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Managing Water in the West

Modeling Surface Water – Groundwater Interaction on the Trinity River

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River Restoration Northwest

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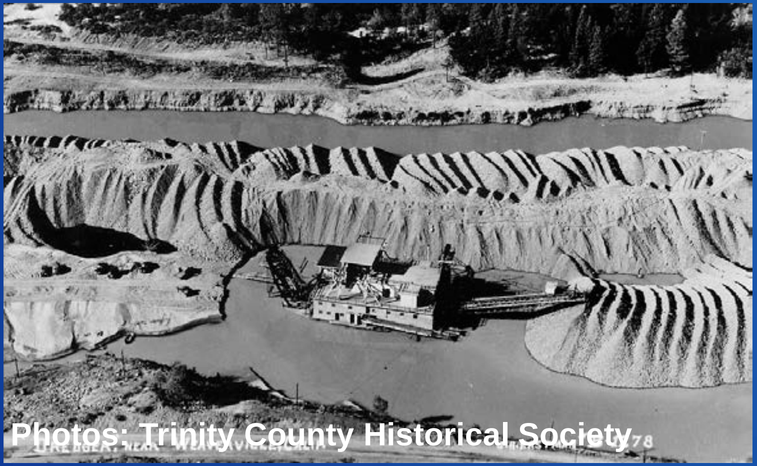
The Trinity River, Northern California

Industrial gold mining (1860s – 1930s)



Photos: Trinity County Historical Society

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Trinity and Lewiston Dams
completed in 1964, part of the Central Valley Project

70 – 90% of the inflow to Trinity Lake diverted to the CVP from 1964 to 2000

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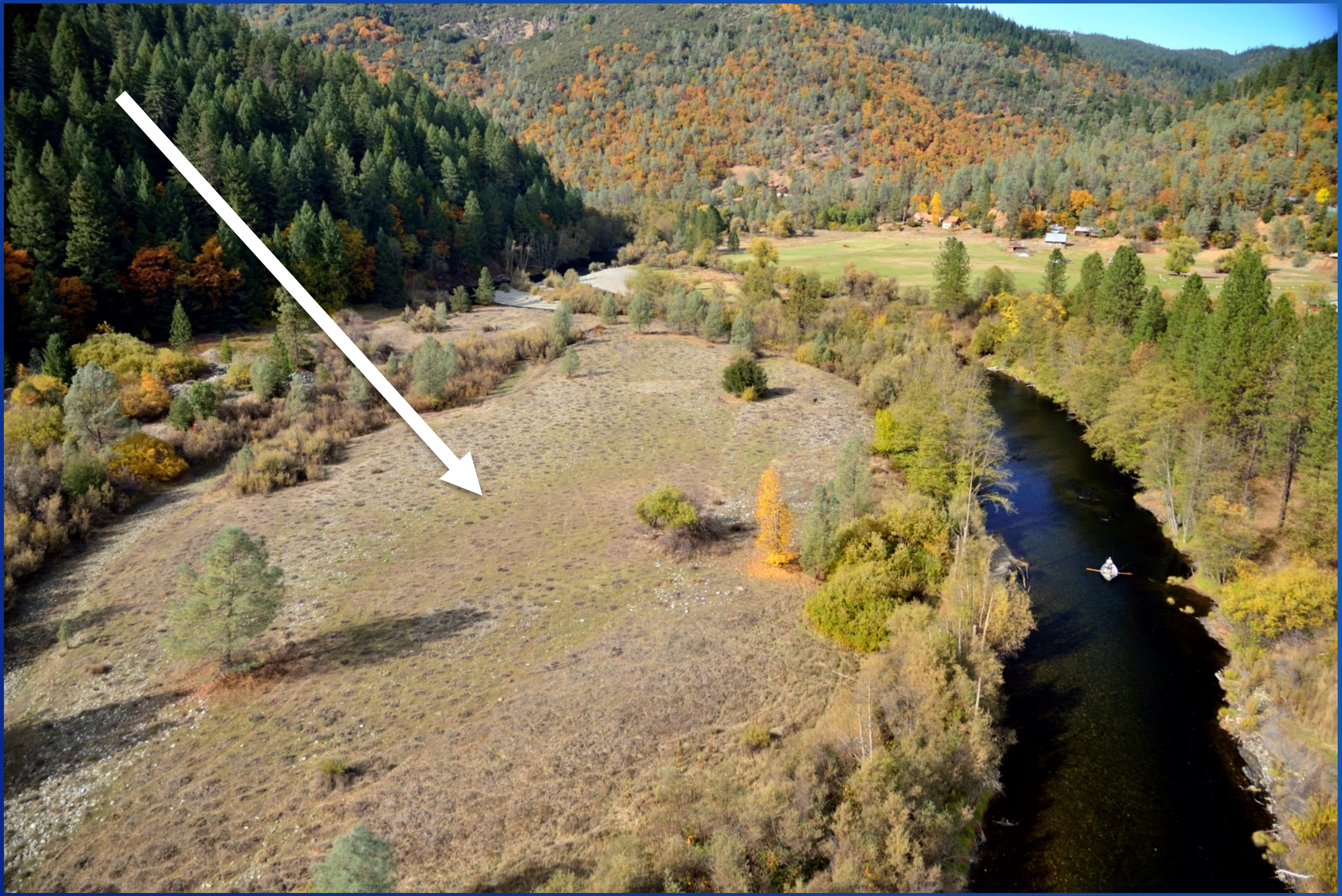
Barren Surfaces Should Be Riparian Forest



