

Predicting Water Quality in Lake Powell: Updates and Improvements to the Existing Mechanistic Model

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Lake Powell Appendix

Project Elements and Objectives

- **USGS Ecosystems Mission Area “Forecasting Fish Population Responses to Drought”**
- **Special statement of work: “Leveraging Existing Data and Improving Existing Models to Better Bound Possible Water Quality Futures for Lake Powell and Its Tailwater”**
- **Lake Powell Water Quality Monitoring Program**

Funding amount and sources:

- **\$100k (USGS Ecosystems Mission Area over 2 years)**
- **\$60k (BOR Statement of Work-AMWG Directive)**
- **\$200k (BOR Interagency Agreement)**

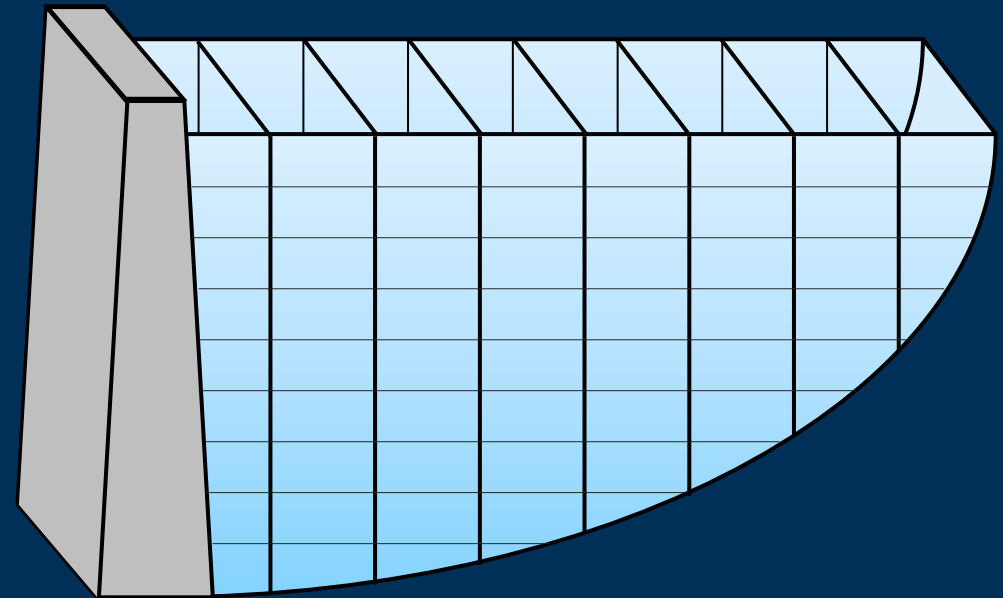
Cooperators: Bureau of Reclamation

LTEMP Resource goals: Natural Processes

What is CE-QUAL-W2?

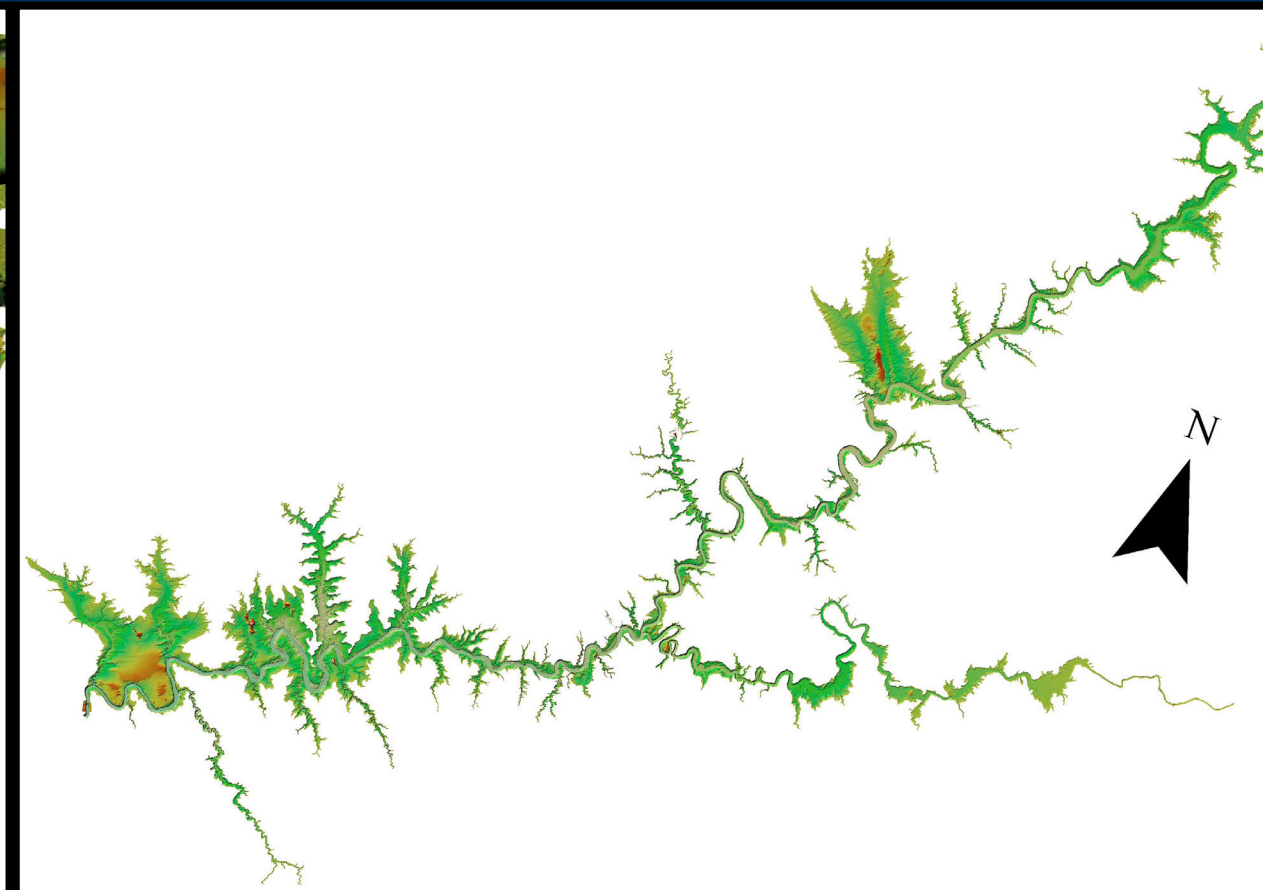
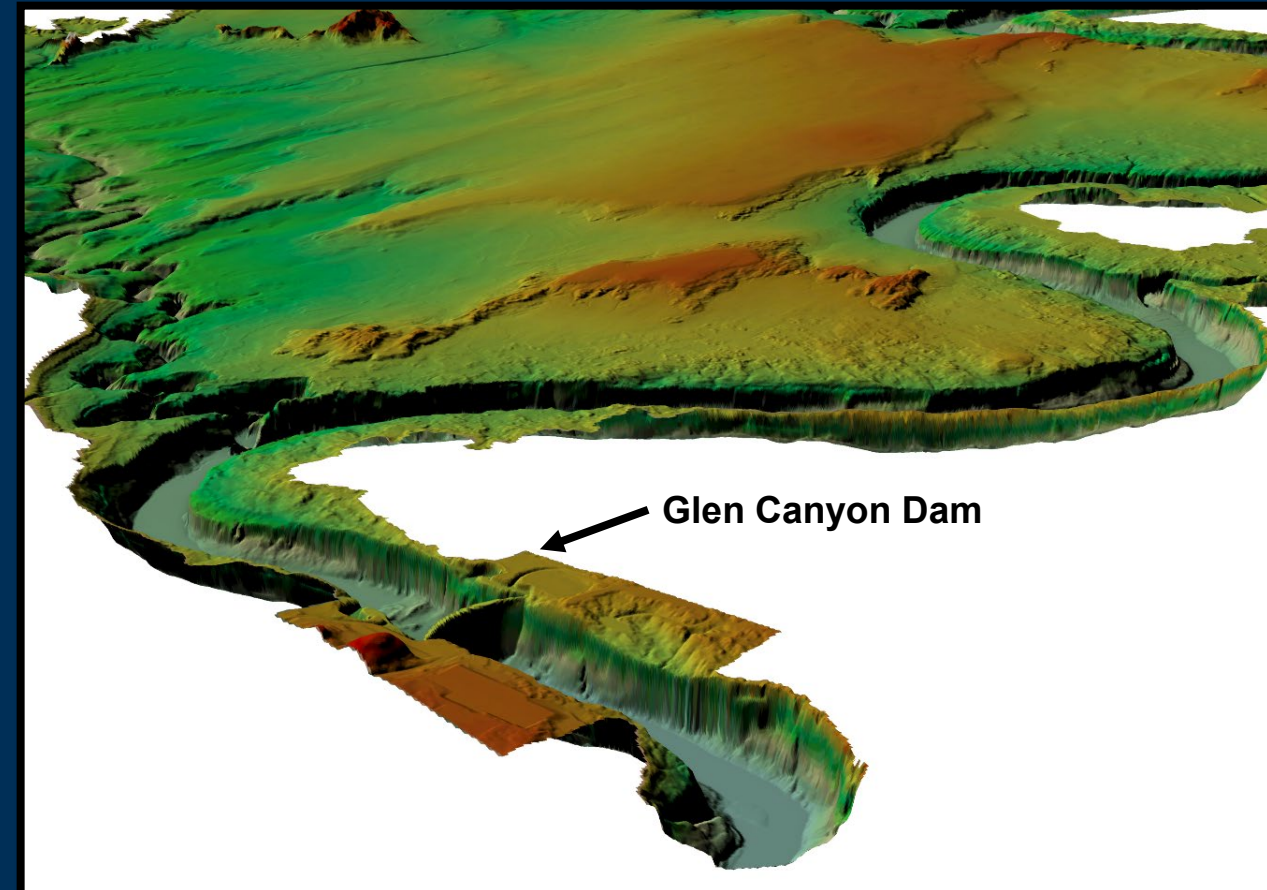


