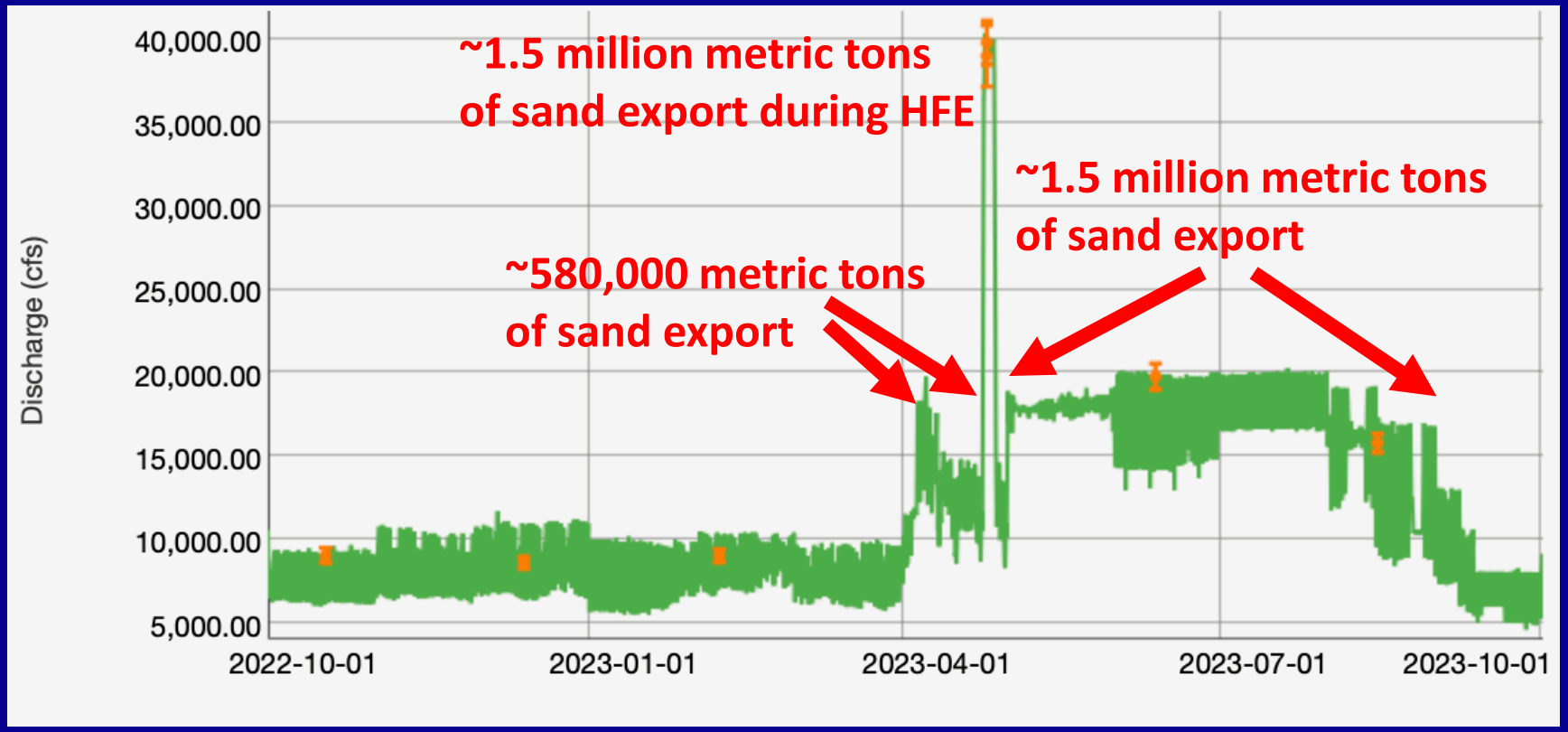
Only minimal QW data have been processed since June 2023

- We have still not backfilled Project A's water-quality specialist (Nick Voichick retired last June)

- Only water temperature and specific conductance at Lees Ferry and water temperature in three tributaries are QA/QCed and posted at: https://www.gcmrc.gov/discharge_qw_sediment/

- Good news is on the horizon, though…

Flows at Lees Ferry and sand export past Diamond Creek during FY 2023



High “balancing” flows that bracketed the HFE exported ~2.1 million metric tons of sand to the Lake Mead Delta

Data from USGS (2024a)

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Evaluation of LTEMP sand management

David J. Topping[1]
Paul E. Grams[1]
Ronald E. Griffiths[1]
Matt Kaplinski[1]
Joel A. Unema[2]
David J. Dean[1]
Katie A. Chapman[1]

[1]U.S. Geological Survey
Southwest Biological Science Center
Grand Canyon Monitoring and Research Center

[2]U.S. Geological Survey
Arizona Water Science Center

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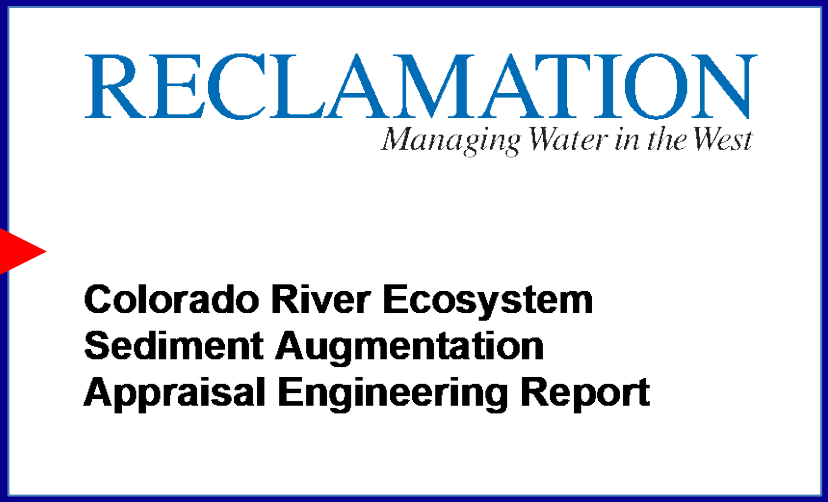
Basics of sand management

- Sand supply is <5% of natural
- Keep dam releases low for part to much of the year to accumulate sand **OR**



Randle and others (2007)

- Episodic short-duration artificial floods (HFEs) to rebuild sandbars
- Avoid sustained high releases (e.g., equalization) that greatly exceed the sand supply and result in widespread erosion

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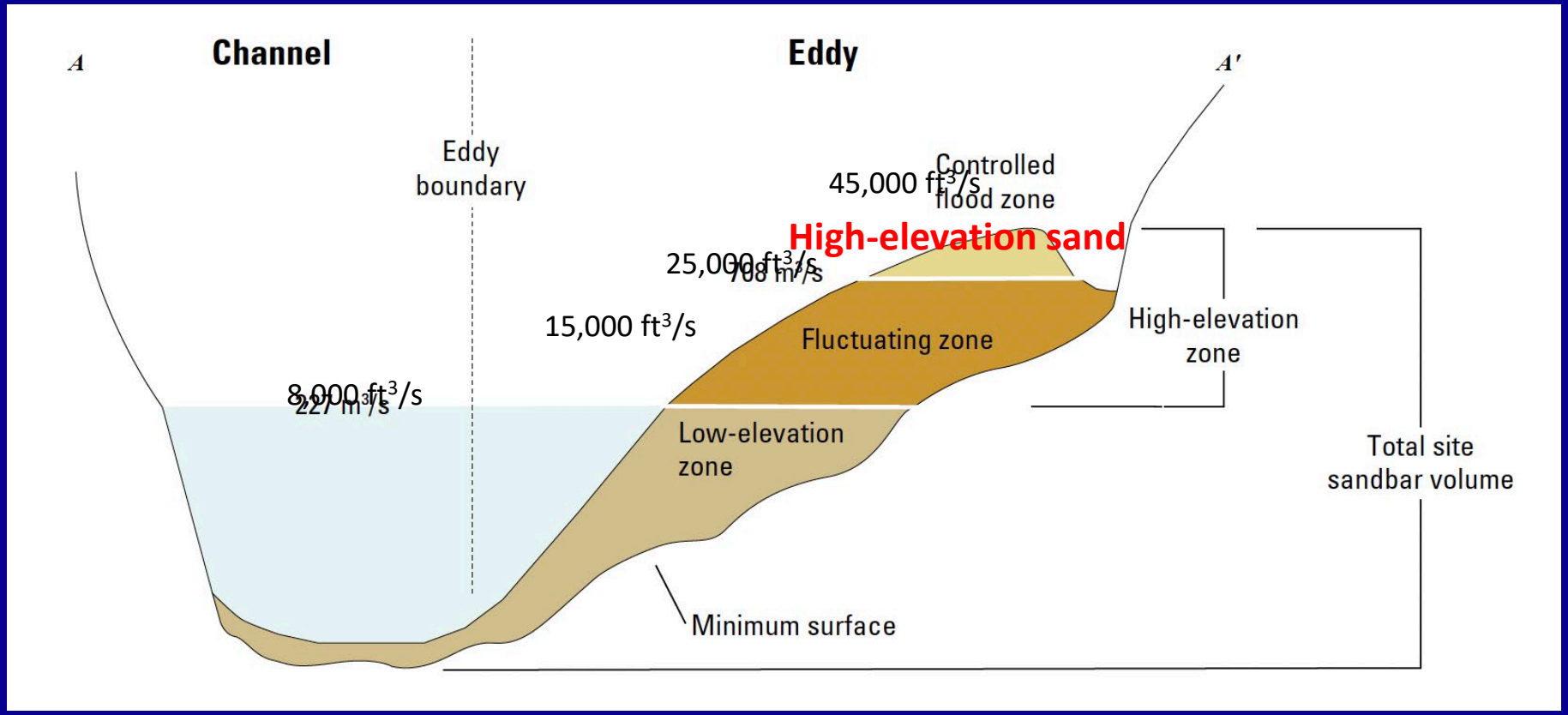

