Evaluation of LTEMP sand management

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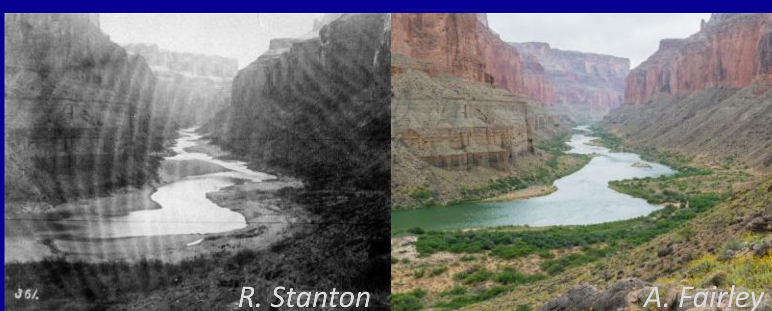
LTEMP Sediment Goal: *Increase and retain fine sediment [sand, silt, and clay] volume, area, and distribution in the Glen, Marble, and Grand Canyon reaches above the elevation of the average base flow for ecological, cultural, and recreational purposes.*

shoreline aquatic habitat

sand dunes


archaeological sites

beaches, campsites, and riparian ecosystem



fundamental part of pre-dam landscape

and major part of post-dam river and reservoir systems (navigation, turbidity, water quality, GPP)

Basics of sand management

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

RECLAMATION
Managing Water in the West

Colorado River Ecosystem Sediment Augmentation Appraisal Engineering Report

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; post-2026 modeling by Salter and others (*WRR*, 2025) shows that this is possible with multi-year water delivery windows

Water Resources Research

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RESEARCH ARTICLE
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Reservoir Operational Strategies for Sustainable Sand Management in the Colorado River

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Key Points:

- High monthly releases reduce sandbar size, both from direct erosion and indirectly through reduced sand availability
- Sandbar size is maximized by eliminating high monthly releases and maintaining reservoir elevations that allow for controlled floods
- Including forecast uncertainty when modeling future operations results in more realistic assessments of operational strategies

- High monthly releases reduce sandbar size; by direct erosion and indirectly by scouring sand from the channel (mining the bank account)
- Sandbar size is maximized by eliminating high monthly releases and maintaining reservoir elevations that allow for HFEs.
- Including forecast uncertainty when modeling future operations results in more realistic assessments of operational strategies

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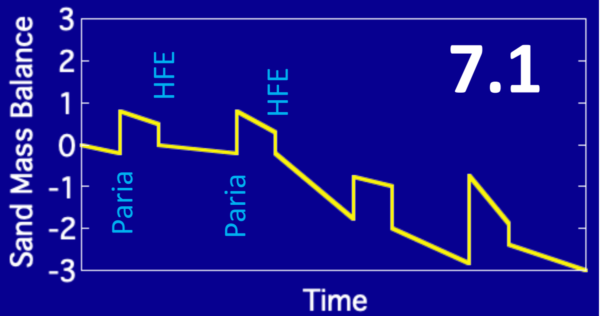
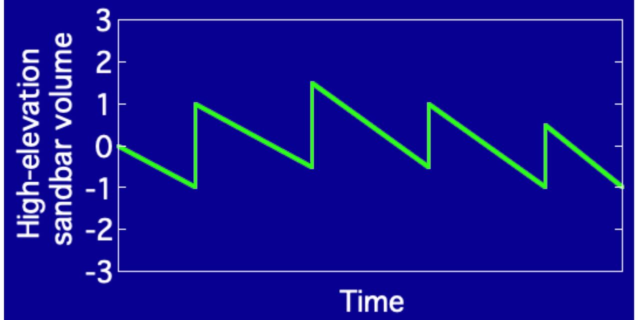
Sustainable sand management occurs when trends in both **METRIC 7.1**, the sand supply (i.e., the sand mass-balance bank account) and **METRIC 7.2.1**, the high-elevation sandbar volume (i.e., your expenditures) are neutral to positive over multiple years