- 2D (laterally averaged) hydrodynamic model
- Individual heat and constituent fluxes
- Simulates stratification and seasonal turnover
- Ability to specify GCD characteristics
 - Penstock and Bypass elevations
- Used in BOR's 24-Month Study's



Model Updates

- 1. Incorporate new bathymetry data
 - Match the volume-elevation curve used by BOR's CRSS
 - Represents ~7% loss in storage from last bathymetry dataset

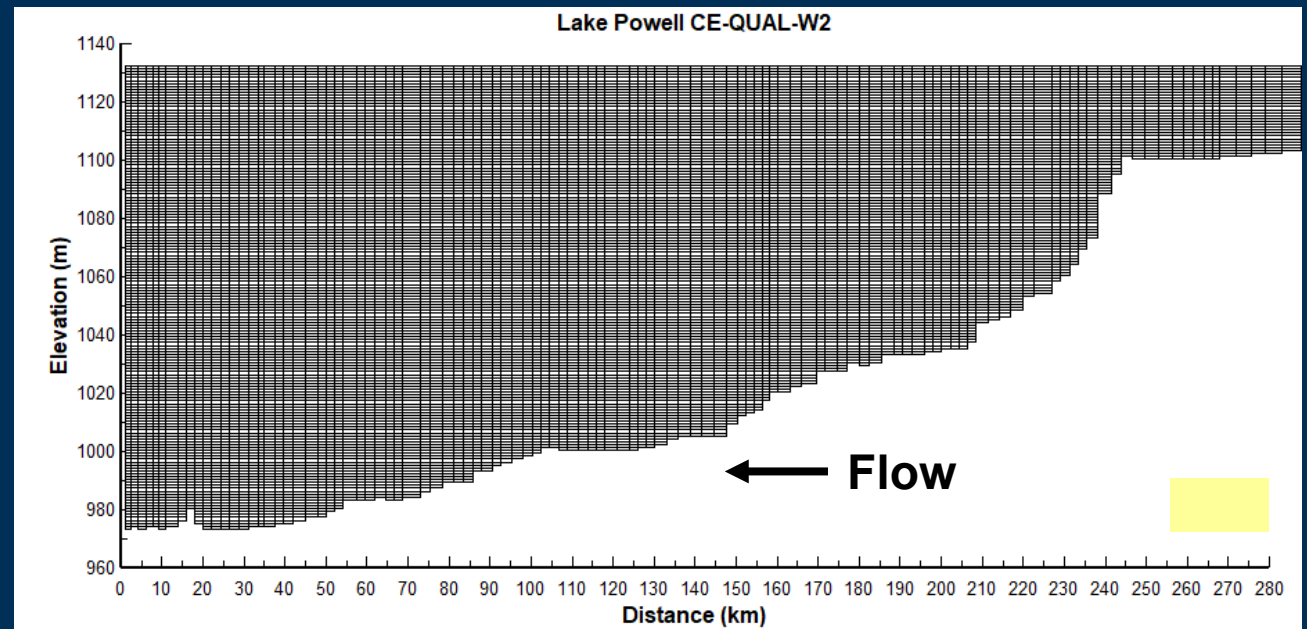
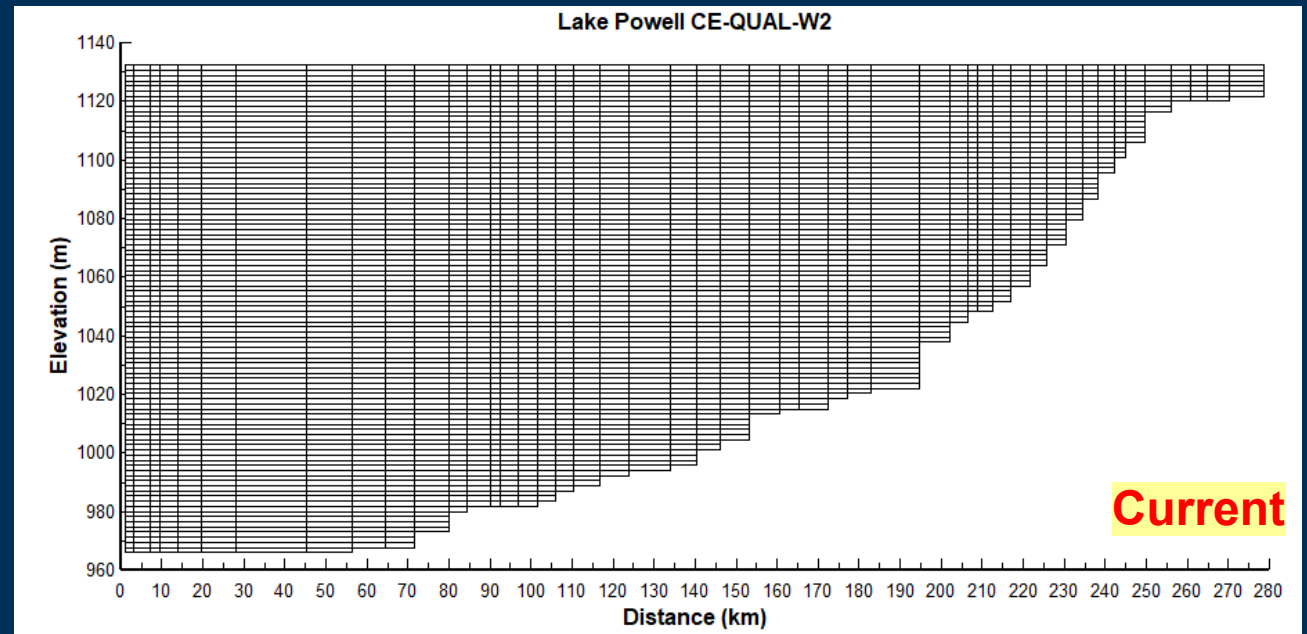