Figure modified from Hazel and others (*USGS-PP*, 2022)

- ~30–50% of the sand stored in sandbars is relict "pre-dam" sand (Chapman and others, *GSA Bulletin*, 2020)
- Stratigraphic and ground-penetrating-radar data indicate pre-dam sand at depth in at least some sandbars (Barnhardt and others, *USGS-OFR*, 2001)

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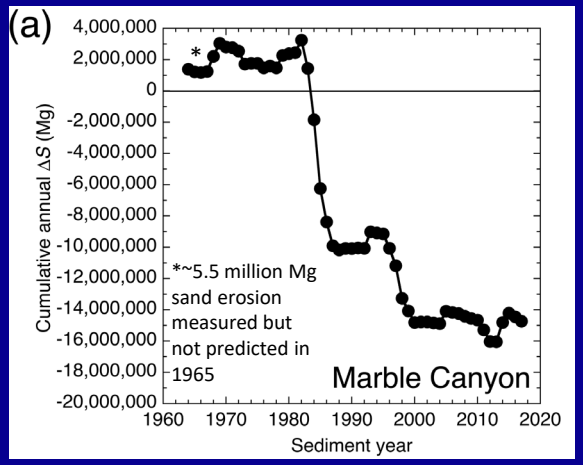
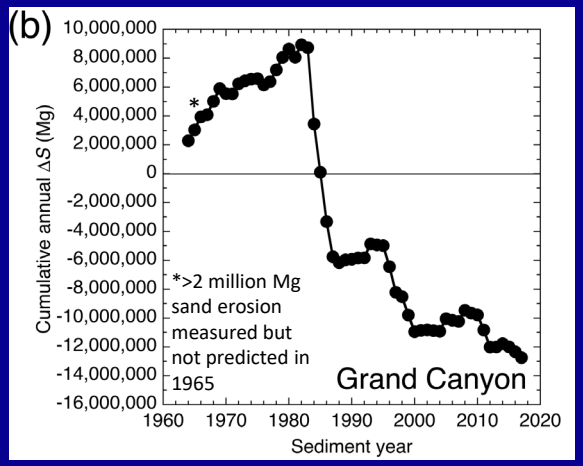
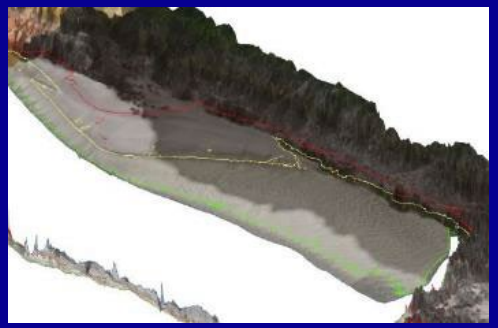
Downward spiral has likely occurred in long-term sand mass balance… and reflected in at least some of the sandbars

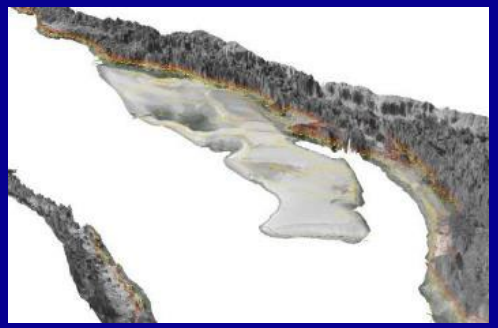
>28 million metric tons of sand eroded since 1963, mostly during 3–4 periods of high dam releases (Topping and others, *JGR*, 2021)

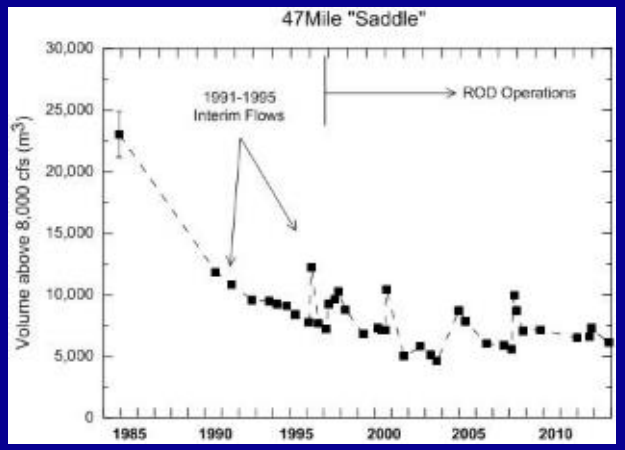
~12 million metric tons eroded in late 1990s alone (6 from Marble and 6 from Grand)

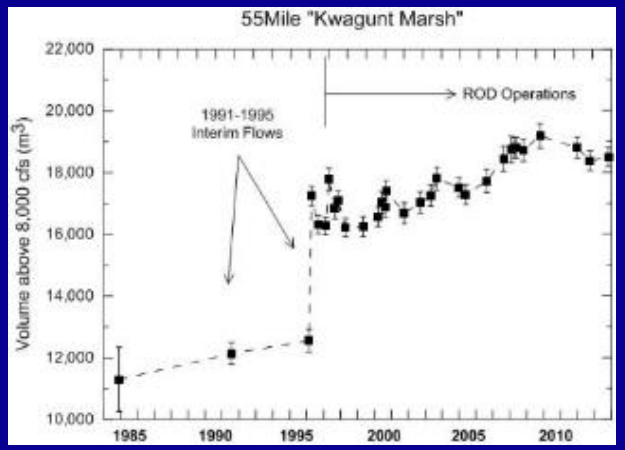












Figures from Topping and others (*JGR*, 2021)

Preliminary figures from Gushue, Weber, Grams, Hazel (do not cite)

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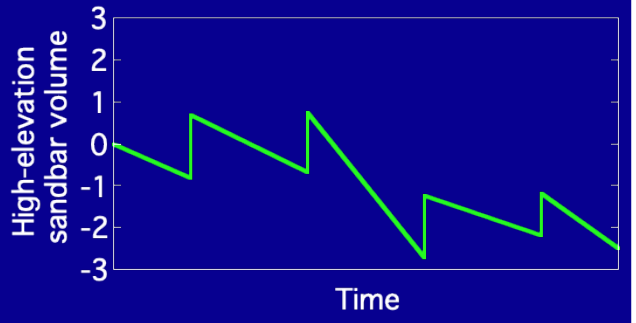
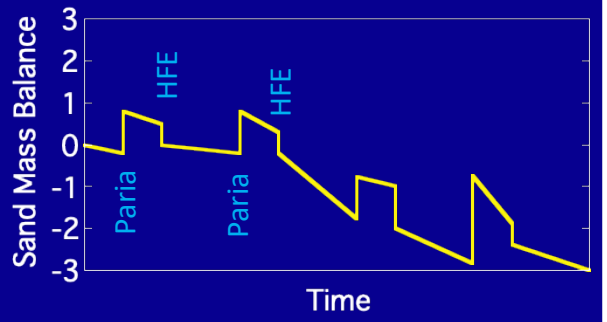
Sustainable management of sand under the LTEMP sediment goal thus requires neutral to positive trends in both the sand mass balance (i.e., the bank account) and the high-elevation sandbar volume (i.e., your expenditures) over decades

