Sedimentation in Lake Powell

Recent USGS Utah Water Science Center activities in cooperation with:

-Utah Department of Environmental Quality

-Bureau of Reclamation

-Bureau of Land Management

-National Park Service

-University of Utah and Utah State University

USGS


Google
Google, Landsat / Copernicus
37.398334°N 110.860943°W 130 mi

Coring the San Juan and Colorado River deltas to determine recent and historical fluxes of metals to Lake Powell

Putting the August 2015 Gold King Mine Release into Perspective:

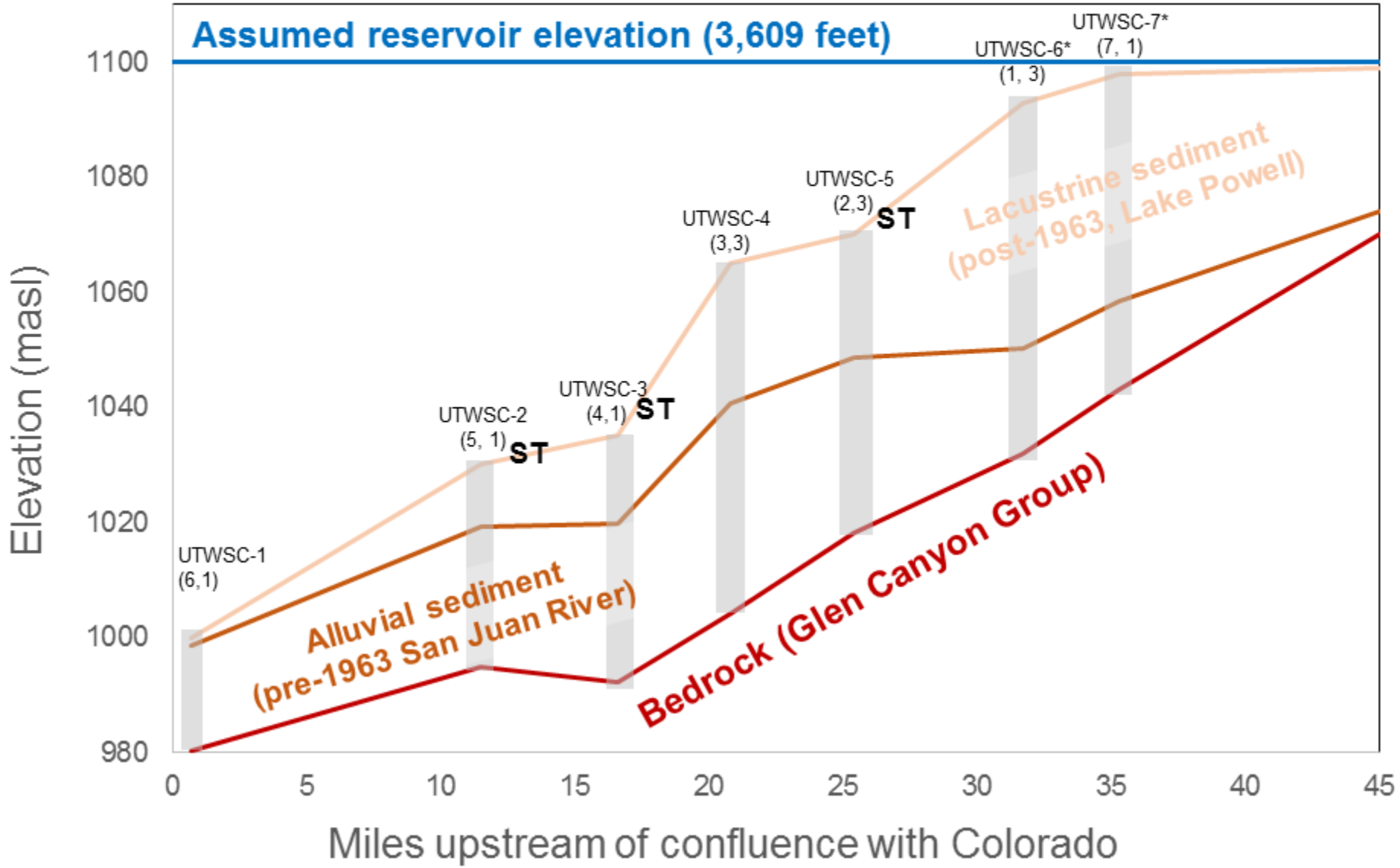
1) What is the total mass of metals deposited in the San Juan Delta?
2) How are metals distributed within the delta?
3) How stable are the metals in the San Juan delta?
4) What longer term trends in metal deposition can be elucidated from pre-Lake Powell deposits?
5) How does this assessment from the San Juan delta compare with the Colorado River delta?
6) If San Juan metal fluxes are exceptional, and depositional and geochemical processes can be relatively well understood, what are the management options and considerations within Lake Powell, the San Juan river basin, and the Upper Colorado river basin to minimize the environmental effects of the metals?

**These questions were developed in coordination with Utah DEQ. Bureau of Reclamation is also a cooperator but their interests lie more in physical sedimentation rates and total sediment volumes.*

Longitudinal profile of San Juan delta and proposed coring sites

Site Name-X (order of priority, # of cores), **ST**= site of currently deployed sediment trap, *denotes site of previously retrieved cores (Hornewer, 2014)

Thickness of alluvial sediment from the USGS Bulletin 471 (Miser, 1921)



Lake Powell Coring Study

Background

Sediment deposits accumulated in the San Juan River (SJR) and Colorado River (COR) deltas of Lake Powell prior to completion of Glen Canyon Dam are known to contain heavy metals from historic mining in the Upper Animas watershed. Understanding the spatial distribution, total mass, and availability of these metals to living organisms is critical for understanding possible risks they pose to water quality in Lake Powell.

The current state of Lake Powell's deltas is unknown, but they continue to accumulate and redistribute potentially harmful concentrations of numerous metals, especially arsenic, cadmium, copper, mercury, lead, selenium, and zinc. Mobilization of these metals in the future from activities that expose sediment could impact or threaten water quality, human health, and aquatic life.

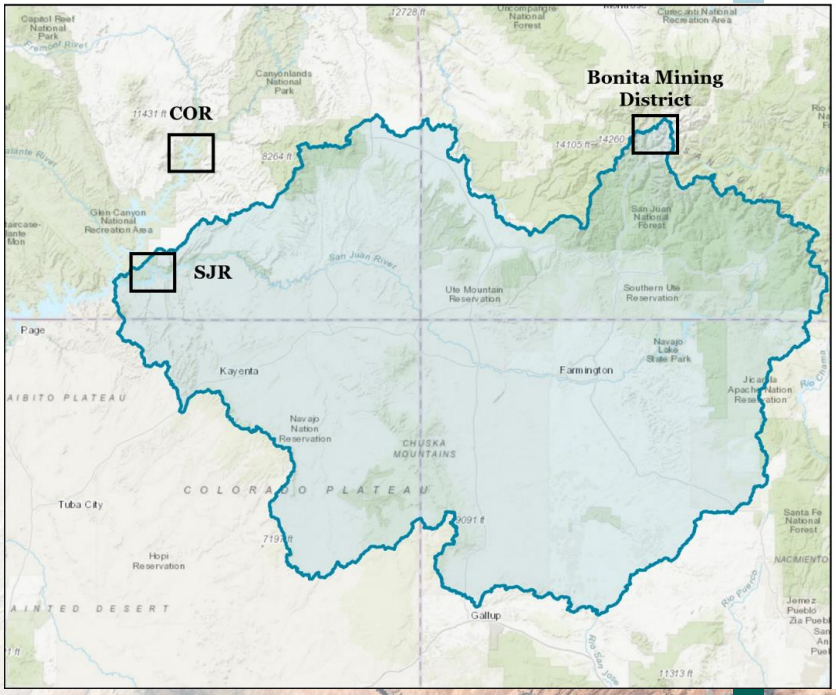
Purpose

To improve understanding of the concentration, loading, distribution, and bioavailability of metals throughout the total thickness of sediment deposits in Lake Powell and to assess the impacts to water quality and associated beneficial uses including human health and aquatic life by answering the following questions:

1. What is the total mass of metals deposited in the SJR delta?
2. What is the distribution and stability of metals in the delta?
3. What long term trends in metal deposition can be clarified from pre-Lake Powell deposits?
4. How does the assessment from the SJR compare to the COR?
5. What are the management options and considerations within Lake Powell, the San Juan River basin, and the Upper Colorado River basin to minimize the environmental effects of the metals?

Sampling Scheme

Sediment coring will occur at 4-6 locations in the SJR delta and at 4-6 locations in the COR delta



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WATER QUALITY

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Project Phases

Phase 1: Retrieve sediment cores

Extract 2.5-in diameter cores from lakebed deposits at depths no greater than 600 meters. Conduct drilling operations 24 hours a day, with two crews working in 12-hour shifts.

Oct. 2018

Phase 2: Conduct preliminary analysis

Scan cores prior to splitting, imaging, and sampling to measure: 1) physical parameters; 2) sediment characteristics and porosity using acoustic wave velocity logging; 3) sediment porosity and permeability using electrical resistivity logging; and 4) magnetic mineral content using magnetic susceptibility logging.

2018 – 2020

Phase 3: Conduct comprehensive analysis

Use data analysis and reporting to determine rates of deposition as well as changes in the rate and character of metal deposition.

2020 – 2021

Project Complete December, 2021

Project Outcomes

- Determine background rates of metal deposition from San Juan River and Colorado River sediment before, during, and after filling of Lake Powell
- Identify timing and nature of sediment deposits from background rates, with characterization of specific events
- Find evidence for and consequences of runoff events during historically low lake levels
- Assess potential risks to aquatic life and human health associated with future sediment remobilization during low lake levels.

Funding

- Utah DEQ Division of Water Quality: $948,796
- U.S. Geological Survey: $316,265

Contact

- Lucy Parham, Utah Division of Water Quality, lparham@utah.gov
- Scott Hynek, U.S. Geological Survey, shynek@usgs.gov

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Coring Lake Powell Deltas

November 1, 2021 outline

- **Approach and Punchline**
- **Sediment Volume**
- **Sediment Chemistry**
- **Chronology of Sedimentation**
- **Where do we stand in 2021?**

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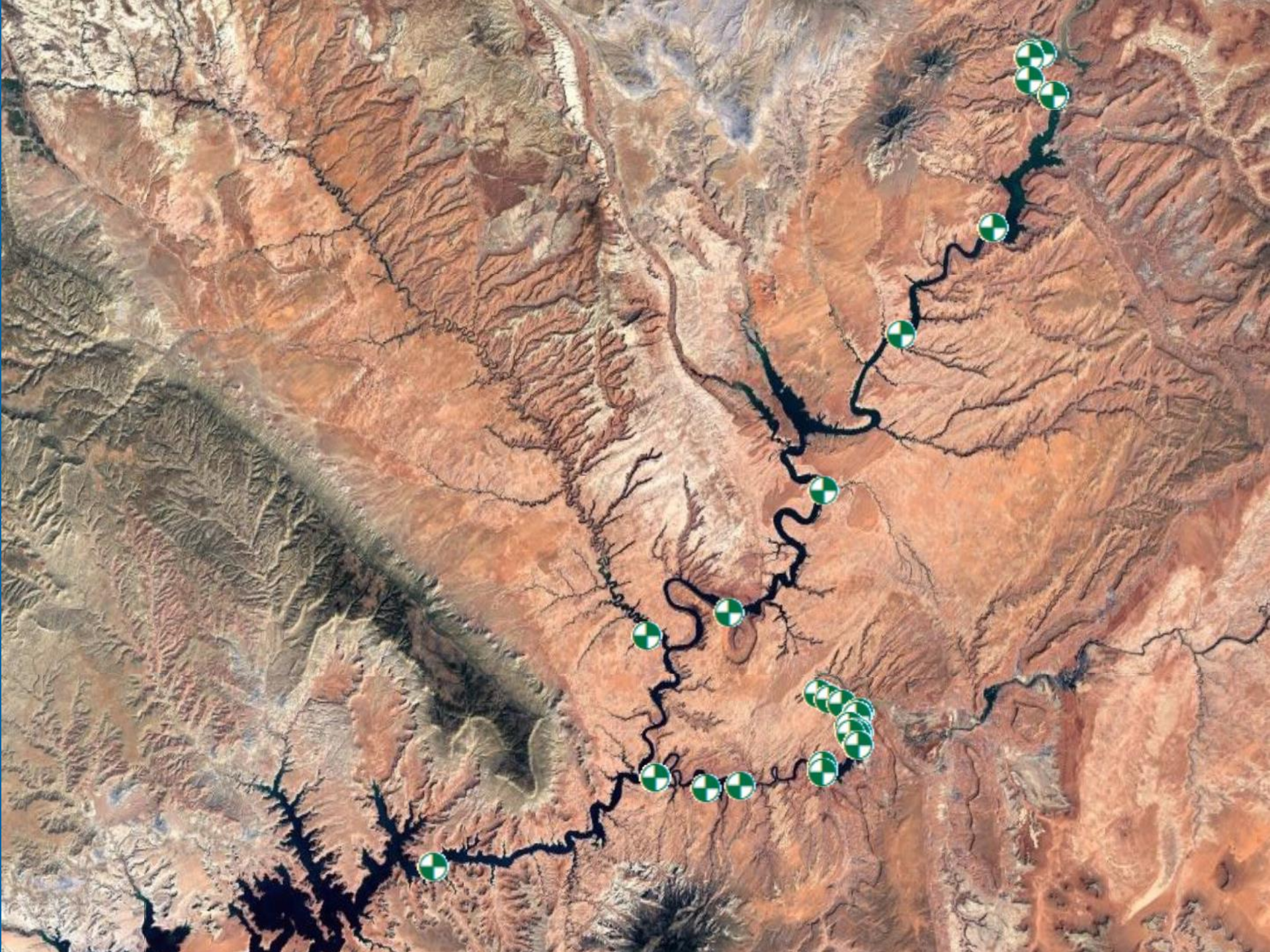
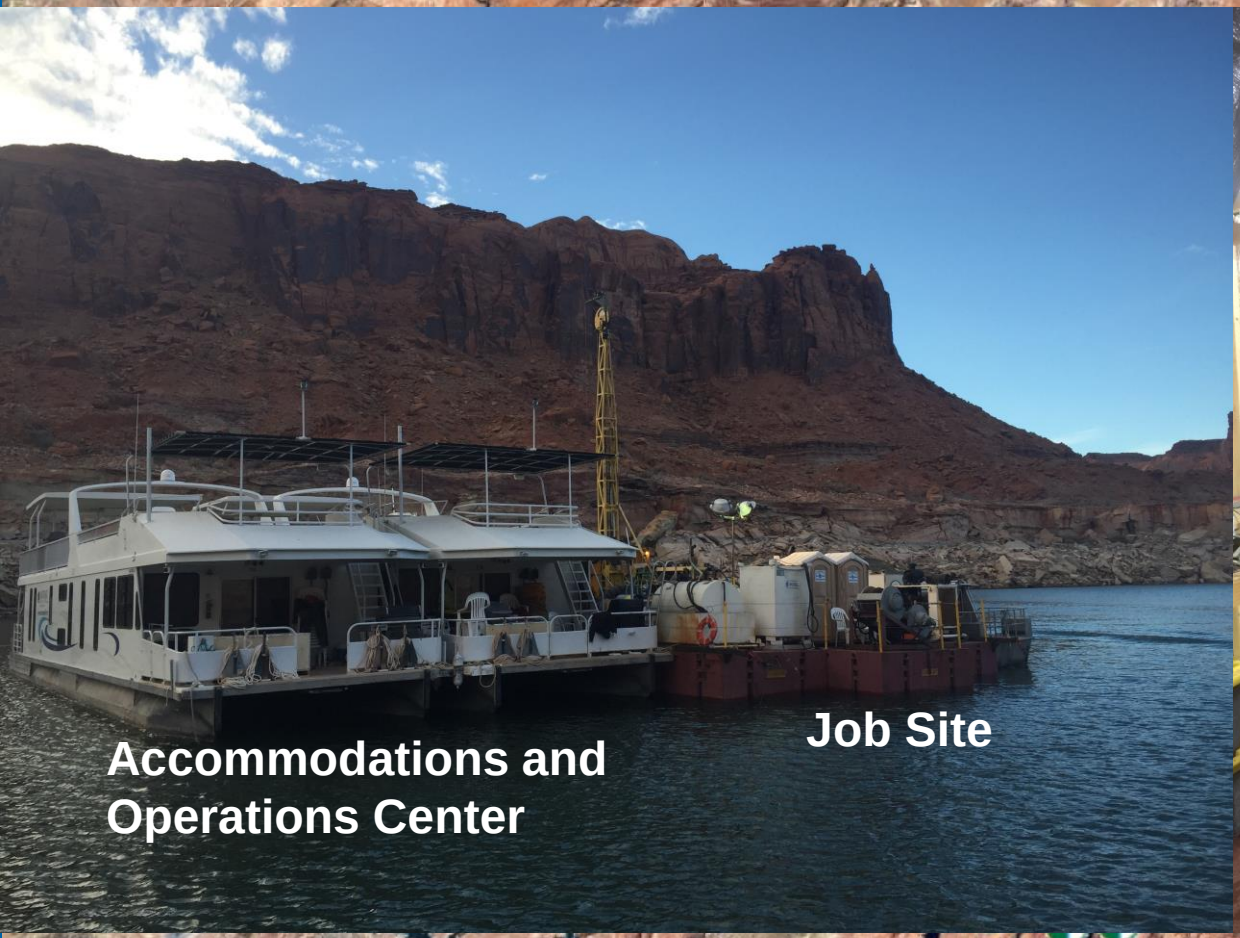




