

# Presentation Layout

- Morning discussion covers the fundamentals of the model development effort:
  - **Phase I**
    - Model Framework Selection
    - Model Selection
    - Data Management
- Afternoon discussion highlights Shasta/Keswick implementation:
  - **Phase I**
    - Data Development
    - Model Development, Calibration and Validation



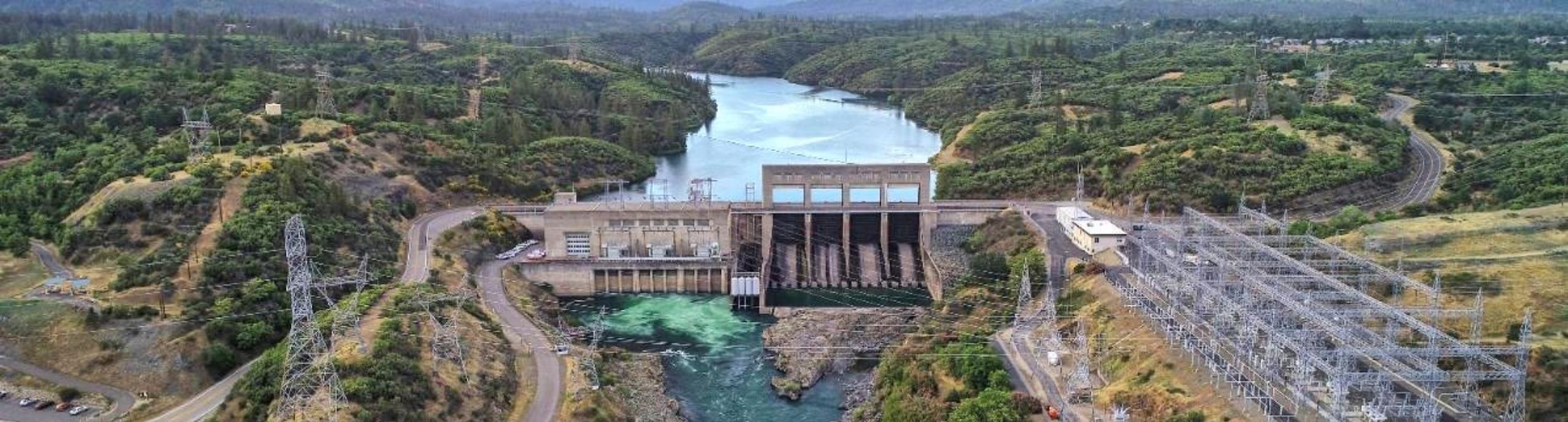


Photo credit: John Hannon, Reclamation

# Data Development

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Reclamation, Central Valley Operations Office



# Data Development Philosophy

- Collaborative data gathering process
- Data Quality
  - Methods for data QA/QC, missing data, gap filling, meta data, and data integrity
  - Support calibration and model performance
  - Identifies opportunities to enhance future monitoring
- Model application needs
  - Effectively capture project operations and water temperatures; appropriate boundary conditions and data frequency to operate facilities to manage downstream water temperature targets



# Documentation

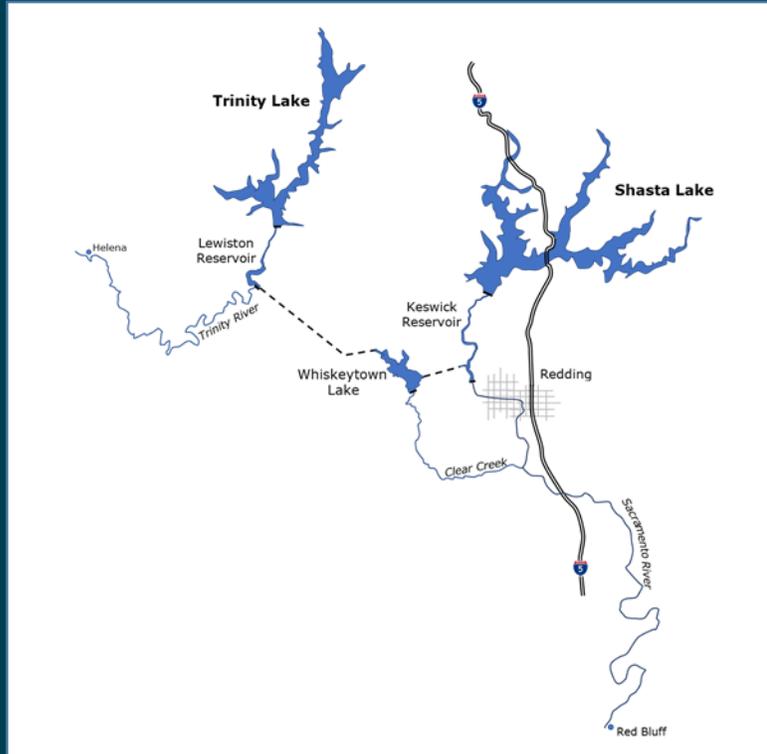
- Technical Memorandum
- Water Temperature Modeling Platform: Data Development – Sacramento, Trinity, and American Rivers Systems (DRAFT 6-1-22)



# WTMP Model Domain

## Sacramento/Trinity River System

Trinity Lake to Helena  
Whiskeytown to Clear Creek confluence  
Lake Shasta to Red Bluff



