Streamflow, Water Temperature and Sediment The Physical Template

Knowledge Assessment Workshop

Paul Grams

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

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Monitoring and understanding the trends of streamflow, water temperature and turbidity is embedded in priority goals and strategic science questions

AMWG Priority 3: What is the best flow regime?

SSQ 2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidities or dam-controlled high-flow releases? (FY2007-2008)

SSQ 5. How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations? (FY2006-2008)

AMWG Priority 5. What will happen when we test or implement the temperature control device (TCD)?

SSQ 3. To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish? (FY2003-2008)

SSQ 4. What is the relative importance of increased water temperatures, shoreline stability, and food availability on the survival and growth of YoY and juvenile native fish? (FY2003-2008)

SSQ 6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance? (FY2007-2011)

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Outline

- Geomorphic context
- Background information on:
  - Streamflow
  - Water temperature
  - Turbidity/suspended sediment concentration

The existence and/or operations of the dam affect both the magnitude and variability of each of these key physical parameters

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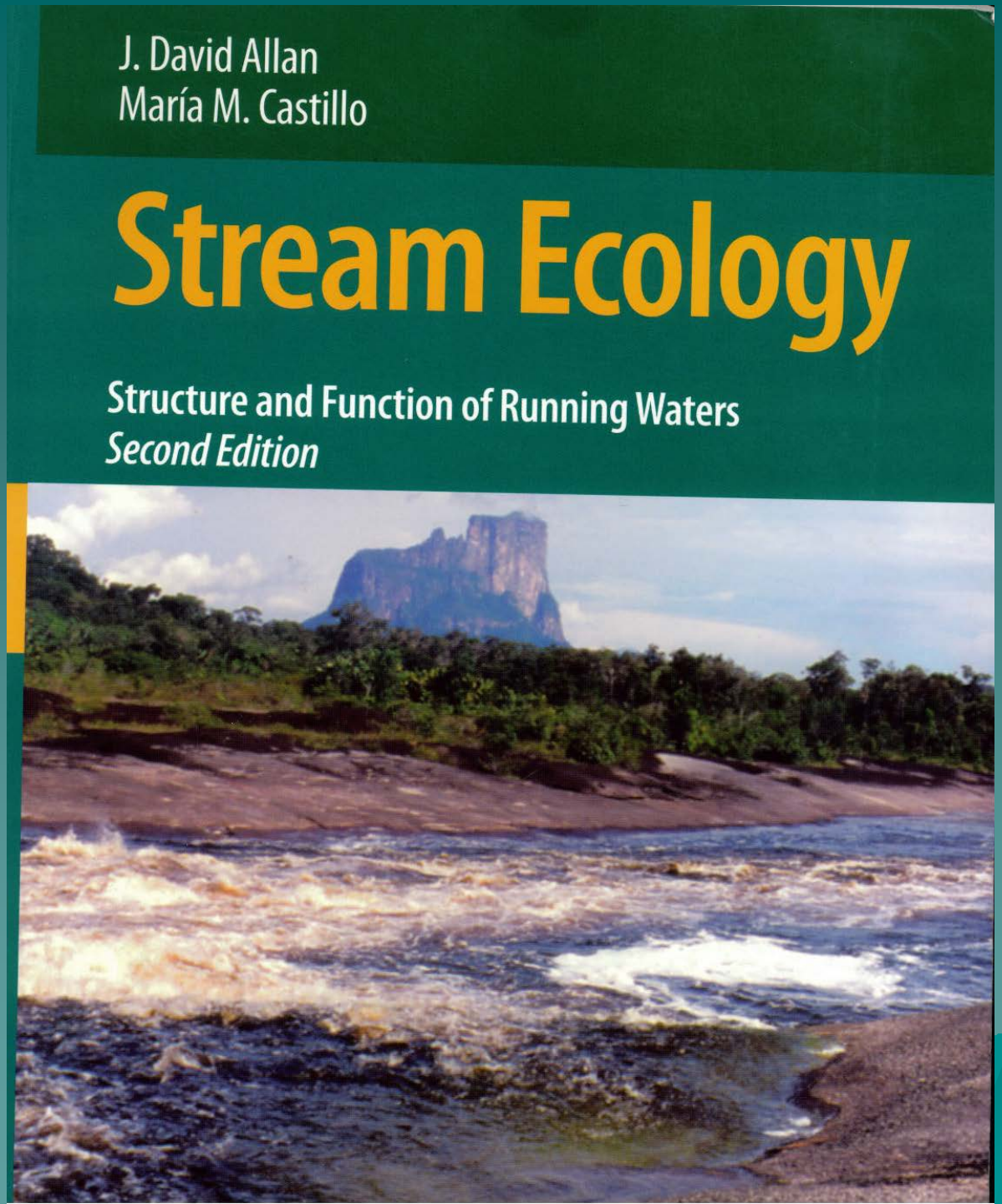
J. David Allan
María M. Castillo
Stream Ecology
Structure and Function of Running Waters
Second Edition

USGS

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Glen Canyon

- Extensive pre-dam data
- Incised meanders
- Pre-dam
  - Sand bed
  - Gravel channel controls
  - Sandbars all over
- Post-dam
  - Gravel bed
  - Bed
    - Scoured at channel controls
    - Evacuation from pools **(both quantified)**
  - Channel narrowing, vegetation encroachment and sandbar erosion

Marble Canyon

- Very little pre-dam data
- Debris-fan/eddy system
- Pre-dam
  - Sand to boulder bed
  - Debris fan controls
  - Sandbars in eddies
- Post-dam
  - Sand to boulder bed
  - Bed
    - Stable at channel controls
    - Evacuation in pools and eddies **(not quantified)**
  - Channel narrowing, vegetation encroachment and sandbar erosion

Glen Canyon 1952 - 1999

1952

1998

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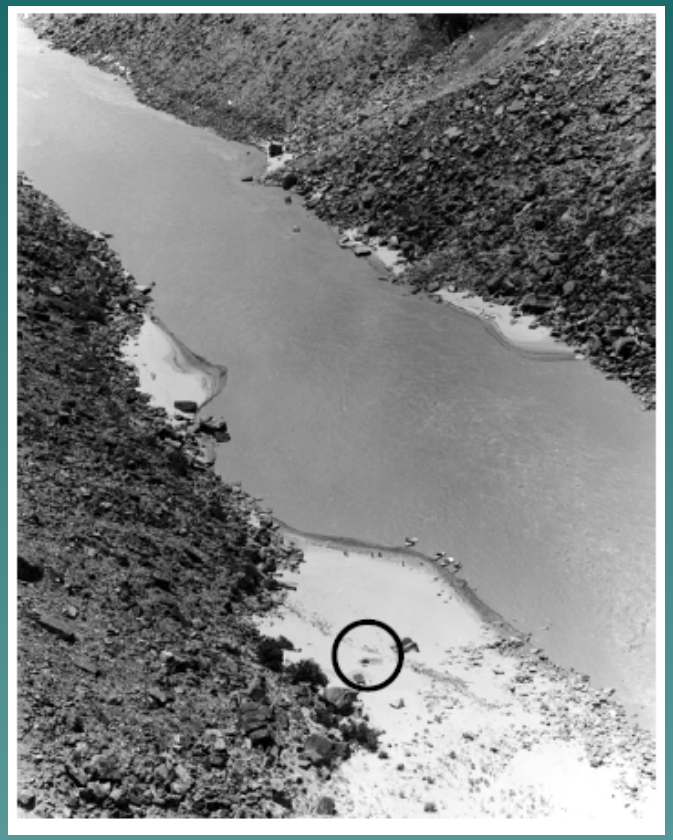
Grams and others (2007)

Badger Rapid in Marble Canyon, 1956 to 1991



July 1956

October 1991

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Schmidt and others (2004)

Streamflow

- Lower annual volume
- Lower peaks, higher baseflows
  - Decreased annual variability
- Increased daily fluctuations

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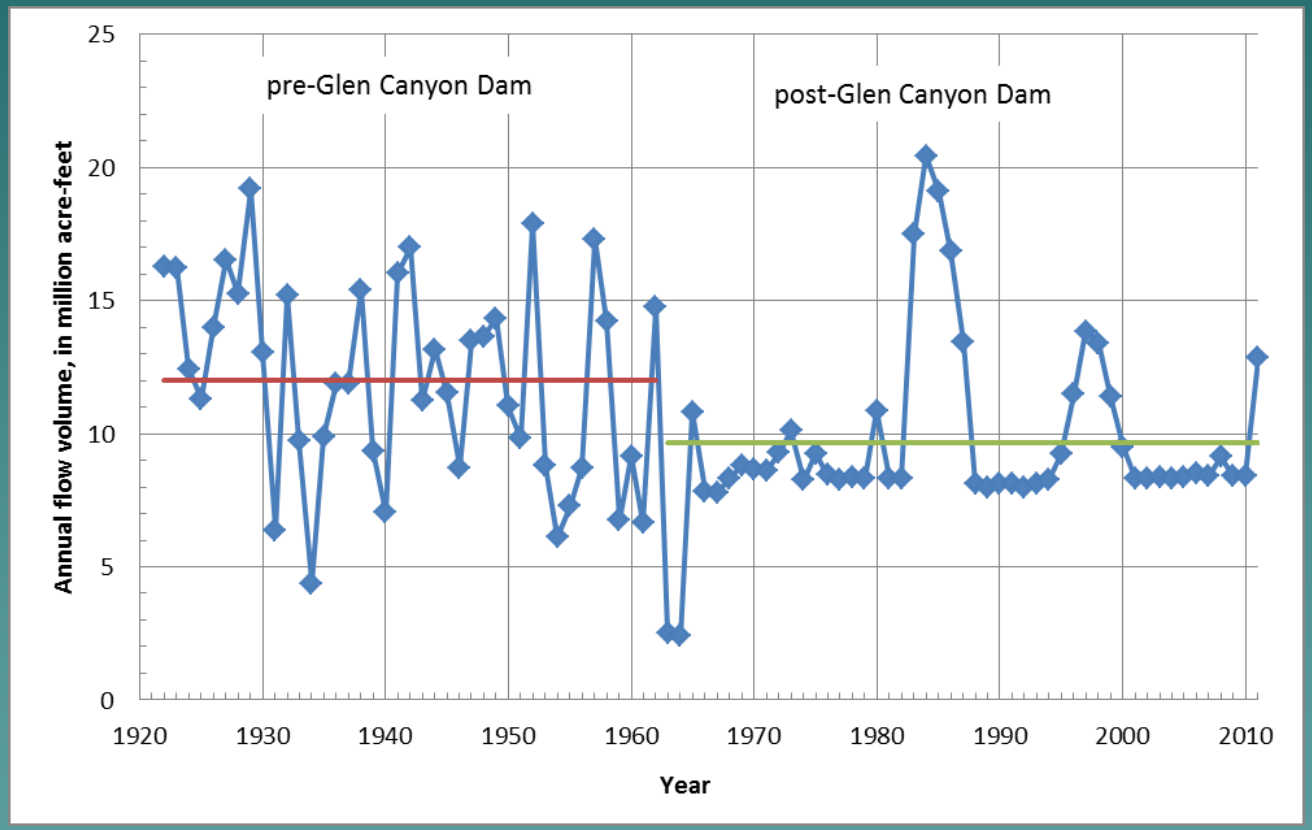
Pre-dam and post-dam annual flow volume at Lees Ferry



- Flow volume matters:
  - Sediment transport
  - Habitat "area/volume"

What do long periods of steady annual volumes do to the aquatic and riparian ecosystems?