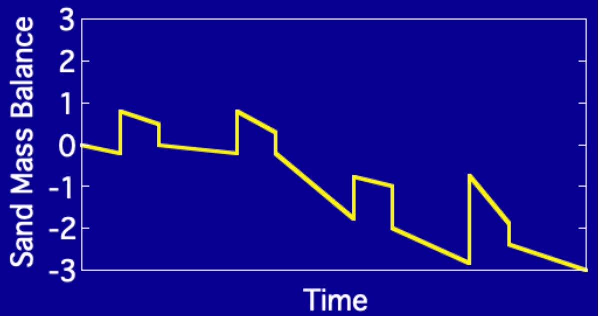
Scenario 1



Not sustainable

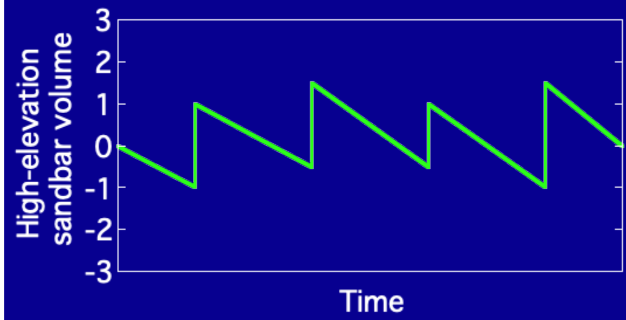
Scenario 2

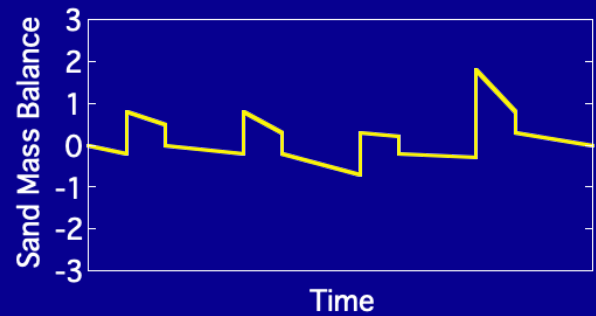




Not sustainable
Bank account mined to deposit sandbars
"Living on credit"

Scenario 3





Sustainable
"Living within your means"

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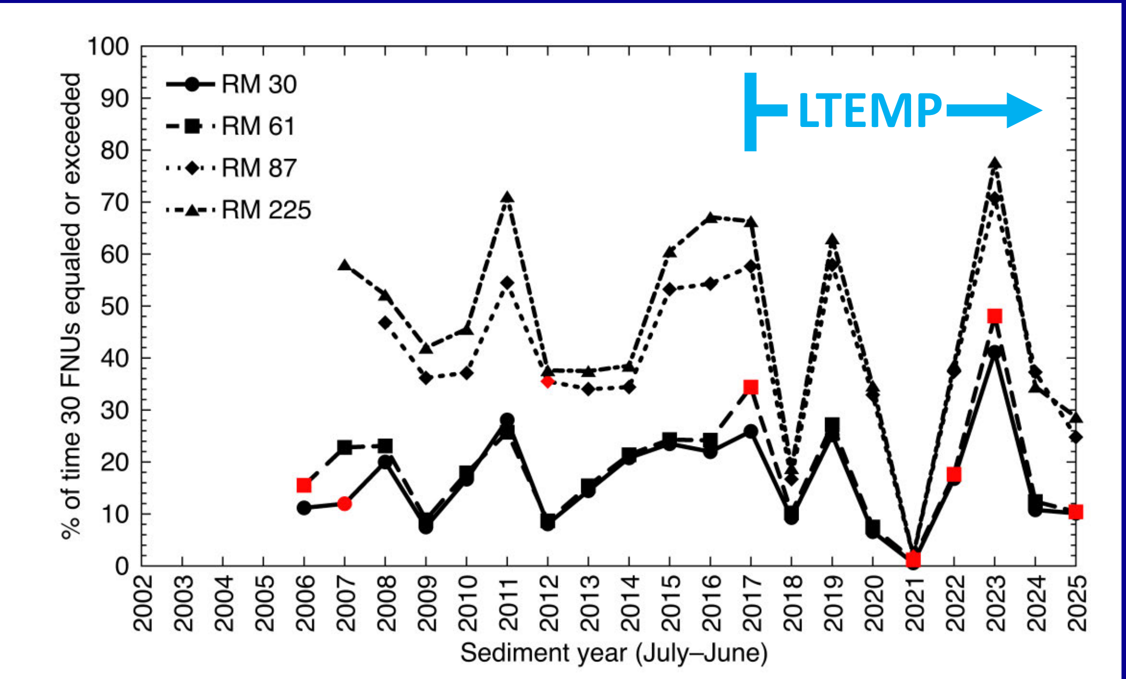
LTEMP sediment metrics