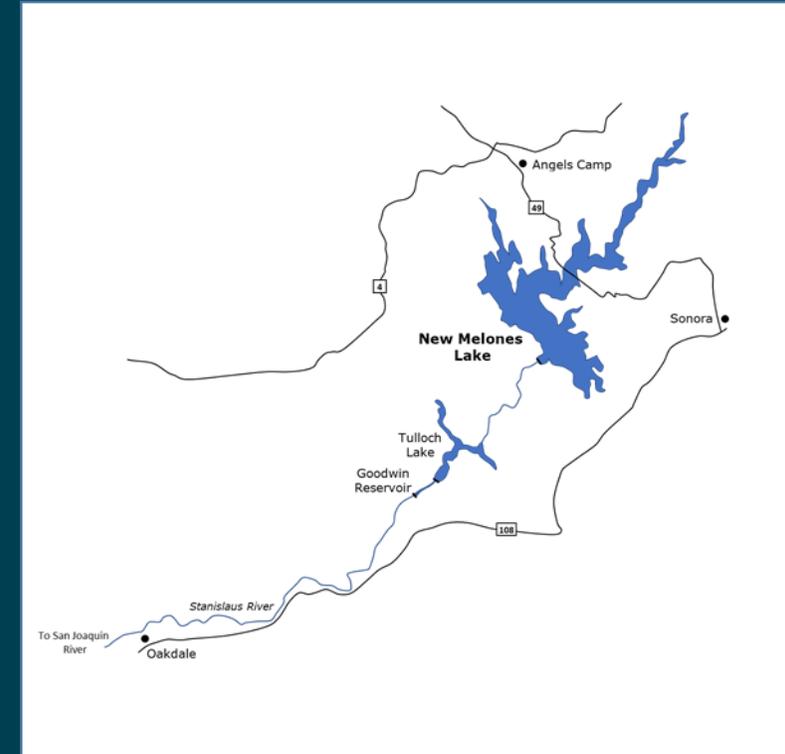
## American River System

Folsom Reservoir to  
American River confluence



## Stanislaus River System

New Melones Reservoir to  
San Joaquin River confluence



# WTMP Model Representations

- Model development data period: 2000 to 2021\*

- Models

Reservoir/River	CE-QUAL-W2	HEC-ResSim
Shasta Lake	2-D vertical & longitudinal	1-D vertical
Keswick Reservoir	2-D vertical & longitudinal	1-D vertical
Sacramento River	--	1-D longitudinal
Trinity Lake	2-D vertical & longitudinal	1-D vertical
Lewiston Lake	2-D vertical & longitudinal	1-D vertical
Trinity River	--	1-D longitudinal
Whiskeytown Lake	2-D vertical & longitudinal	1-D vertical
Clear Creek	--	1-D longitudinal
<b>Folsom Lake</b>	2-D vertical & longitudinal	1-D vertical
Lake Natoma	2-D vertical & longitudinal	1-D vertical
American River	--	1-D longitudinal

- HEC-ResSim is also applied as a system model



# WTMP Modeling Data Development

- Boundary Conditions
- Initial Conditions
- Calibration/Validation Data
- Draft Data Table
  - Sacramento
  - Trinity/Whiskeytown/Clear Creek
  - American
- Data Gaps
  - Fill – Boundary conditions
  - Not filled – Calibration/Validation data
  - Approaches



# WTMP Modeling Data Development

- Reservoir and River Model Data/Information
  - Geometry
  - Hydrology
  - Temperature
  - Meteorology
- Data Inventory Tables



# Geometry: Sacramento River

- Shasta Lake
  - Bathymetry/Stage-Area-Volume (S-A-V)
  - TCD
  - Dam infrastructure (outlets, spillway)
- Keswick Reservoir
  - Bathymetry/S-A-V
  - Spring Creek Powerhouse
  - Dam infrastructure (outlets, spillway)
- Sacramento River
  - Bathymetry (x-y-z yields planform, gradient, and cross section)\*
  - Diversions/return flows (incl. ACID diversion dam operation)
  - Tributary confluences

\* Bathymetry incomplete from approximately Clear Creek to Bend Bridge



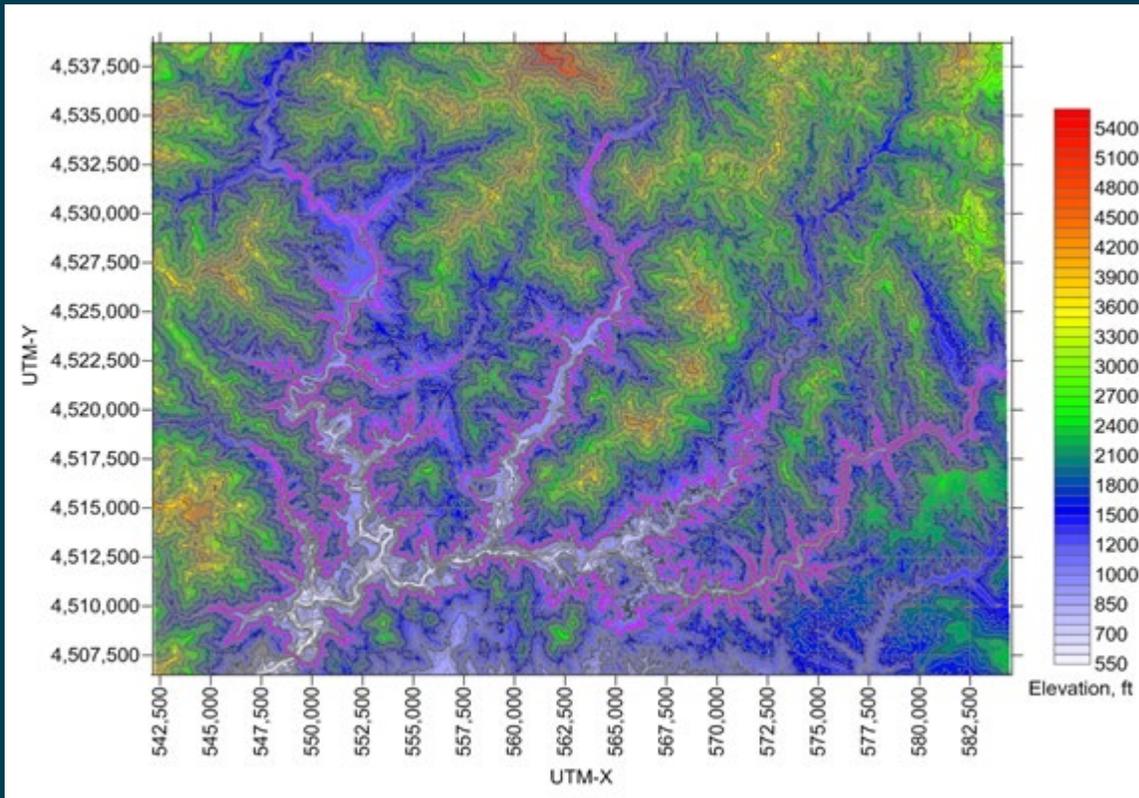
# Geometry

- Reservoirs and River

Reservoir/River	Bathymetry	Stage-Area-Volume	Cross Section	Plan form (x-y)	Gradient
Shasta Lake	X	X	-	-	-
Keswick Reservoir	X	X	-	-	-
Sacramento River	Partial	-	X	X	X
Trinity Lake	X	X	-	-	-
Lewiston Lake	X	X	X	-	-
Trinity River	X	-	X	X	X
Whiskeytown Lake	X	X	-	-	-
Clear Creek	Limited	-	X	X	X
Folsom Lake	X	X	-	-	-
Lake Natoma	X	X	-	-	-
American River	X	-	X	X	X