Accommodations and Operations Center

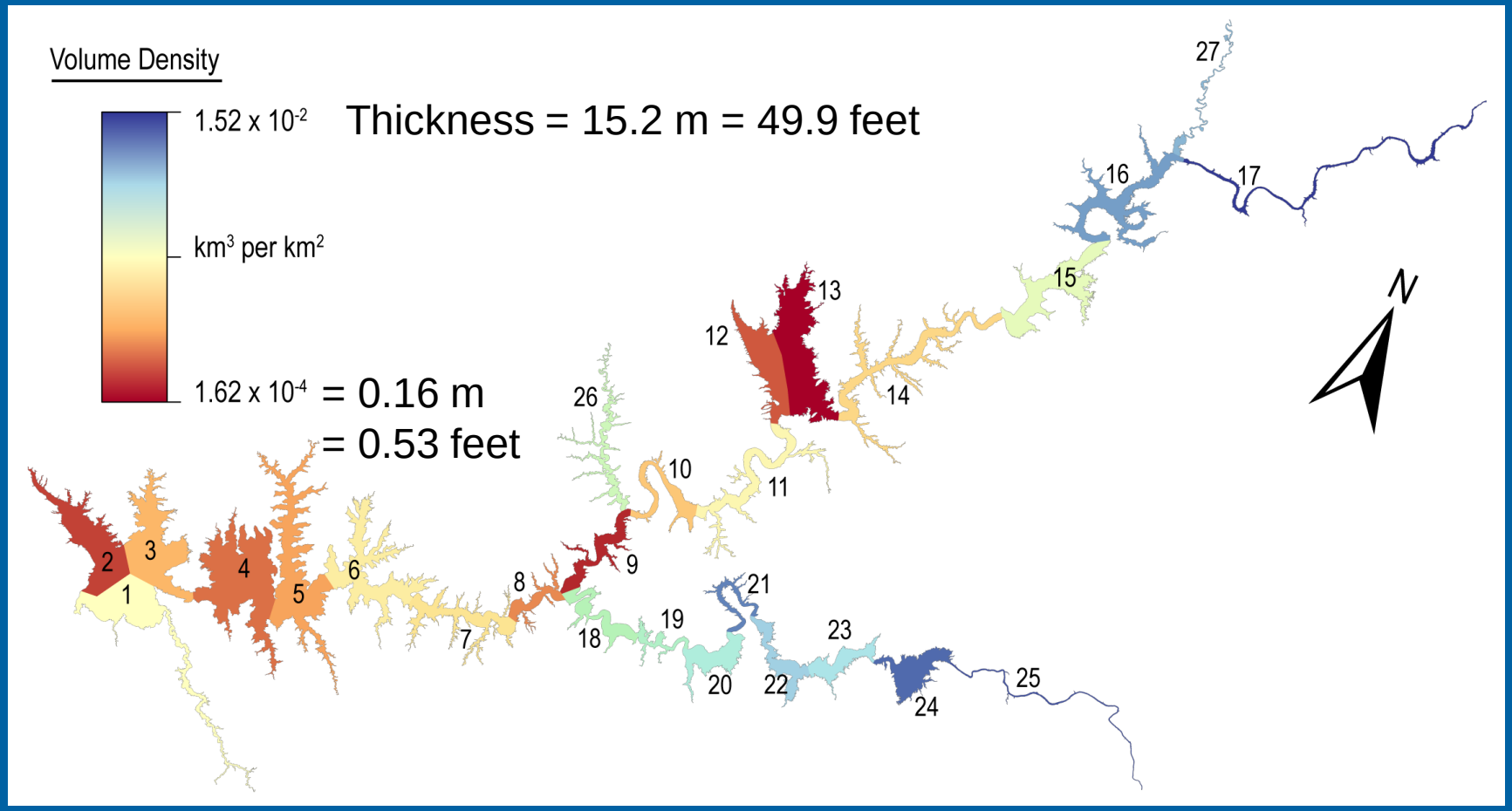
Job Site

24-7 OPS

Laboratory

1963–2017:

Long term sediment accumulation dominated by deltas.



USGS

New material available for Science

Coring: Nov 4–Dec 5, 2018

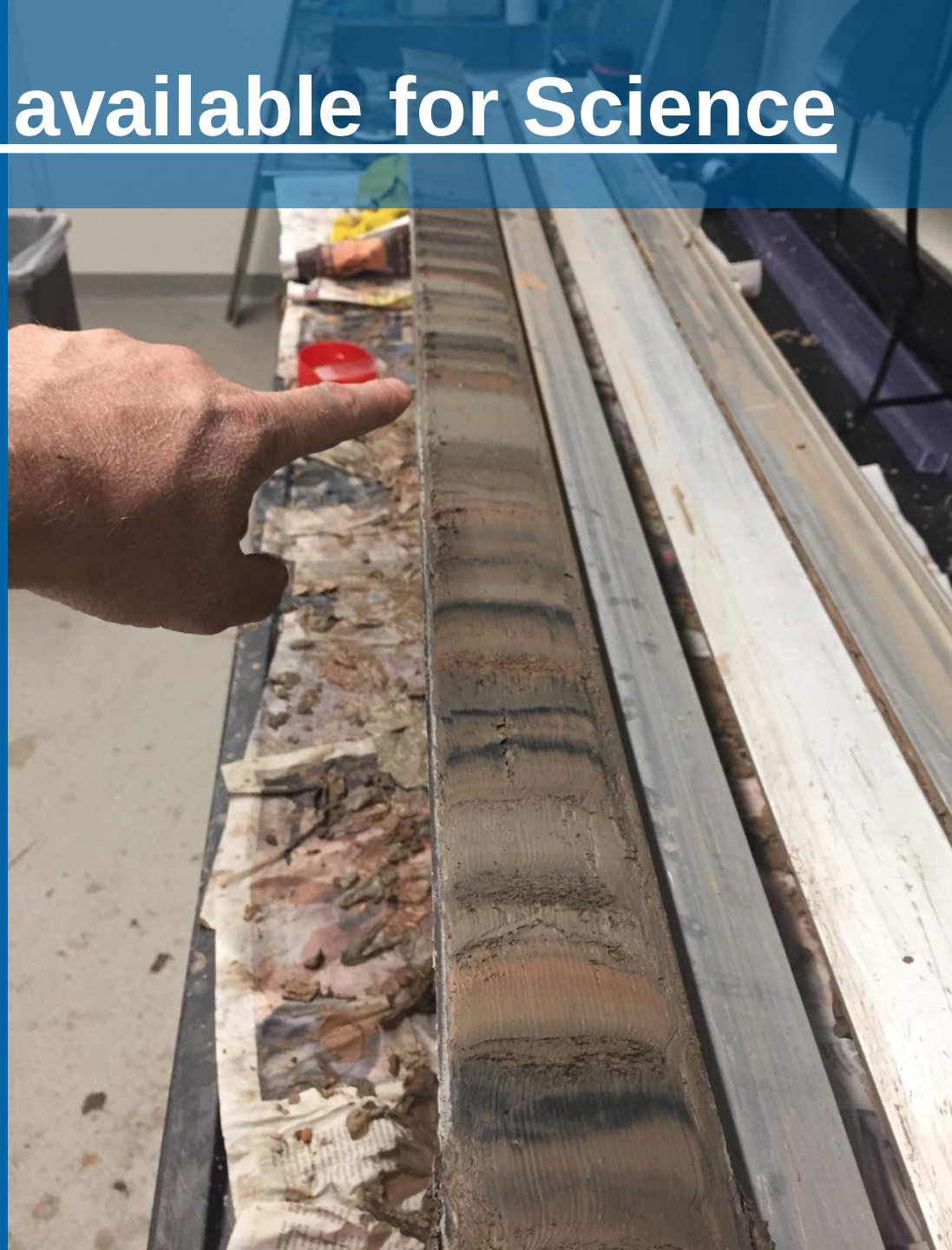
39 cores

13 Colorado
23 San Juan
1 Escalante Arm
2 below CO/SJ confluence

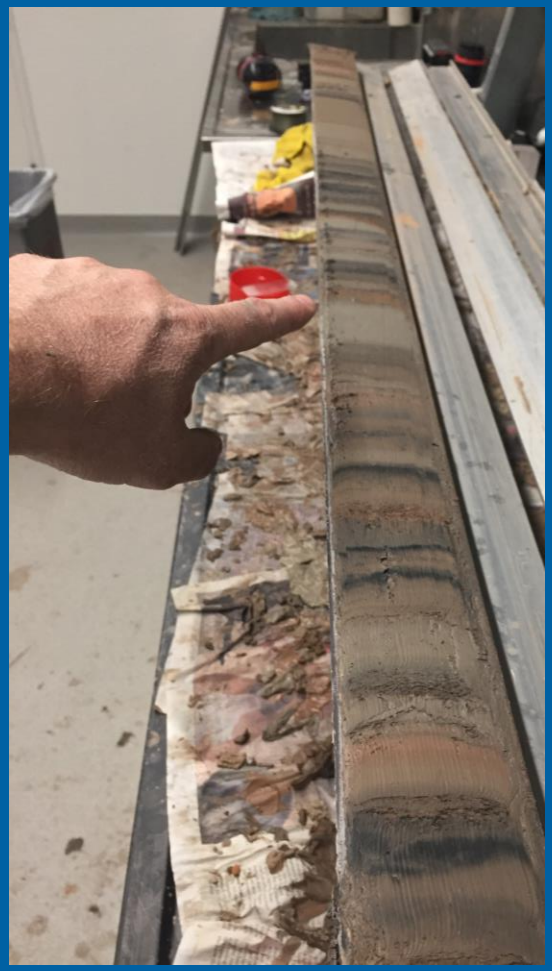
493.74 meters

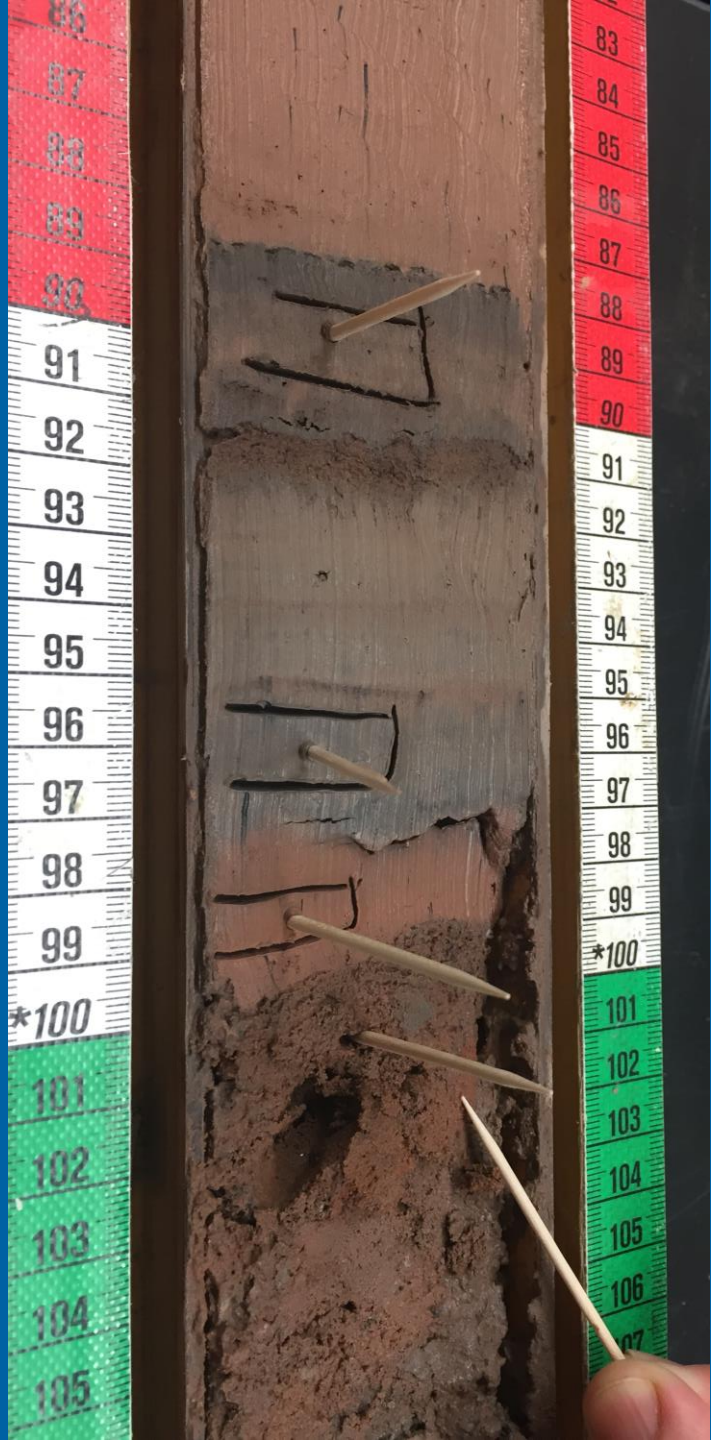
211.98 Colorado
269.05 San Juan
2.13 Escalante Arm
10.59 below CO/SJ confluence

USGS



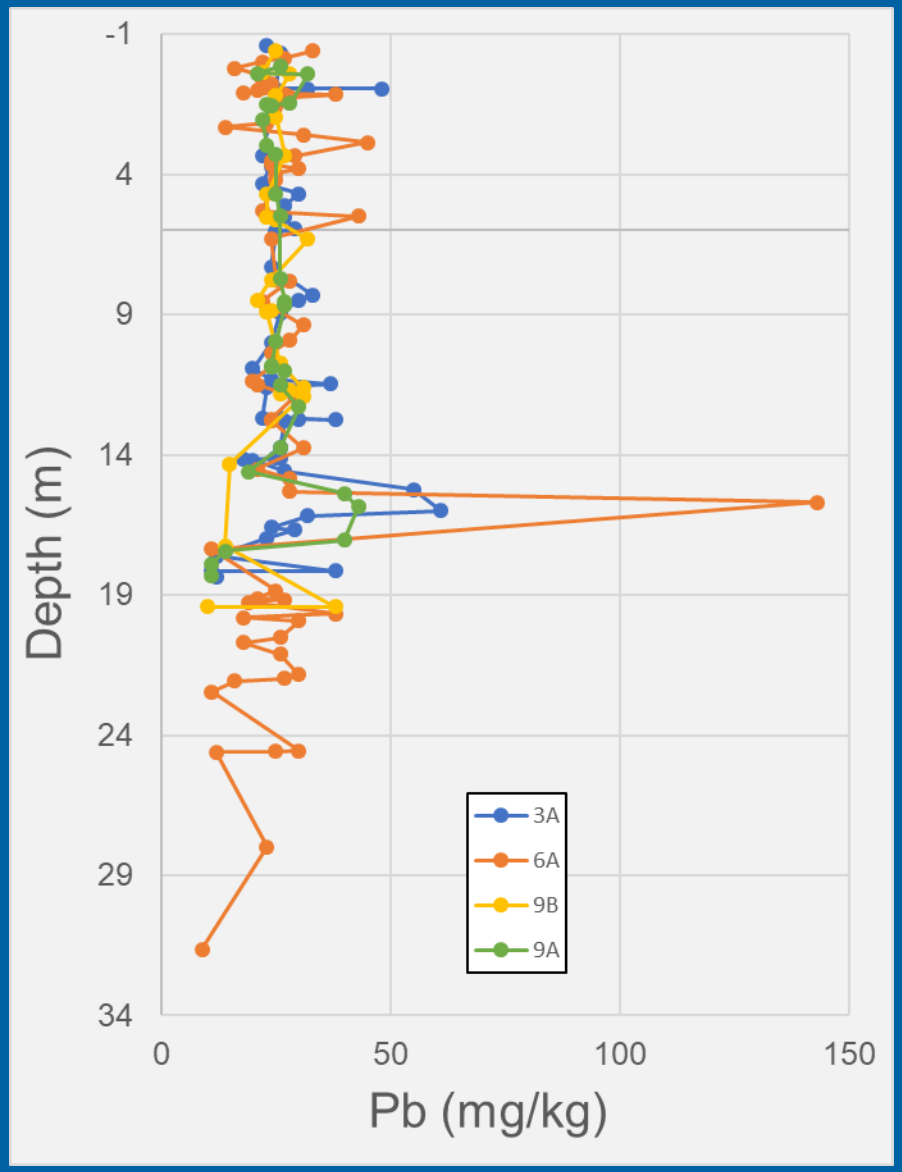
Turning raw material into science.