- 7.1 The sand supply (i.e., sand mass-balance bank account) INCREASING IN 3 OUT OF 5 RIVER SEGMENTS
- 7.2.1 Mid- and high-elevation sand in sandbars DECREASING IN 3 OUT OF 5 RIVER SEGMENTS
- 7.2.2 Sandbar enlargement during HFEs YES AT ~60% OF SITES; NET EROSION AT ONLY ~10% OF SITES
- 7.3 Silt-and-clay on banks inferred from turbidity MOSTLY LOW DURING LTEMP

Water during 6 out of 8 LTEMP years clearer than normal



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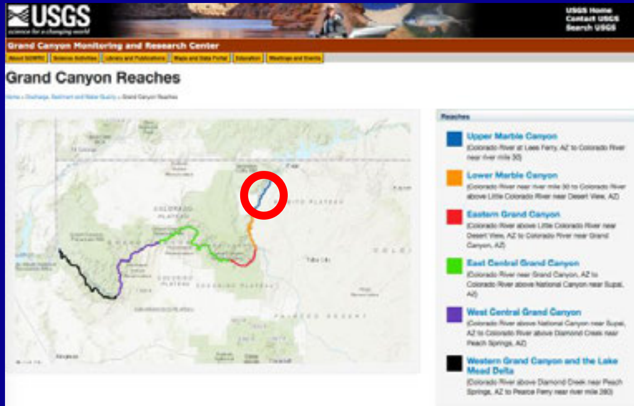
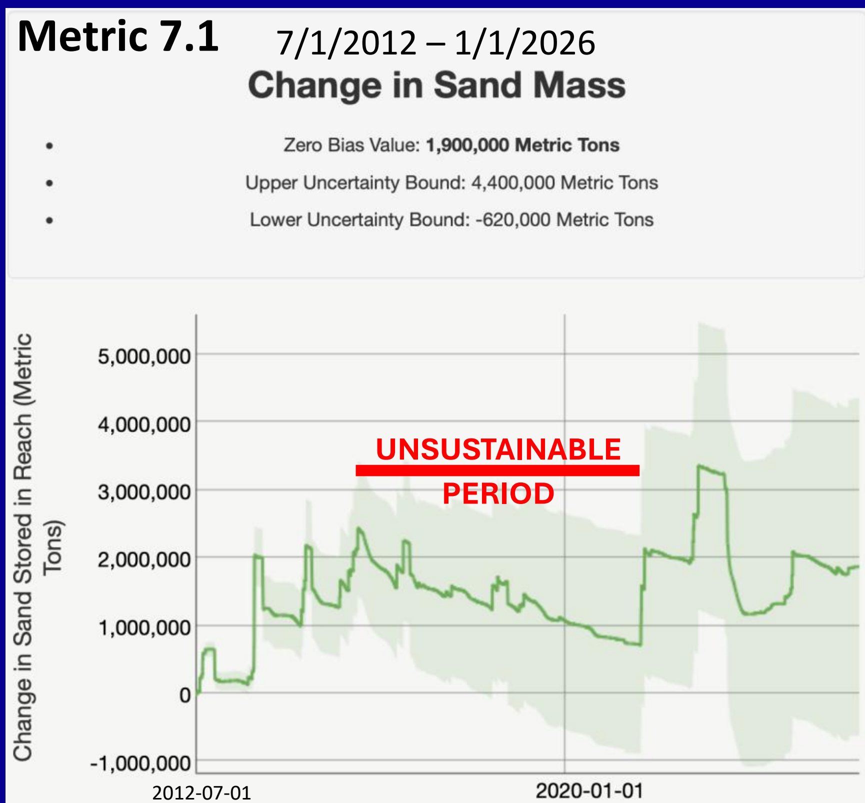
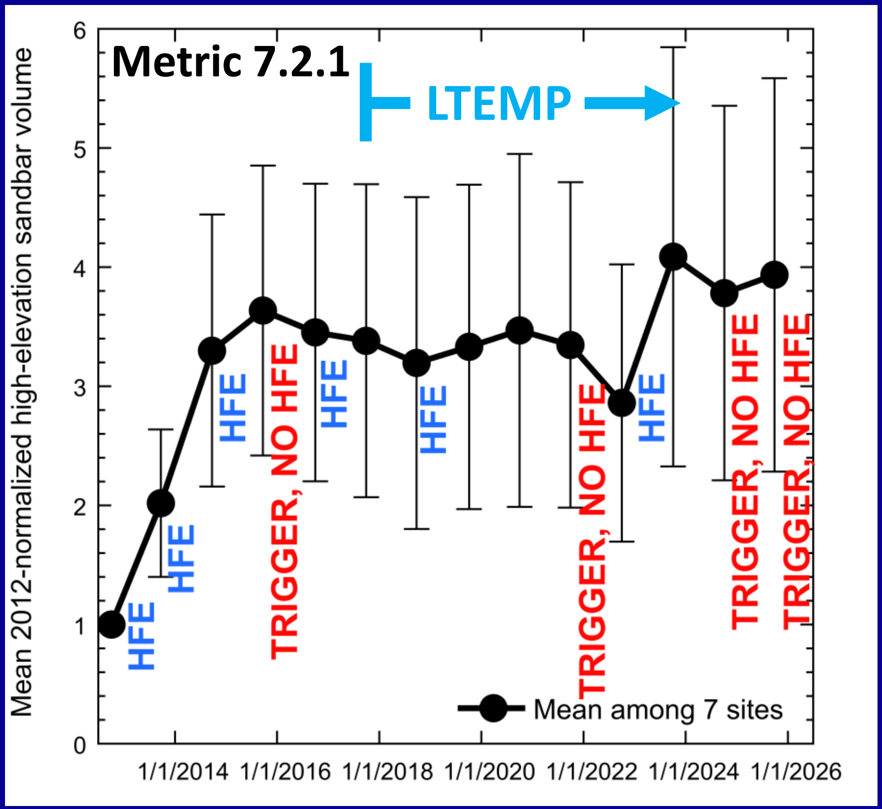
Data from USGS (2026a)