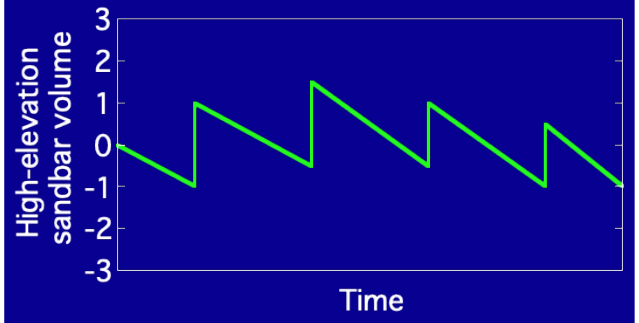
Scenario 1

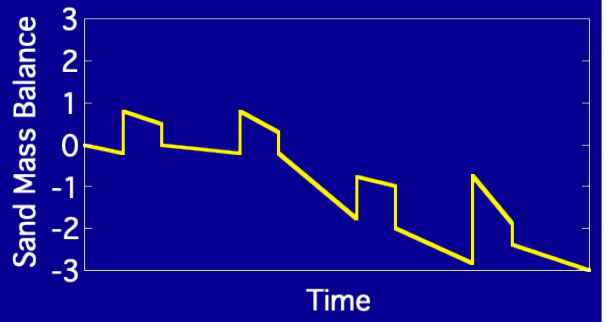




Not sustainable

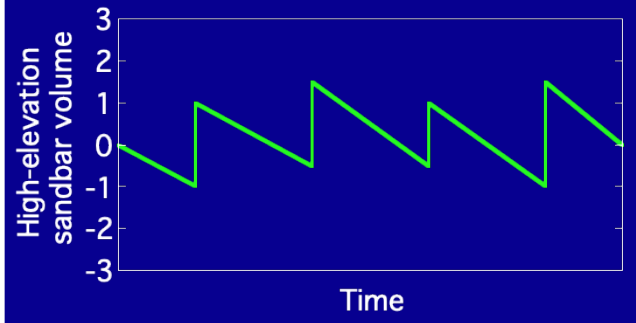
Scenario 2

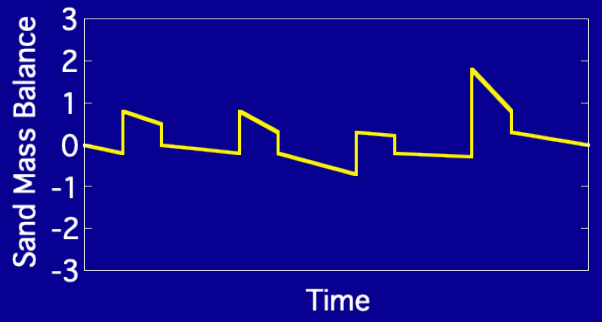




Not sustainable
Bank account mined to deposit sandbars
"Living on credit"

Scenario 3





Sustainable
"Living within your means"

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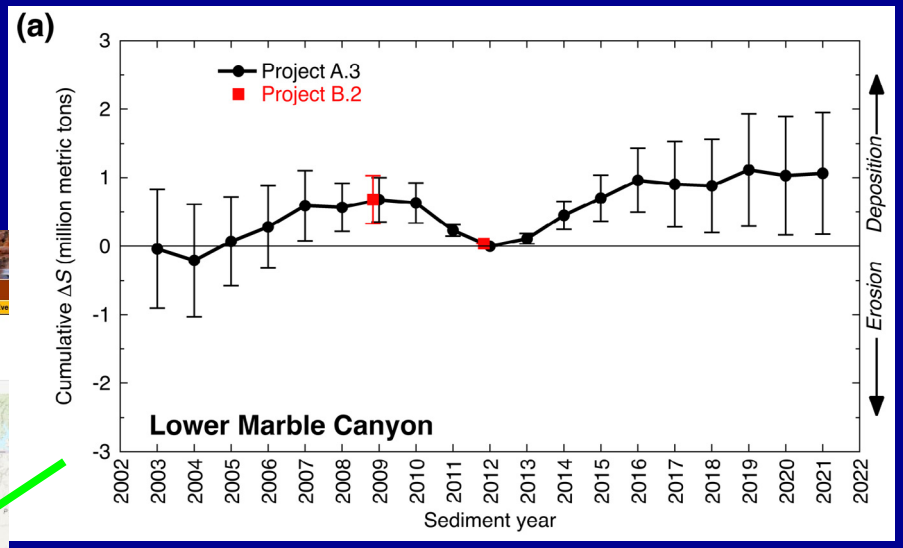
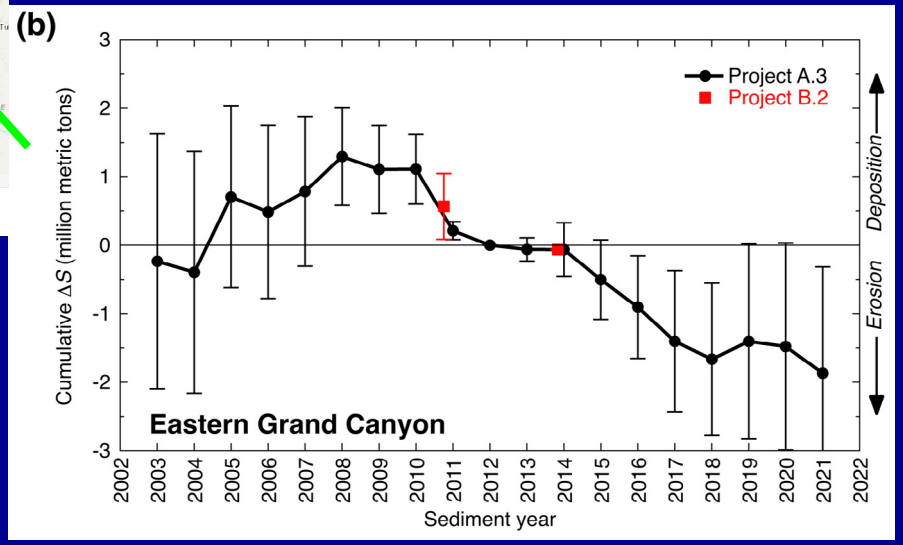
Metrics Example: The Bank Account





POSSIBLE SUCCESS! Sustainable in Lower Marble Canyon if high-elevation sandbar volume is positive during this period.

POSSIBLE FAILURE Not sustainable in Eastern Grand Canyon regardless of whether high-elevation sandbar volume is positive during this period.

Data from Topping and others (*JGR*, 2021); USGS (2024a)

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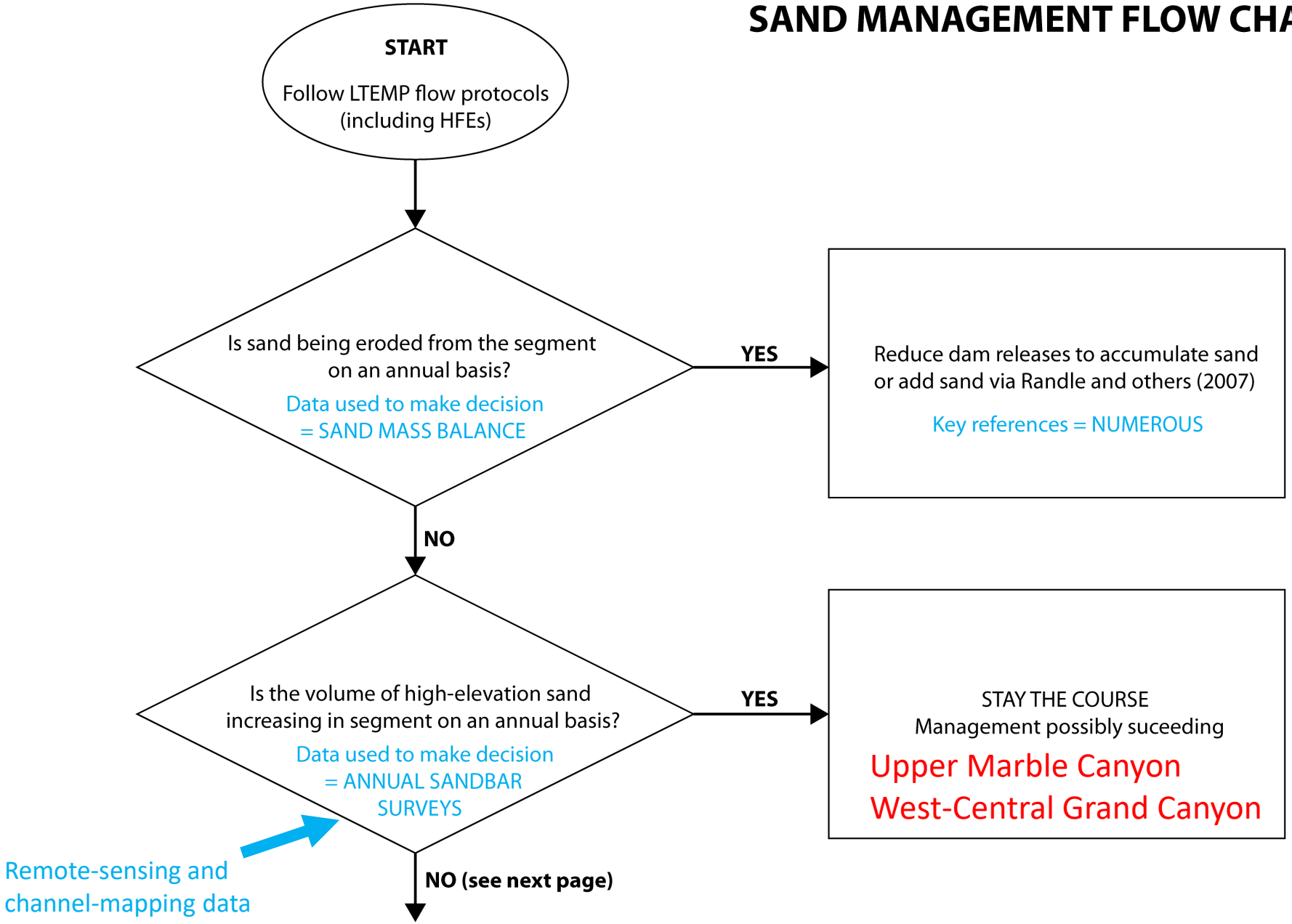
SAND MANAGEMENT FLOW CHART