USGS

Via a cooperative agreement with the National Lacustrine Core Repository (LacCore) at the University of Minnesota.


-1
4
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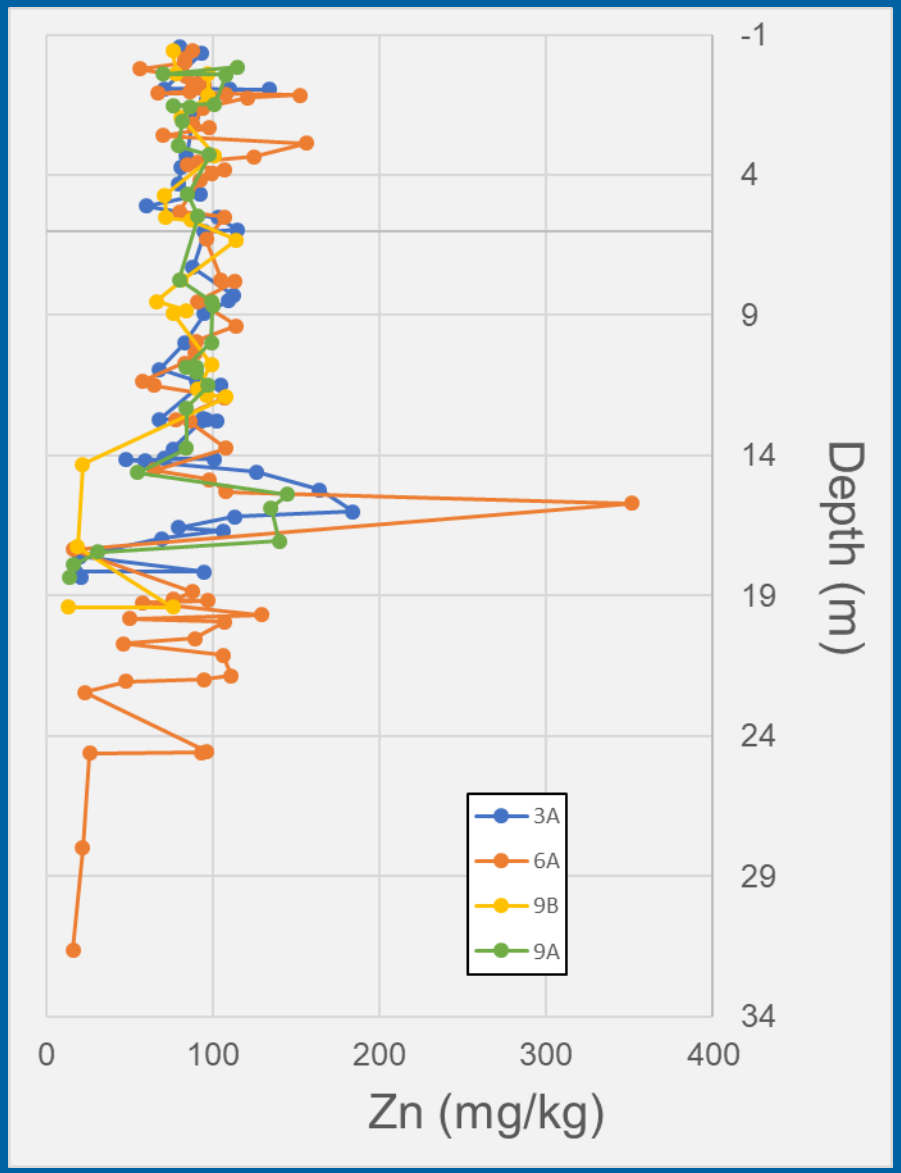
Depth (m)
0
50
100
150
Pb (mg/kg)
3A
6A
9B
9A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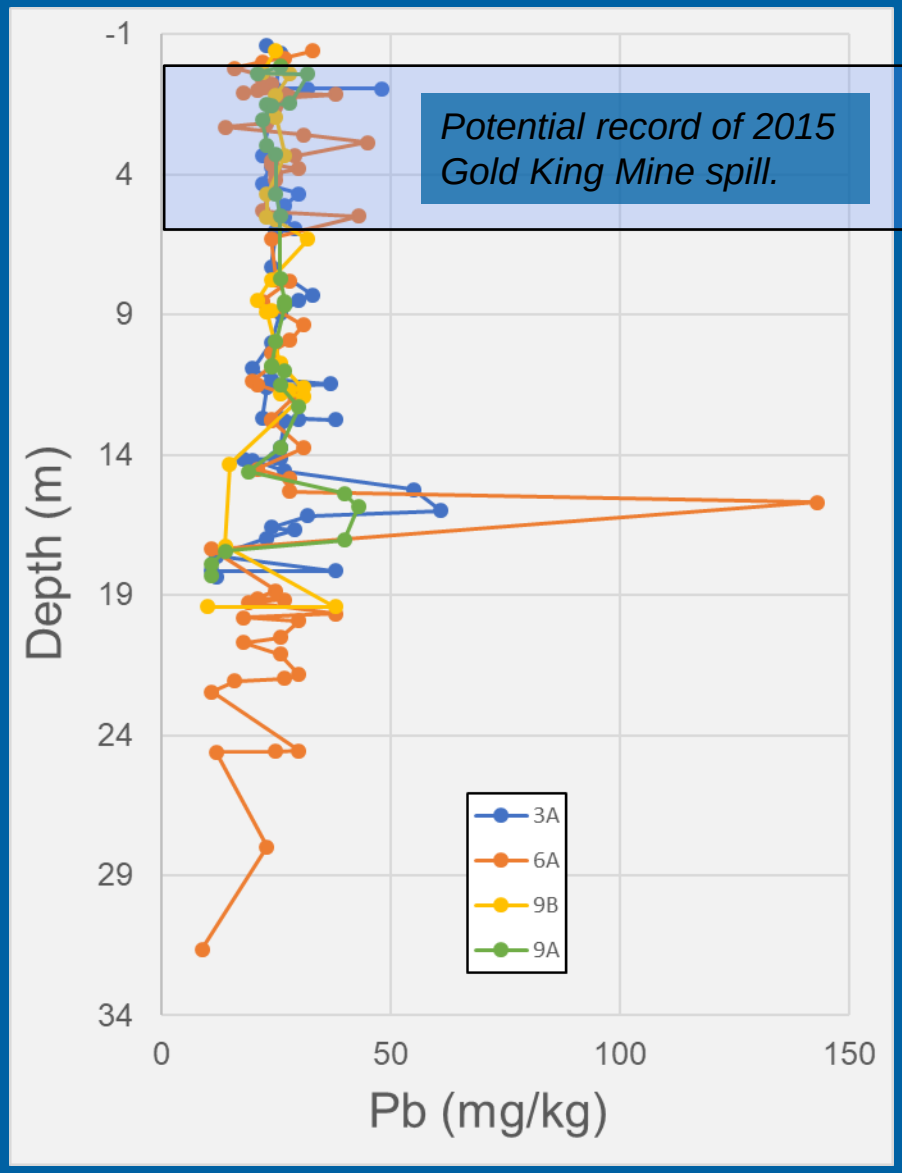
USGS


Potential record of 2015 Gold King Mine spill.
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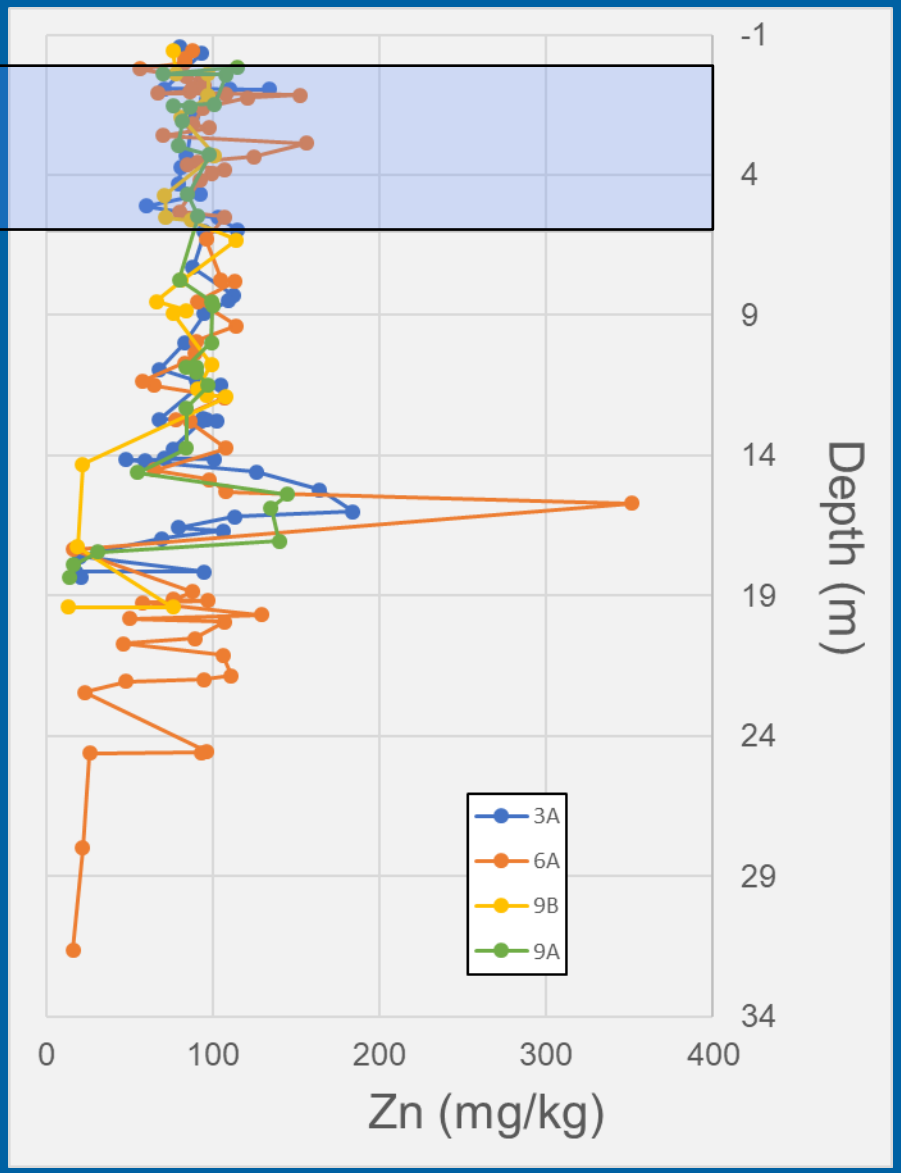
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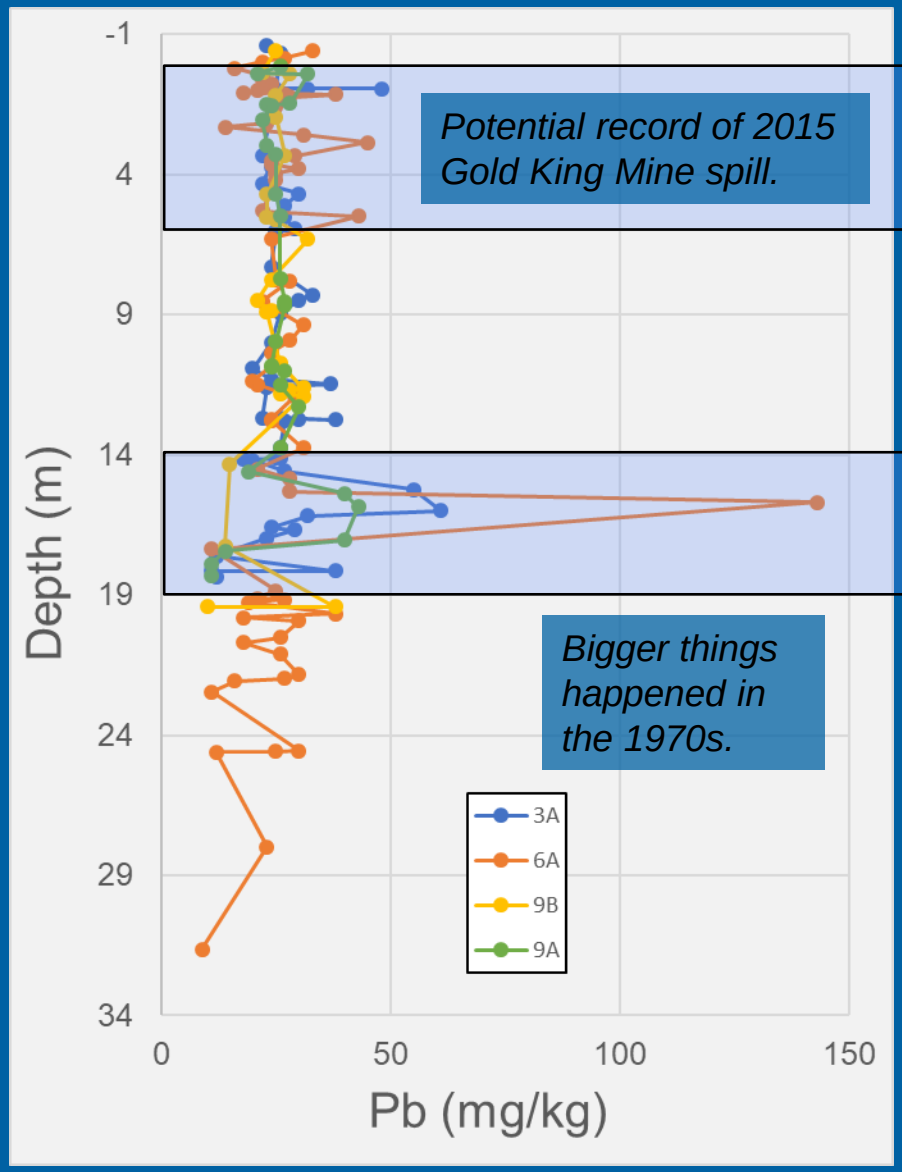

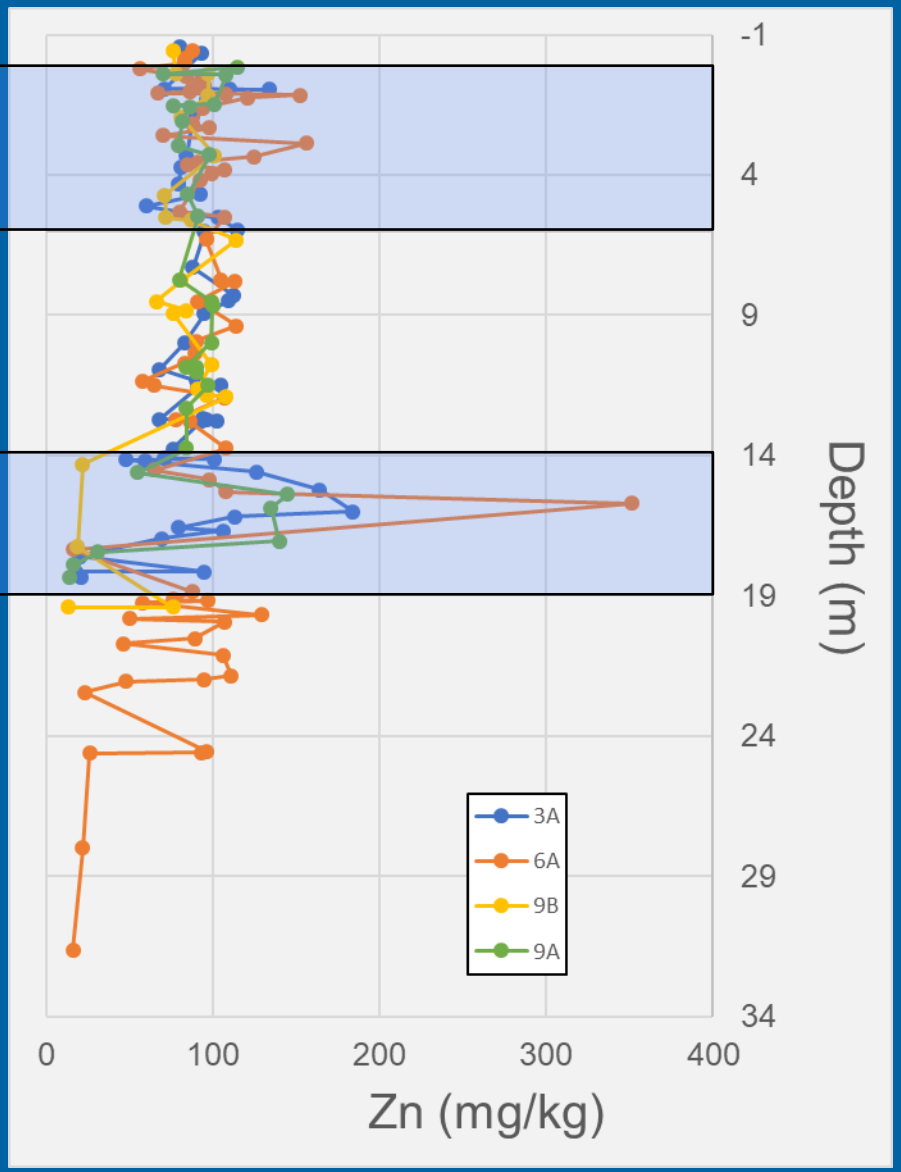

USGS

Major hydrologic event sourced from a metal rich watershed (two options):