HFE-Protocol/LTEMP Period
Upper Marble Canyon



POSITIVE



HFE Protocol: NET + ; 3/5 years +

LTEMP: NET + ; 2/8 years +

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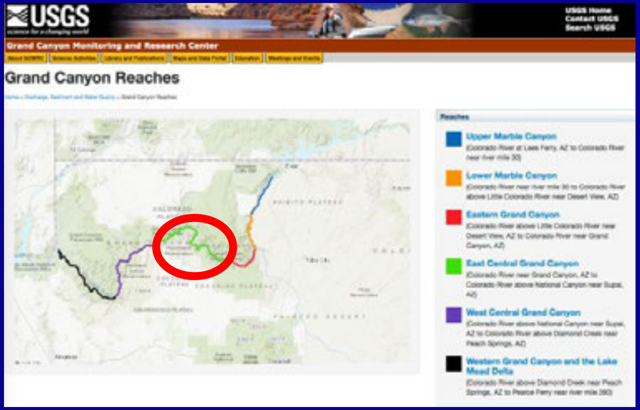
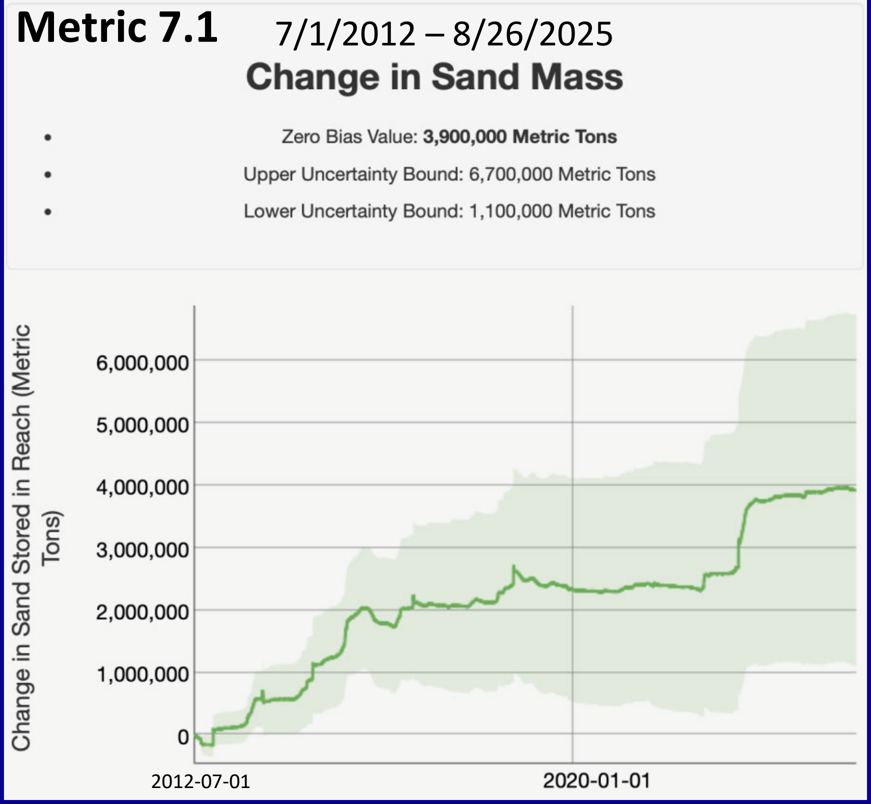
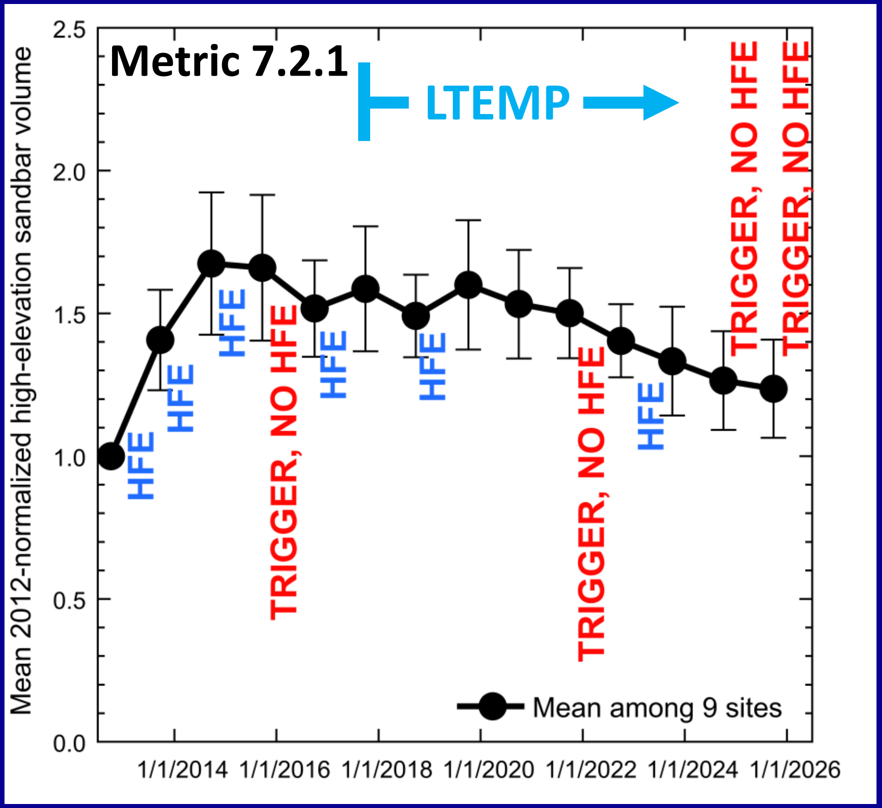
Data from USGS (2026a, b)