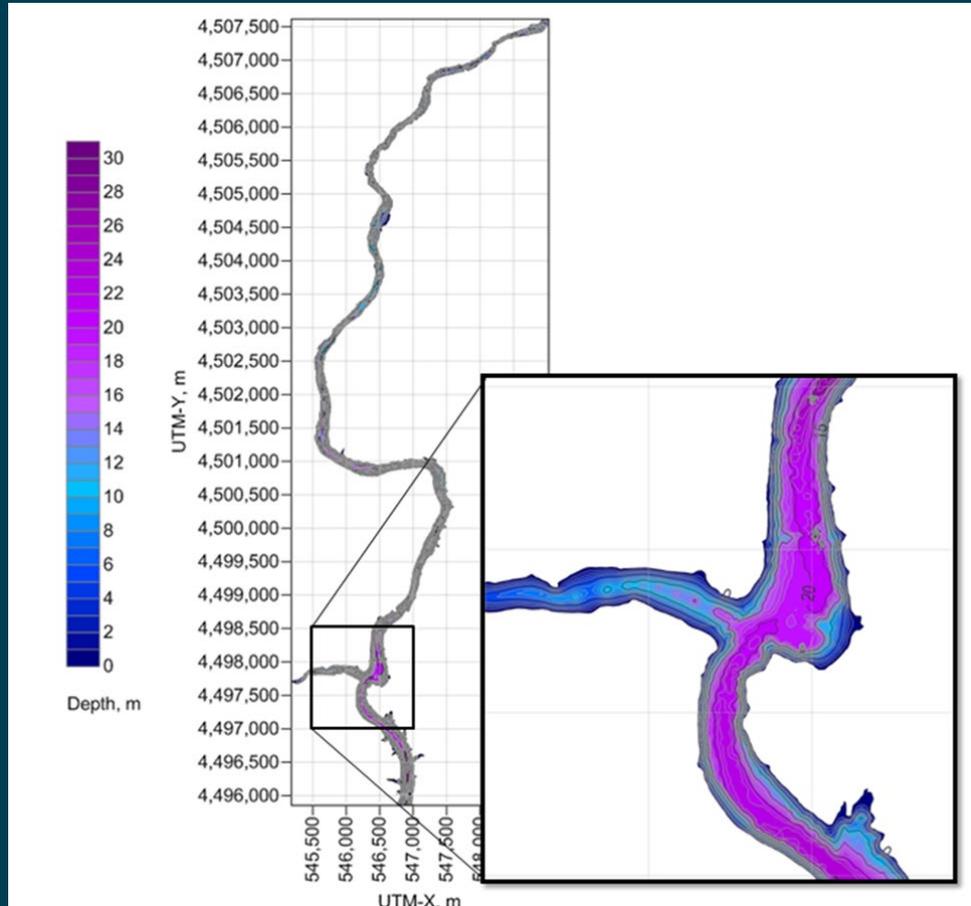
# Shasta Lake Topography and Bathymetry



Title	Source
USGS 1:24,000 – scale digital elevation models (DEM)	USGS
Google Earth (GE)	2014
USGS Historical topographic map	1901