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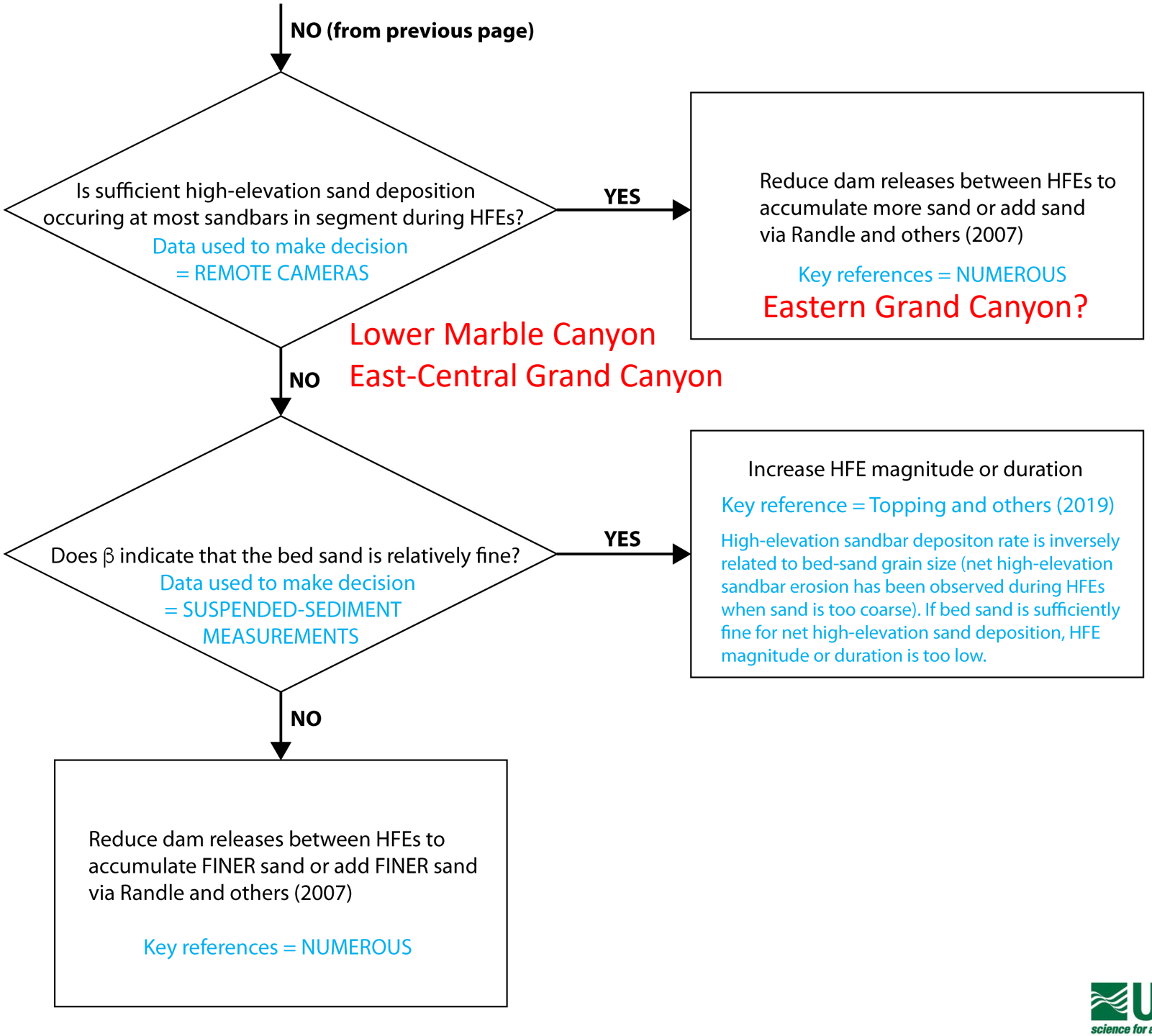
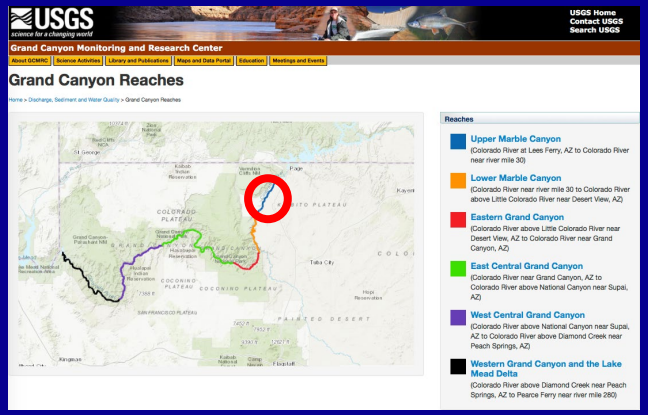
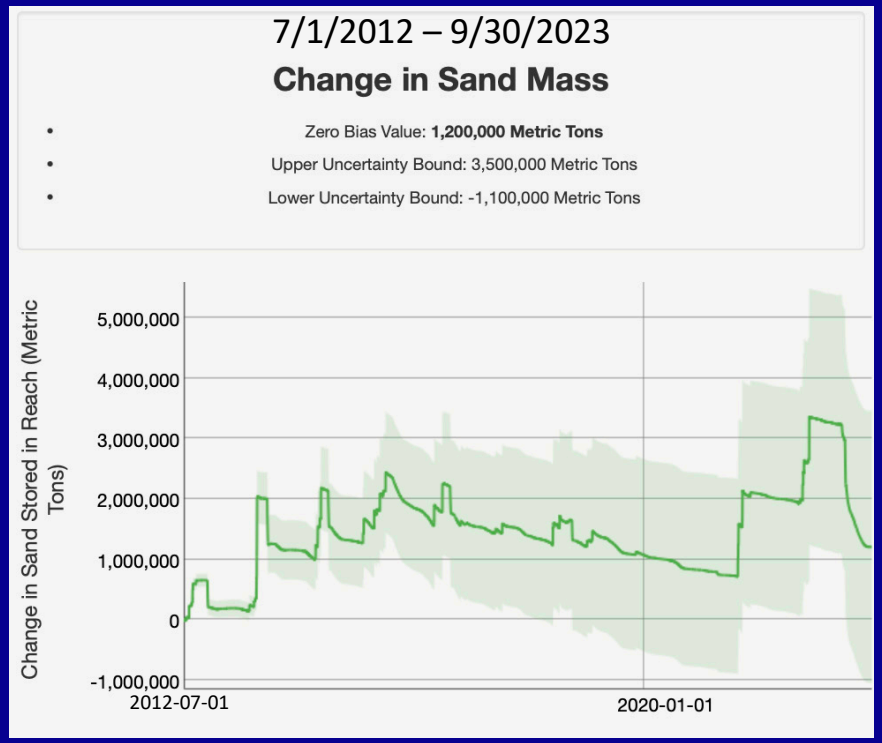