HFE-Protocol/LTEMP Period East-Central Grand Canyon





POSITIVE



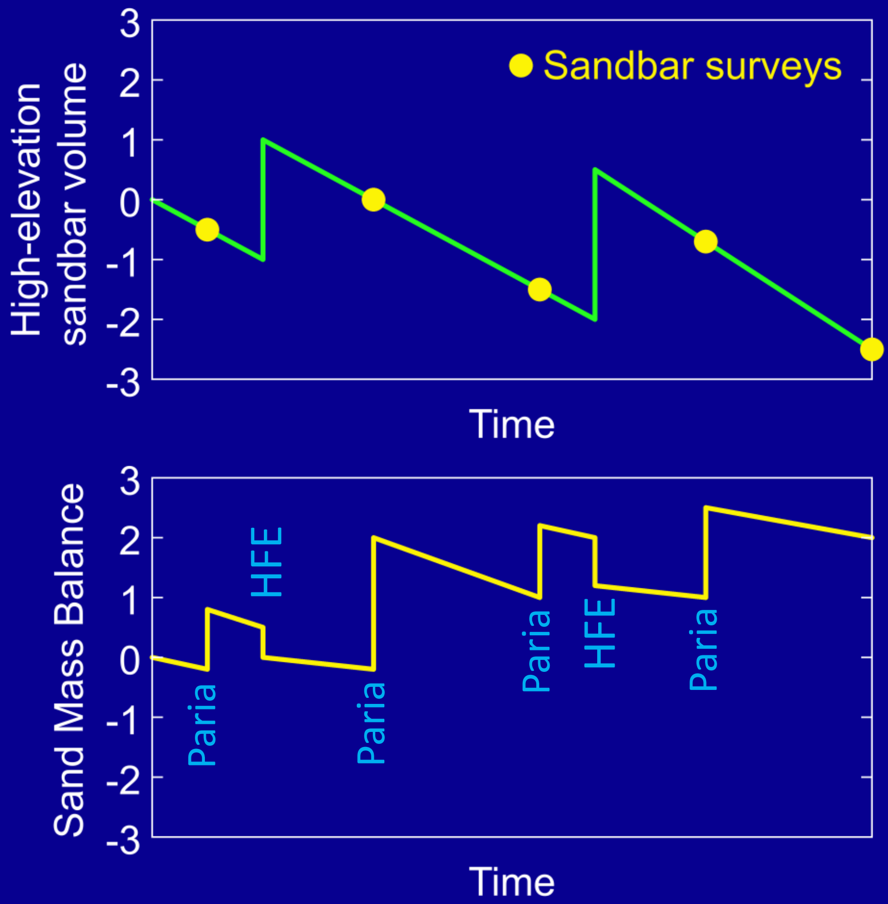
HFE Protocol: NET + ; 3/5 years +

LTEMP: NET – ; 1/8 years +

Note: Metric 7.1 is not positive in the other 2 Grand Canyon segments

Data from USGS (2026a, b)