1) *Mine spill incident in upper Animas watershed*
2) *Monsoon flow in the lower San Juan watershed*

Coring Lake Powell Deltas

November 1, 2021 outline

- Approach and Punchline
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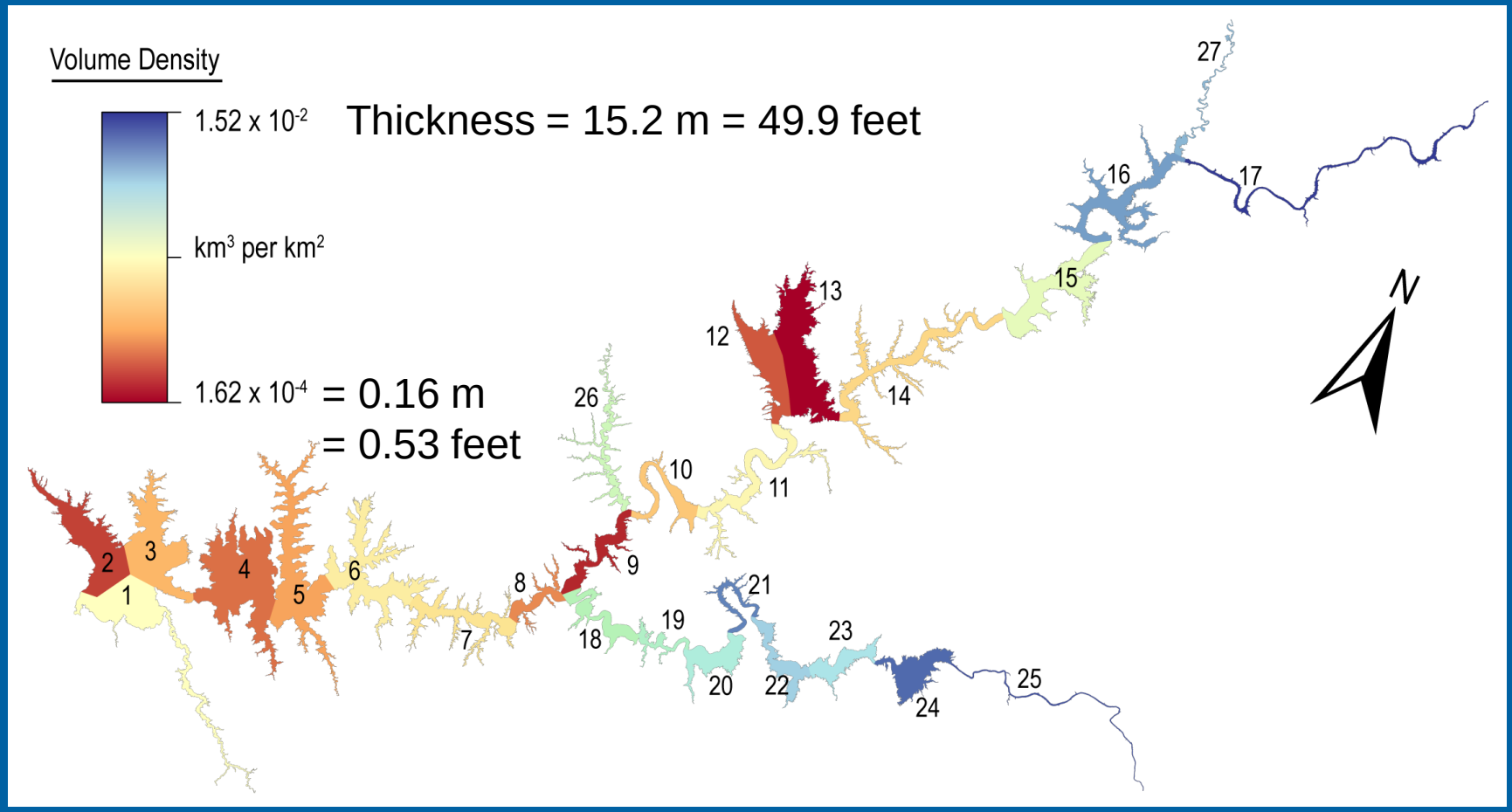
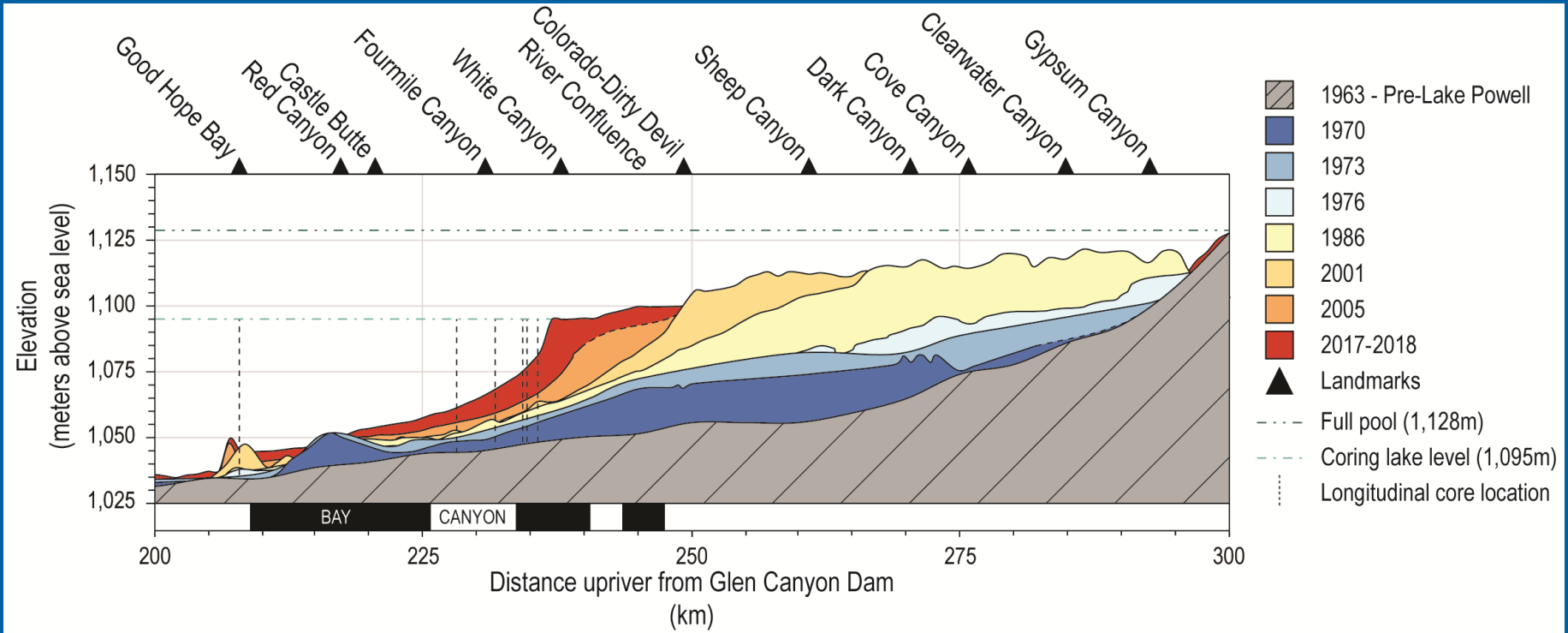
USGS

It's all about deltas; *and canyons and bays*.