Model Updates

- 2. Increased vertical and longitudinal resolutions (mainly in mainstem)
 - Improves numerical stability
 - Better represents physical features

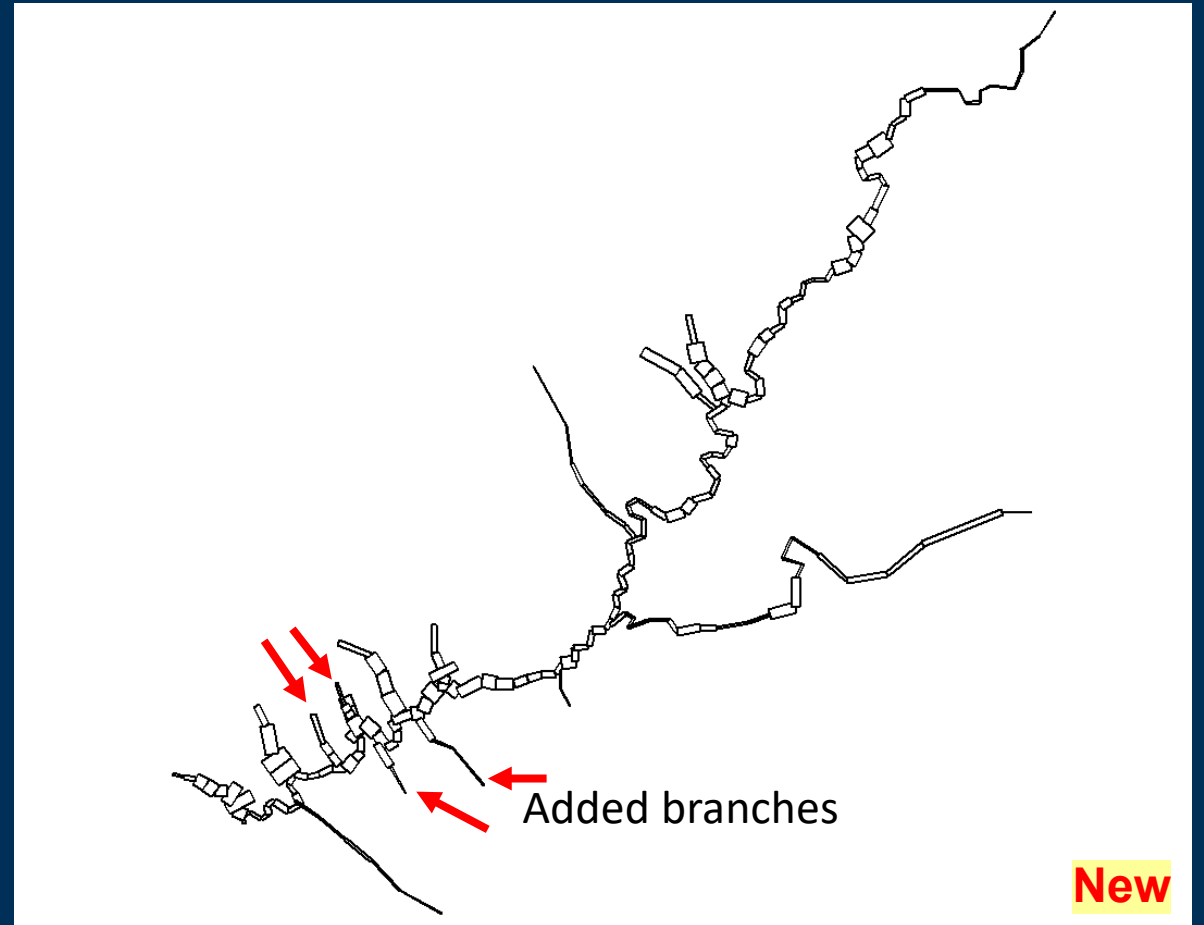
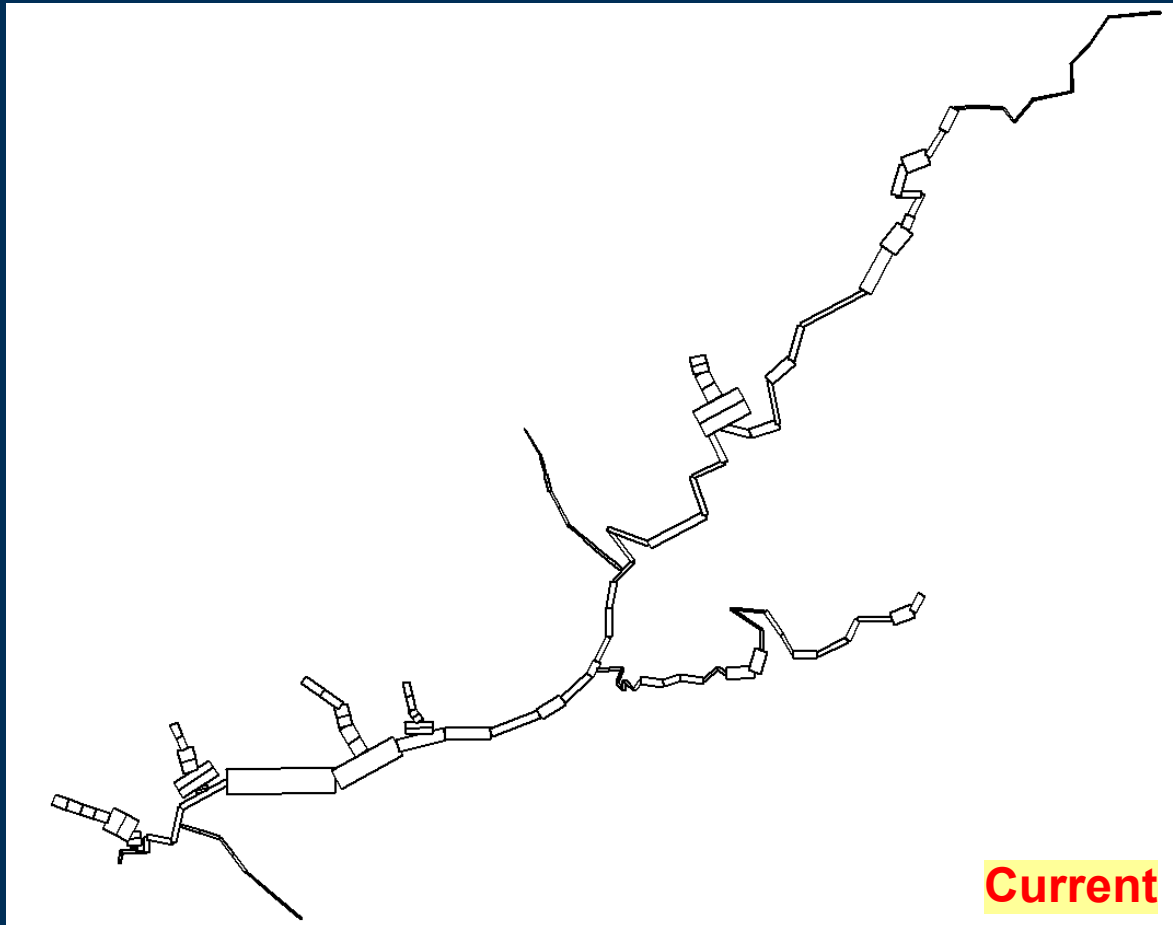
	Current	New
Cell Depth (m)	1.75	1.00
Avg Cell Length (km)	~ 5.8	~ 2.5
Min Cell (km)	2	1.5
Max Cell Length (km)	17.4	4.75