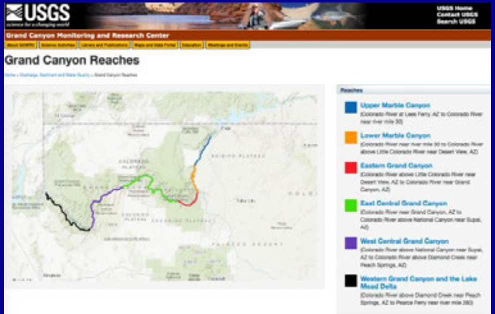
Generalized LTEMP scenario among the 5 river segments
"Not following the experimental design"



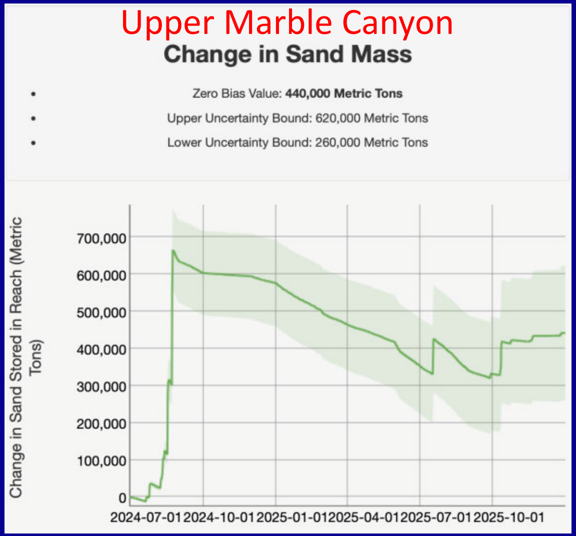
Sandbar erosion during intervening dam operations WINS over sandbar deposition during HFEs

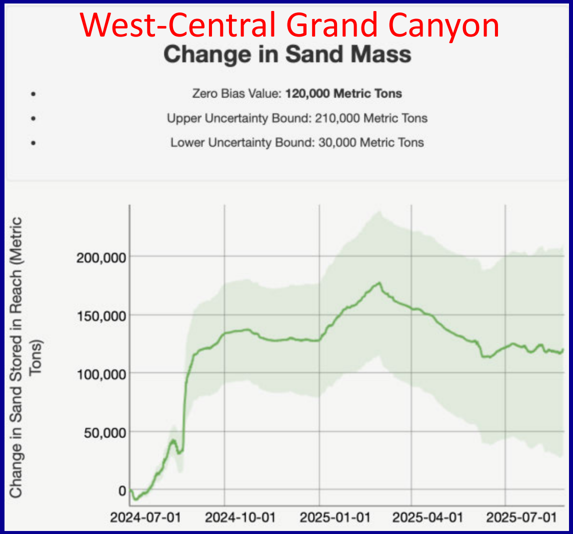
Not all "new" Paria sand is used during rare HFEs and *sand export increases as bed-sand accumulates and fines* (Topping and others, 2021)