USGS

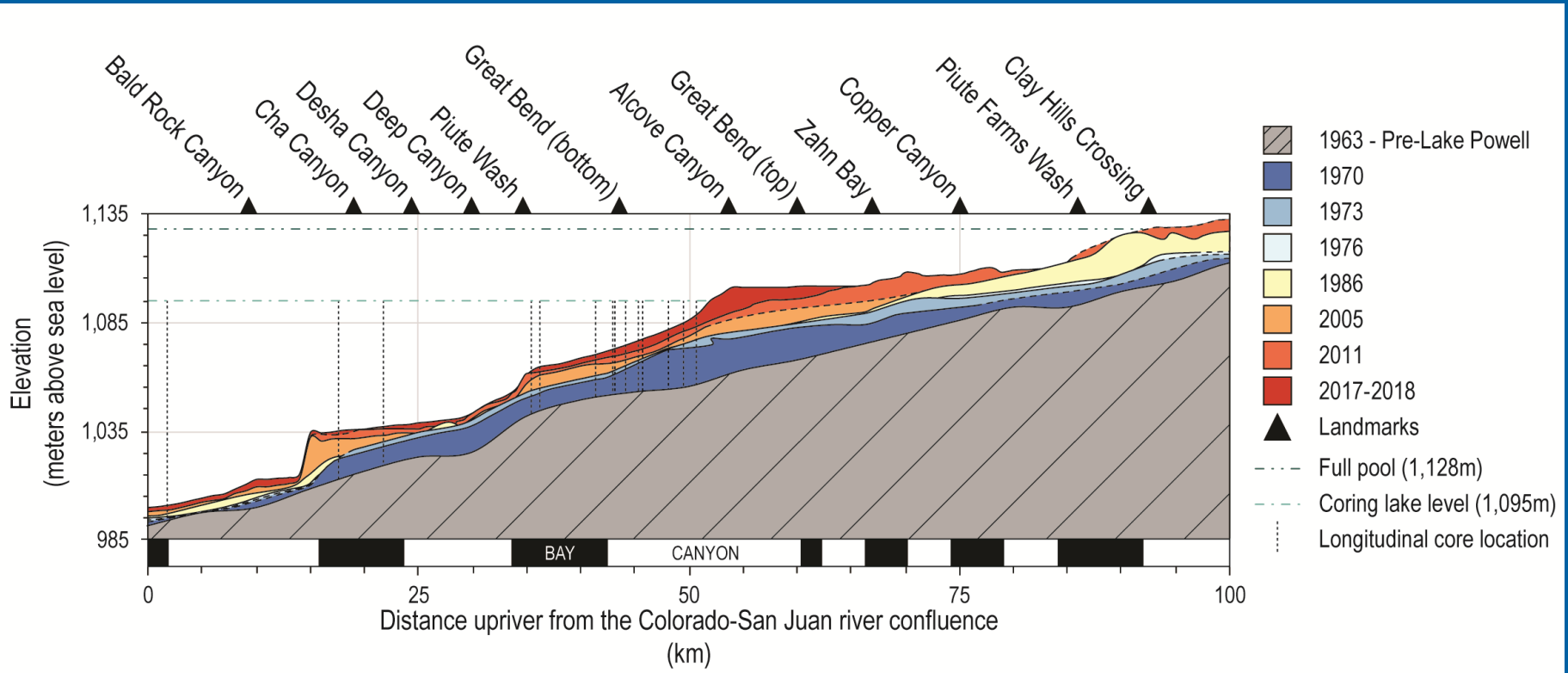
The Colorado River Delta



**Bay vs canyon is a function of cross-sectional area divided by the maximum height from the thalweg to 3,700'*

USGS

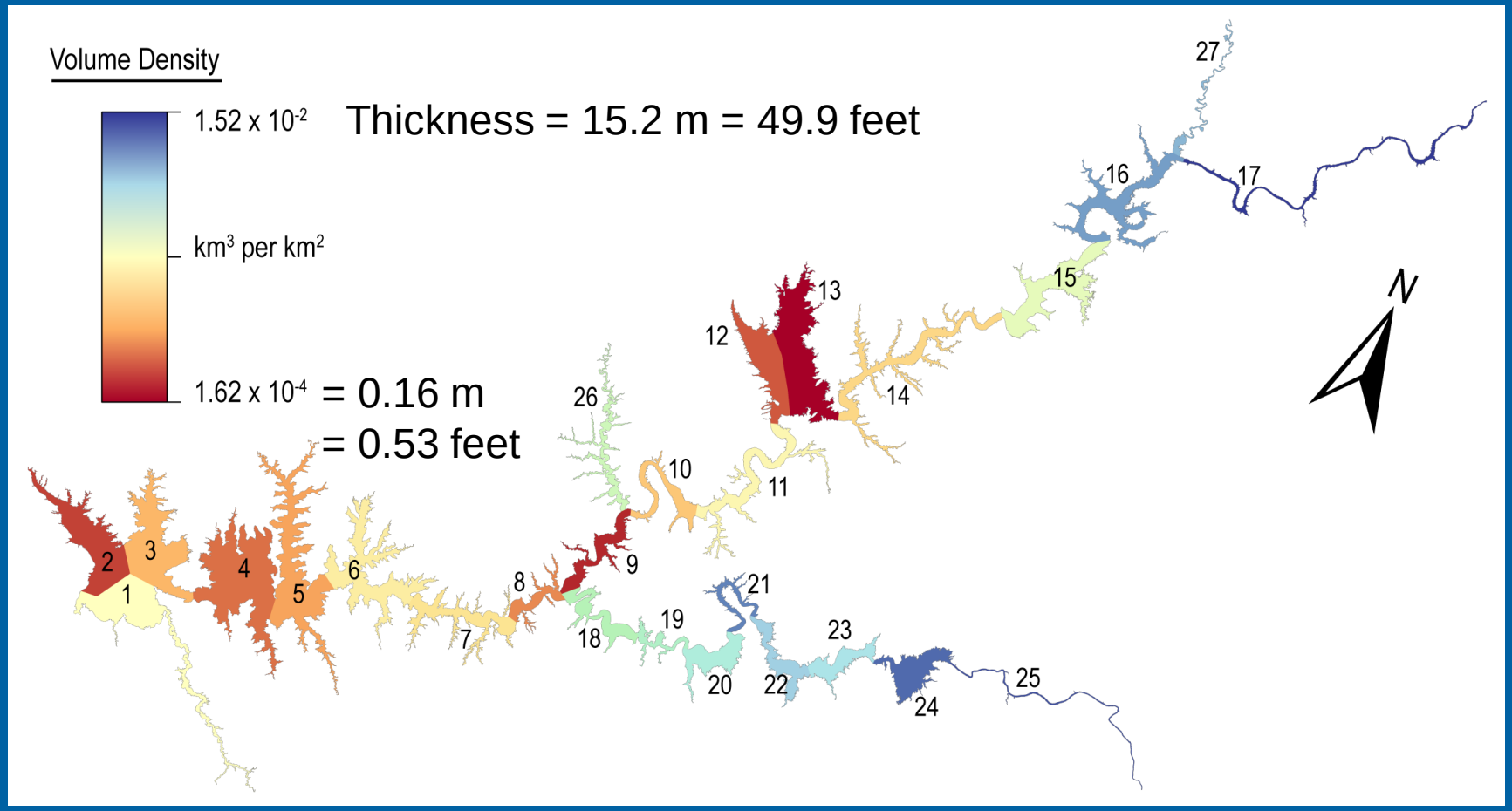
The San Juan River Delta



**Bay vs canyon is a function of cross-sectional area divided by the maximum height from the thalweg to 3,700'*

USGS

Total volume of reservoir sediment is ~2.25 km^3



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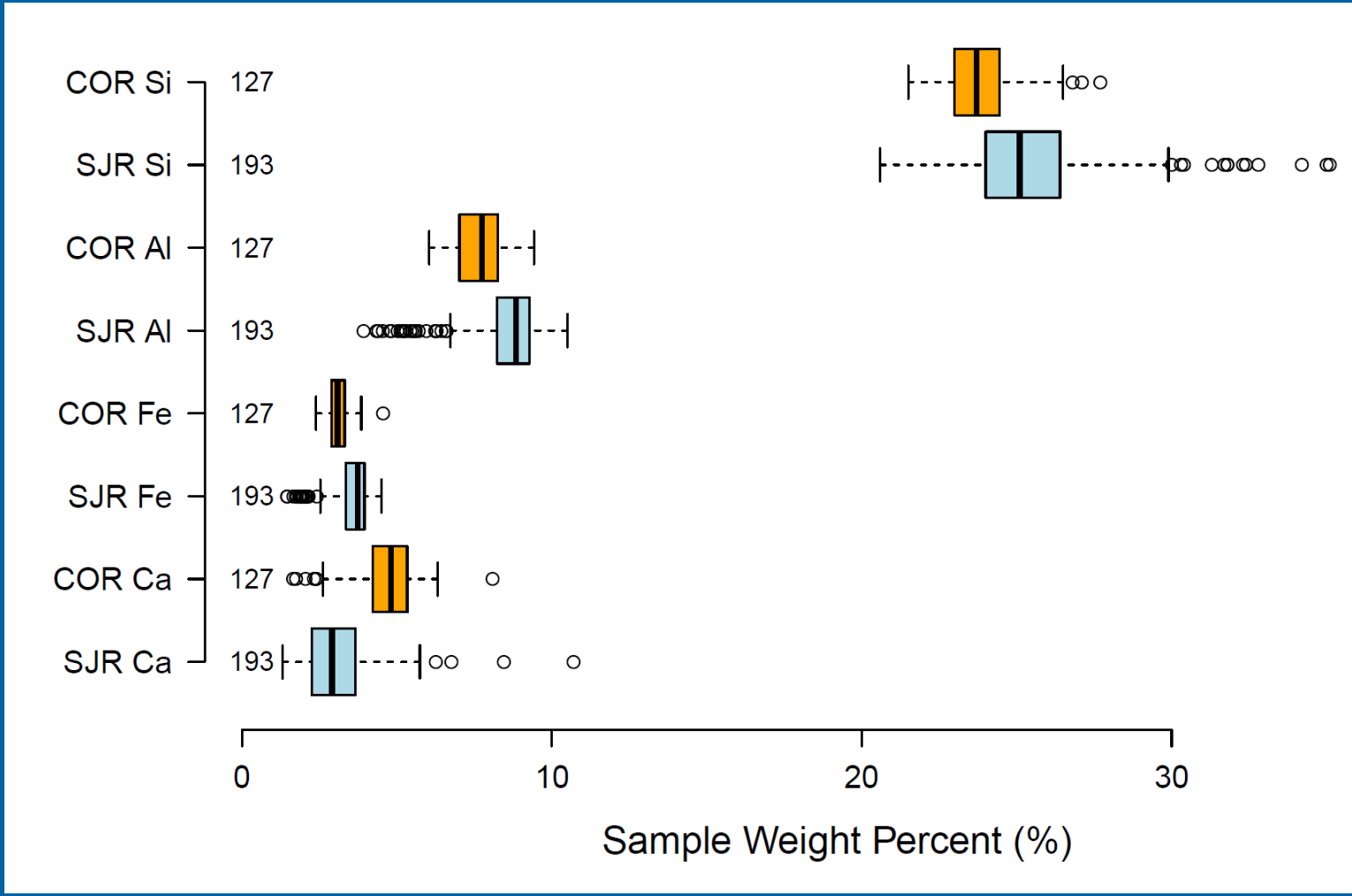
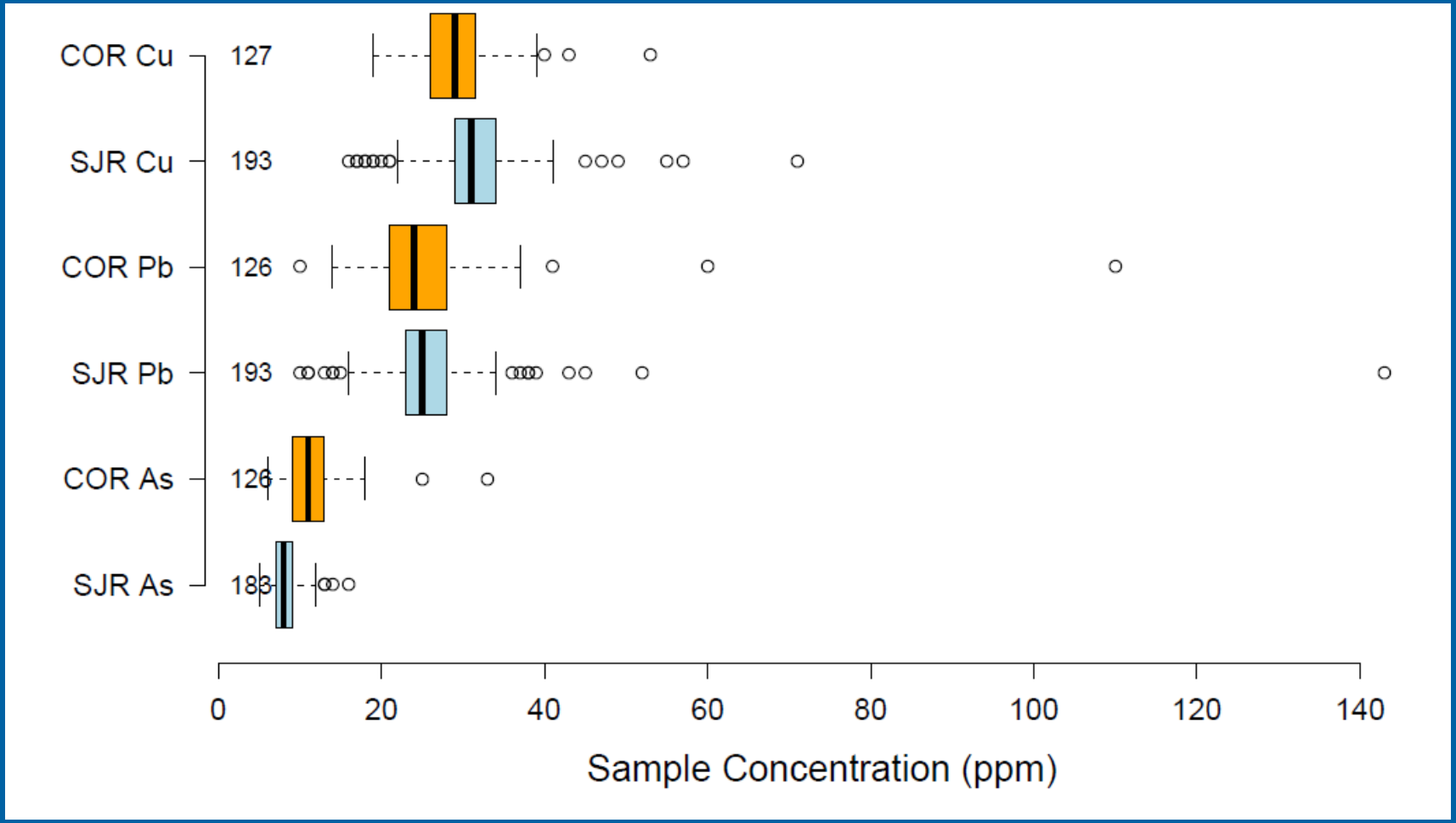
Chemistry of lake muds:

Colorado and San Juan have different mineralogy.



Chemistry of lake muds:

Mind the outliers.



USGS

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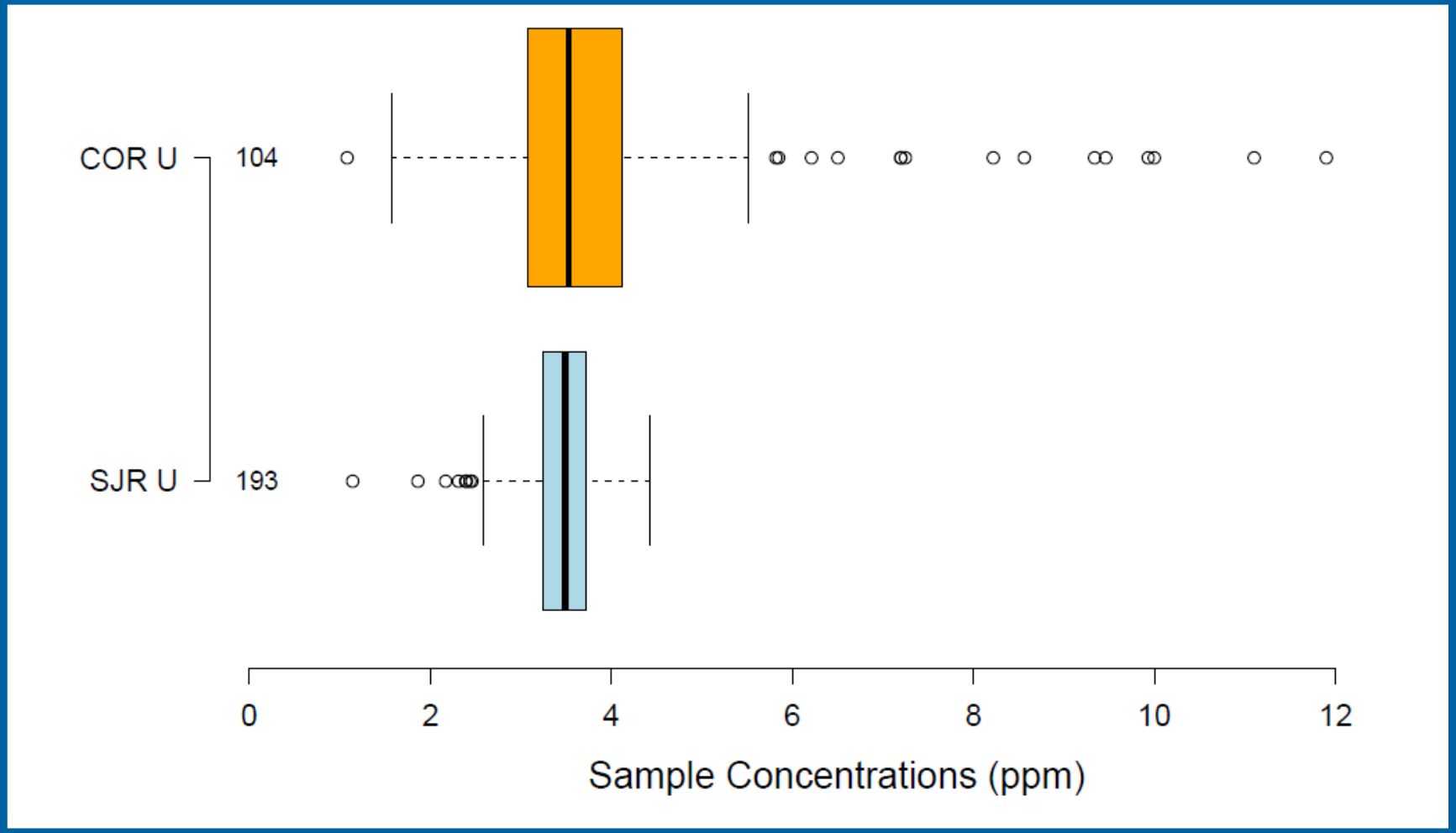

USGS

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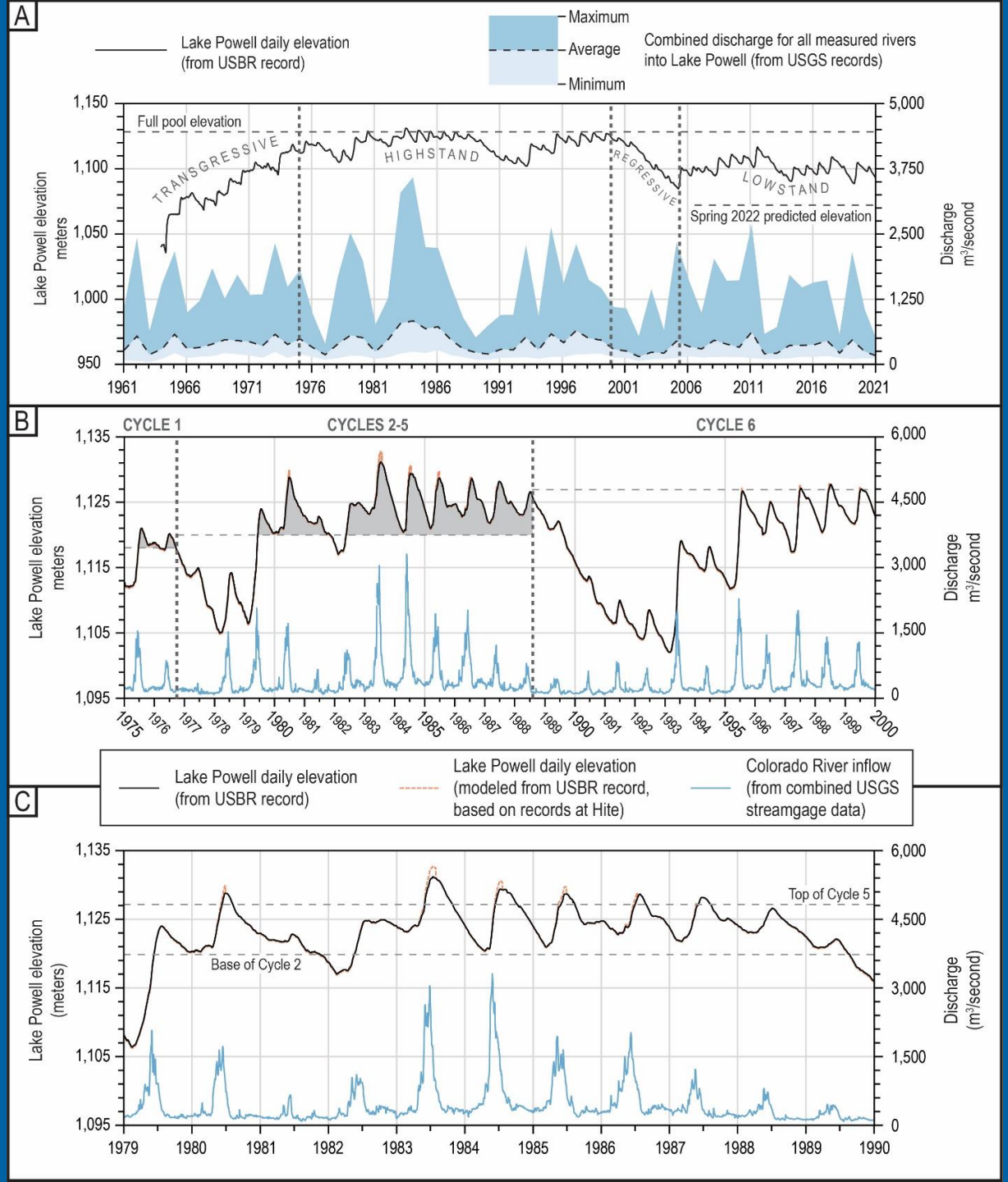
Lake Level, discharge, and sediment character are related by temporal records.