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Model Updates

- 3. Improve spatial representation
 - More side branches (less volume in the mainstem)



Model Testing

- **Long-term historical model run (2010-present)**
 - **Calibrate model under variety of conditions**
 - **Increases confidence in forecasting applications**
 - **Shows that we are predicting – not propagating**

Model Inputs

- **Inflows**

- Discharge
- Temperature
- Constituents (TDS)

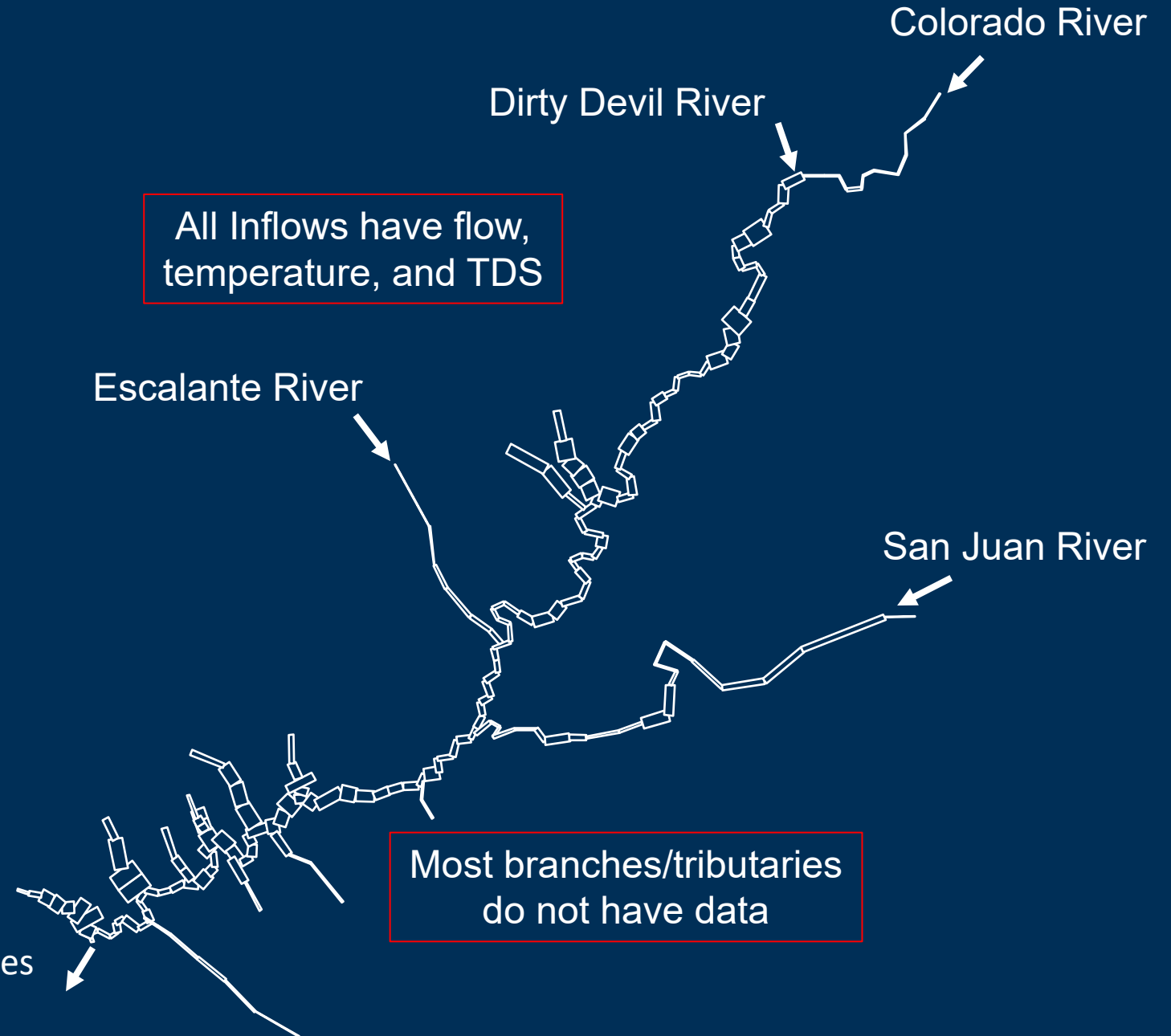
- **Outflows**

- Penstock and Bypass Release