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Dead Cottonwood Seedlings

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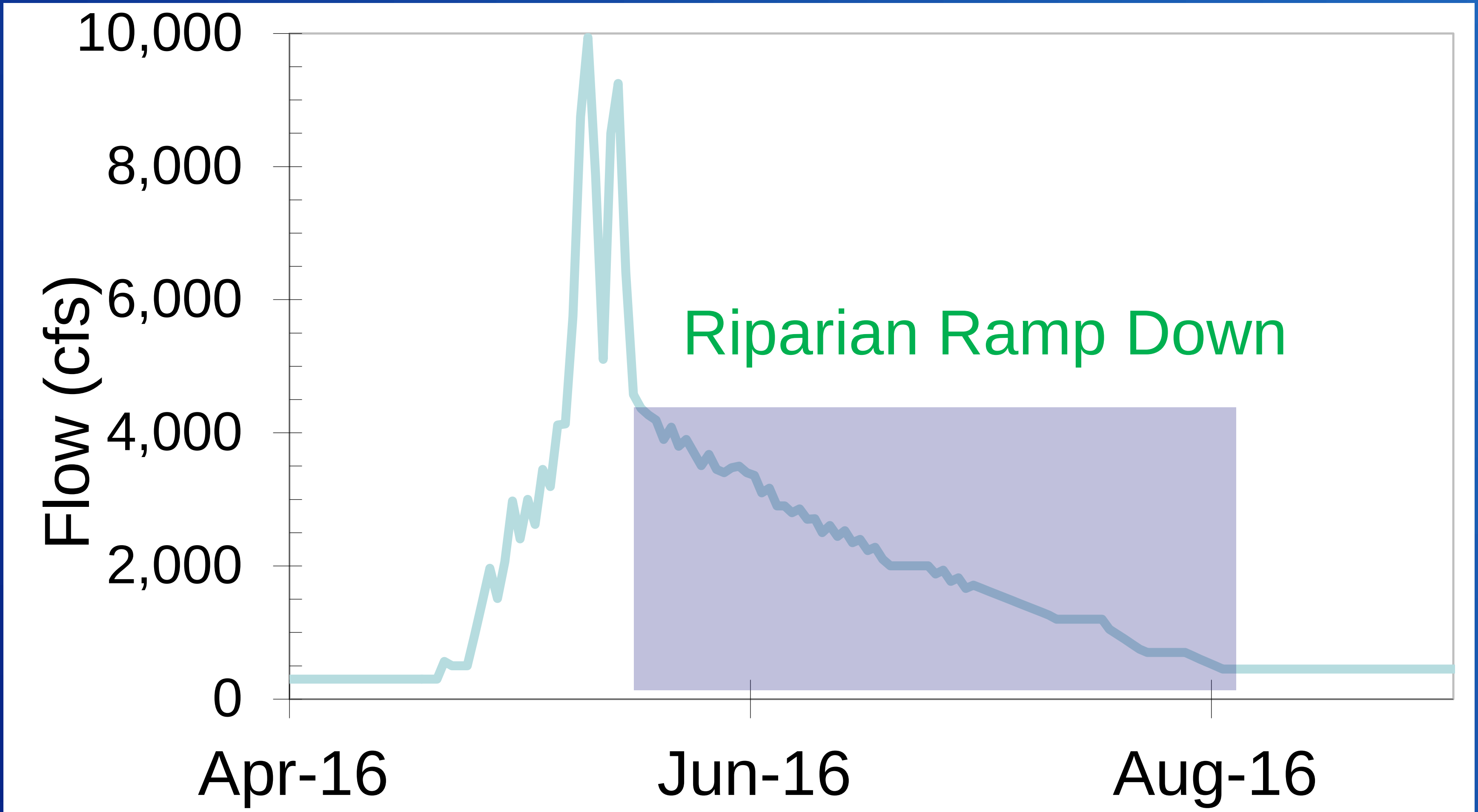
Environmental Flow Releases