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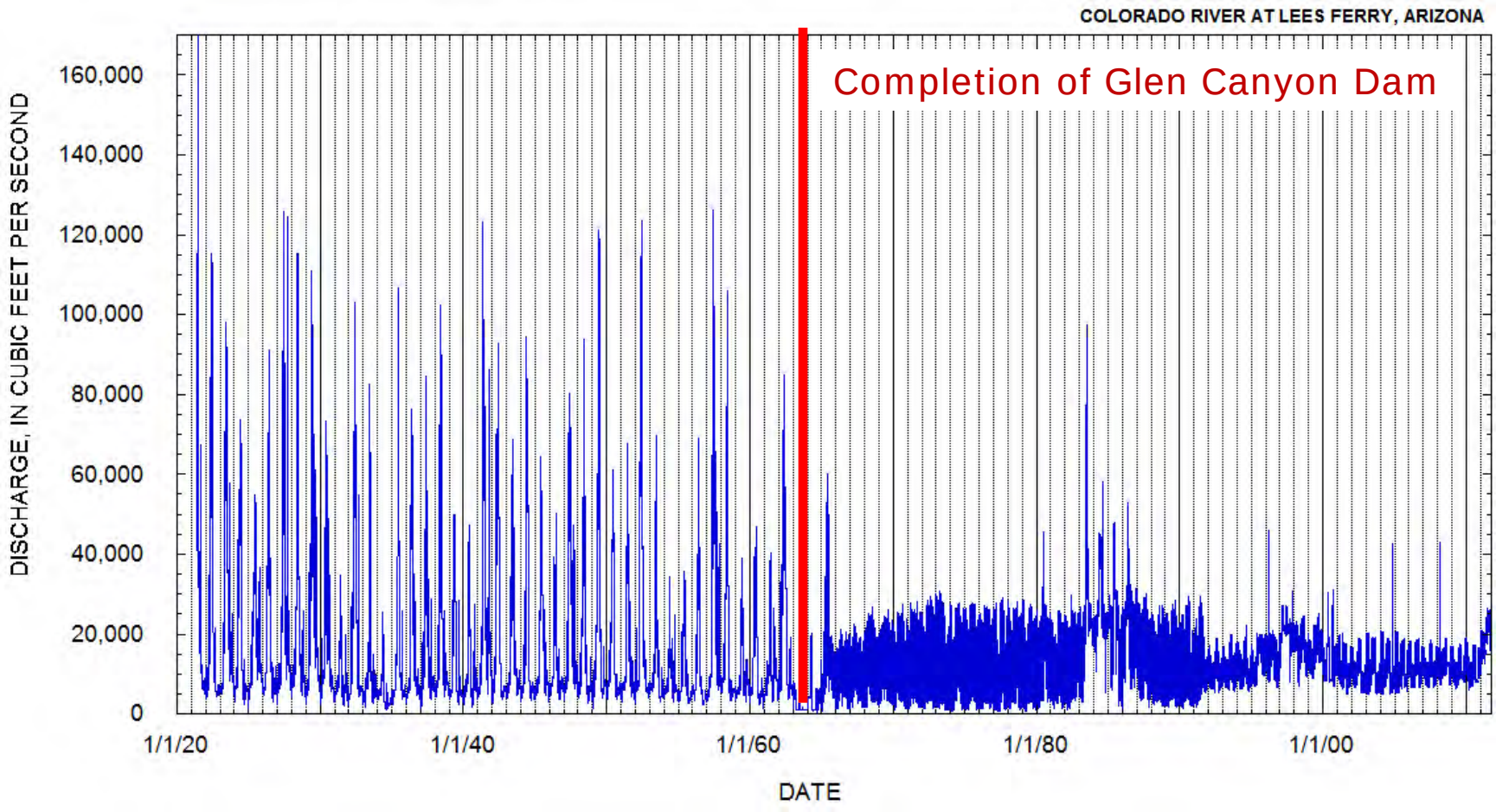
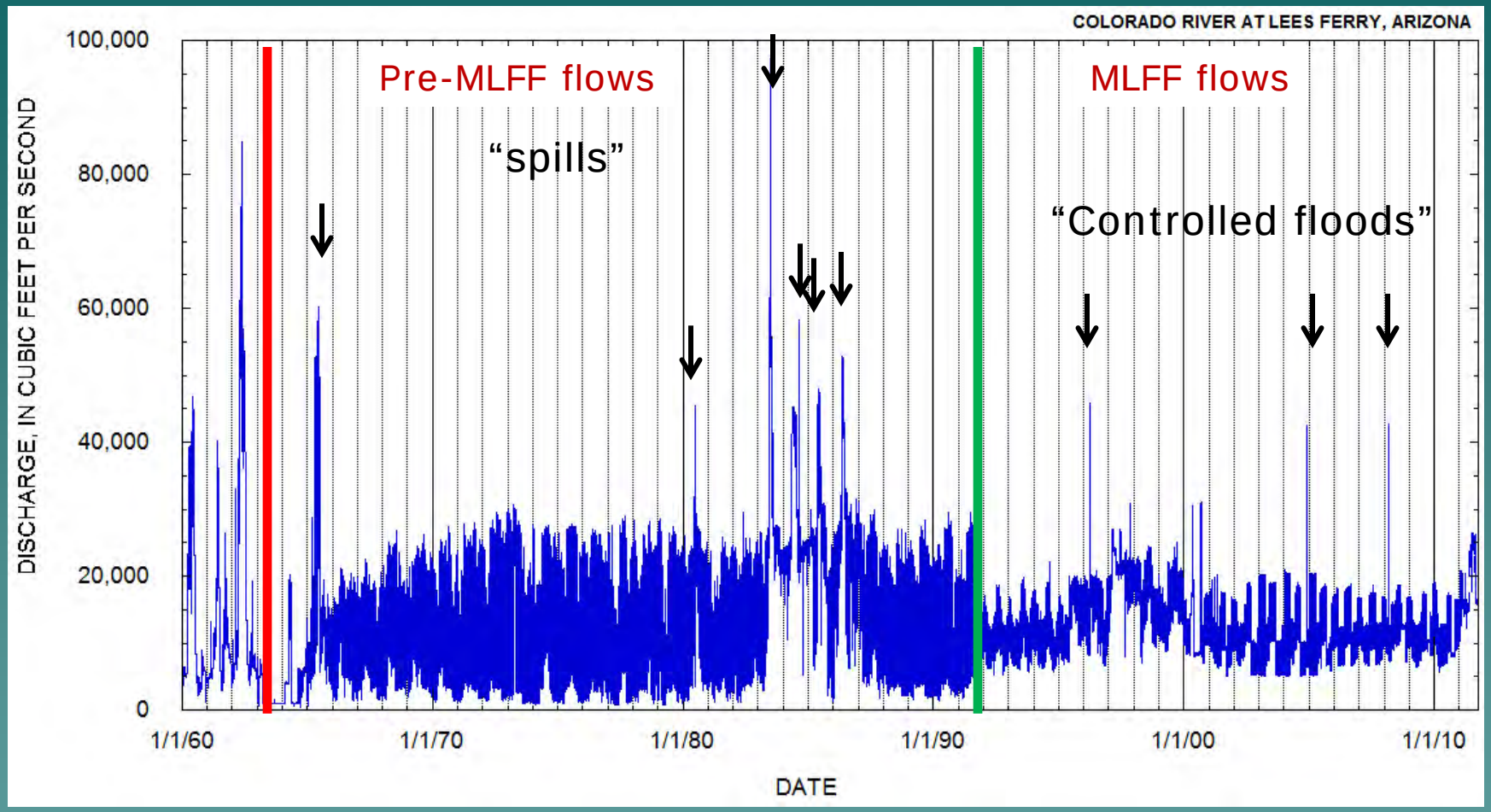
Pre-dam and post-dam instantaneous flow at Lees Ferry



Pre-dam average flood was ~ 82,000 cfs
Post-dam average flood is now about 27,000 cfs

MLFF flows



- MLFF compared to pre-ROD
  - Lower peaks
  - Higher low flows
  - Lower magnitude and less frequent floods

Topographic data from overflights and flow models have been used to estimate the shoreline for discharges of interest