- **Weather**

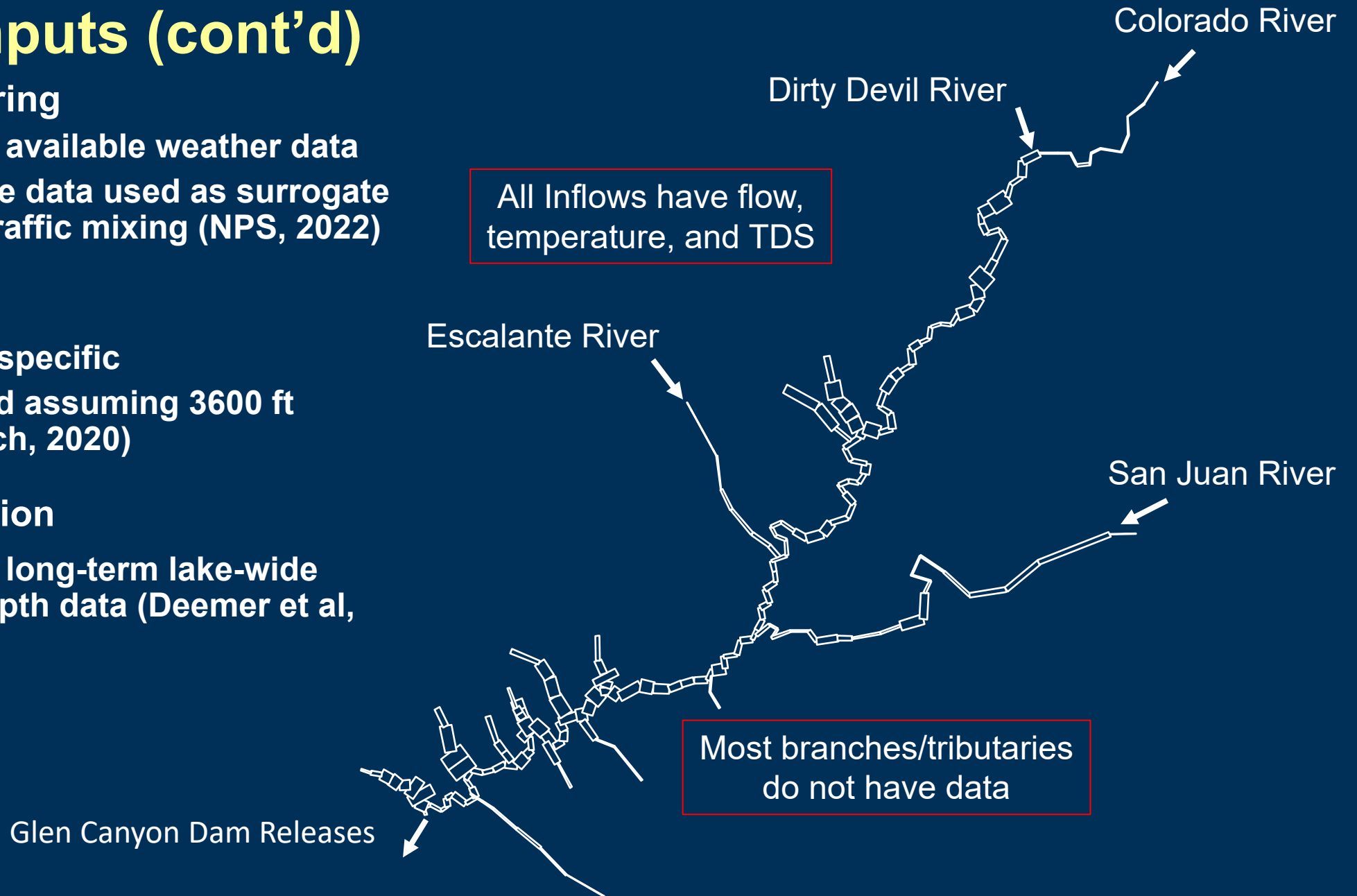
- Air Temperature
- Dew Point Temperature
- Solar Radiation
- Wind Speed/Direction
- Cloud Cover

Glen Canyon Dam Releases



Model Inputs (cont'd)

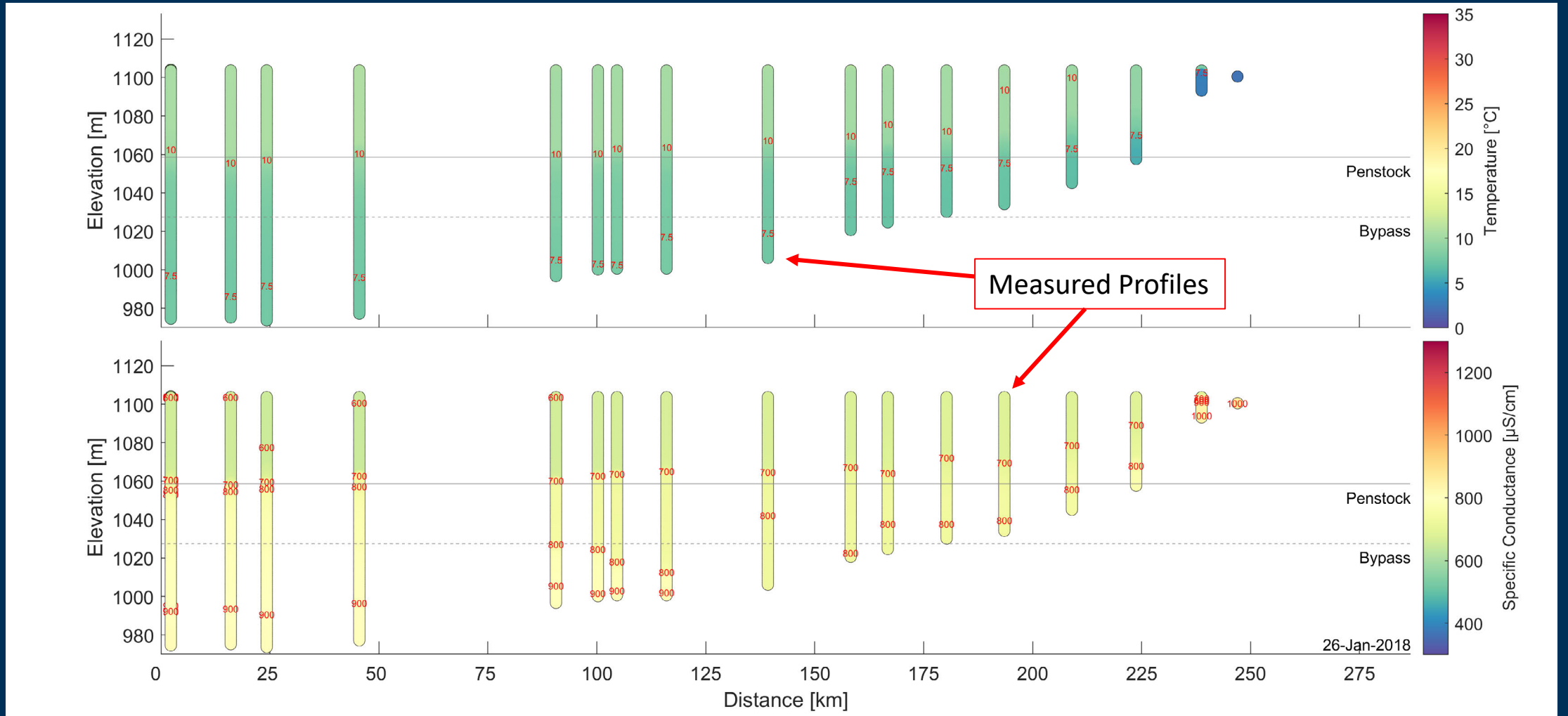
- **Wind Sheltering**
 - Based on available weather data
 - Visitor use data used as surrogate for boat traffic mixing (NPS, 2022)
- **Shading**
 - Segment specific
 - Calculated assuming 3600 ft (Mihalevich, 2020)
- **Light extinction**
 - Based on long-term lake-wide secchi depth data (Deemer et al, 2023)