USGS



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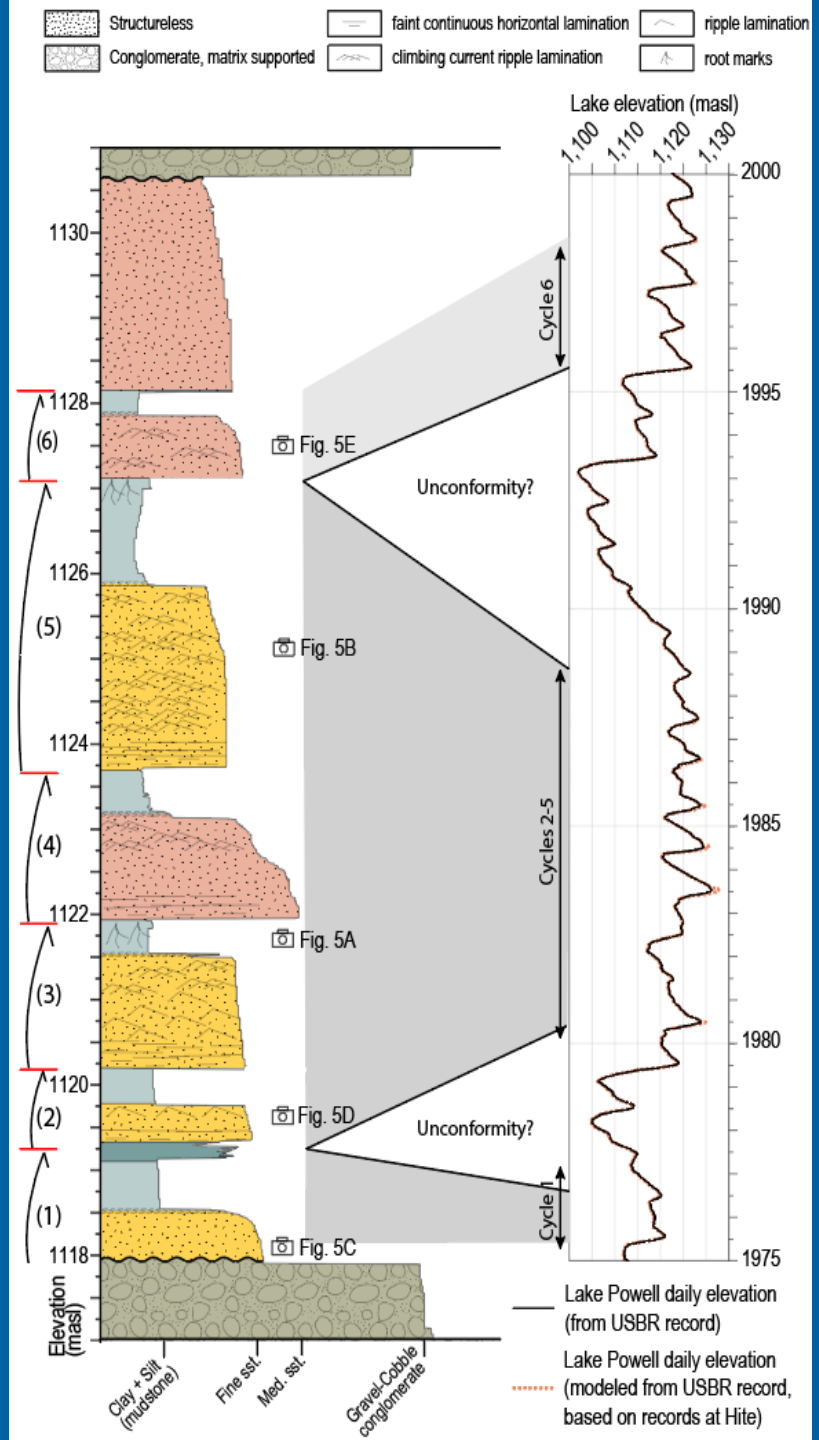
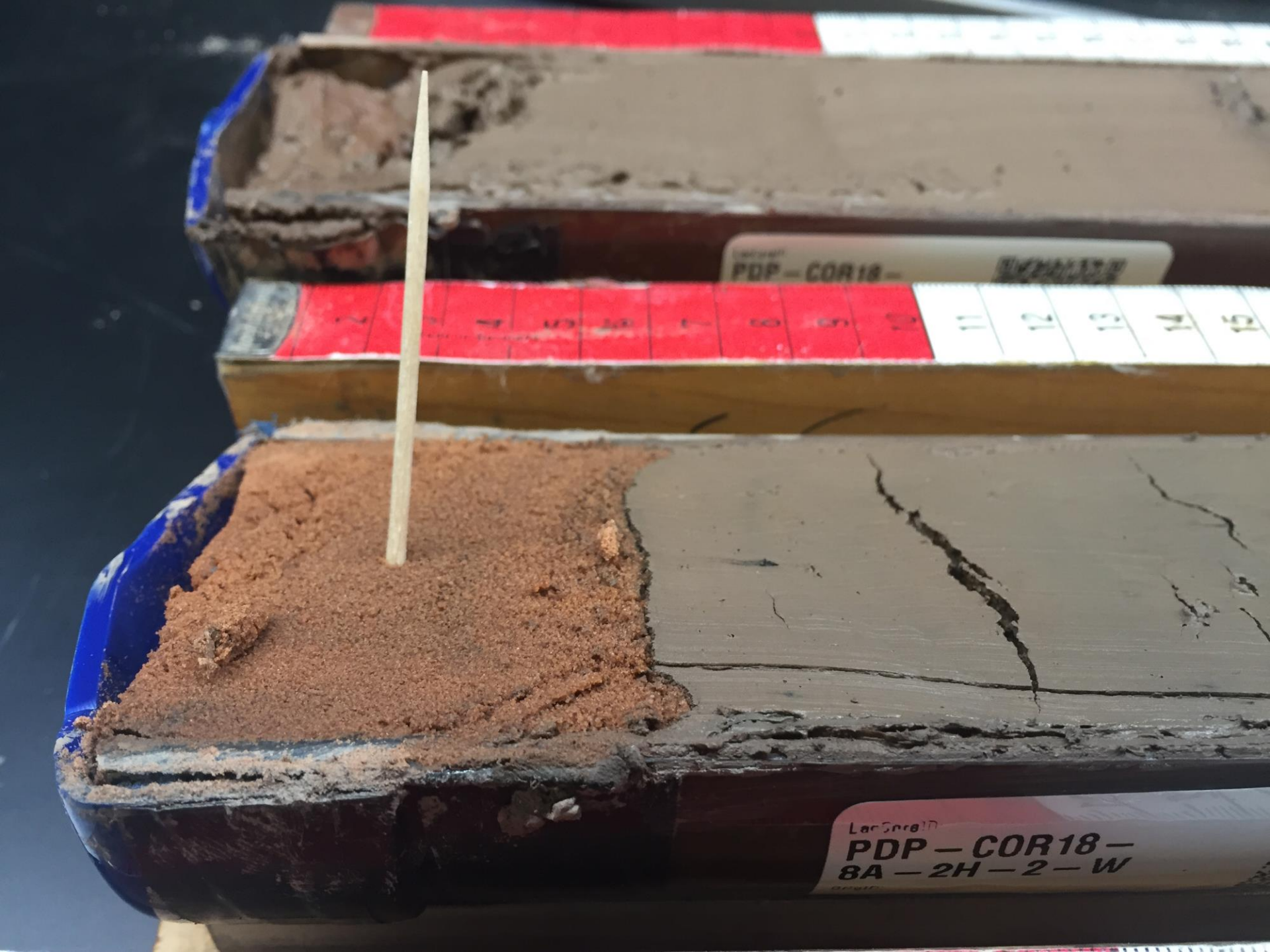
Johnson et al., in review
Preliminary interpretation of reservoir sediment in Waterhole Canyon.

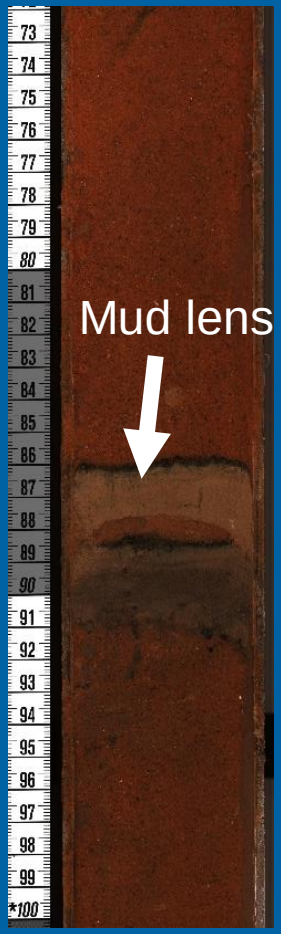
USGS




PDP – COR18 –
8A – 2H – 2 – W

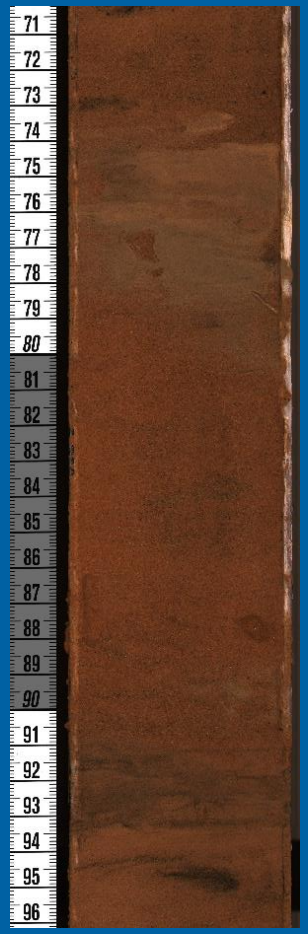
Photos picking bottom of reservoir sediment