# Keswick Lake Bathymetry

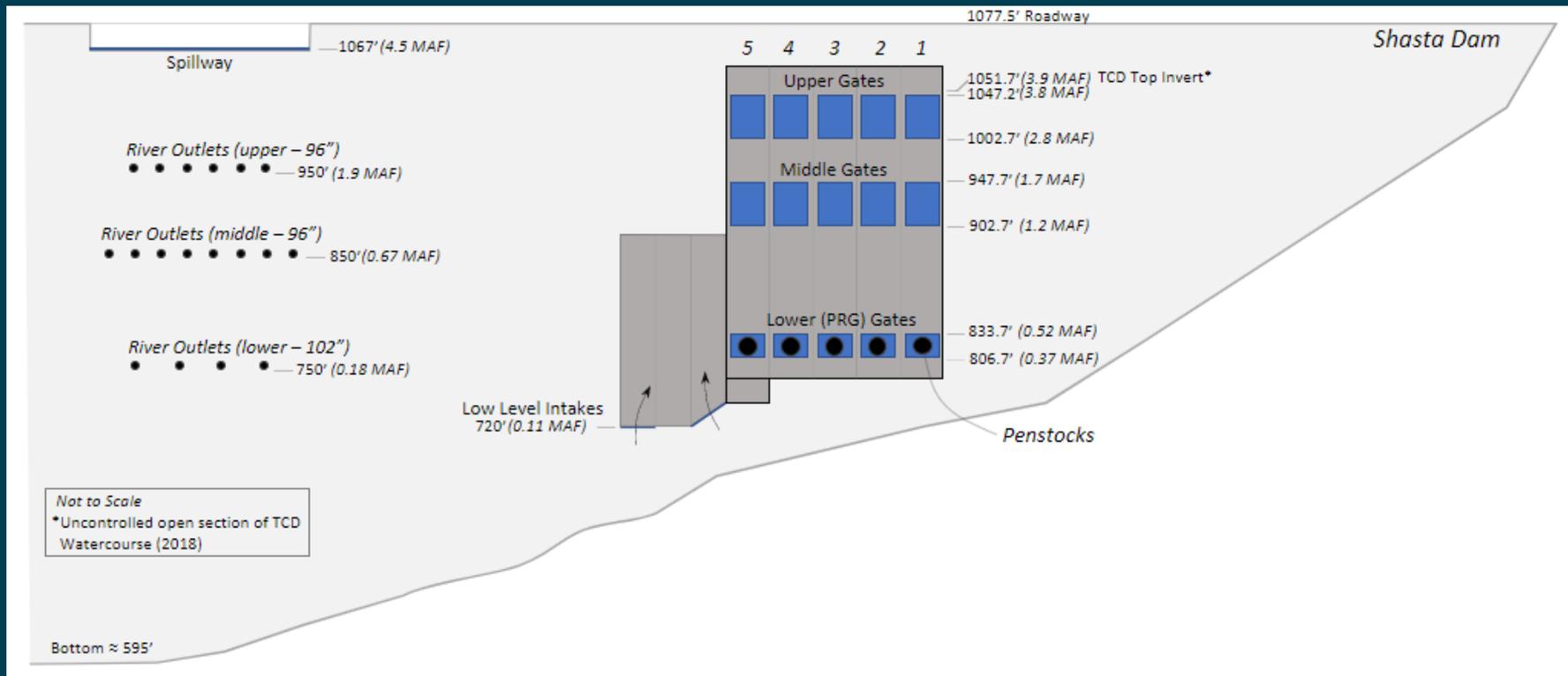


Title	Source
Keswick Reservoir Bathymetry Study	Deas and Sogutlugil 2017



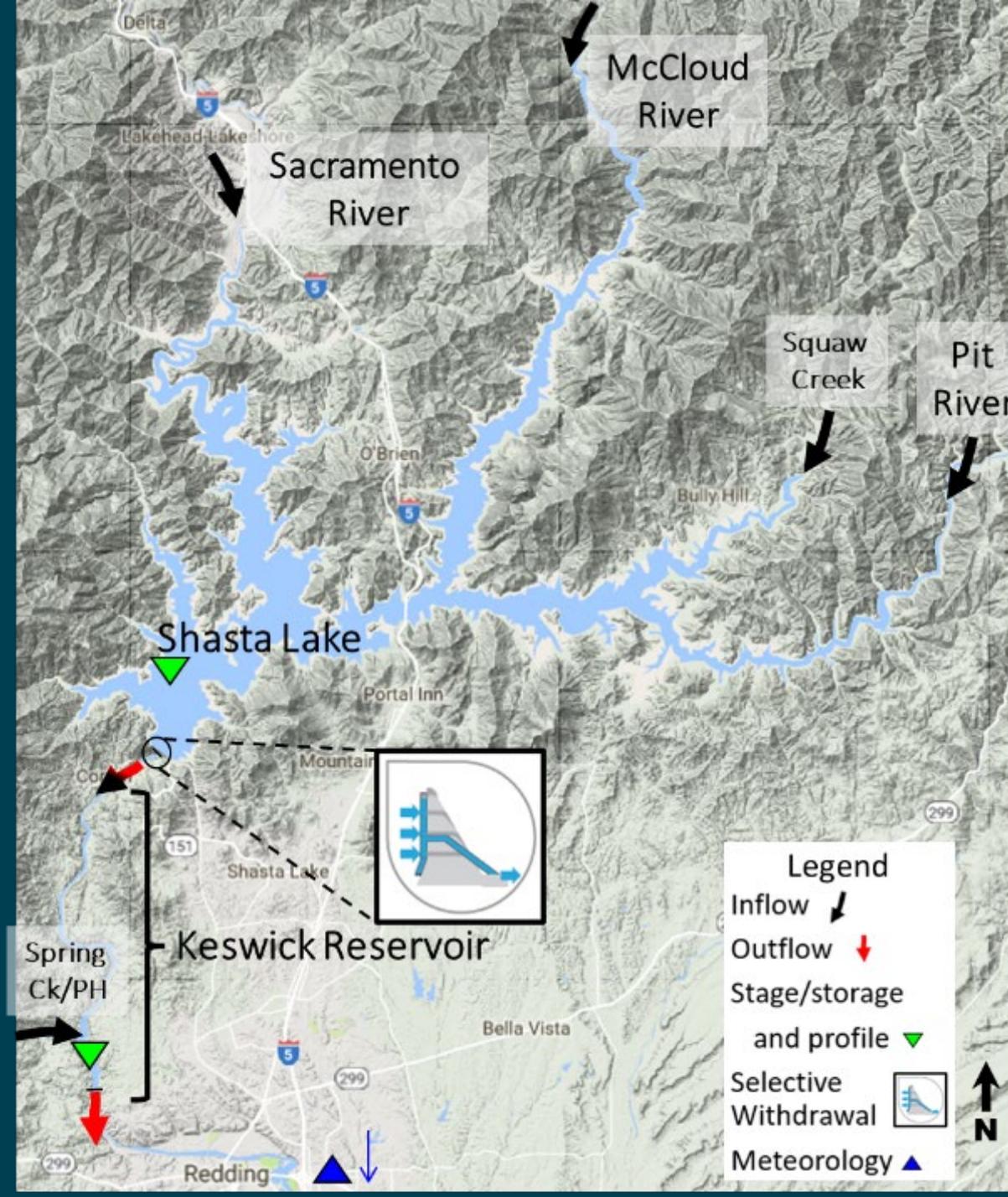
# Shasta Lake Model: CE-QUAL-W2 Representations

- Shasta Dam River Outlets and Spill
- Shasta Dam Temperature Control Device (TCD)



# Hydrology, Temperature, Meteorology Data

- Flow
  - Inflow (hourly, daily) USGS
  - Outflow/operations (hourly) USBR
  - Storage (hourly, daily) USBR
  - Selective withdrawal operations (daily, weekly) USBR
- Water Temperature
  - Inflow (hourly, daily) USGS
  - Outflow (hourly, daily) USBR
  - Temperature profiles (weekly, monthly) USBR
- Meteorology
  - Solar, air temperature, dew point, wind speed/direction, cloud cover, barometric pressure (hourly) NWS



# Hydrology – Sacramento River

- Shasta Lake
  - Inflow
    - Sacramento, McCloud, and Pit rivers
    - Squaw Creek
    - Accretion/depletion
  - Outflow
    - Shasta Dam (spill, river outlets, TCD)
  - Stage
- Keswick Reservoir
  - Inflow
    - Shasta Dam release
    - Spring Creek Powerhouse
    - Spring Creek debris dam
    - Accretion/depletion
- Keswick Reservoir (cont.)
  - Outflow
    - Keswick Dam (spill, river gates)
  - Stage
- Sacramento River
  - Inflow
    - Return flows
    - Tributary inflows
    - Accretion/depletion
  - Outflow
    - Diversion
  - Flow/stage\*

\* Initial condition, boundary condition, and/or calibration data



# Temperature – Sacramento River

- Shasta Lake
  - Inflow Temperature
    - Sacramento, McCloud, and Pit rivers
    - Squaw Creek
    - Accretion/depletion
  - Outflow Temperature\*
    - Shasta Dam (tailbay)
  - Vertical Temperature Profiles\*
- Keswick Reservoir
  - Inflow Temperature
    - Shasta Dam release
    - Spring Creek Powerhouse
    - Spring Creek debris dam
    - Accretion/depletion
- Keswick Reservoir (cont.)
  - Outflow Temperature\*
    - Keswick Dam (tailbay)
  - Vertical Temperature Profiles\*
- Sacramento River
  - Inflow Temperature
    - Return flows
    - Tributary inflows
    - Accretion/depletion
  - Stream Temperature \*

\* Initial condition and/or calibration data



# Meteorology

- Sacramento River System
  - Redding Airport
- Clear Creek System
  - Redding Airport
- Trinity River System
  - Trinity Lake and Lewiston Lake: Trinity Camp (A)
  - Trinity River: Trinity Camp (B)
- Development goal: best long-term record from local, representative stations