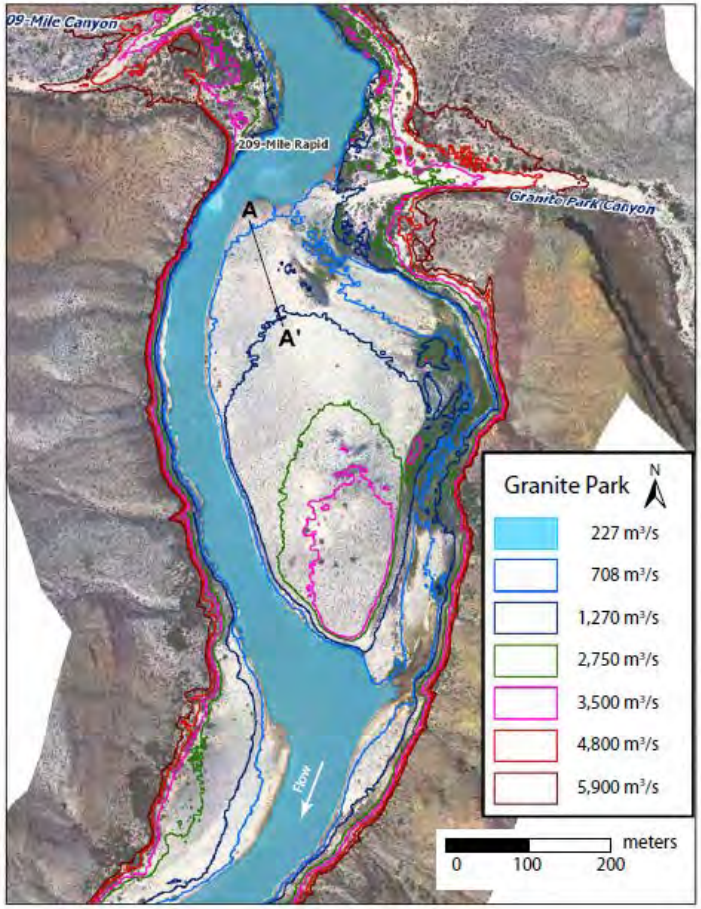


Figure 21. Virtual shorelines at Granite Park (river mile 209) as predicted by the hydraulic model. The line A-A' extends between the 708 and 1,274 m³/s shorelines and rises 1.9 meters across a distance of 100 meters.

Magirl and others (2008)

Water Temperature

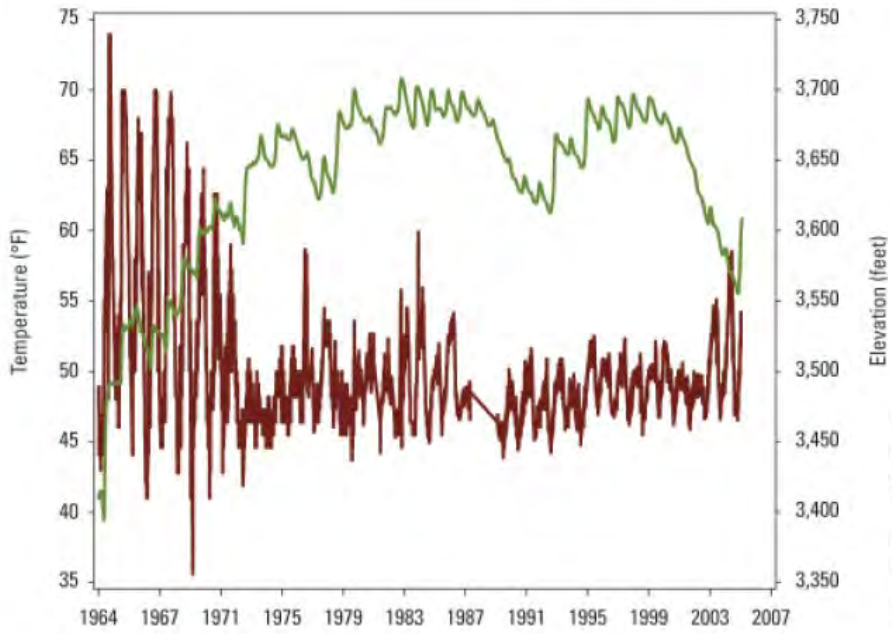
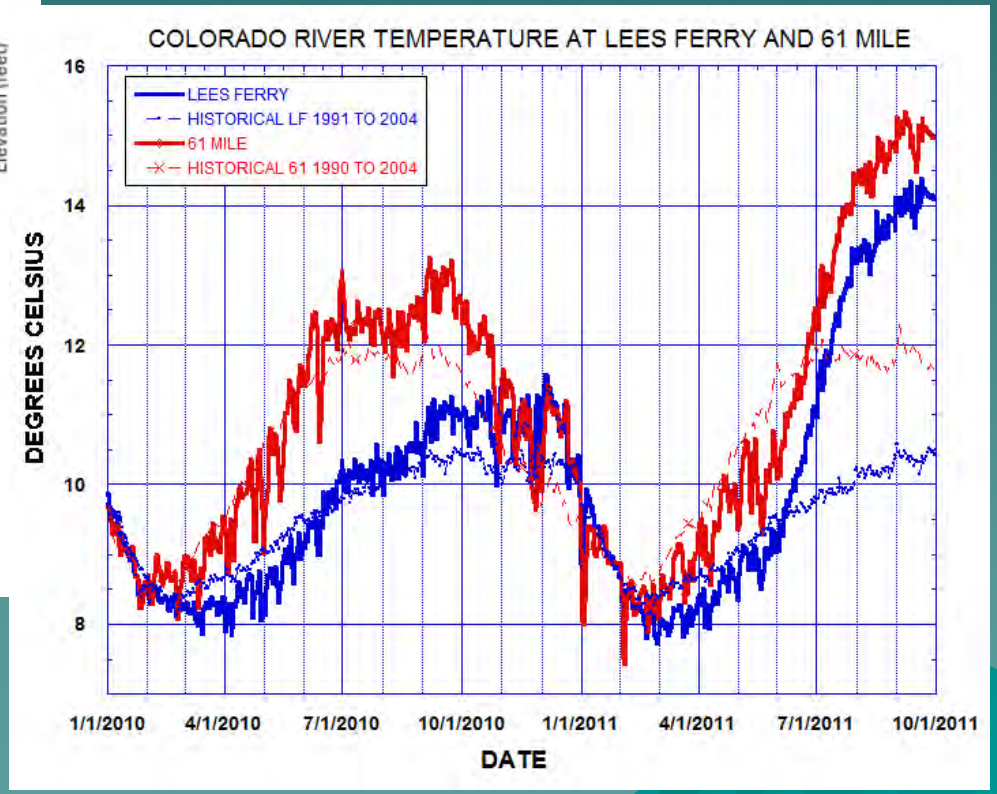


Figure 6. Daily water temperature (red line) at Lees Ferry as affected by changes in Lake Powell's elevation (green line).



Vernieu and others (2005)

Preliminary Data: Subject to Review and Revision

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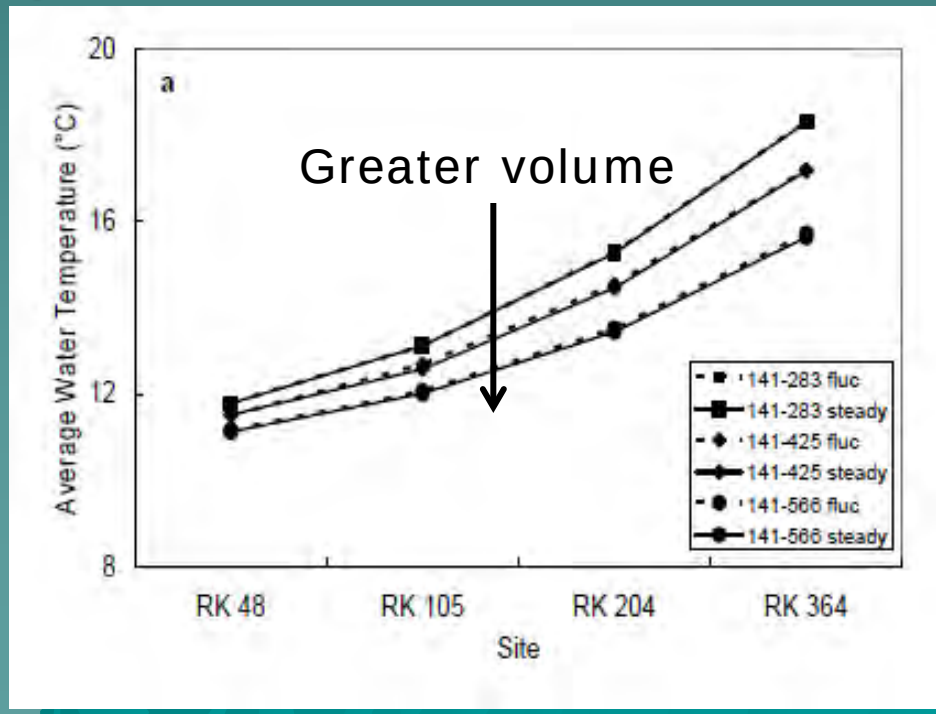
Pre-dam: from nearly freezing up to 30 deg celsius

Temperature Modeling

- Unsteady temperature model (Anderson and Wright, 2007)
  - Can predict mainstem temperature for steady and fluctuating flows by distance downstream
- No significant difference between steady and fluctuating flows
- **Flow volume is strongest control on warming**