PDP-COR18-1A-1H-1



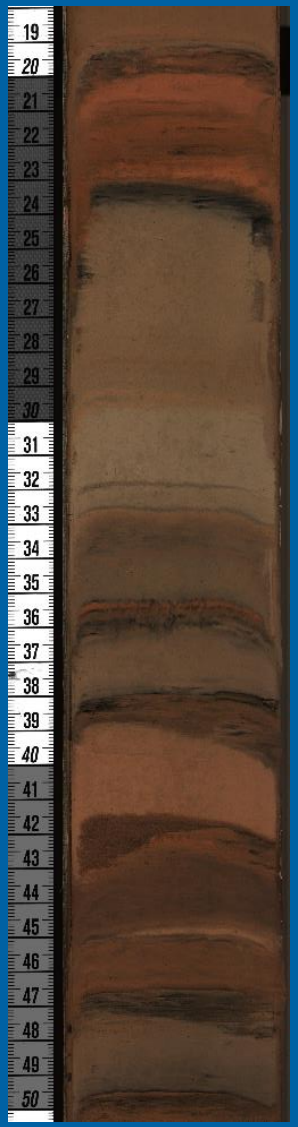
Sand - eolian

PDP-COR18-5A-1H-1



Sand - deltaic

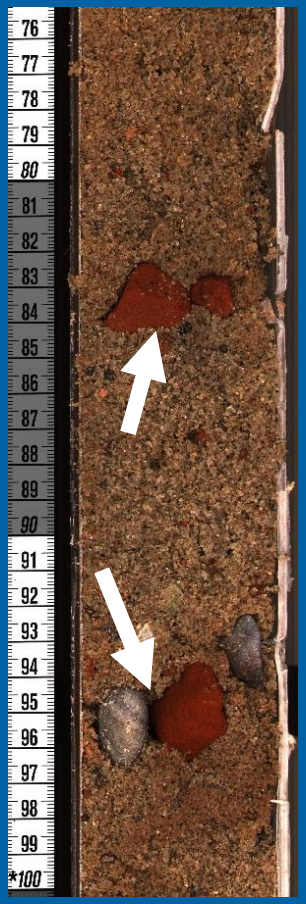
PDP-SJR18-6A-5H-2



Mud – lake

PDP-COR18-7B-7H-1

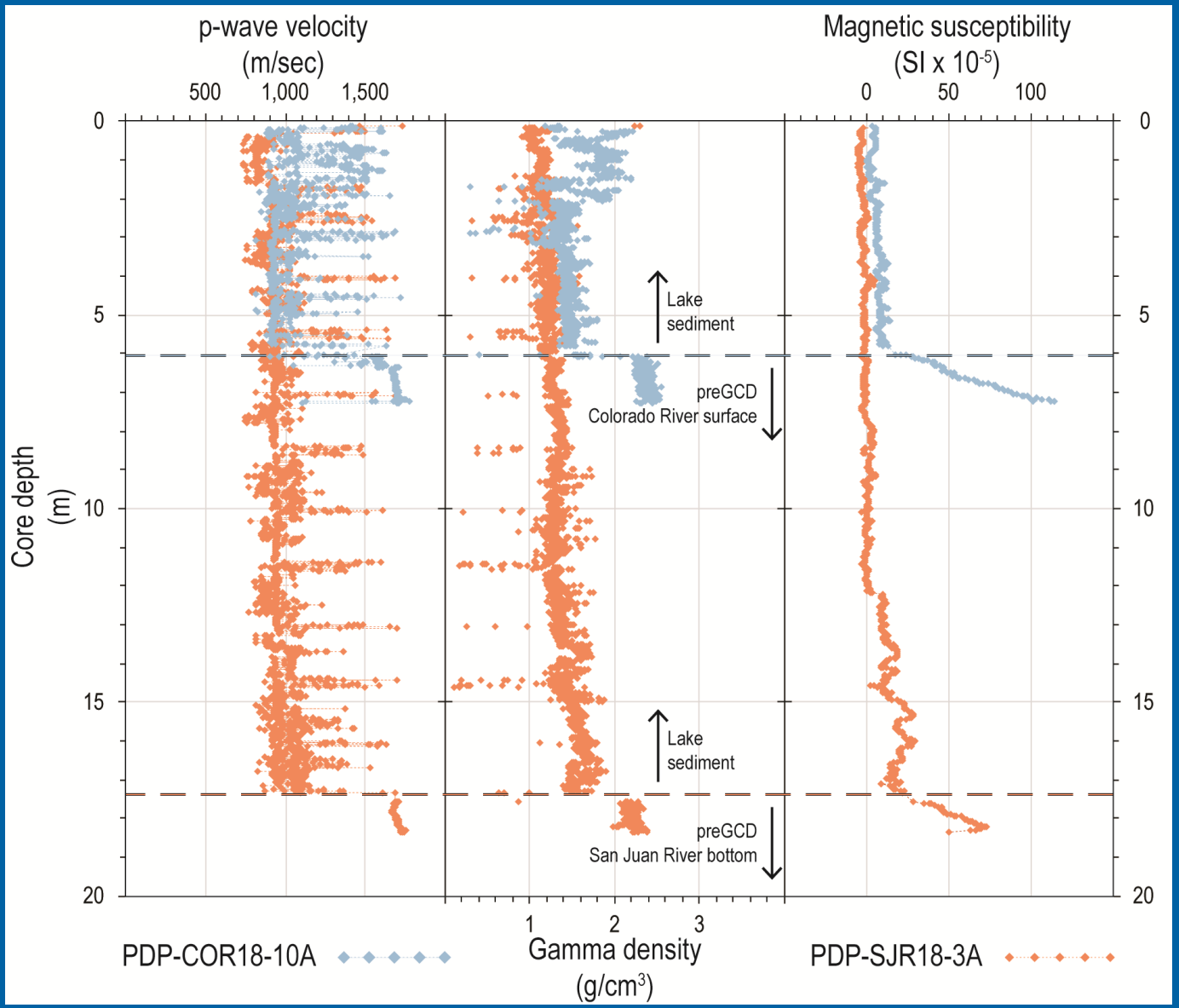
PDP-SJR18-2C-8H-2



Cobbles - fluvial

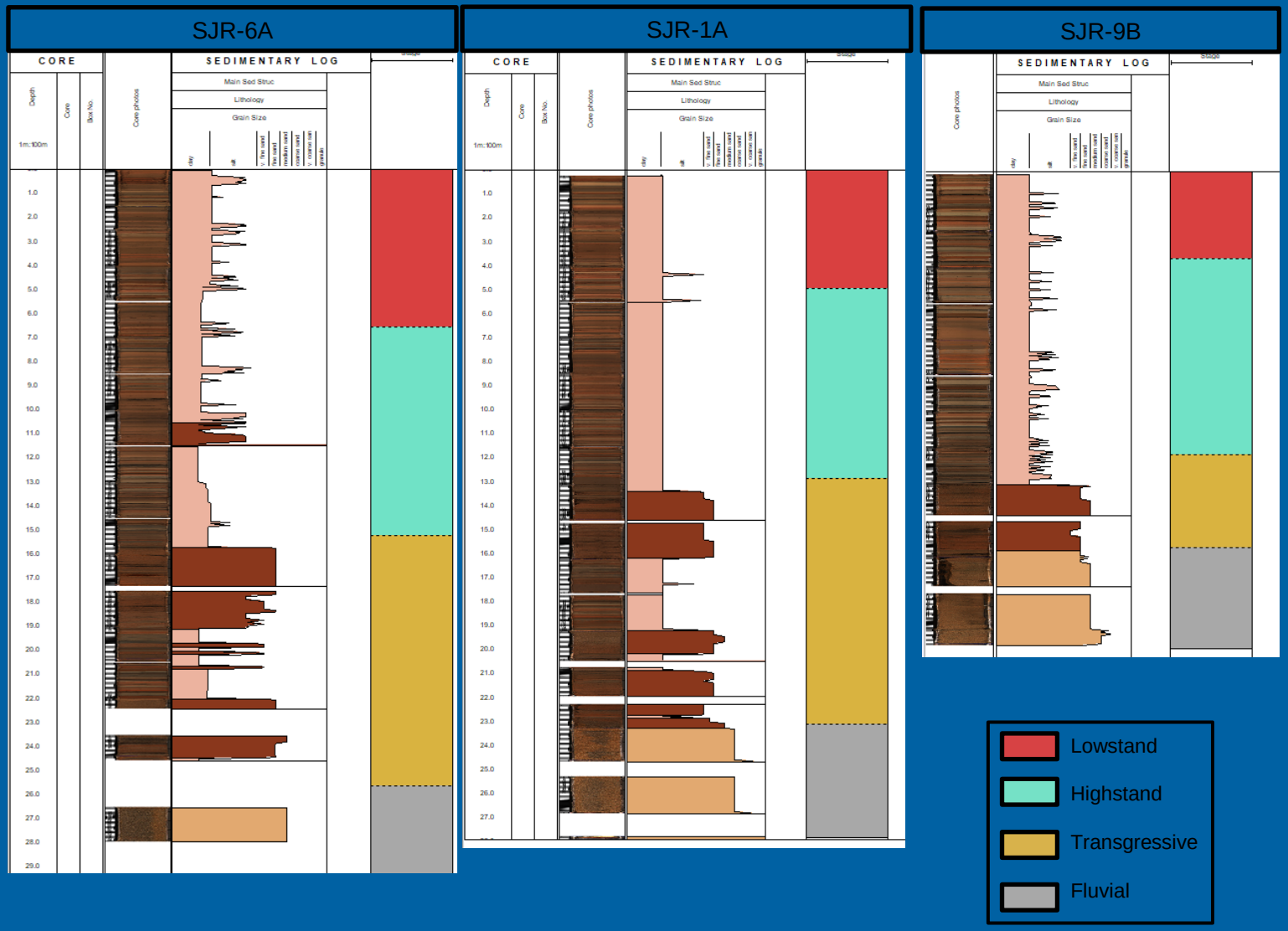
USGS

Picking bottom of reservoir sediment: geophysical logs



USGS

Temporal division of key San Juan cores



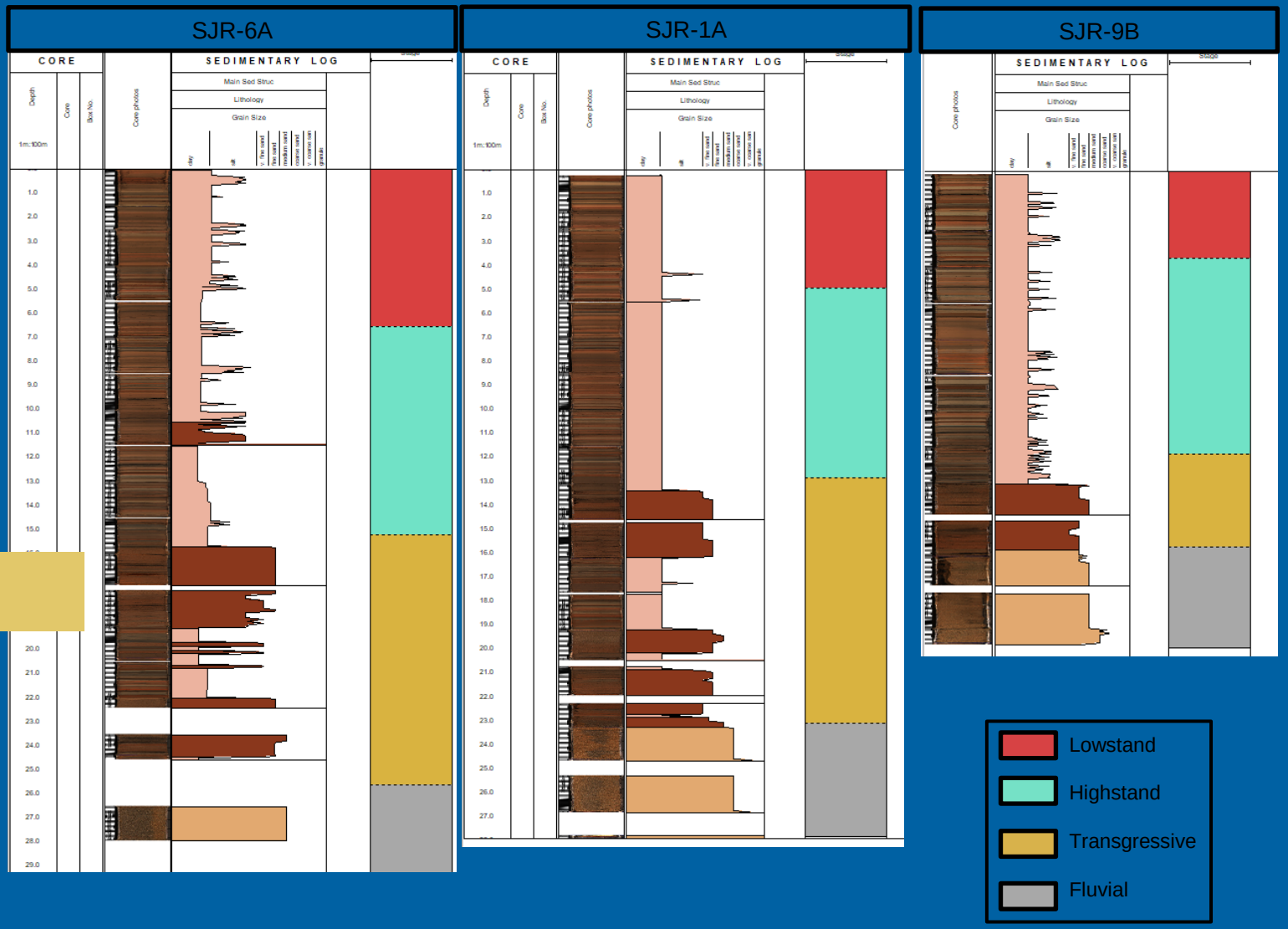
Temporal division of key San Juan cores

Lowstand

Highstand

Transgress

Flooding Surface

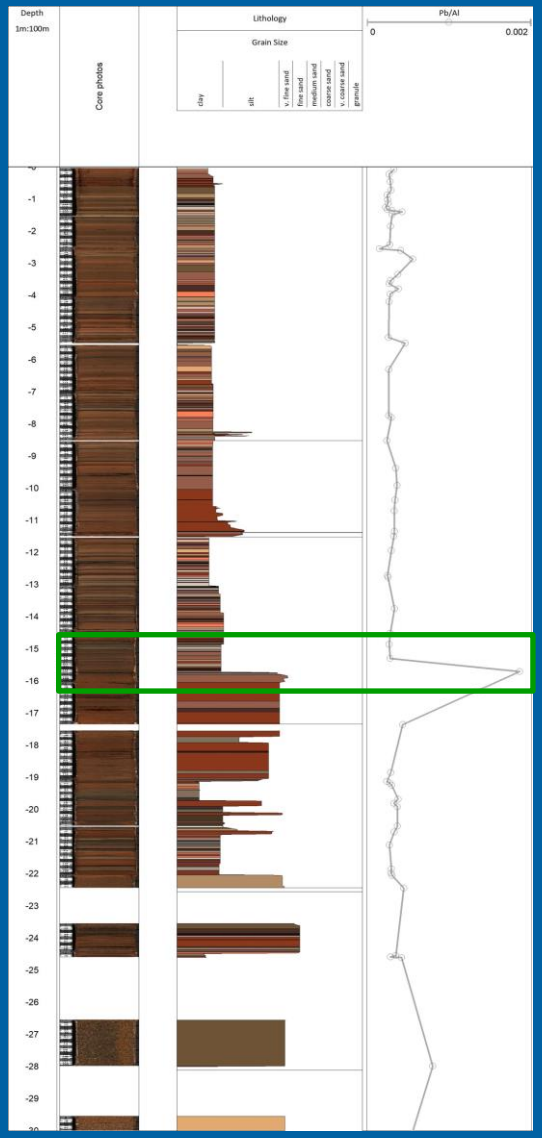


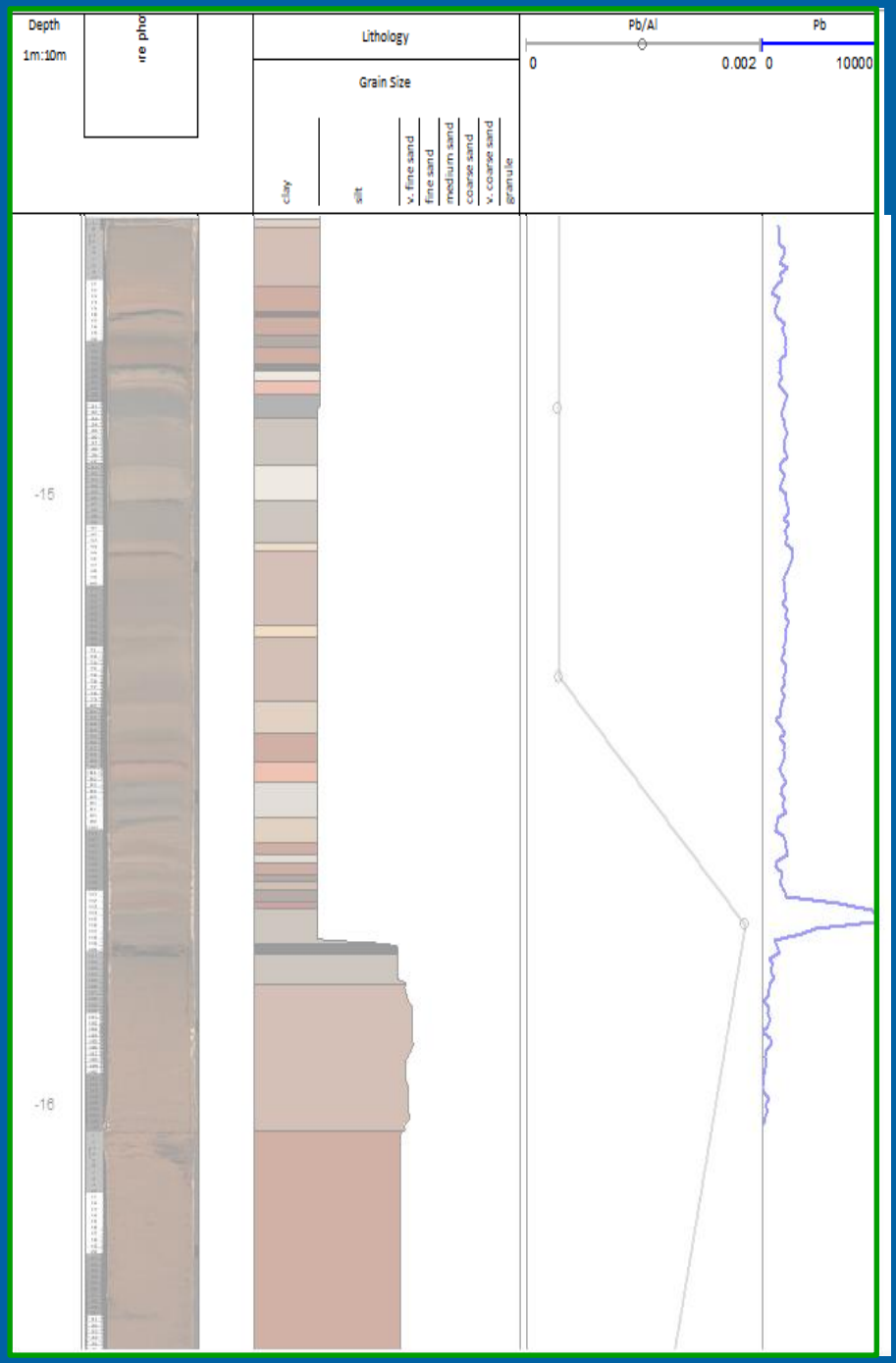
USGS

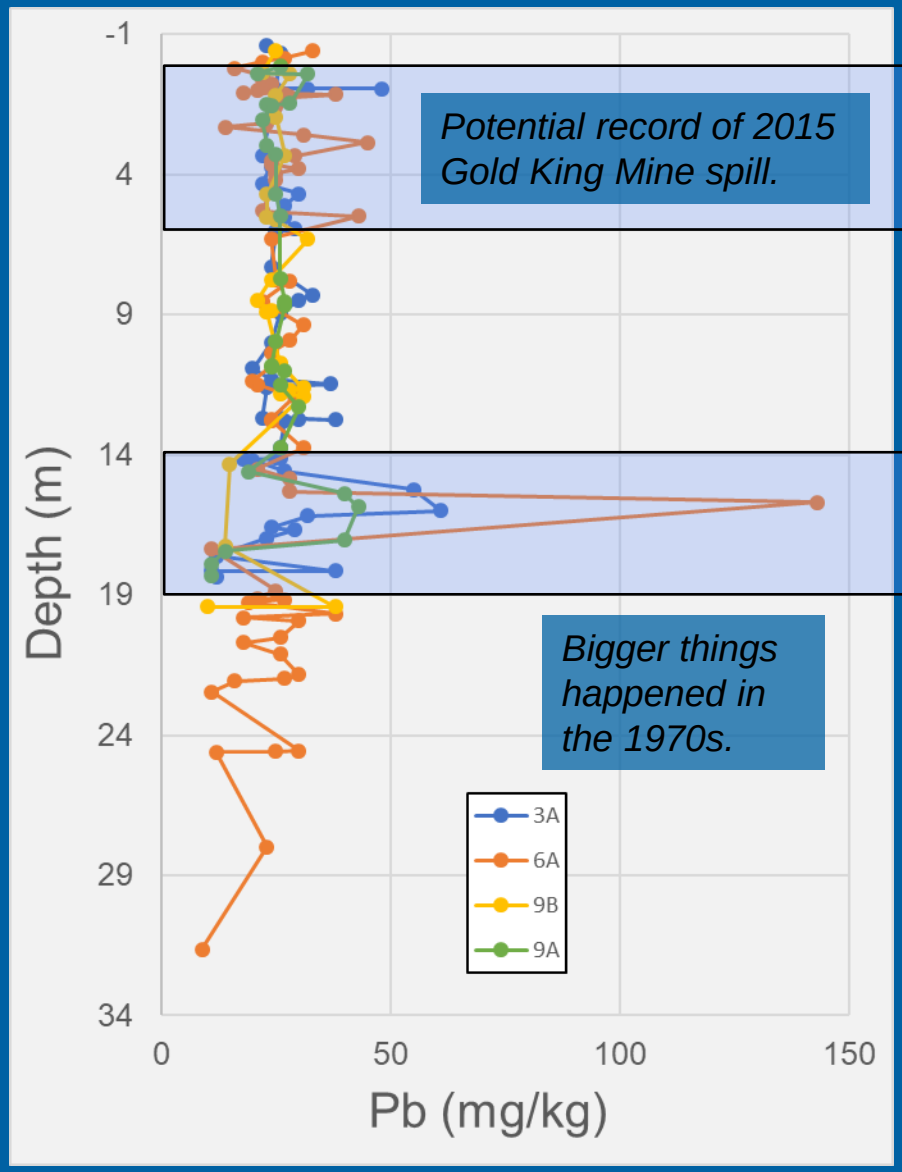
Mind the outliers:

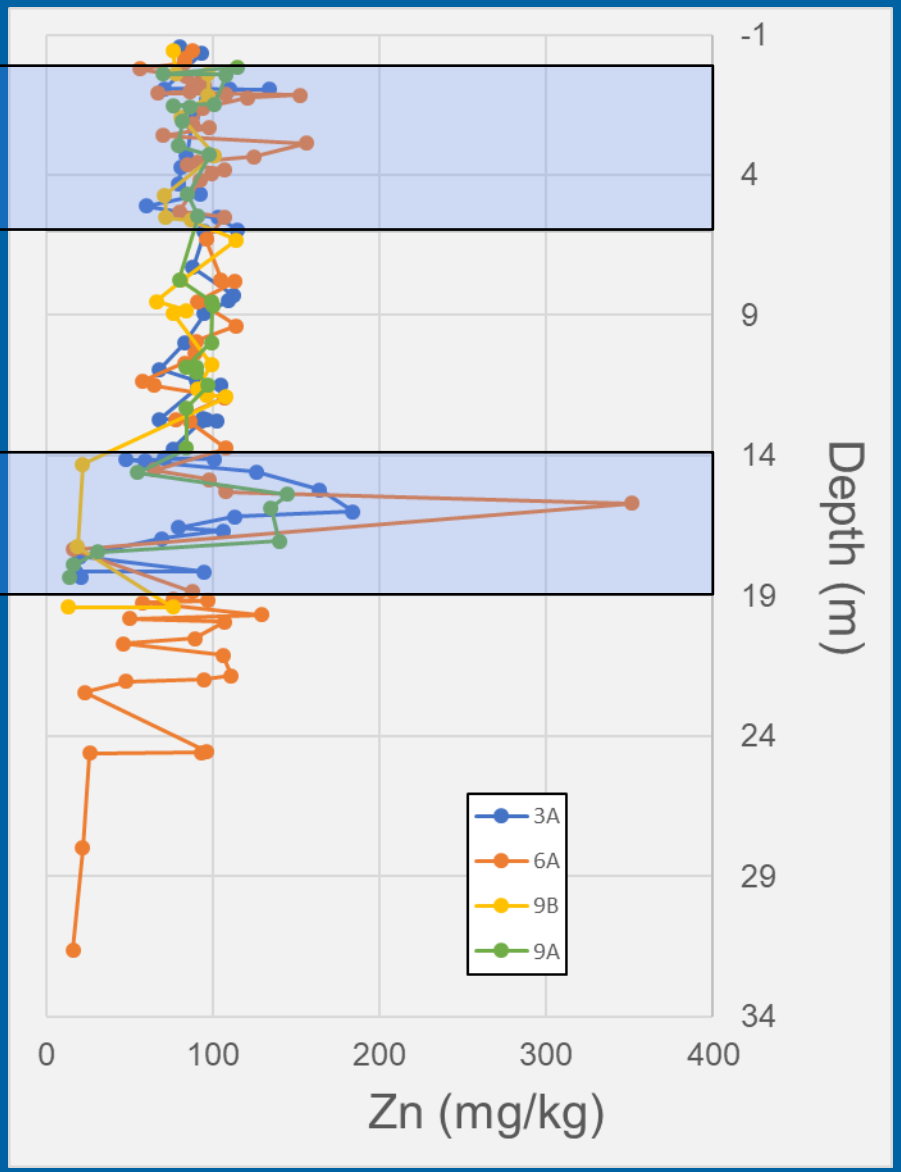
Lead (Pb)

Core:
SJR-6A









USGS

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**These questions were developed in coordination with Utah DEQ. Bureau of Reclamation is also a cooperator but their interests lie more in physical sedimentation rates and total sediment volumes.*

San Juan Delta, upper bays. ~10% of total river length.