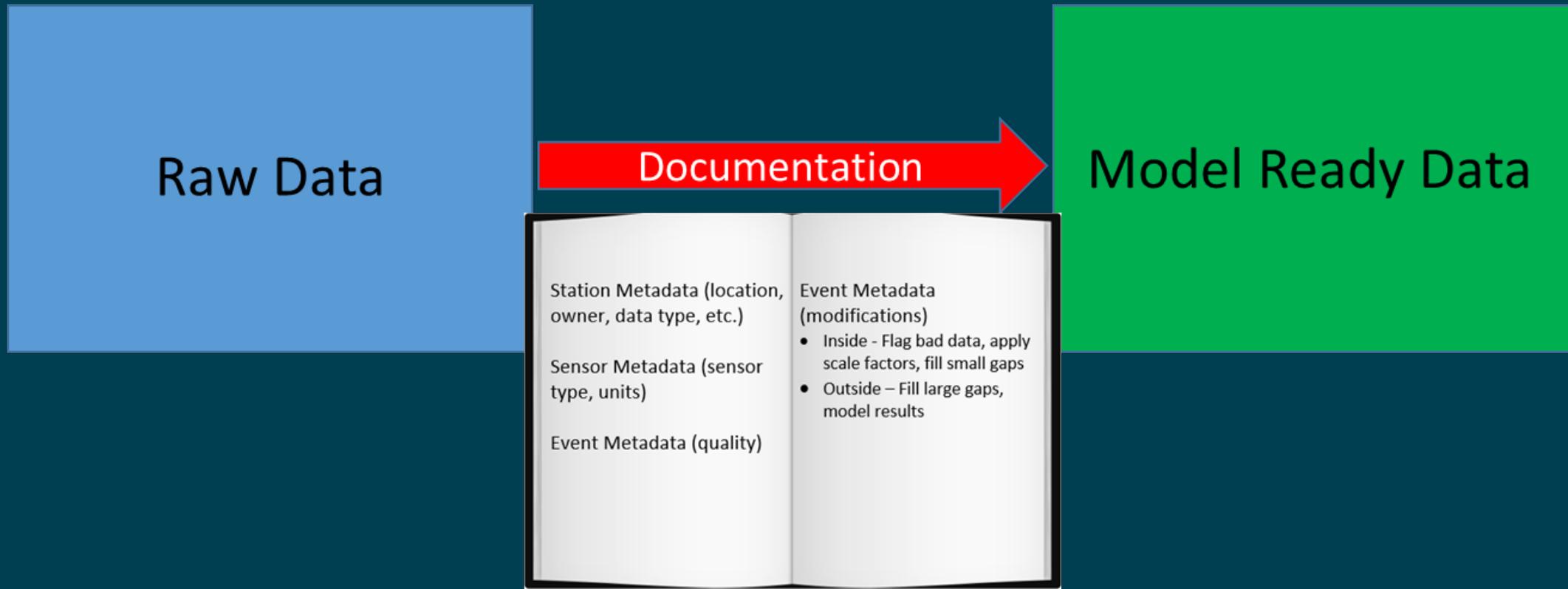
# Metadata

- Station Metadata (location, owner, data type, etc.)
- Sensor Metadata (sensor type, units)
- Event Metadata (quality, source)
- Event Metadata (modifications)
  - Internal - Flag bad data, unit conversion, time steps, fill small gaps
  - External – Fill large gaps, model results
- Documenting lack of meta data, particularly in older data



# Metadata –Model Ready Data

The goal of data processing is not only to produce "Model Ready Data", but to track changes to and maintain a connection to raw data by using metadata applied at the appropriate place in the DMS.



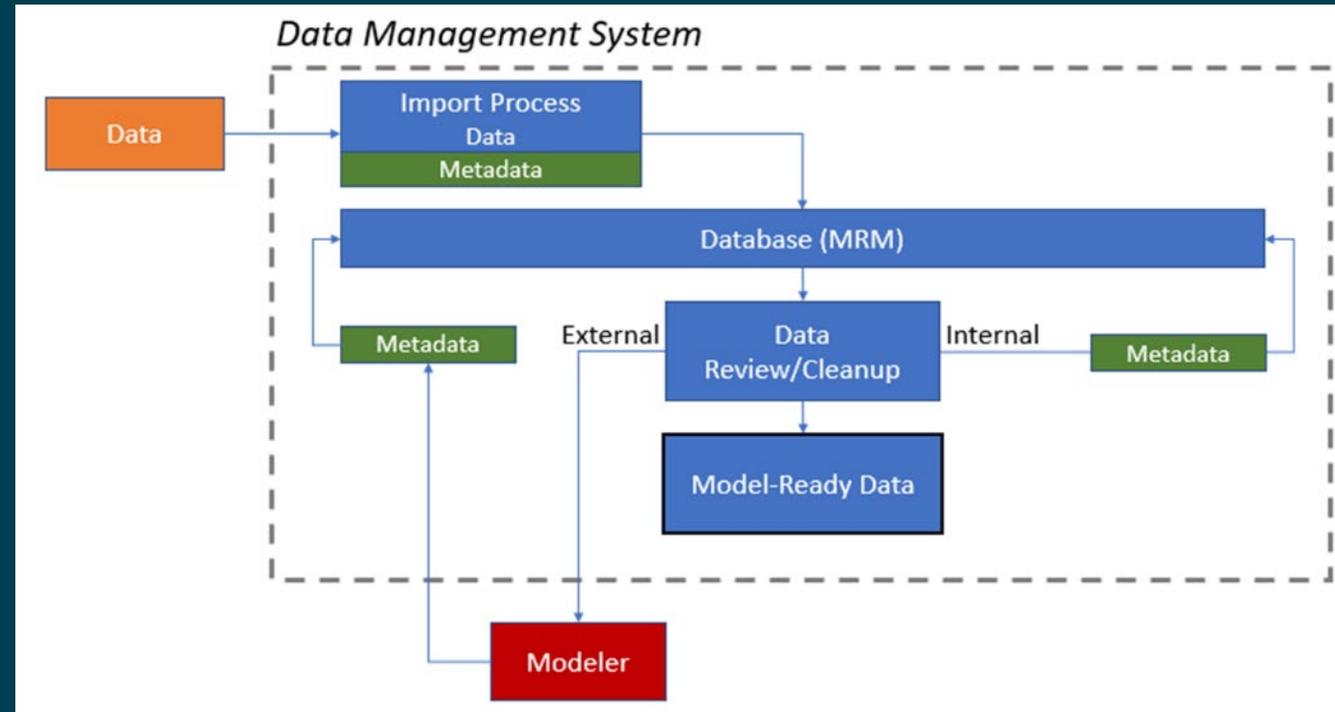
# Data Processing

- Filter to allow/not-allow provisional data
- Apply scale factor and offset (e.g., change units)
- Flag data that falls out of acceptable range
- Fill gaps
- Normalize time steps
- Retain raw data