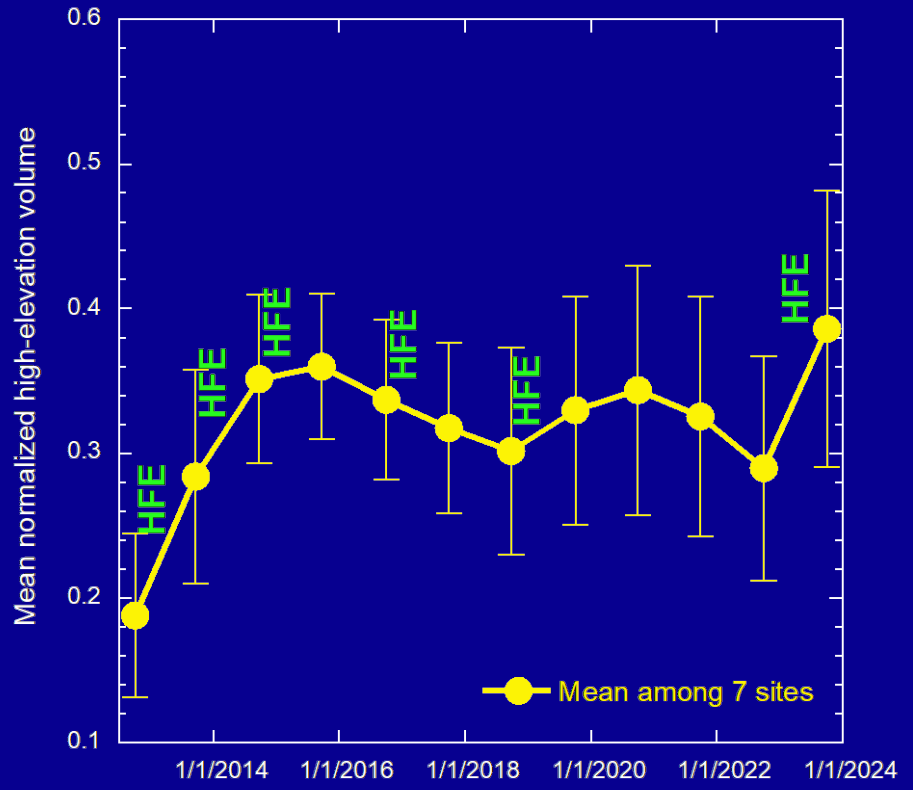
USGS science for a changing world



HFE-Protocol/LTEMP Period
Upper Marble Canyon



POSITIVE

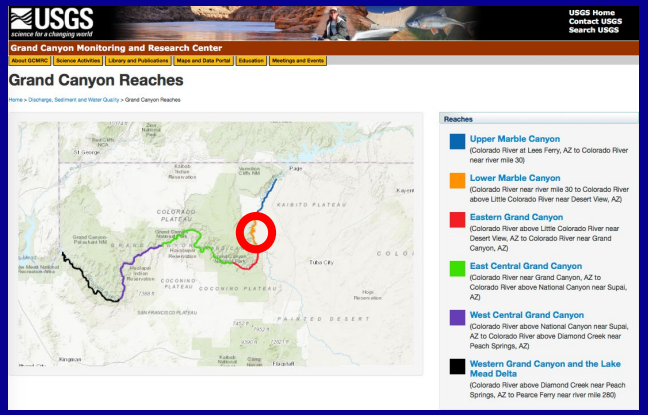


POSITIVE

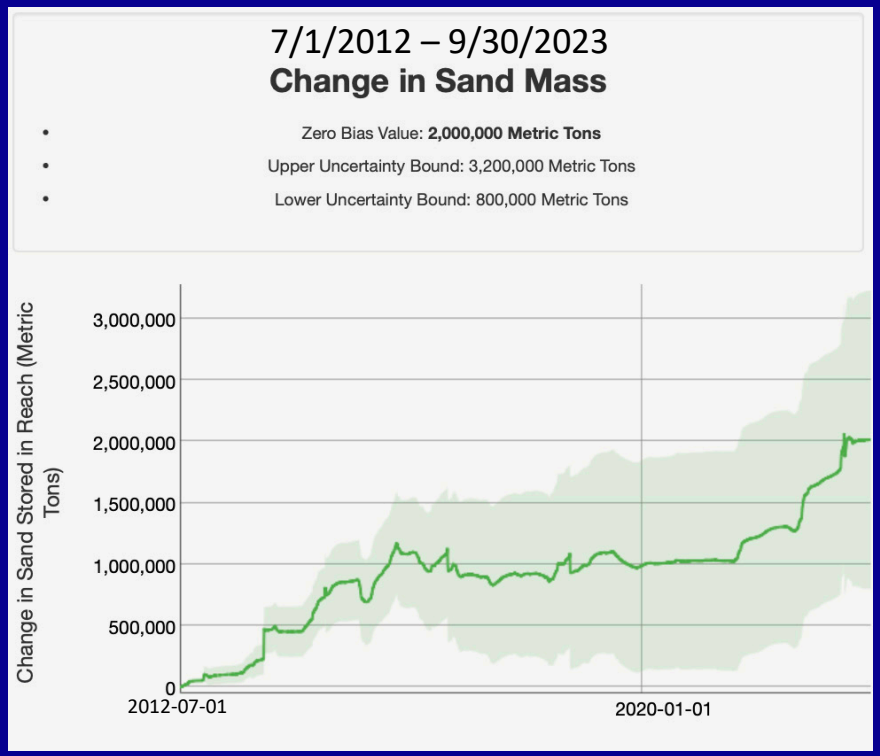
Possibly sustainable

Data from USGS (2024a, b)

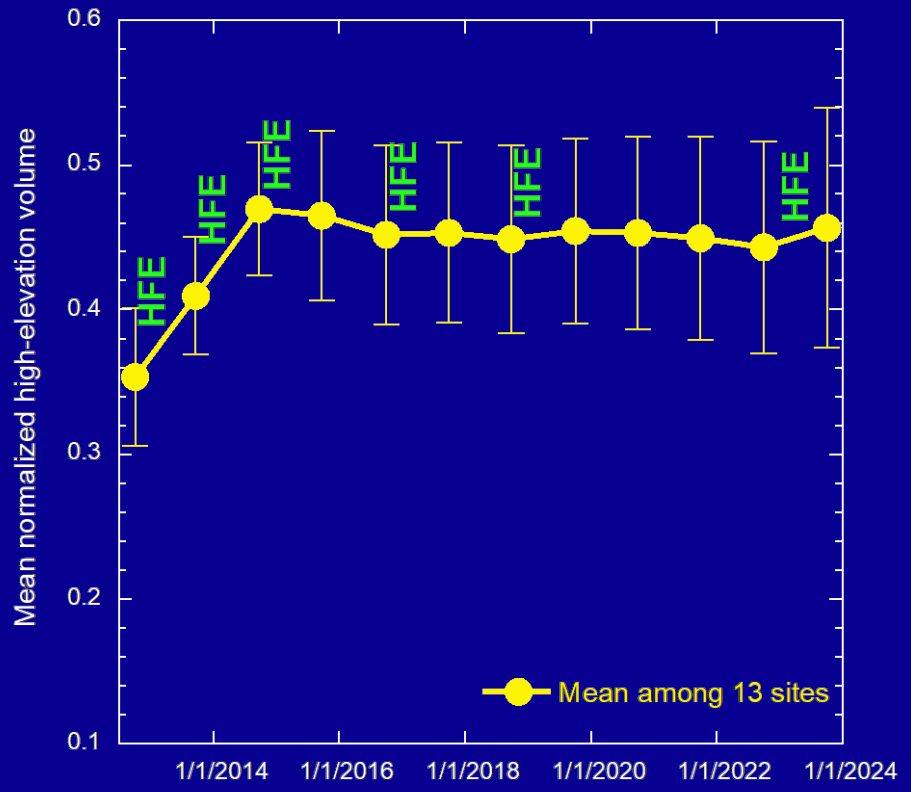
USGS science for a changing world



HFE-Protocol/LTEMP Period
Lower Marble Canyon



POSITIVE



POSITIVE(?)