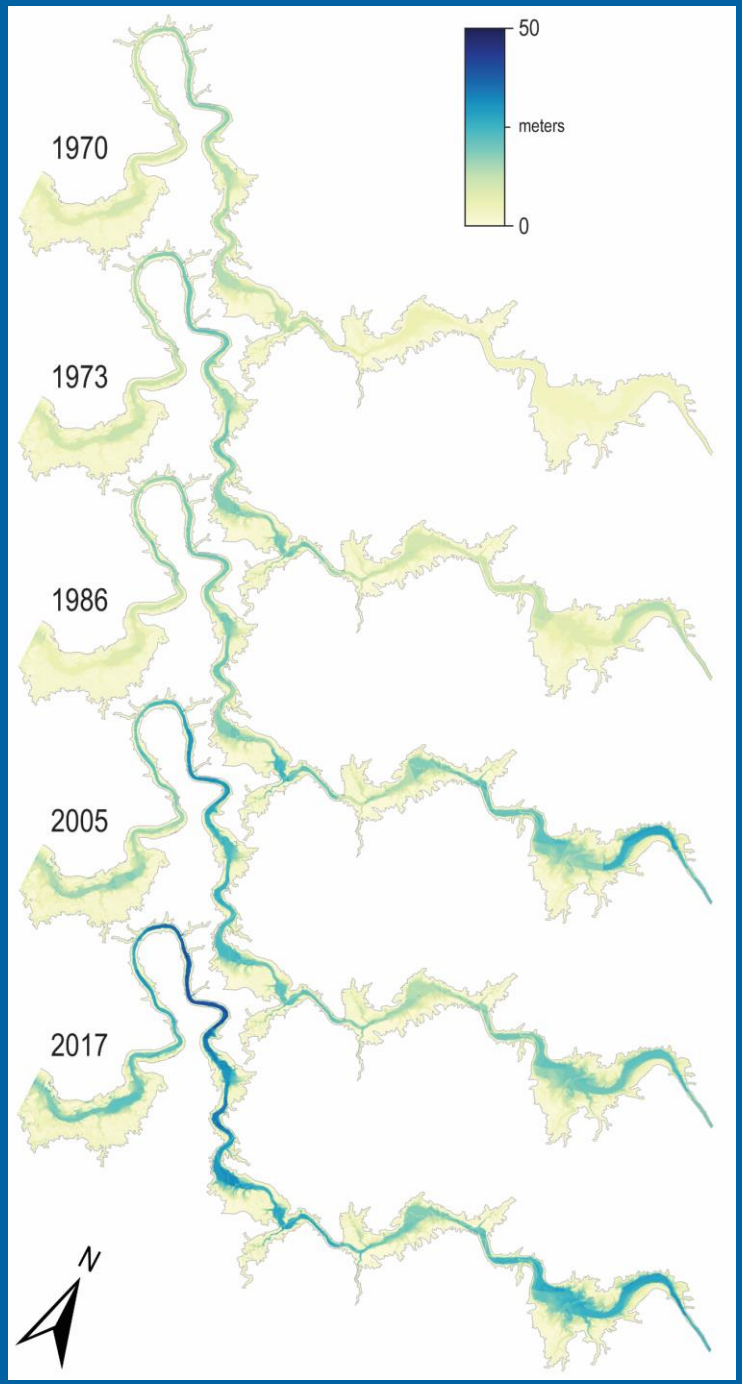
Significant sedimentation between 1973-1986.

Likely reworking of this sediment.

Potential for metal-rich sediment to impact the San Juan River locally.

Relative to the Gold King Mine, deposits from the 1970s appear to be of greater concern.

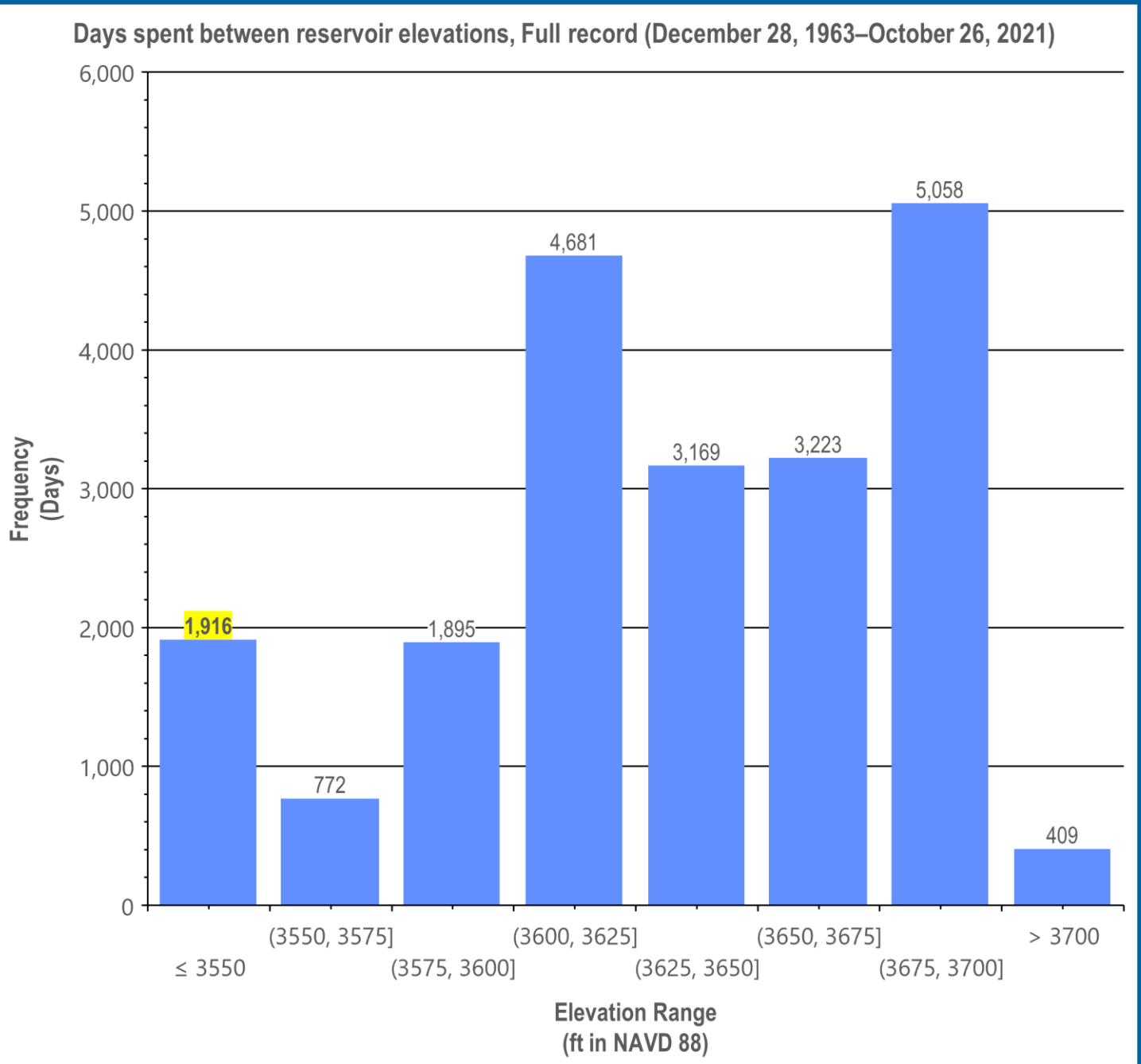
USGS



Lake Level Histogram

Two modes:
1) *Full pool*
2) *~3,6000*

And filling:
nearly 2,000 days before June 28, 1970



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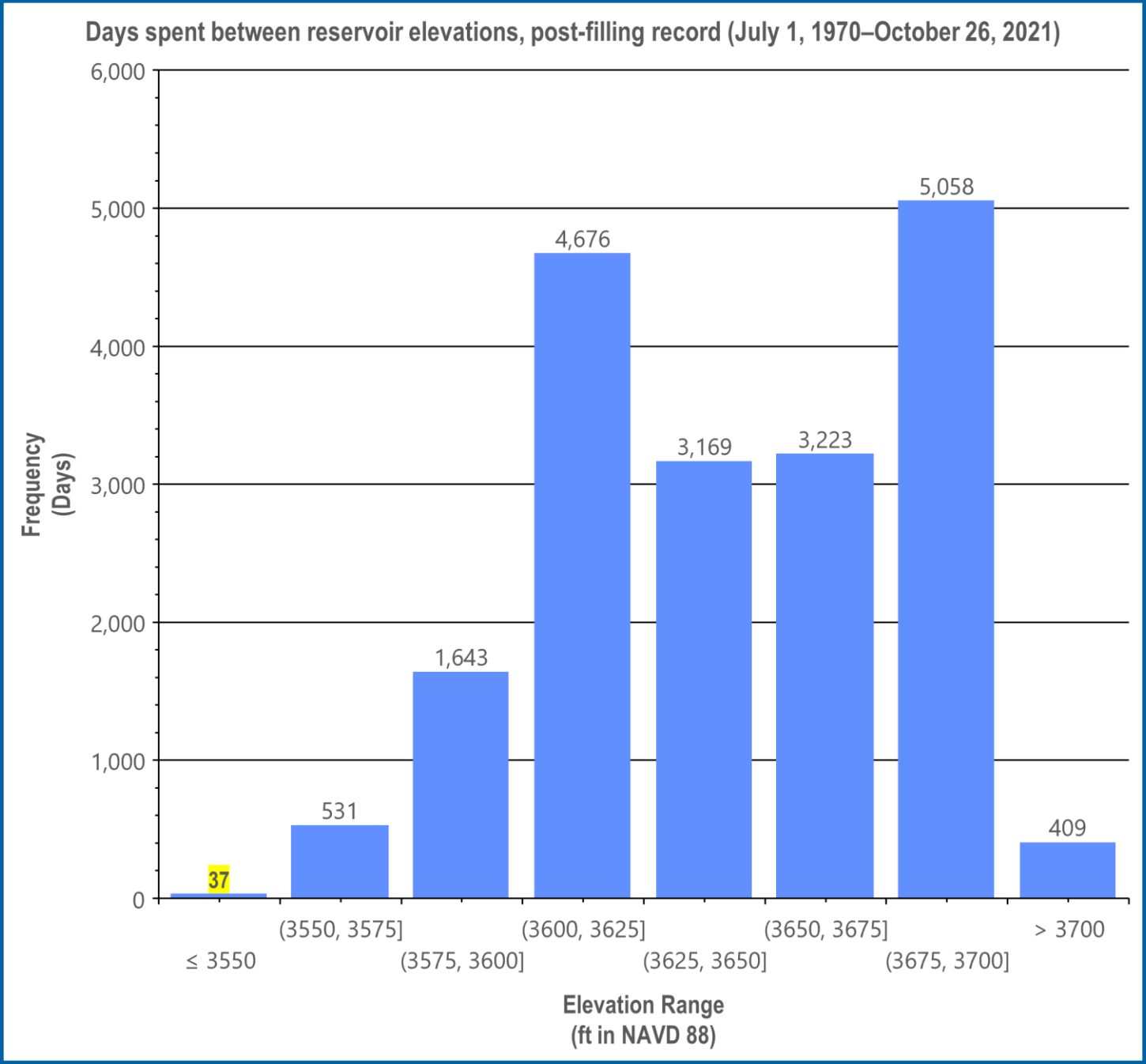

Unprecedented lake levels.

USGS

Where do we stand in 2021?

Major uncertainties are hydroclimatic:
-lake level
-monsoon

Longitudinal profile of San Juan delta and proposed coring sites

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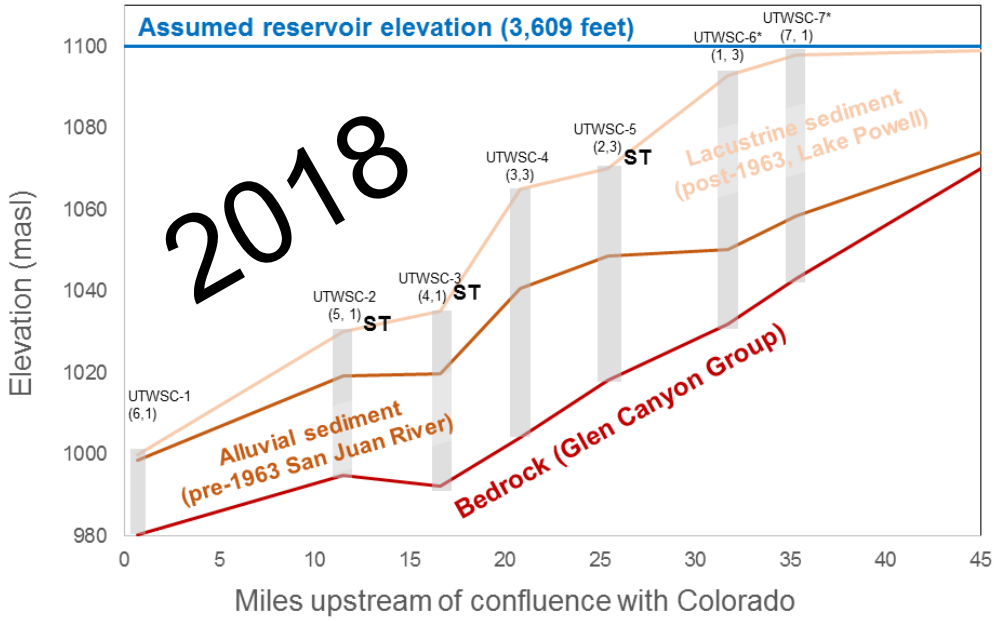
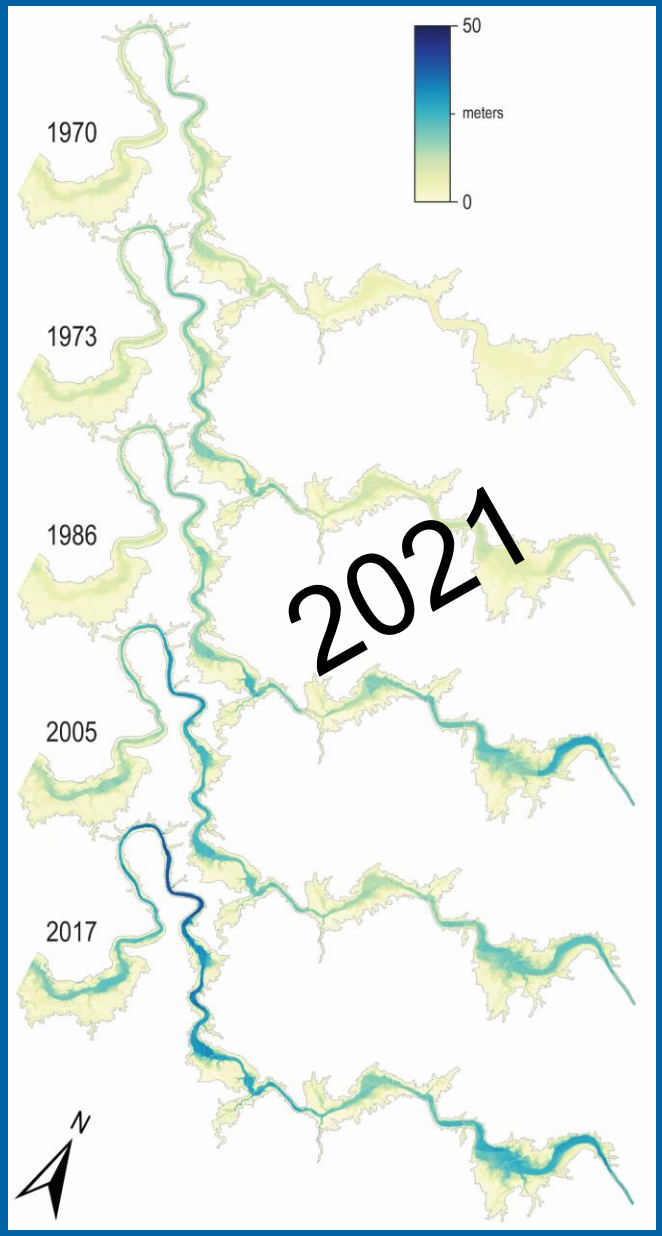
Thickness of alluvial sediment from the USGS Bulletin 471 (Miser, 1921)





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