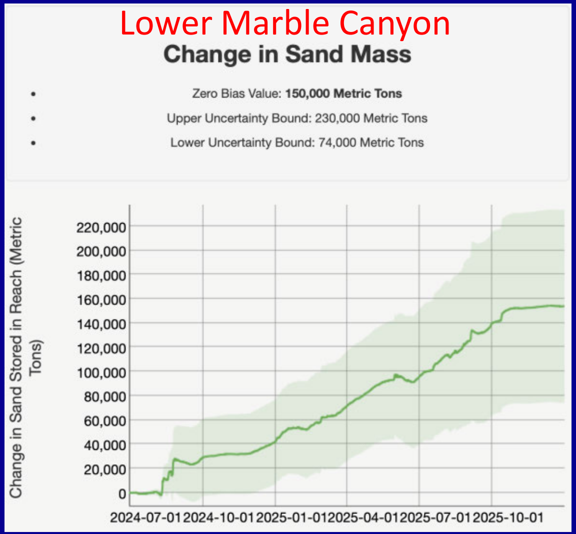
We will still have a robust HFE trigger in spring 2026 and most segments are positive

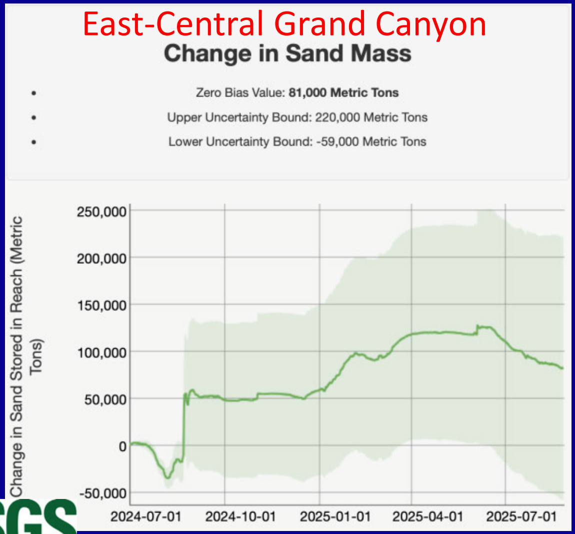


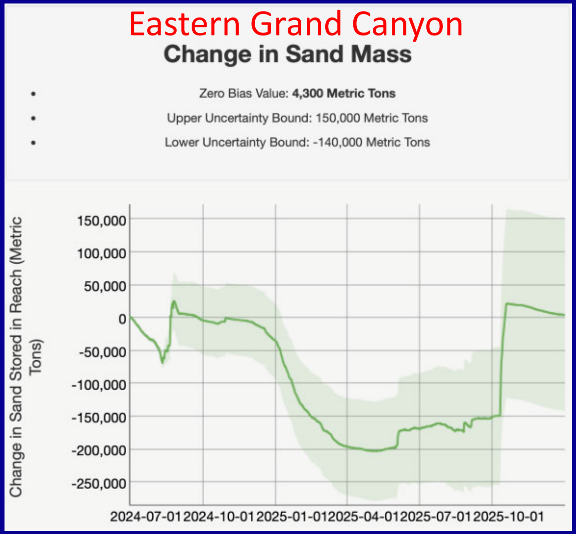
- Since July 1, 2024, the Paria River has supplied 860,000 to 1,100,000 metric tons of sand
- > 330,000 metric tons of this sand is still in Marble Canyon
- Between now and the spring, there will be a transfer of some sand from Upper to Lower Marble Canyon with little net change in all of Marble Canyon











Data from USGS (2026a)

Conclusions

- Results were promising during the “period of frequent HFEs” (2012–2016; HFE Protocol period) when sandbar deposition during HFEs generally outweighed sandbar erosion during intervening dam operations
- HFEs during 2012–2016 were conducted following 4 out of 5 triggers
- Results have been mixed to negative during the “period of infrequent HFEs” (2017–present; LTEMP period) when sandbar erosion during intervening dam operations has generally outweighed sandbar deposition during HFEs
- Only 2 HFEs were conducted during 2017–2025 despite there being 5 triggers
- Learning has been hampered during LTEMP owing to lack of HFEs despite there being triggers
- What about low reservoir elevations?

Thank you

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