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Anderson and Wright, 2007

Predicted effect of temperature control device on downstream temperatures

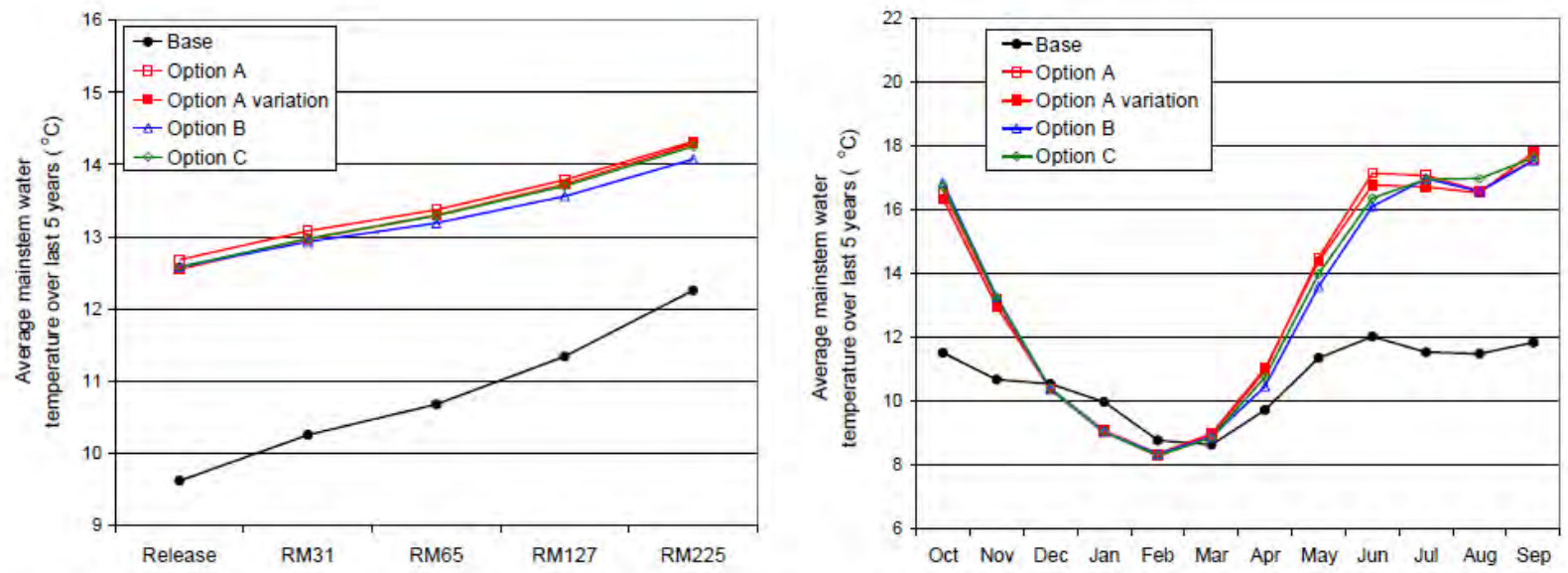

Figure E.1 Average mainstem water temperatures at 5 locations (left) and average monthly temperatures at river mile 65 (right) for the last 5 years of the simulation period (i.e. period with TCD) for most probable hydrologic scenario.

- Effect of operations is insignificant compared to effect of changing release temperature

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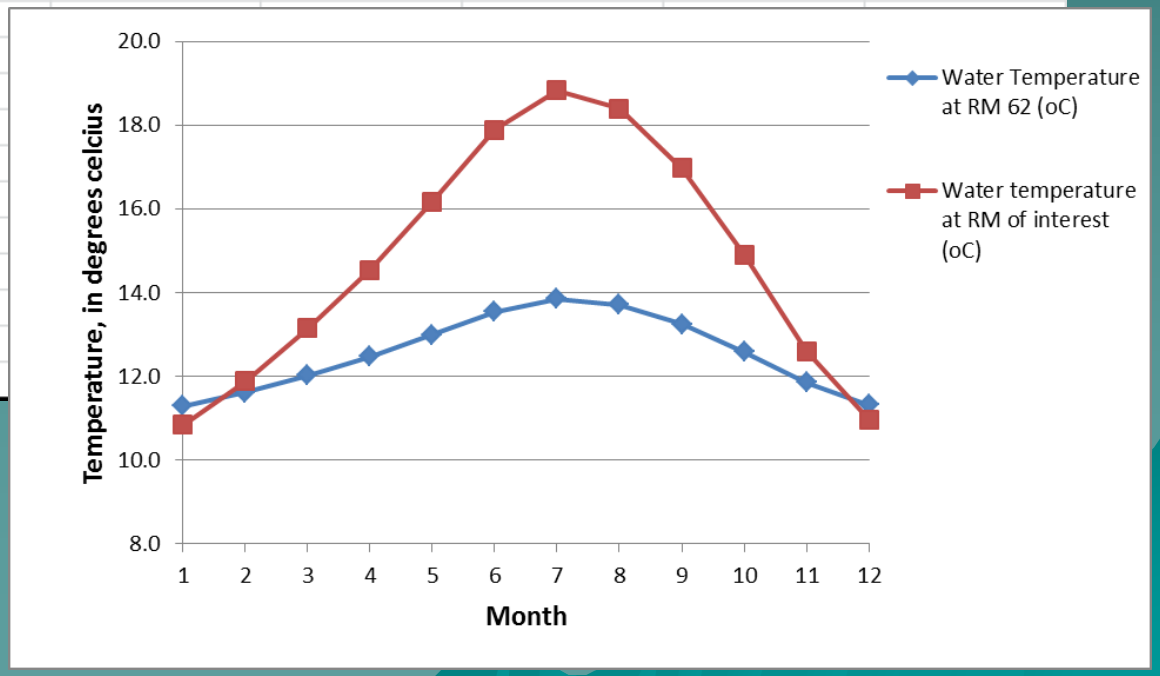
Downstream temperature model that you can use!

- Because flow volume (not release pattern) is strongest control on downstream warming, it is possible to construct a very simple temperature model
- Monthly average temperature model:
  - Average air temperature at Page, AZ
  - Temperature of water released through dam
  - Monthly release volume

USGS

Wright and others(2008)

	ENTER VALUE IN EACH ROW	ENTER VALUE IN EACH ROW	ENTER VALUE IN EACH ROW	CALCULATED	CALCULATED	ENTER VALUE IN TOP ROW ONLY	CALCULATED
Month	Monthly Average Air Temperature (oC)*	Water temperature at Glen Canyon Dam (oC)	Monthly average discharge (ft^3/s)	Water Temperature at RM 62 (oC)	Water Temperature at RM 225 (oC)	River Mile of interest	Water temperature at RM of interest (oC)
January	1.4	11.5	12,570	11.3	10.9	225	10.9
February	4.9	11.5					
March	9.2	11.5					
April	13.9	11.5					
May	19.4	11.5					
June	25.2	11.5					
July	28.4	11.5					
August	26.9	11.5					
September	22.1	11.5					
October	15.1	11.5					
November	7.3	11.5					
December	1.8	11.5					



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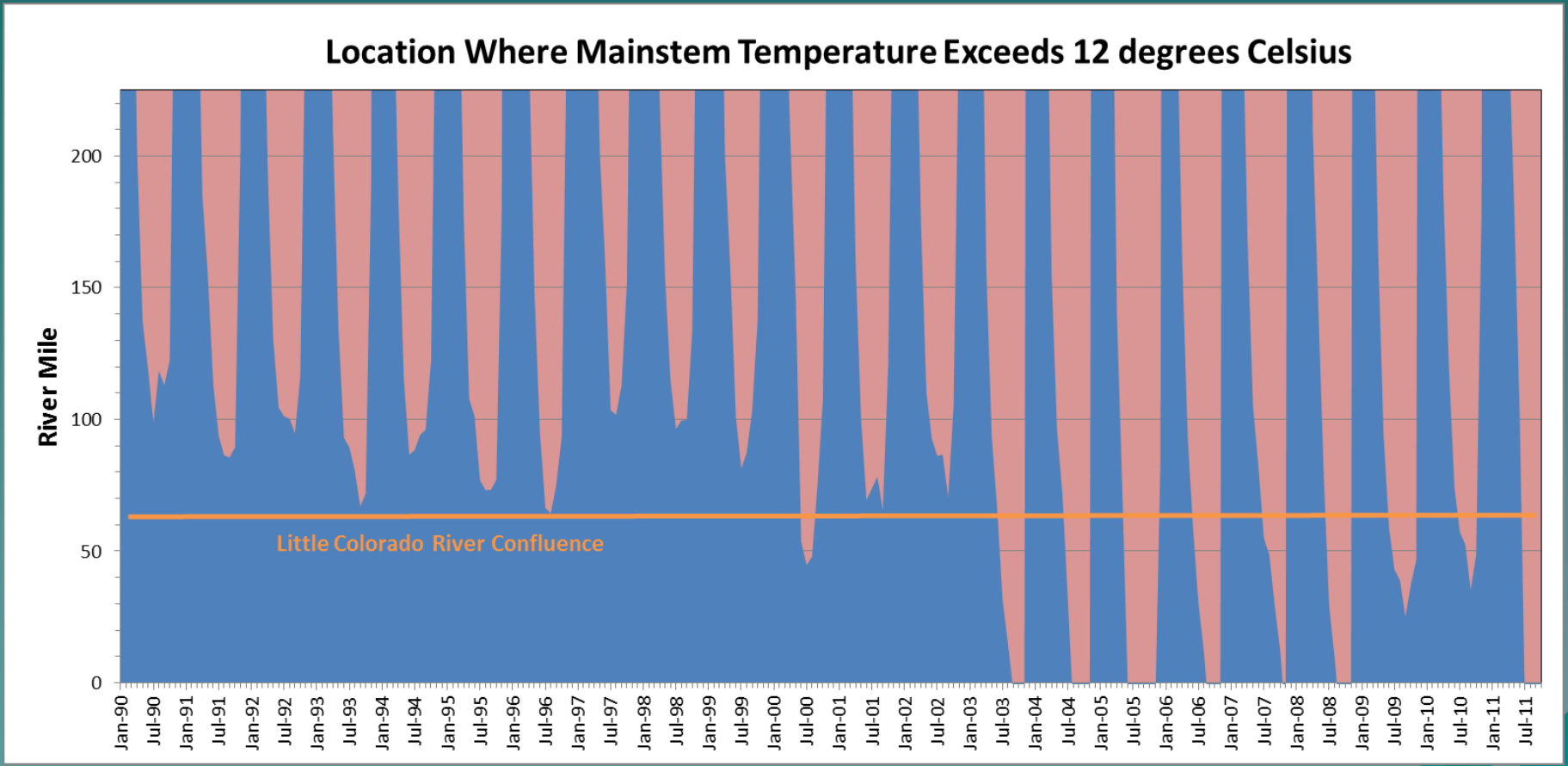
Preliminary Results: Subject to Review and Revision