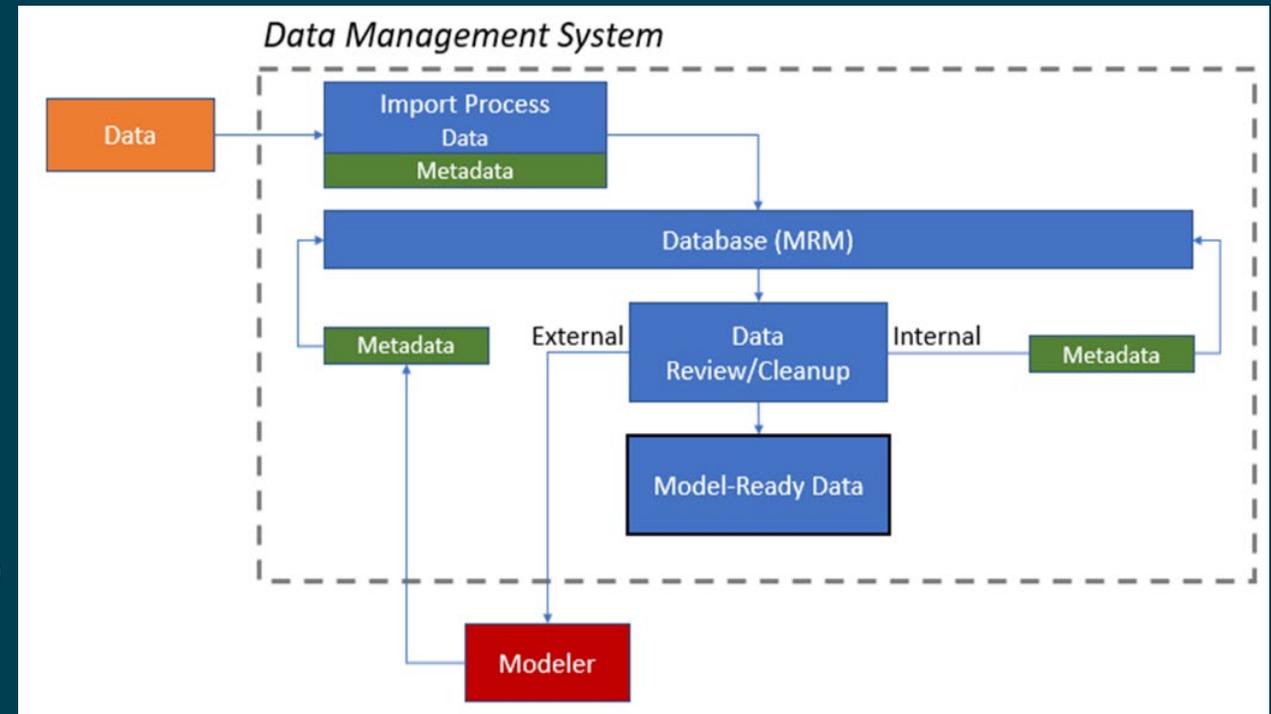
# Data Gap Filling

- Geometry
  - Case-by-case
- Time Series
  - Hourly, daily, weekly, monthly, longer
  - Short or stable data – automatic
  - Longer or complex data – “modeler”
- Short
  - Linear interpolation
  - Previous day(s)
  - Neighboring station
  - Constant



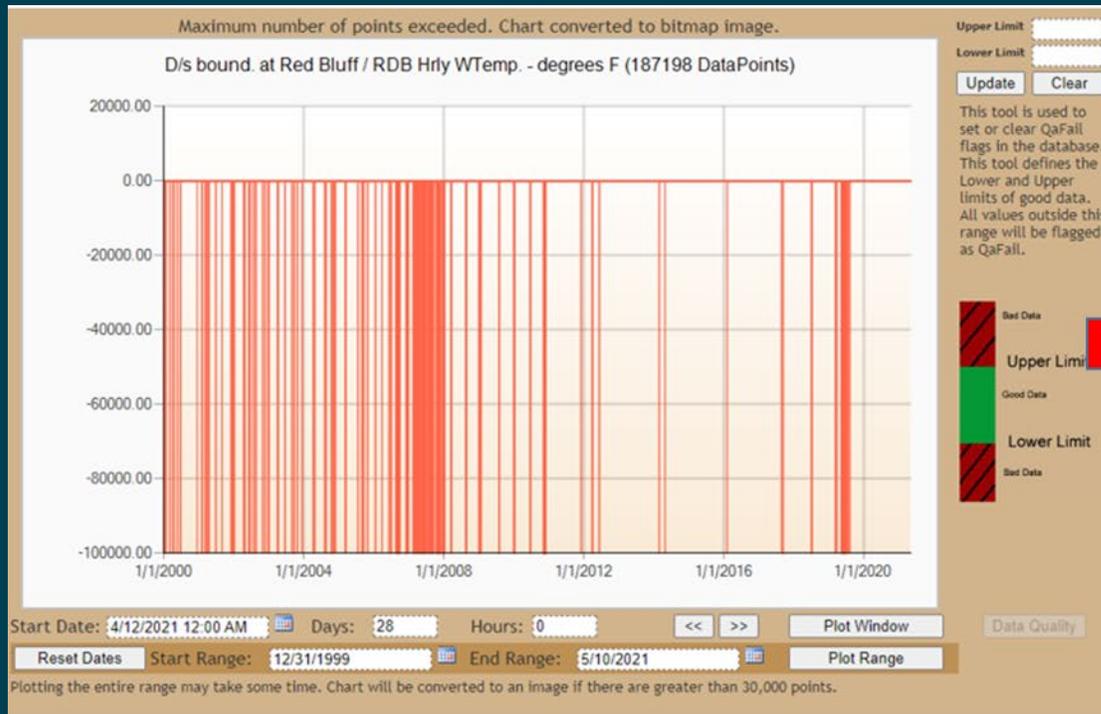
# Data Gap Filling

- Long
  - Linear interpolation
  - Statistical assessment
  - Neighboring station
  - Long-Term average
  - Modeled value
    - Regression
    - Equilibrium Temperature Model
    - Other (e.g., Singular Spectrum Analysis)
- Documentation/metadata
- Completed by technician or modeler