Model Inputs (cont'd)

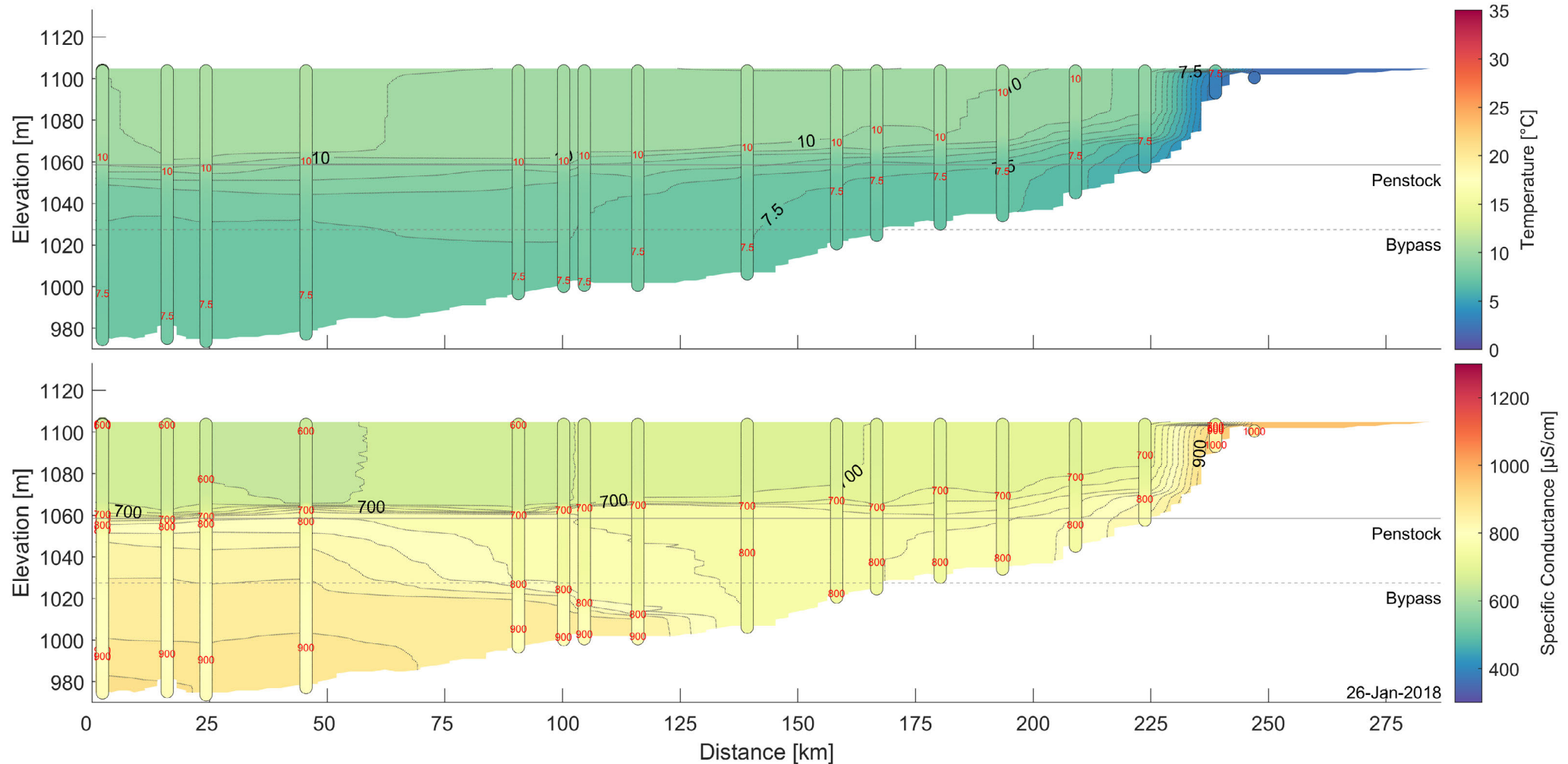
- Initial Conditions (Starting value of each model cell)

January 2018



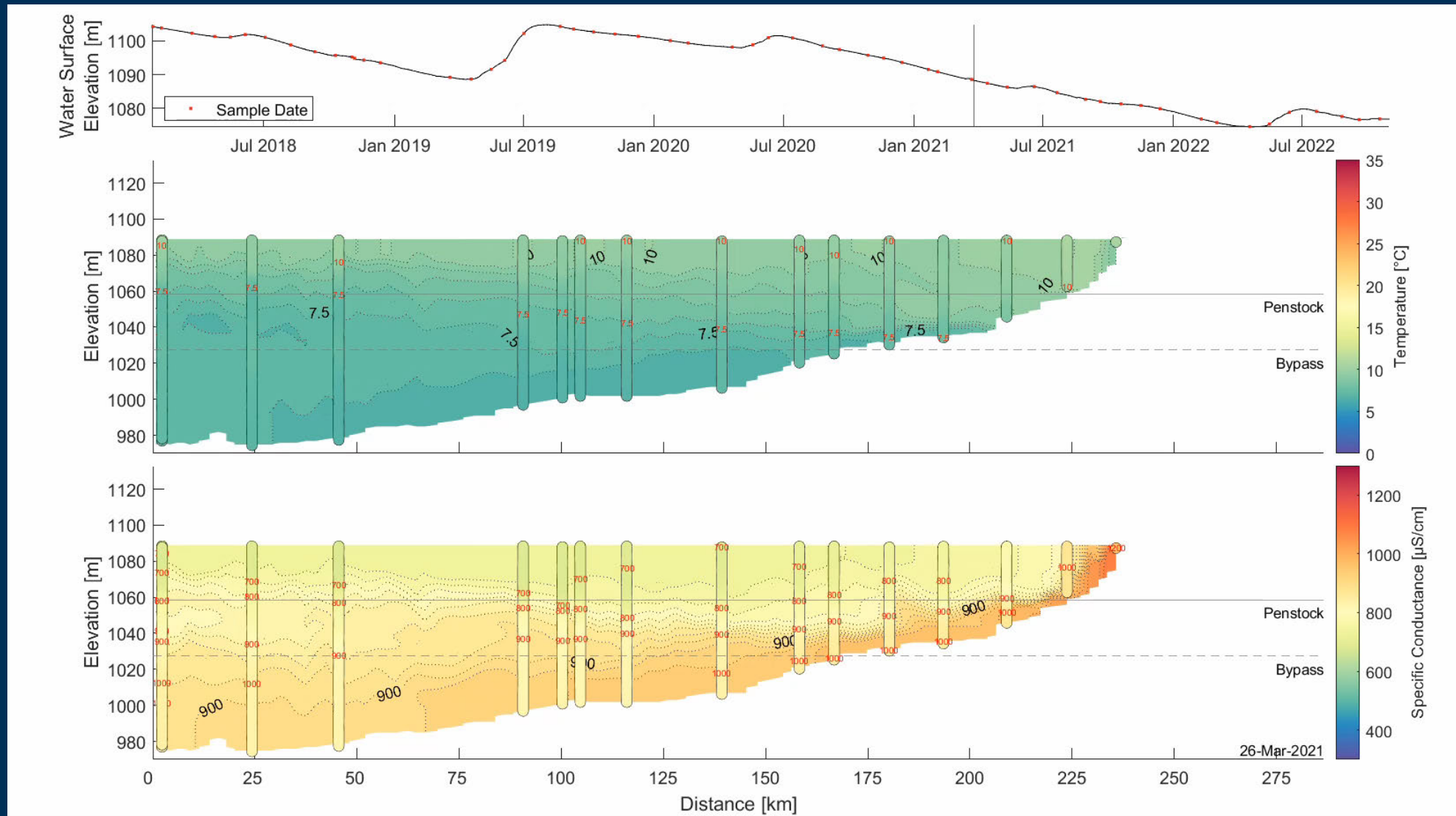
Model Inputs (cont'd)