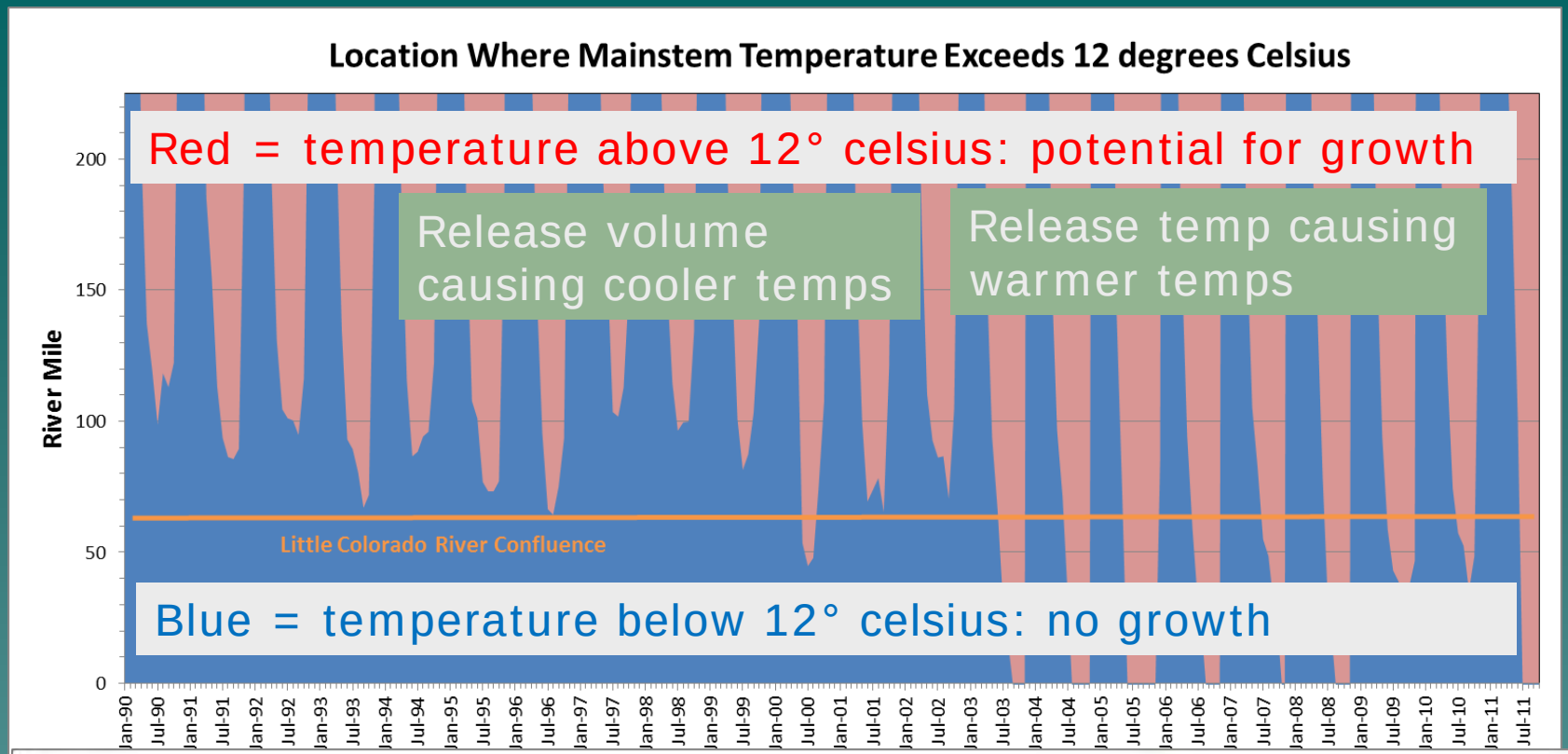
Temperature Model Application: Scope for Growth of Humpback Chub

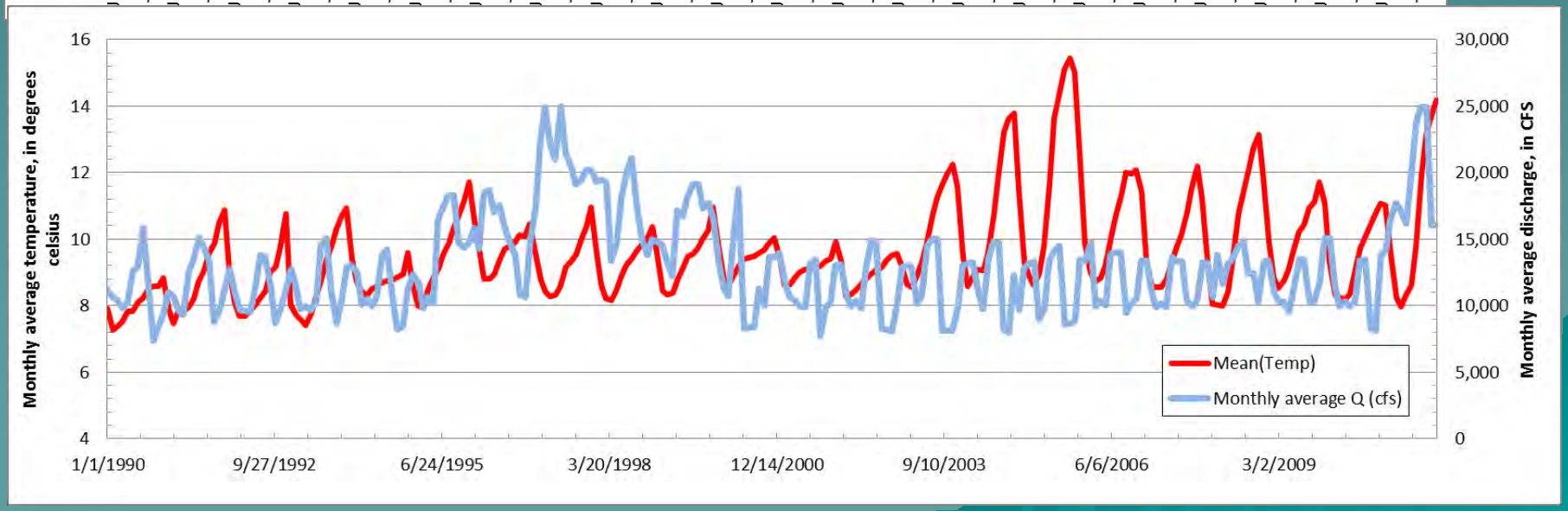


Blue = temperature below 12° celsius – no growth

Red = temperature above 12° celsius – potential for growth

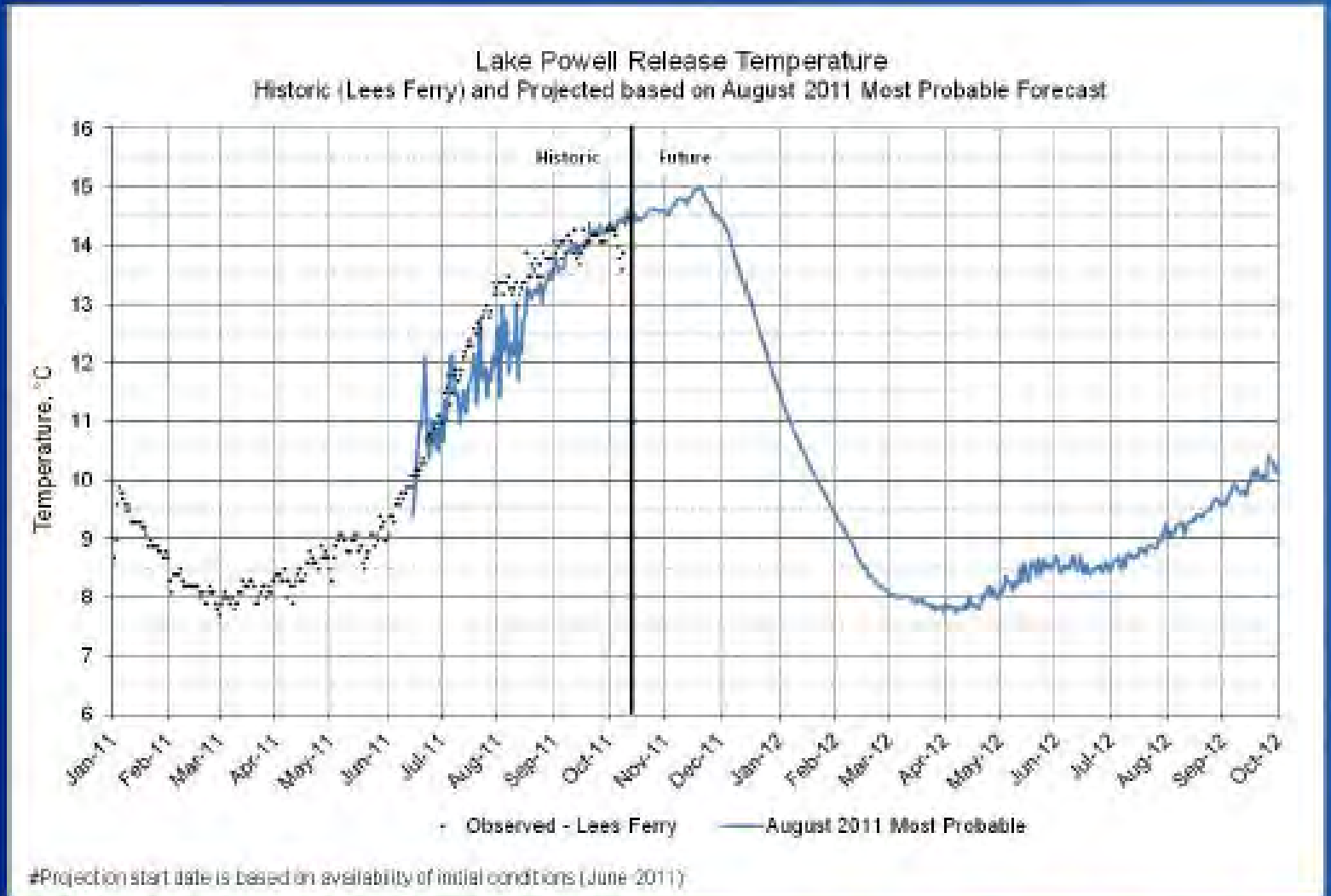
Preliminary Results: Subject to Review and Revision