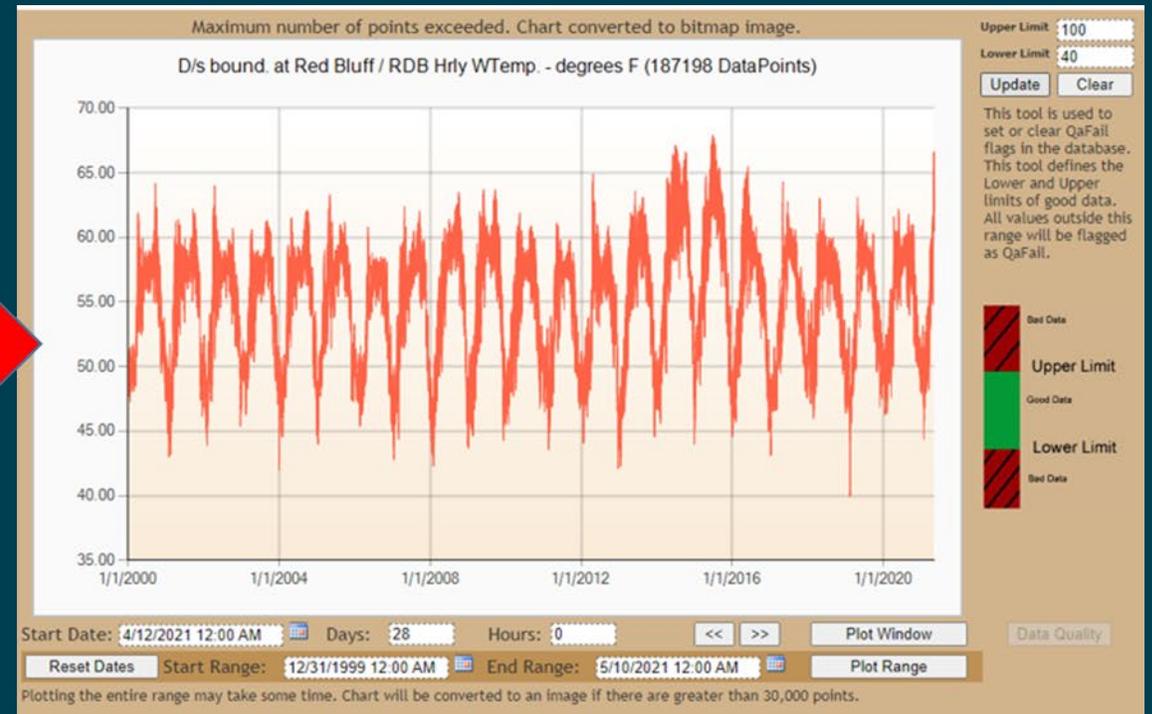


# Data Processing: QA/QC

The import process can apply linear thresholds to flag data which is outside normal operating limits in order to improve visualization and speed up the process of producing model ready data.



QA/QC



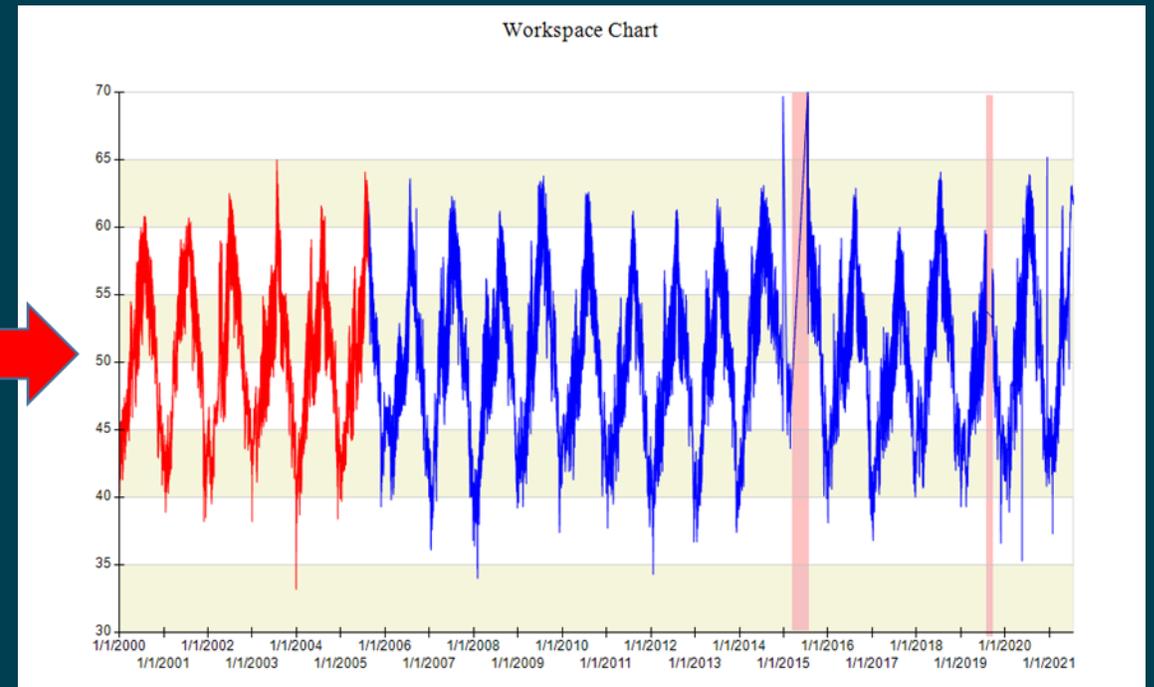
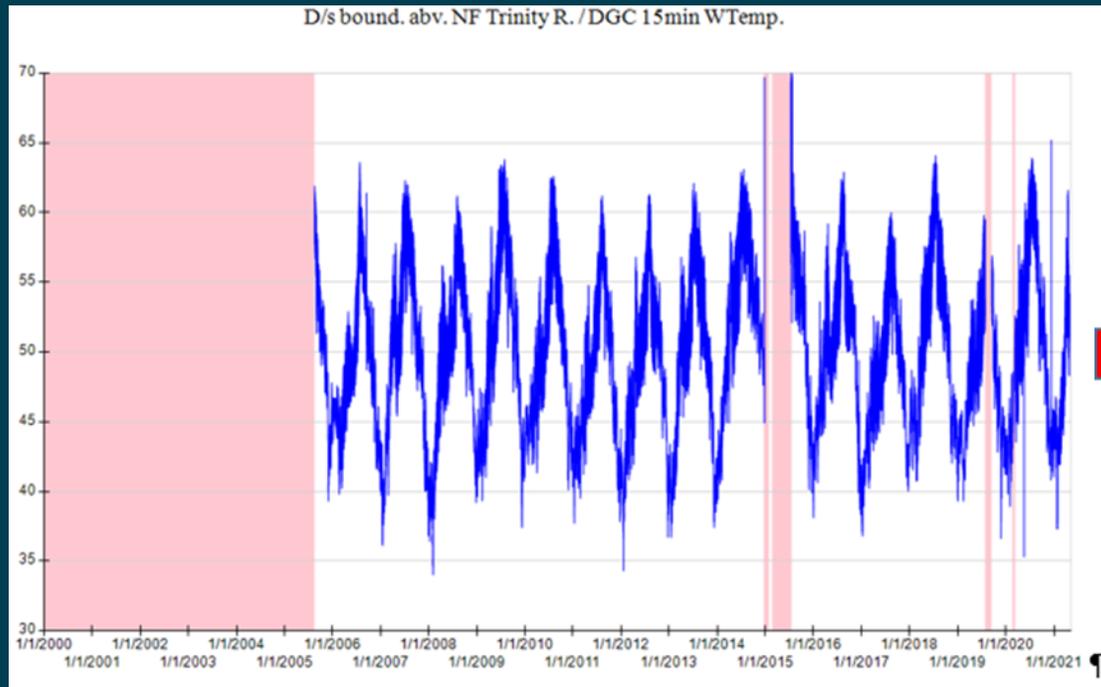
# Data Processing: Fill Gaps

Gap filling may be completed inside or outside the DMS depending on size of gap and complexity of model required to adequately represent the physical process.