January 2018



Preliminary Results

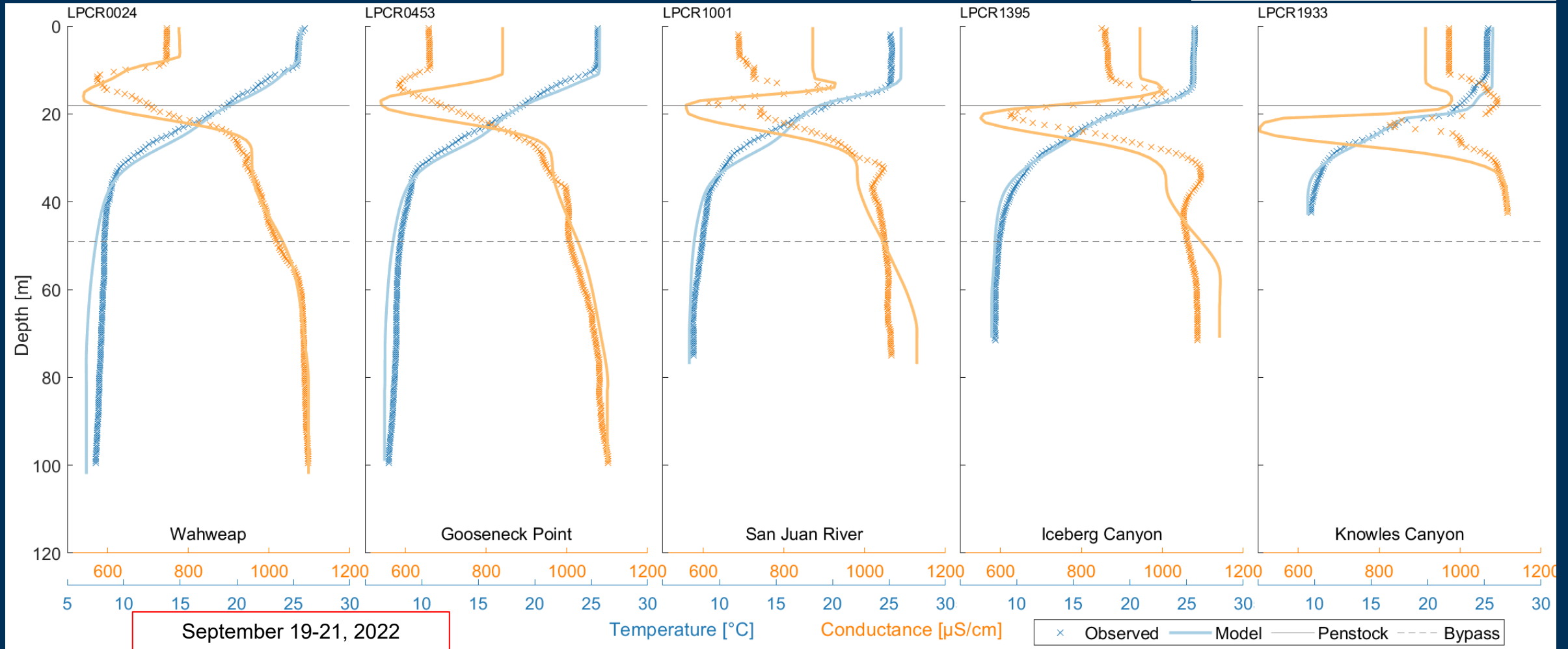
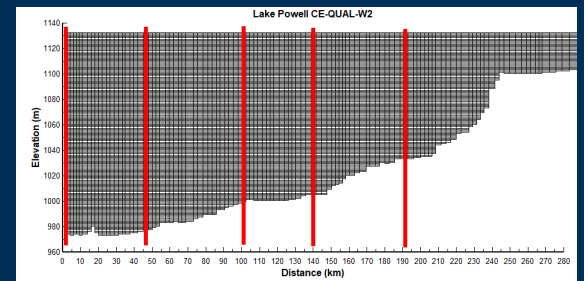
March 2021 – September 2022



"Preliminary Information-Subject to Revision. Not for Citation or Distribution." Measured profiles from Deamer et al. (2023)