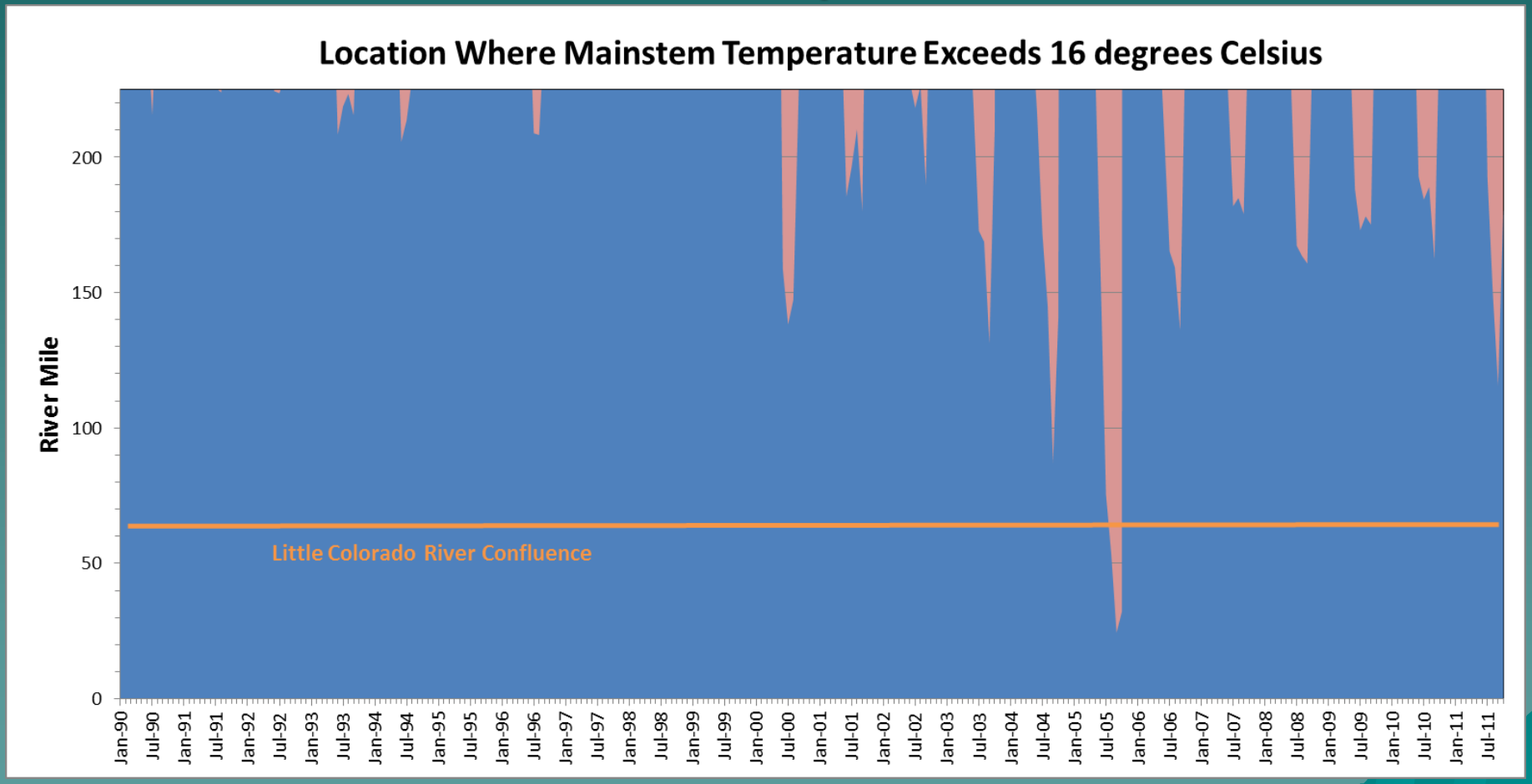
Preliminary Results: Subject to Review and Revision

Lake Powell Temperature Simulation WY 2012 (courtesy of Nick Williams)



RECLAMATION

Temperature Model Application: Scope for Growth of Humpback Chub



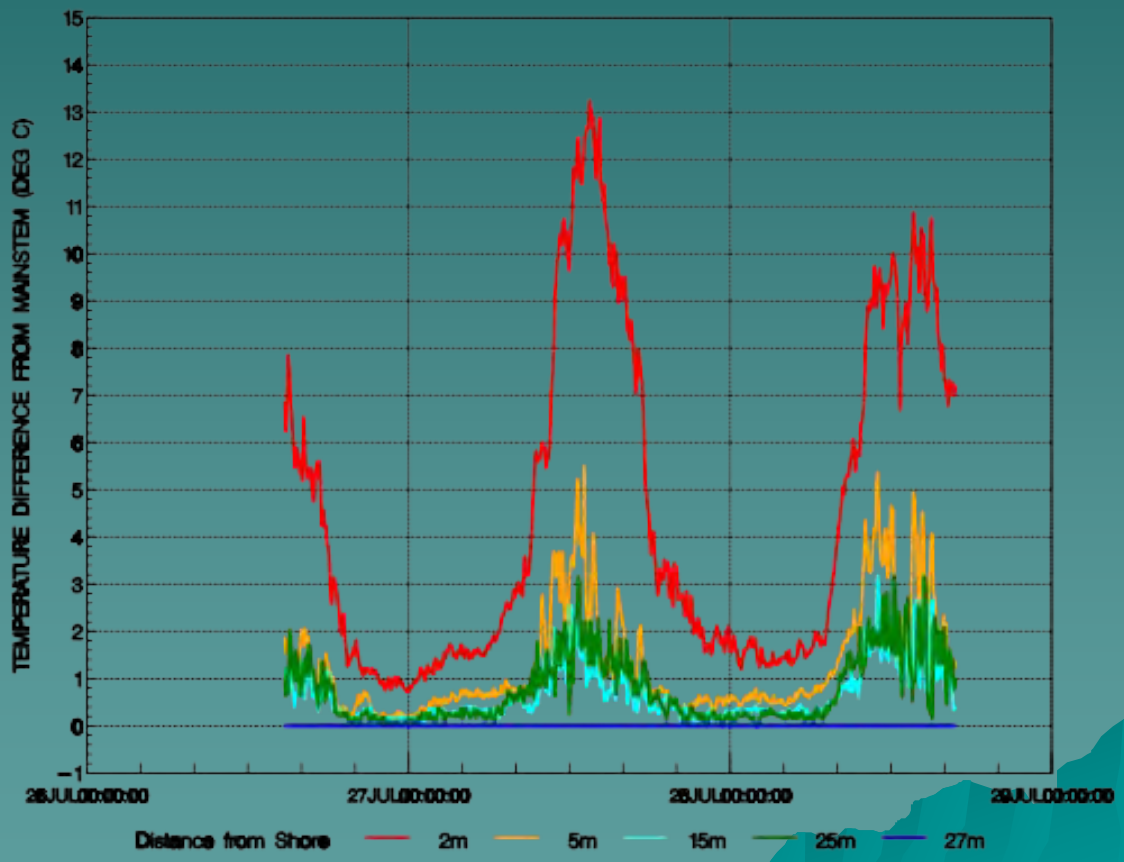
Blue = temperature below 16° celsius

Red = temperature above 16° celsius

Preliminary Results: Subject to Review and Revision

Backwater Temperatures

- Backwaters warm during daytime and return to mainstem temperature at night
- Occurs in fluctuating and steady flows

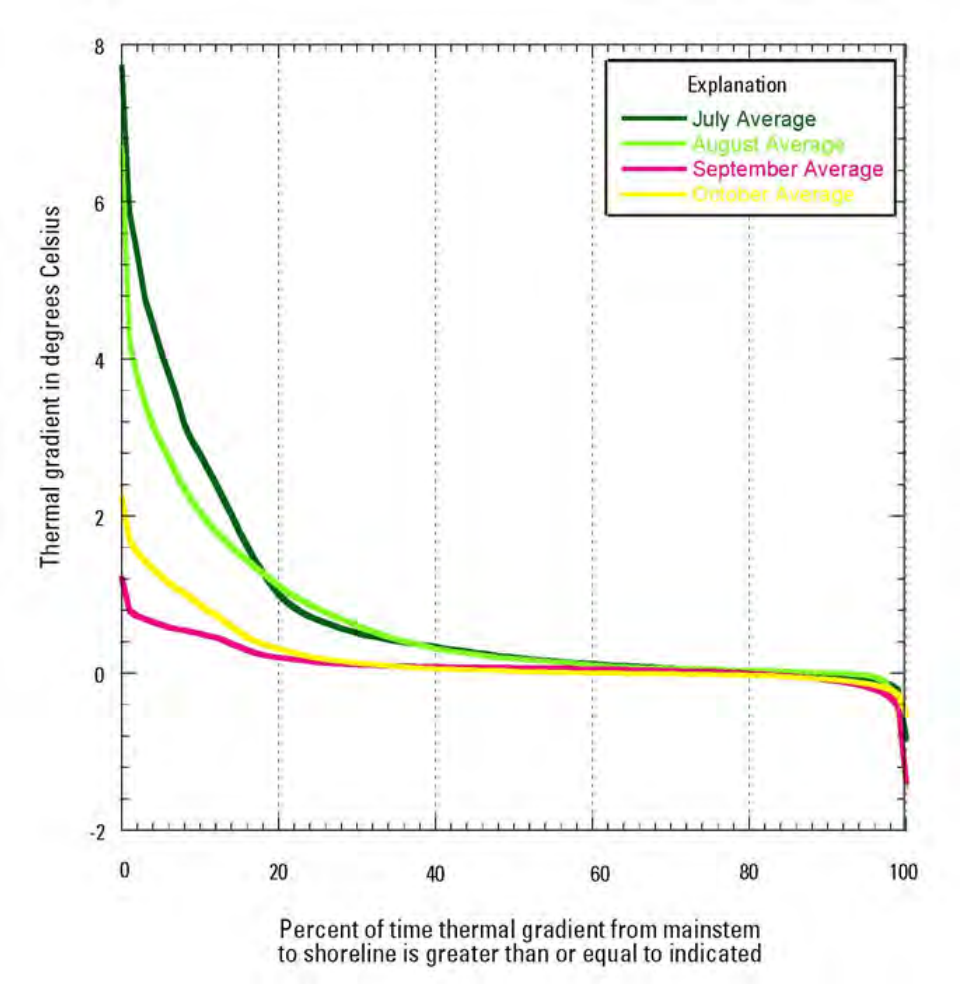


USGS

Vernieu and Anderson (in press)