Insufficient HFE magnitude/duration or intervening flows too high

Data from USGS (2024a, b)

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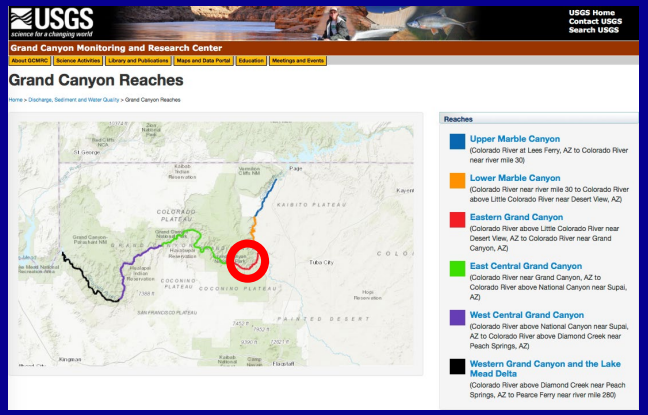
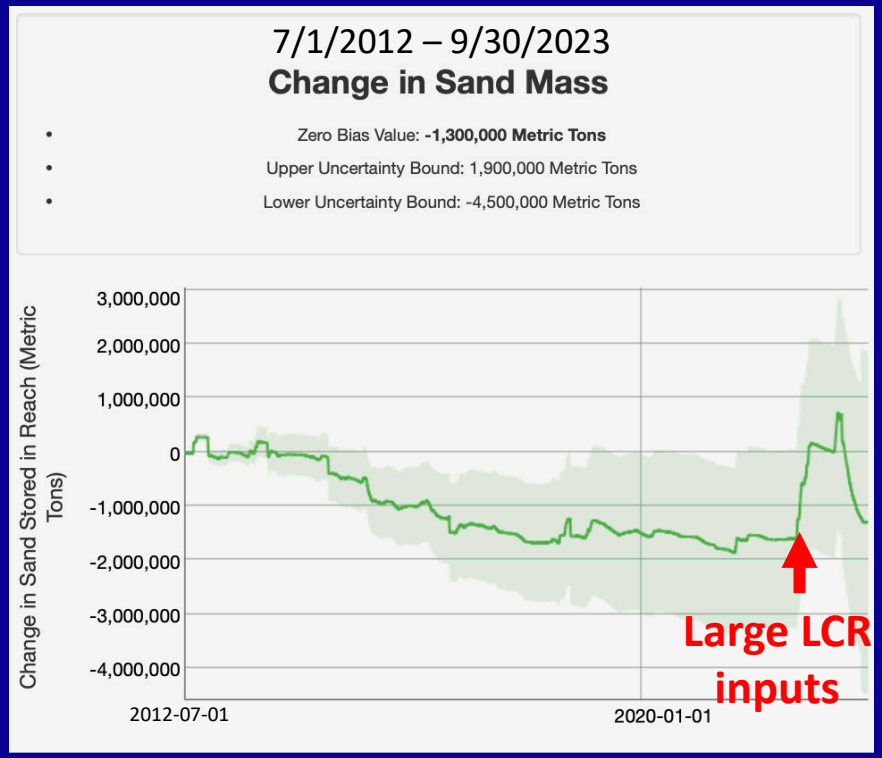
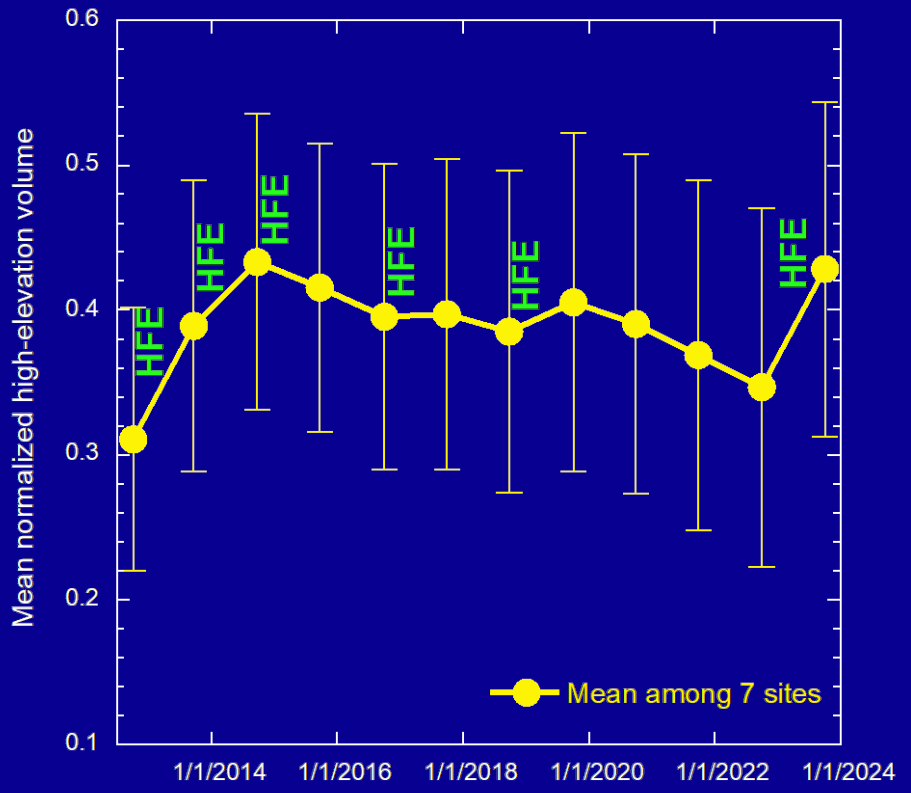


HFE-Protocol/LTEMP Period
Eastern Grand Canyon





INDETERMINATE

POSITIVE(?)

Intervening flows likely too high (SAVED BY THE LCR)

Data from USGS (2024a, b)

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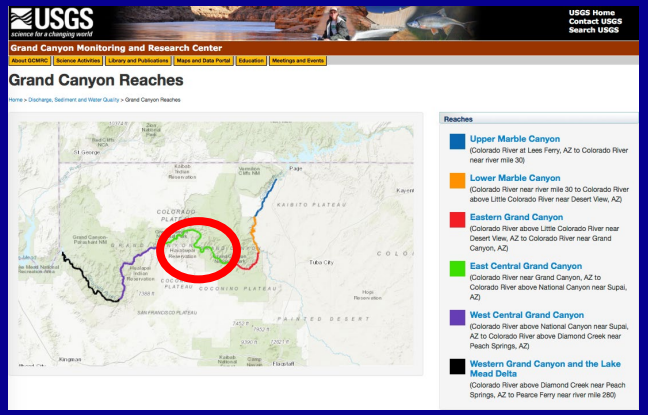
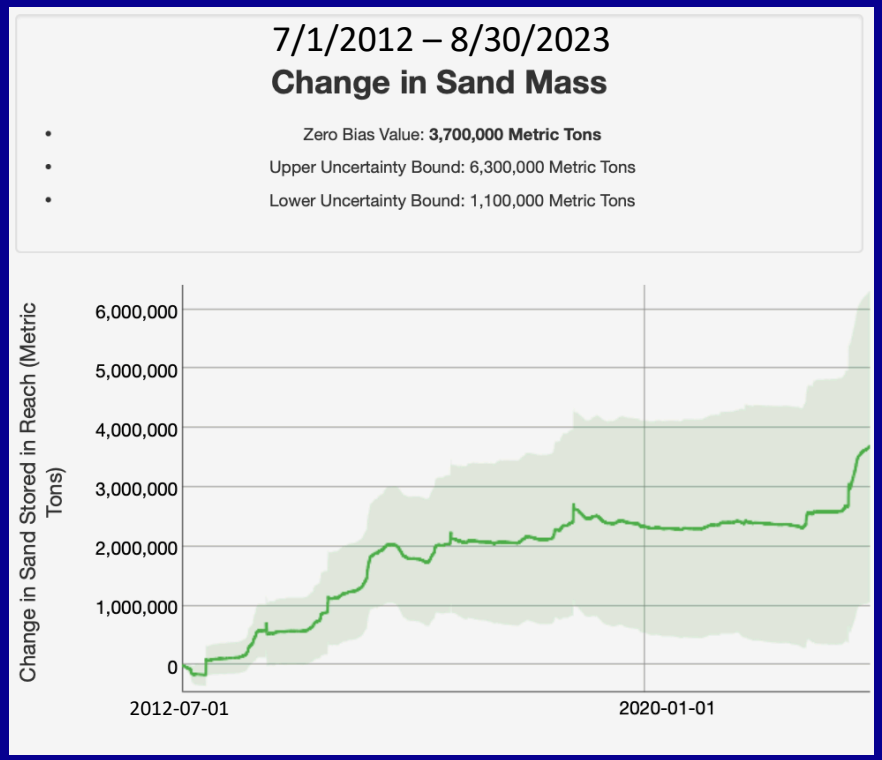
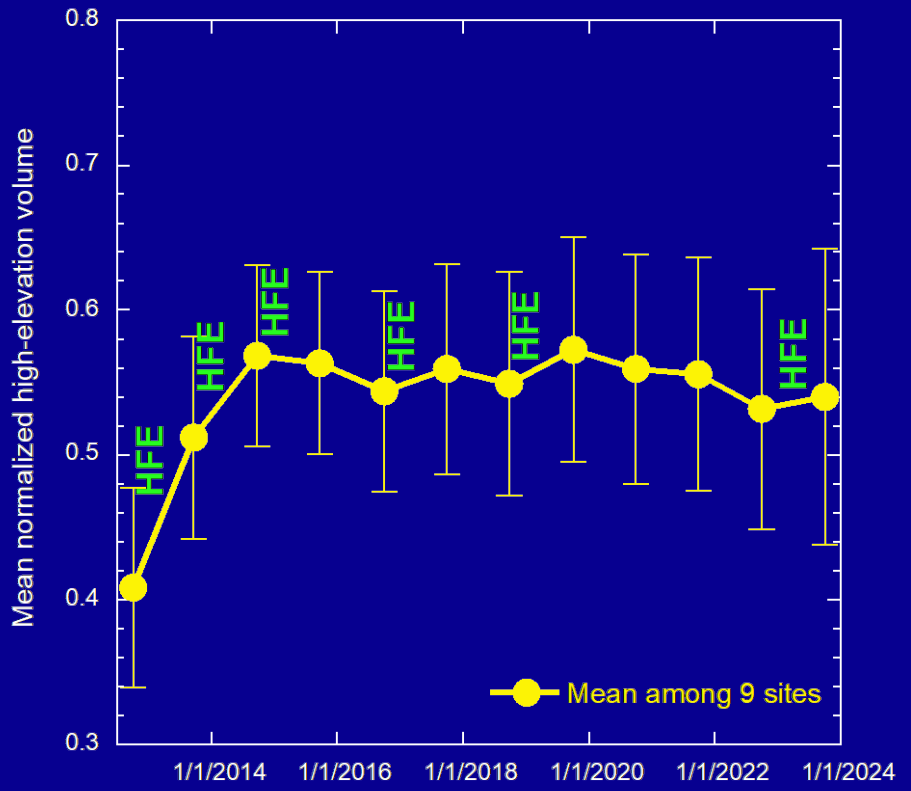