Preliminary Results Cont'd

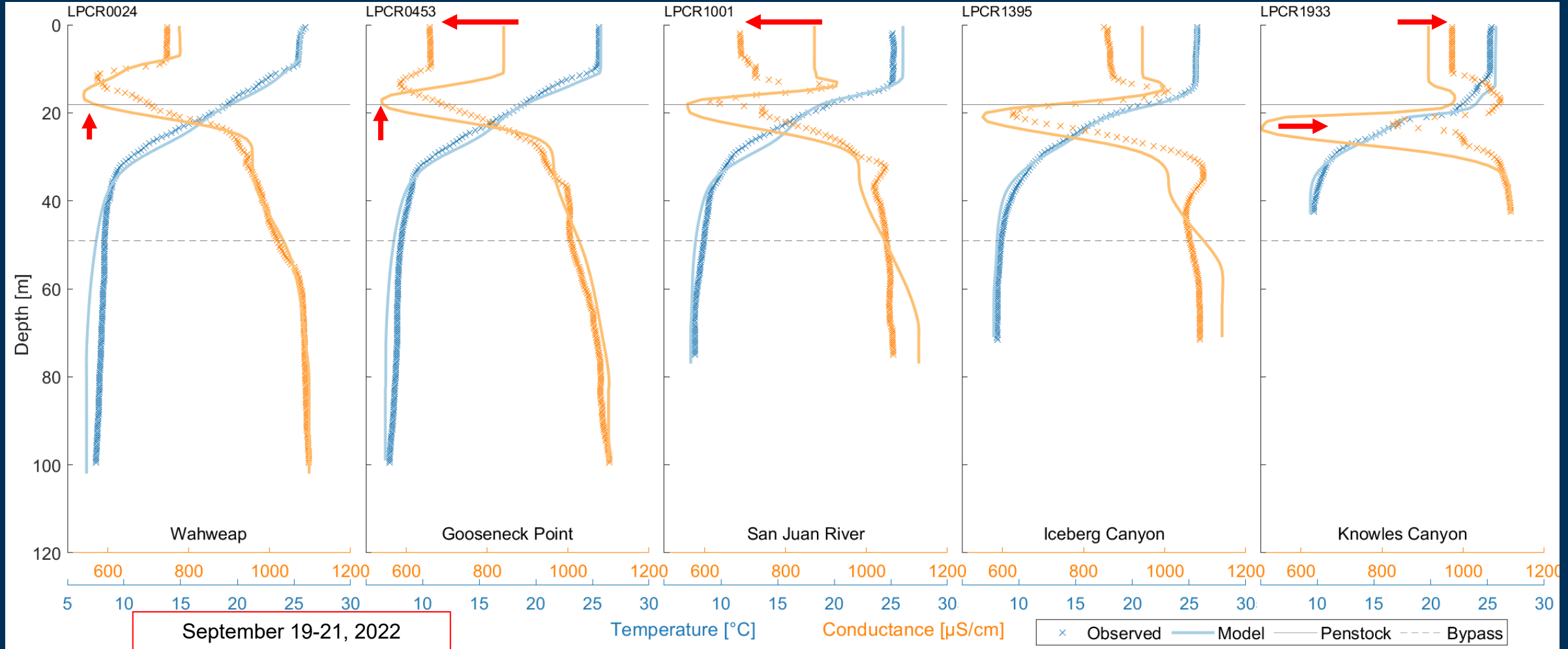
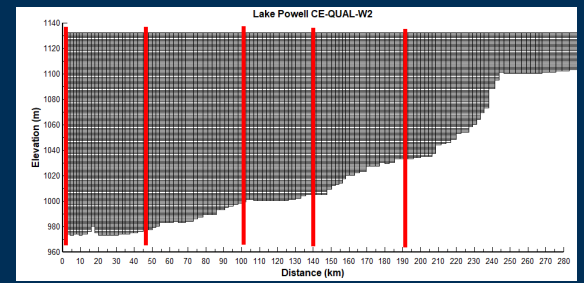
Model started in 2010



"Preliminary Information-Subject to Revision. Not for Citation or Distribution." Measured profiles from Deamer et al. (2023)

Preliminary Results Cont'd

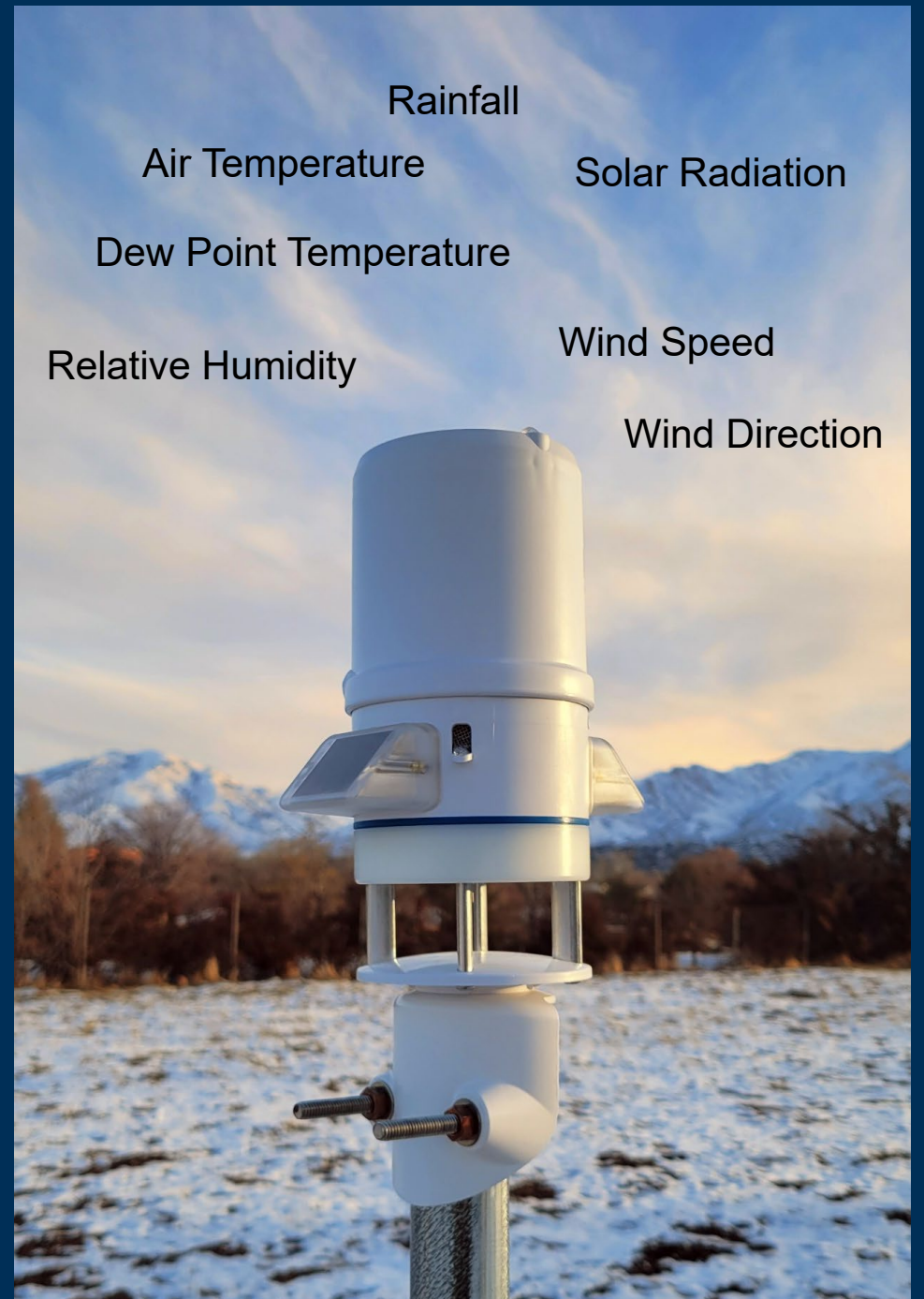
Model started in 2010



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Next Steps

- **Install weather stations on Powell**
 - **Validate input weather data**
 - **Improve wind sheltering inputs**



Next Steps Cont'd

- Continued model calibration
- Include more constituents
 - Dissolved oxygen, pH, nutrients (P, N)
- Transfer updated version to BOR
- Predictions under specific scenarios

Acknowledgments

- Many contributors to the long-term water quality monitoring program including Robert Radtke, Nick Voichick, Tom Sabol, Caitlin Andrews, Alex Walker, and Dean Sedgwick.
- Mentors that have provided model guidance including Scott Wells and Bethany Nielsen



— BUREAU OF —
RECLAMATION



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