Near-shore temperatures

- Observed more warming during Jul-Aug fluctuating flows than in Sep-Oct steady flows
- Confounding factors
  - Warmer air temperatures in July and August
  - Fluctuating flows creat a different sampling environment than steady flows



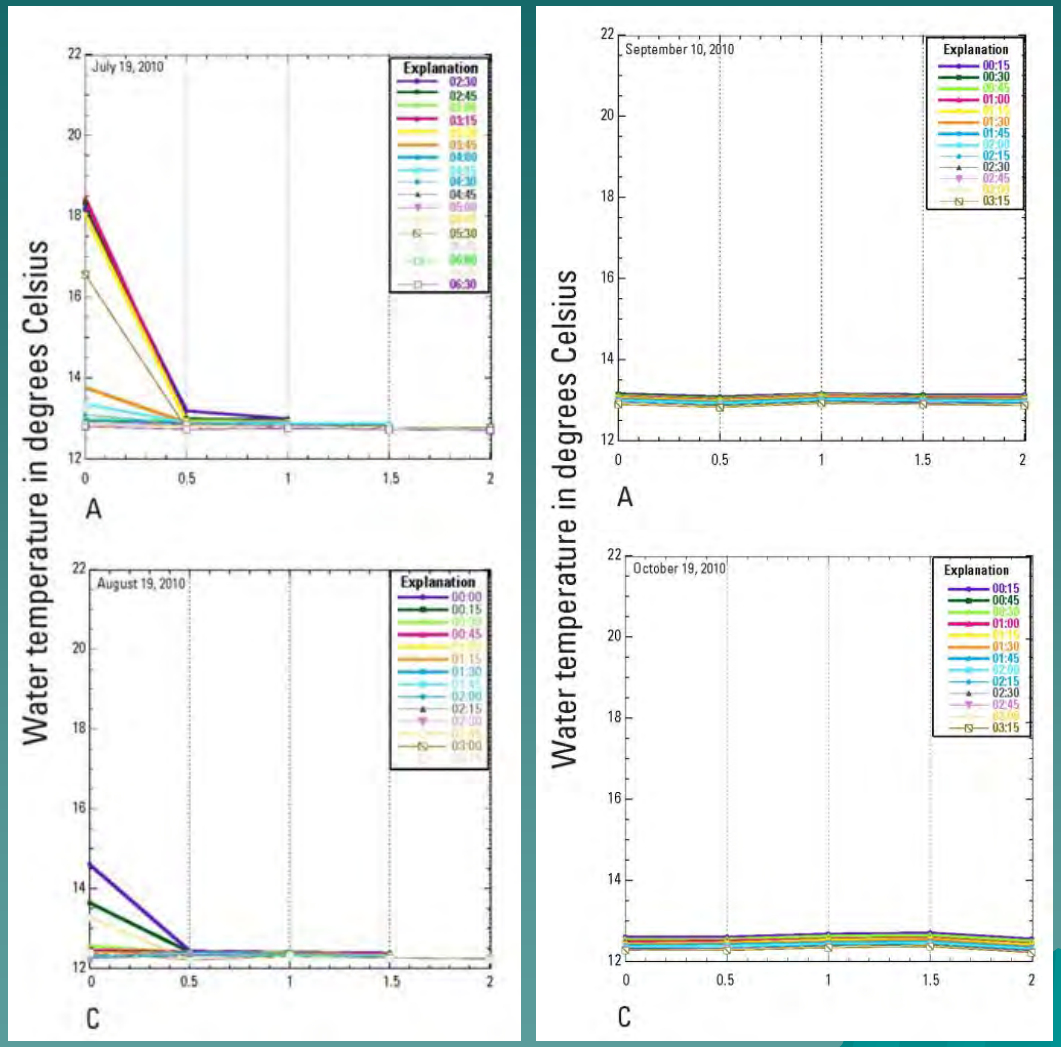
Ross and Grams (in preparation)

USGS

Preliminary Results: Subject to Review and Revision

Near-shore temperatures

- Observed more warming during Jul-Aug fluctuating flows than in Sep-Oct steady flows
- Confounding factors
  - Warmer air temperatures in July and August
  - Fluctuating flows create a different sampling environment than steady flows
- There is near shore warming, but it is limited to the very shallow environment less than ~1 m from shore



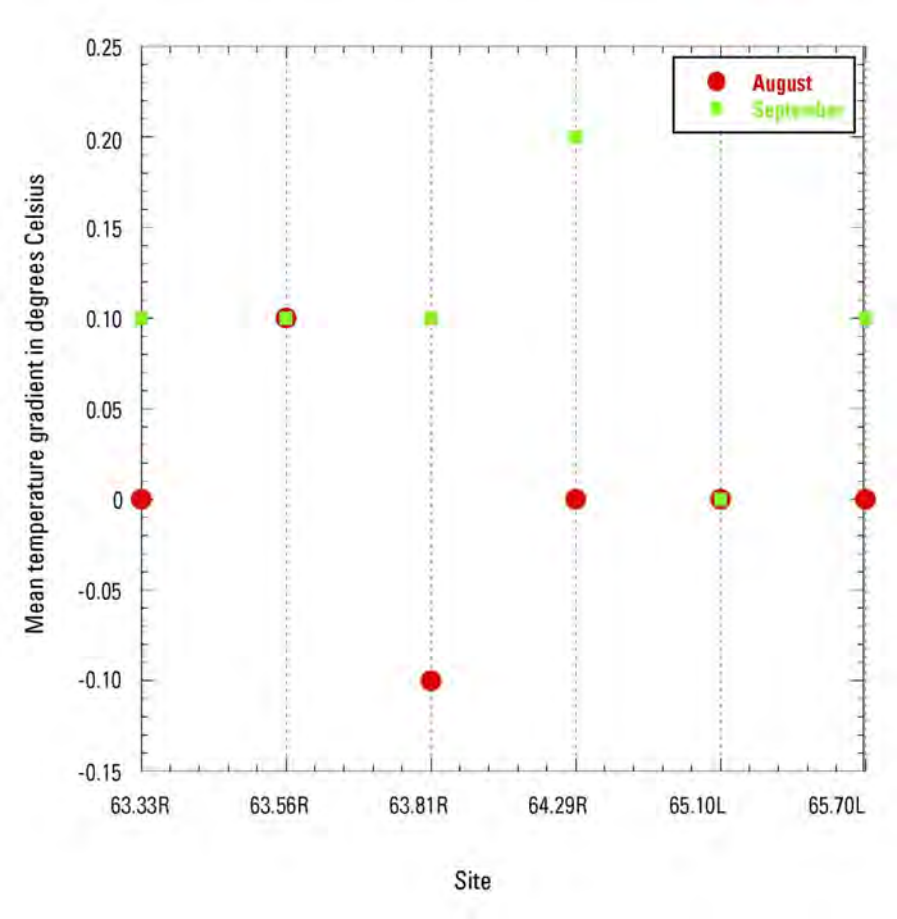
Distance from first submerged thermistor (meters)

Ross and Grams (in preparation)

Preliminary Results: Subject to Review and Revision

Near-shore temperatures

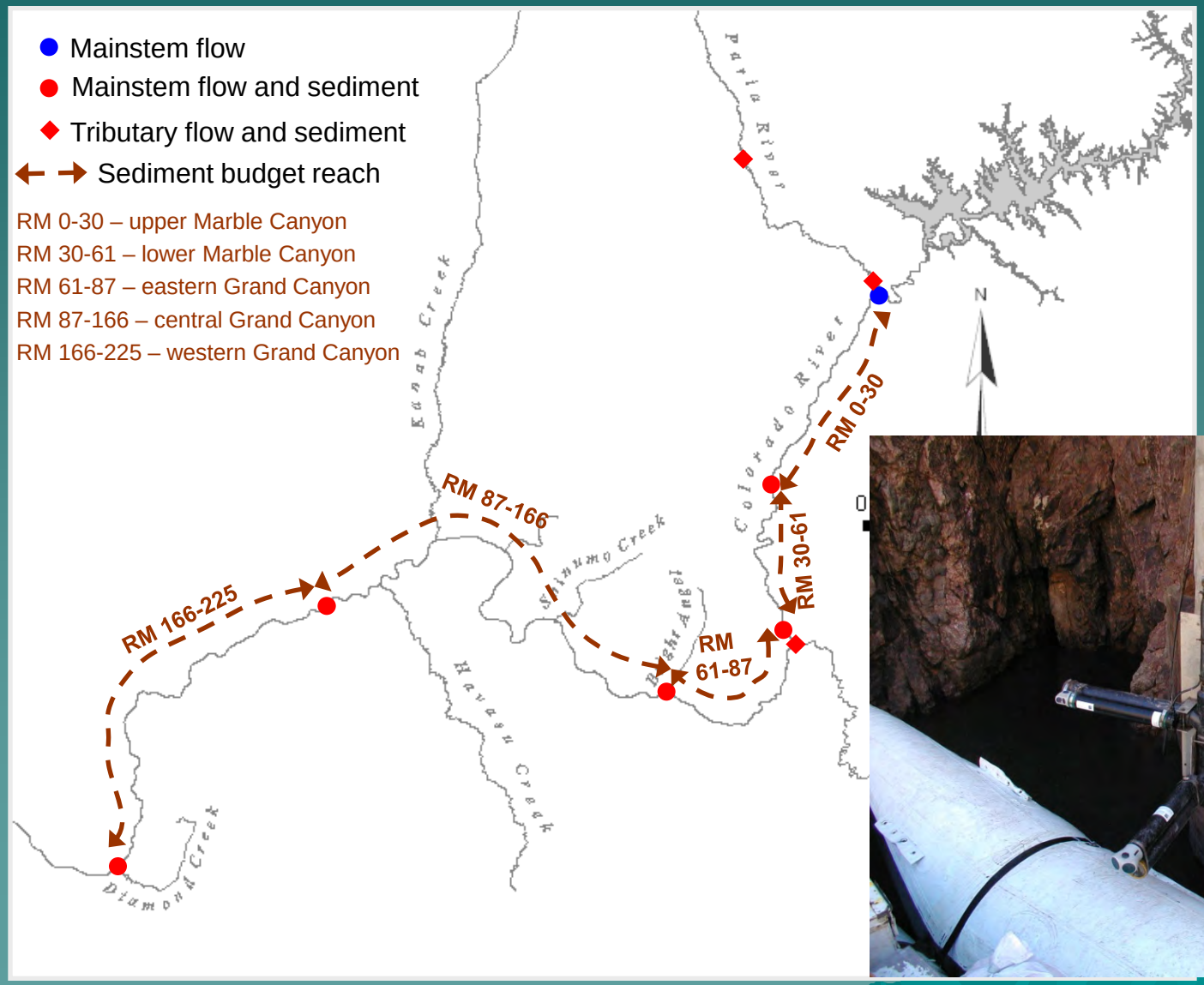
- Evaluating only temperature probes that were always > ~1 m from shore
  - No significant difference between fluctuating and steady flows