HFE-Protocol/LTEMP Period
East-Central Grand Canyon



POSITIVE



POSITIVE(?)

Insufficient HFE magnitude/duration or intervening flows too high

Data from USGS (2024a, b)

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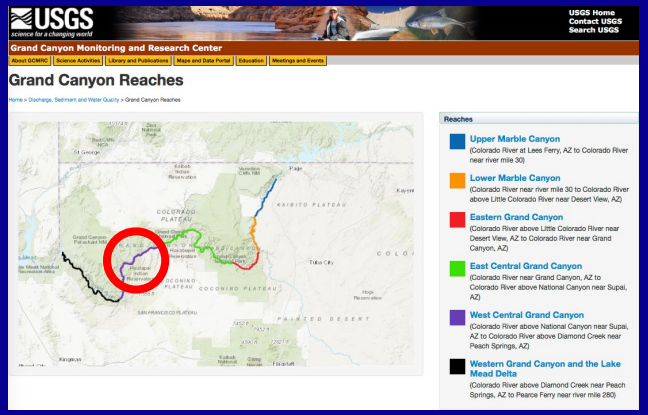
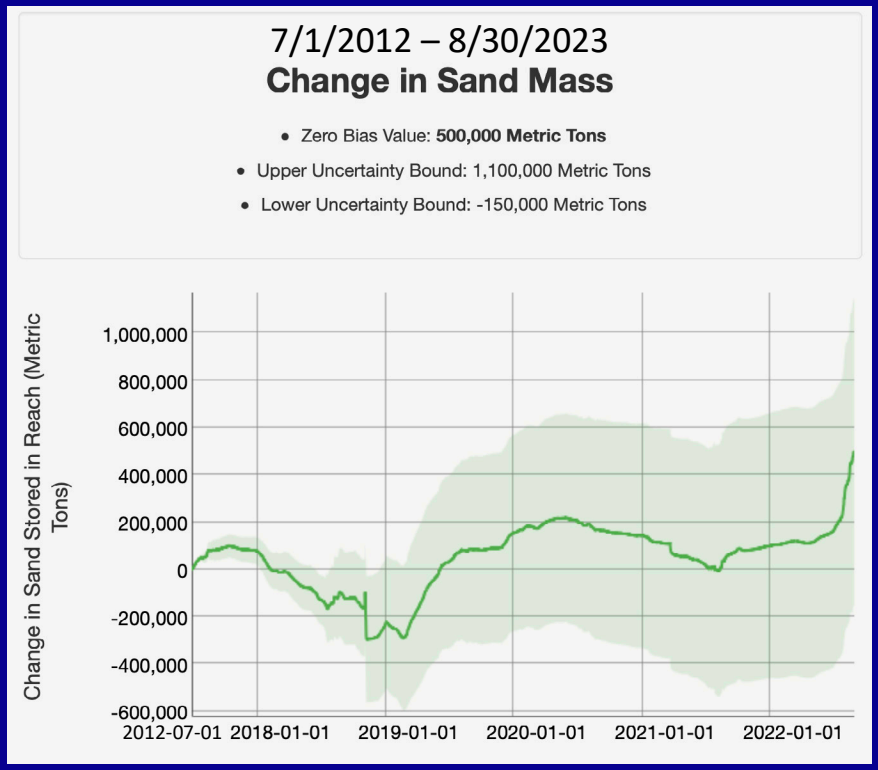
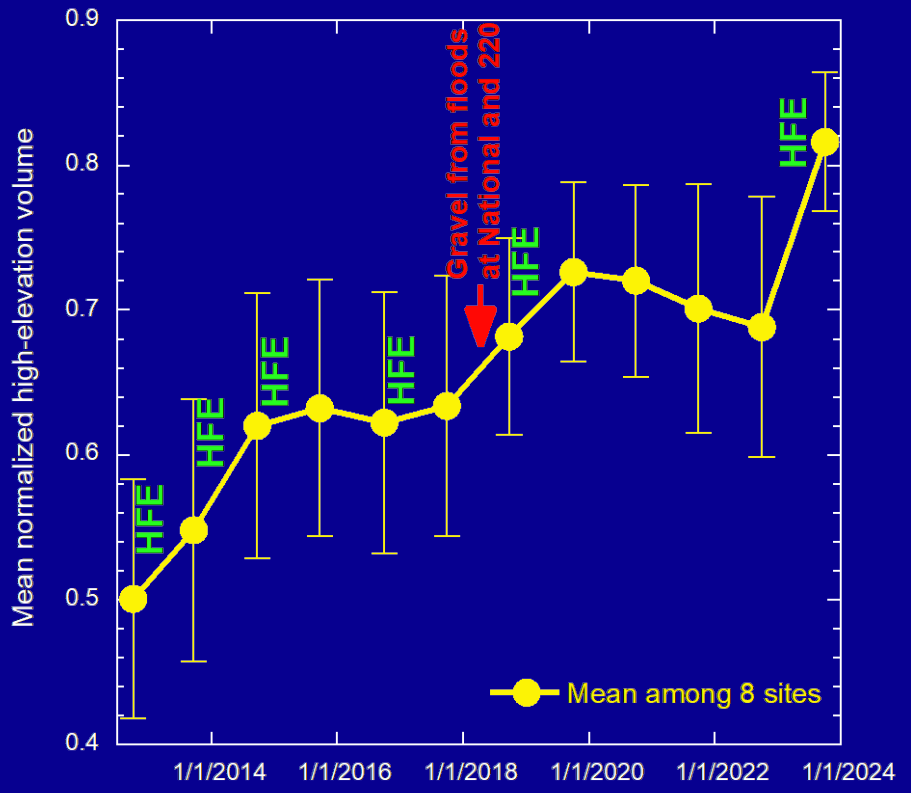
HFE-Protocol/LTEMP Period
West-Central Grand Canyon





POSITIVE



POSITIVE

Possibly sustainable

Data from USGS (2024a, b)