Minor gap filling (e.g., PDT to PST)

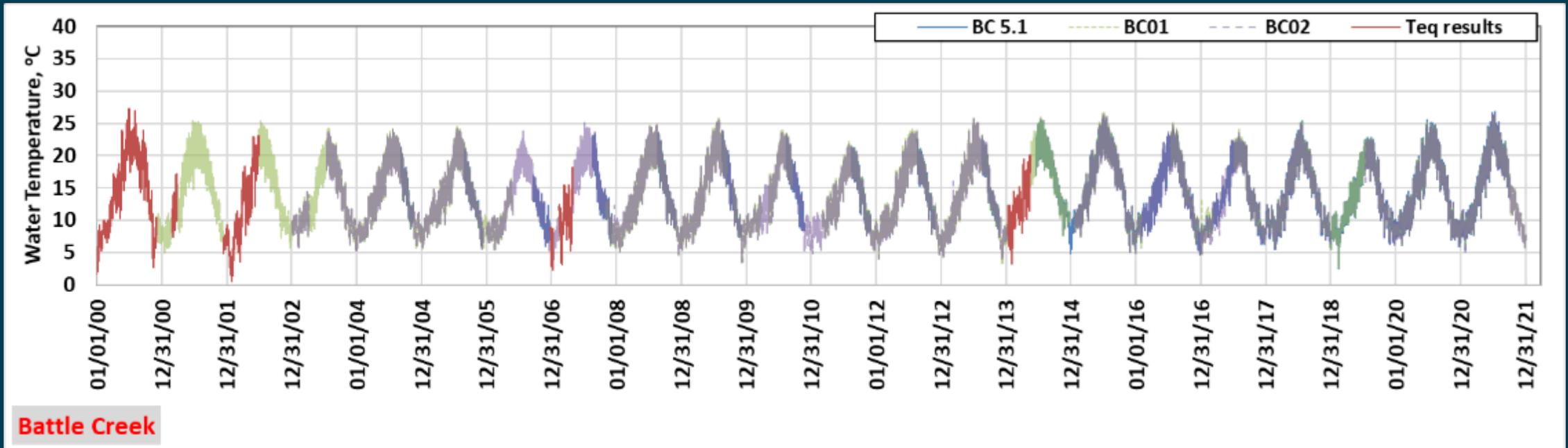
Major gap filling (Modeler)

The DMS includes tools for rapid identification and display of data gaps



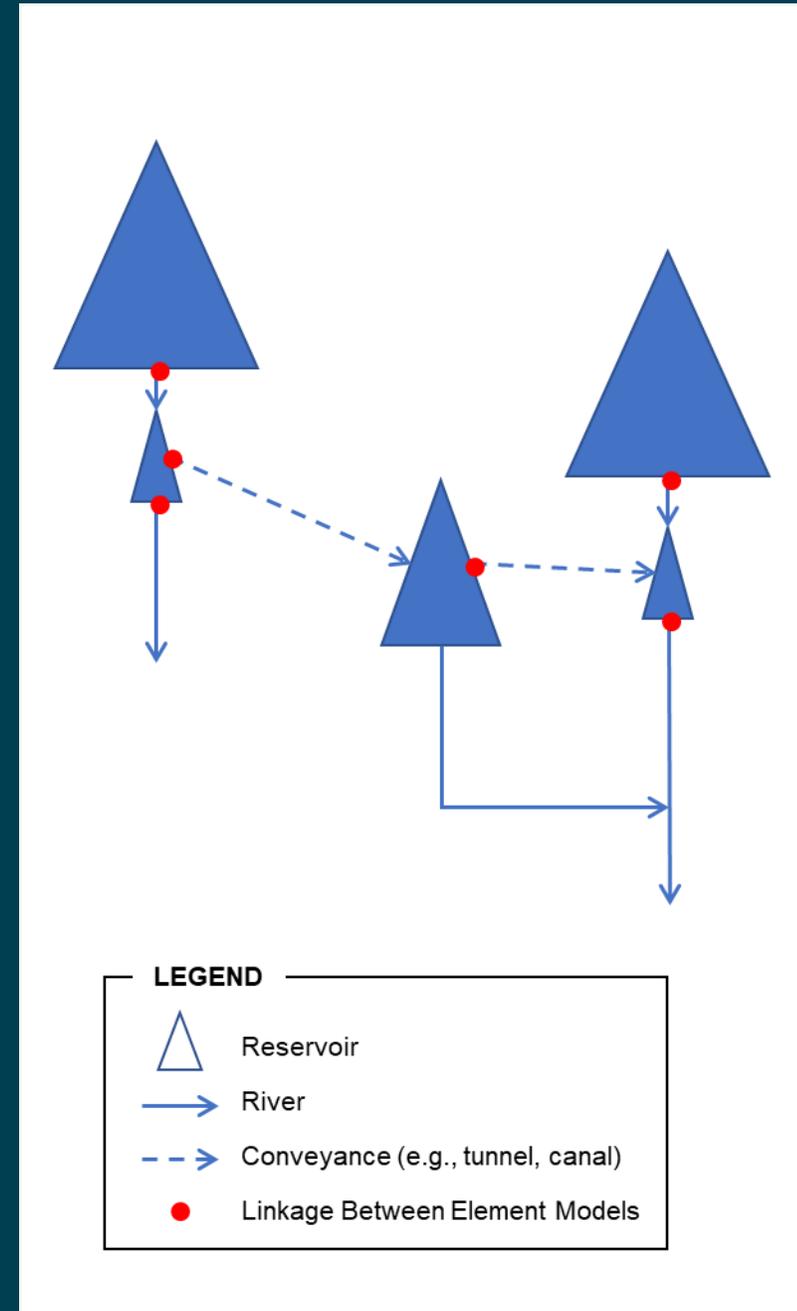
# Modeled Value

- Water Temperatures: Equilibrium Temperature (flow and meteorology)



# Modeled Value

- Modeled Value
  - Upstream model (Trinity outflow)
  - Other
    - Singular spectrum analysis
- Pros and cons
  - Testing to assess as appropriate



# Data Development Summary

- Collected and modified data as necessary: all data met quality thresholds for modeling use, per documentation
- Data Quality:
  - Most data streams have robust QA/QC protocols
  - Model Ready data represents 172 input data sets (years 2000 – 2021)
  - Gap filling represents 19 of the 172 input data sets
  - All data sets have been assessed and accepted as suitable for modeling purposes