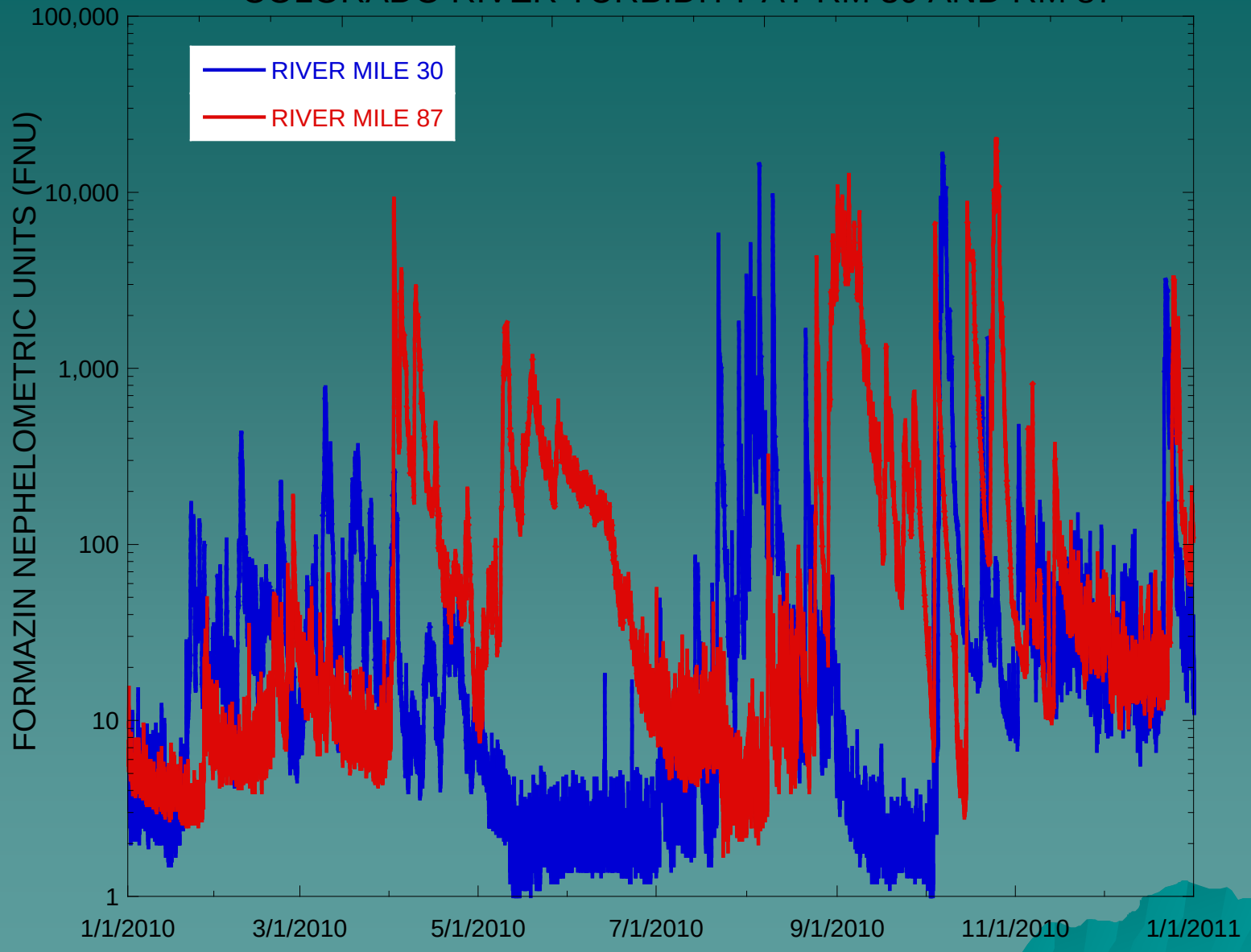
Ross and Grams (in preparation)

Preliminary Results: Subject to Review and Revision

Monitoring for Sediment Concentration and Turbidity



COLORADO RIVER TURBIDITY AT RM 30 AND RM 87



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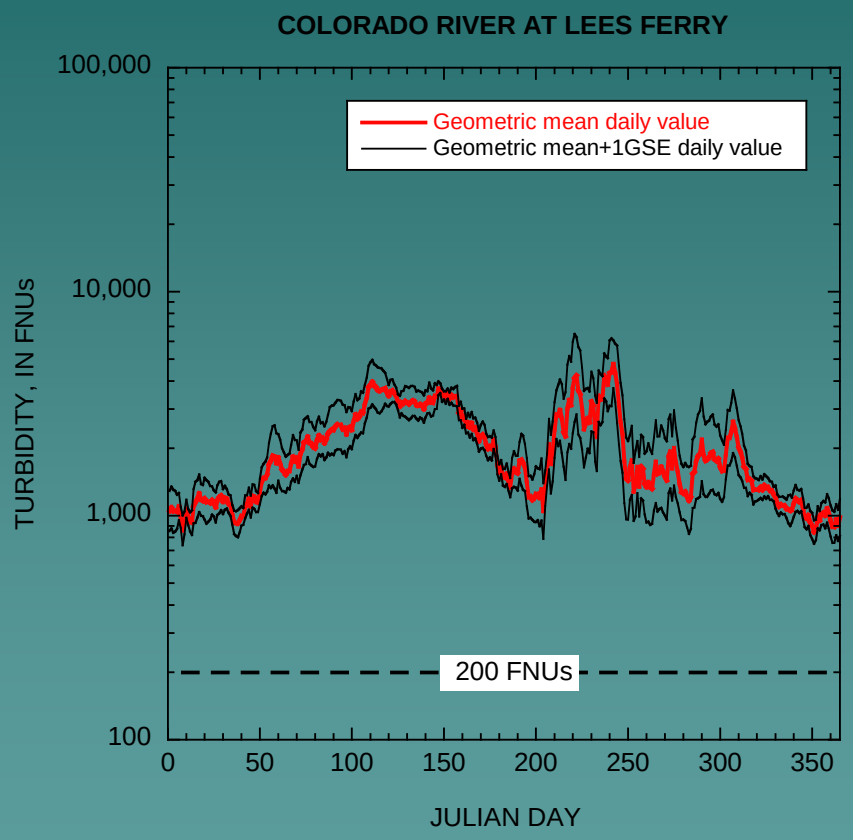
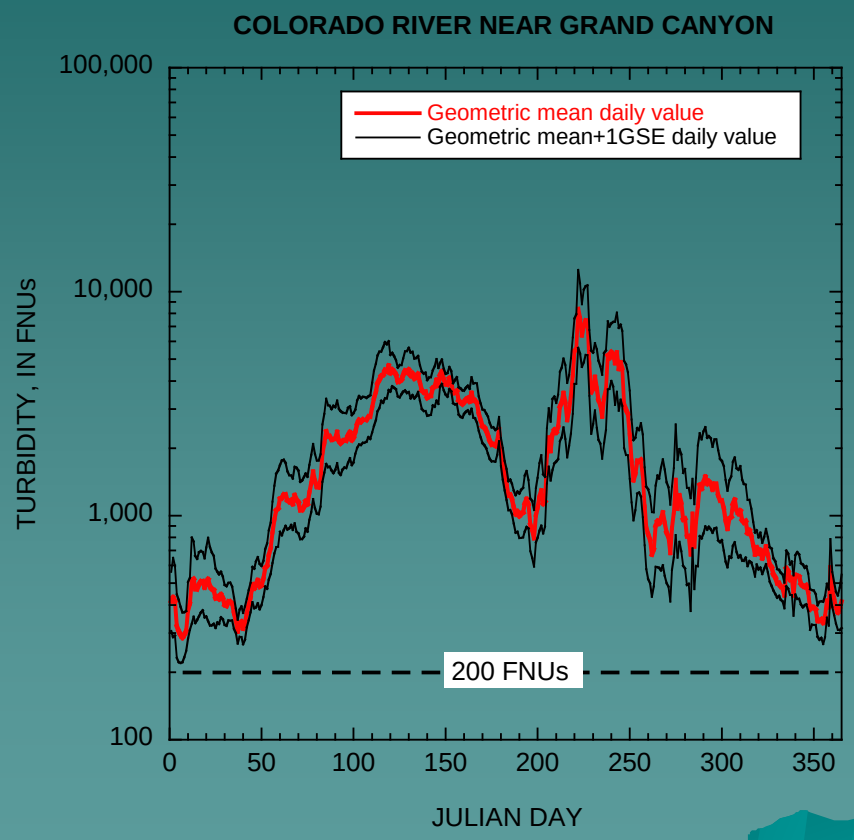
Preliminary Results: Subject to Review and Revision

Pre-dam Turbidity





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October 1, 1947, through February 10, 1959

June 1, 1944, through February 10, 1959

Preliminary Results: Subject to Review and Revision