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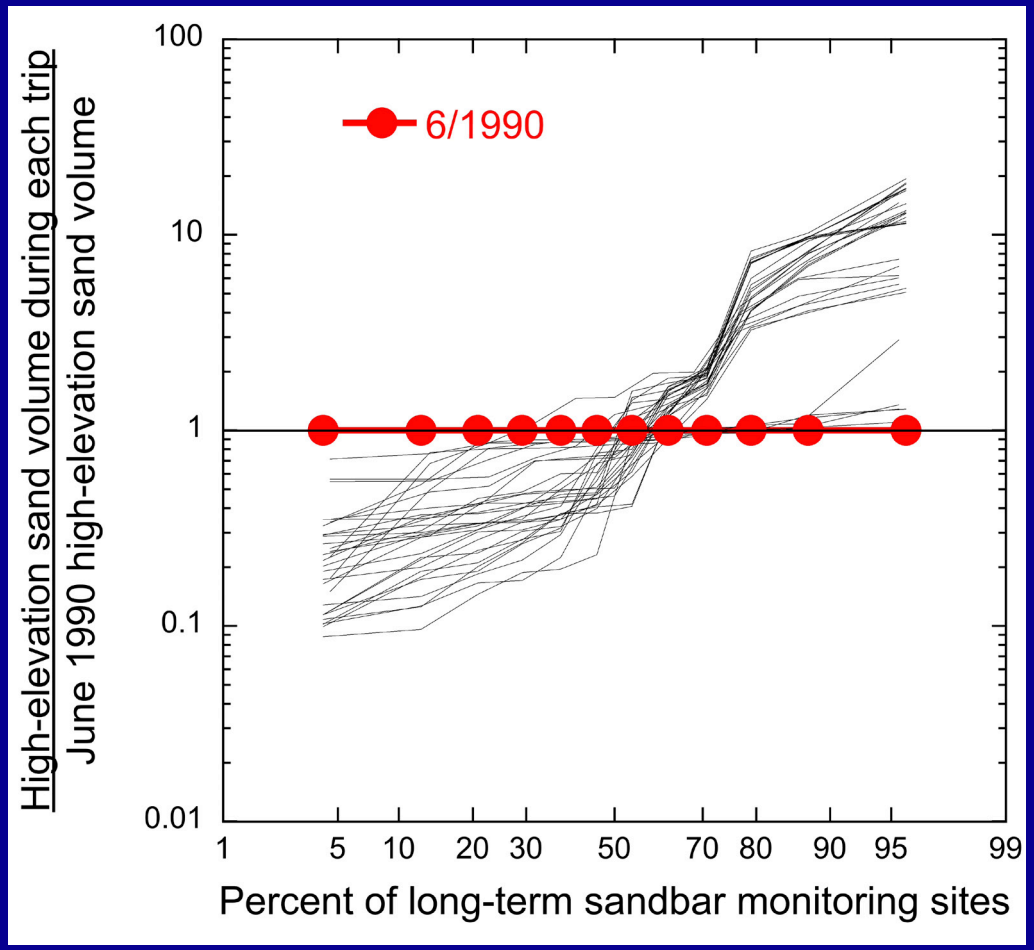
- Mean high-elevation normalized sand volume is unchanged between 1990 and 2023
- High-elevation sand at half of the 12 long-term sandbar monitoring sites in Marble Canyon defines a downward spiral between 1990 and 2023
- High-elevation sand at almost half of these sites defines an upward spiral



Data from USGS (2024b)

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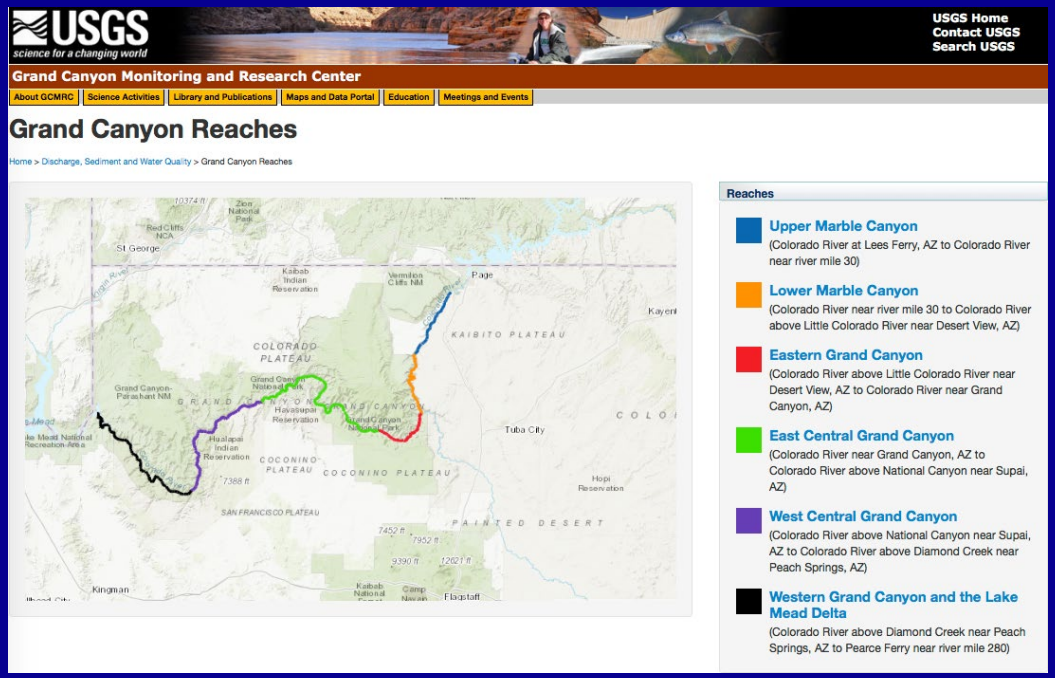
Conclusions

- High risk to GCDAMP of catastrophic data loss and inability to plan HFEs until computer-science support to Project A's database gets restored
- LTEMP sand management seems to be "working" in two segments (Upper Marble Canyon and West-Central Grand Canyon)
- LTEMP sand management may require adjustment in two segments (Lower Marble Canyon and East-Central Grand Canyon) by increasing HFE magnitude/duration or by reducing dam releases between HFEs

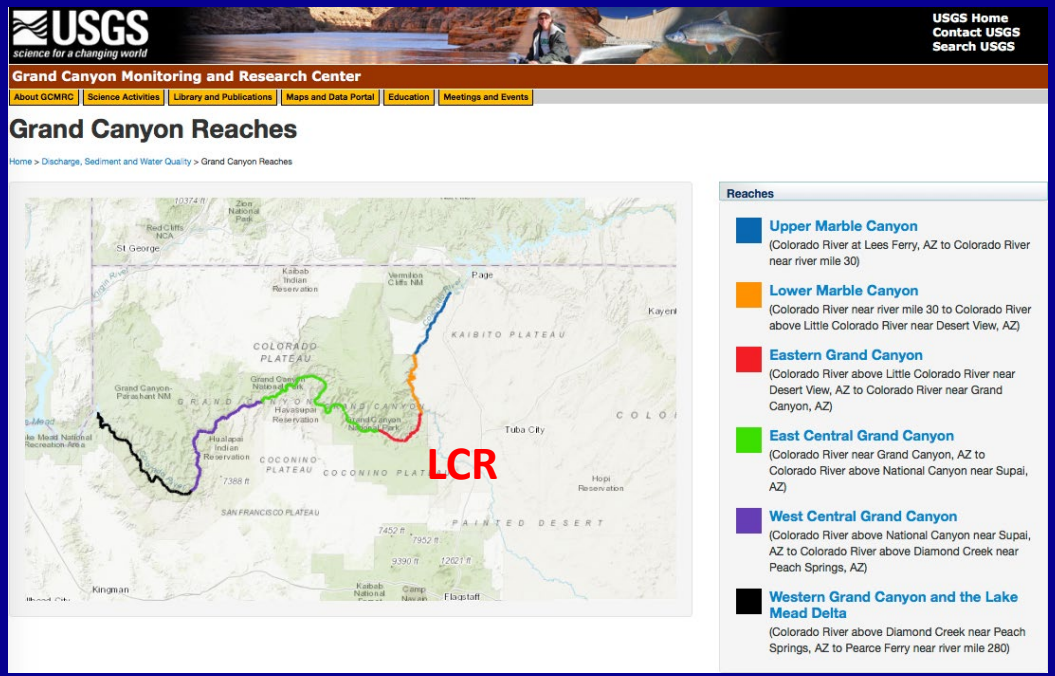


Conclusions continued

- As with the mass balance in Eastern Grand Canyon (Topping and others, *JGR*, 2021), sandbar response in this segment during HFEs seems to be driven largely by LCR activity

- Because the LCR cannot be easily controlled, LTEMP sand management in the Eastern Grand Canyon segment may also require a reduction in dam releases between HFEs

- Evaluation of only the time series of mean sandbar volume can be misleading because of the variation in response among sandbars (this is why we need to examine sandbar response in more than one way)



Thank you

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- Topping, D.J., Grams, P.E., Griffiths, R.E., Dean, D.J., Wright, S.A., and Unema, J.A., 2021, Self-limitation of sand storage in a bedrock-canyon river arising from the interaction of flow and grain size: *Journal of Geophysical Research: Earth Surface*, v. 126, e2020JF005565. https://doi.org/10.1029/2020JF005565

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- U.S. Geological Survey, 2024b, Grand Canyon sandbar monitoring, Grand Canyon Monitoring and Research Center: accessed on January 11, 2024, at http://www.usgs.gov/apps/sandbar/

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