Constructed Off-Channel Wetlands

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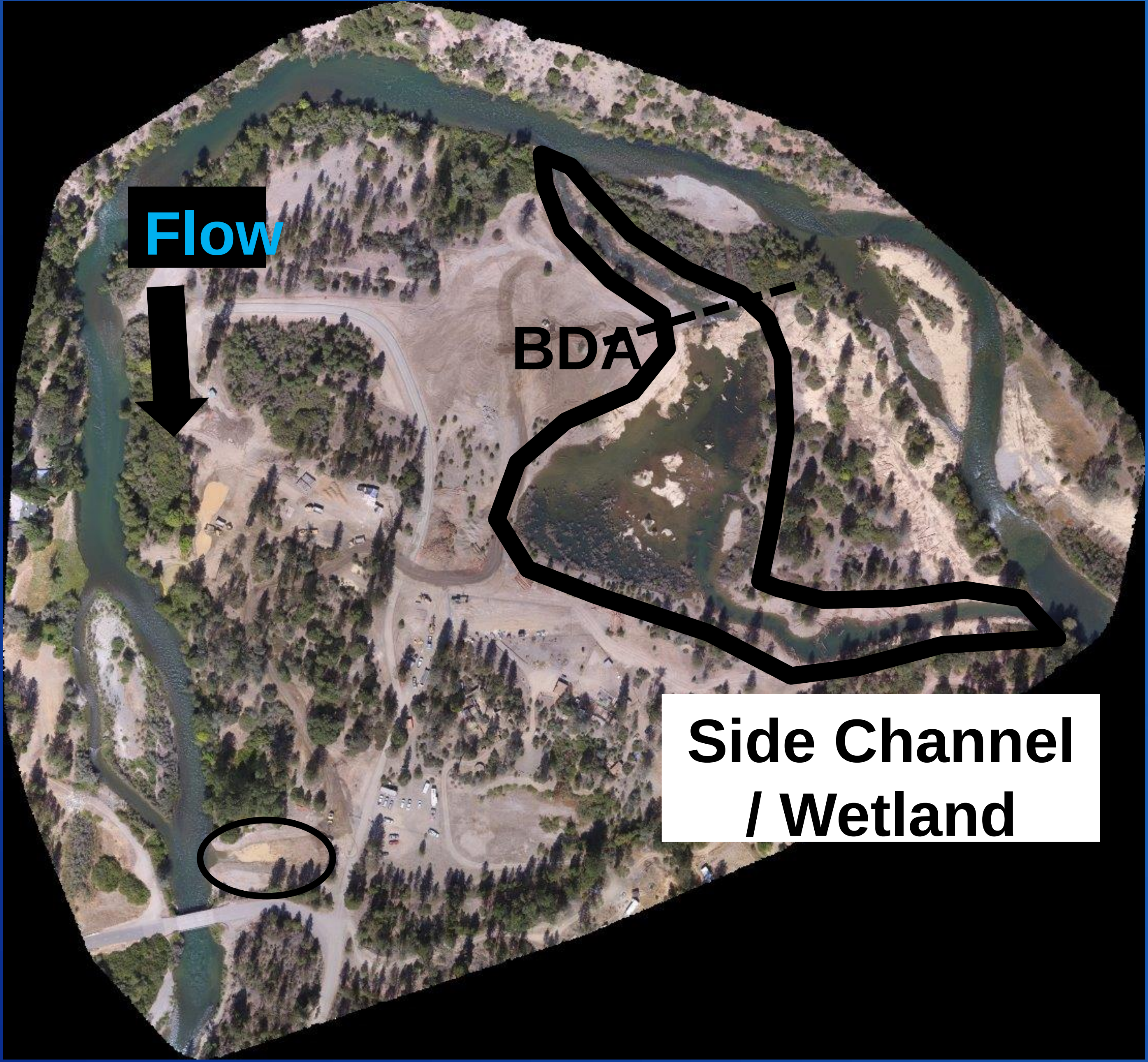
Constructed wetlands can have unexpected benefits



Bucktail Groundwater Seep

Salmon Jumping Beaver Dam Analog

Immediate Beaver Use

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Sedimentation and River Hydraulics Model (SRH-2D)

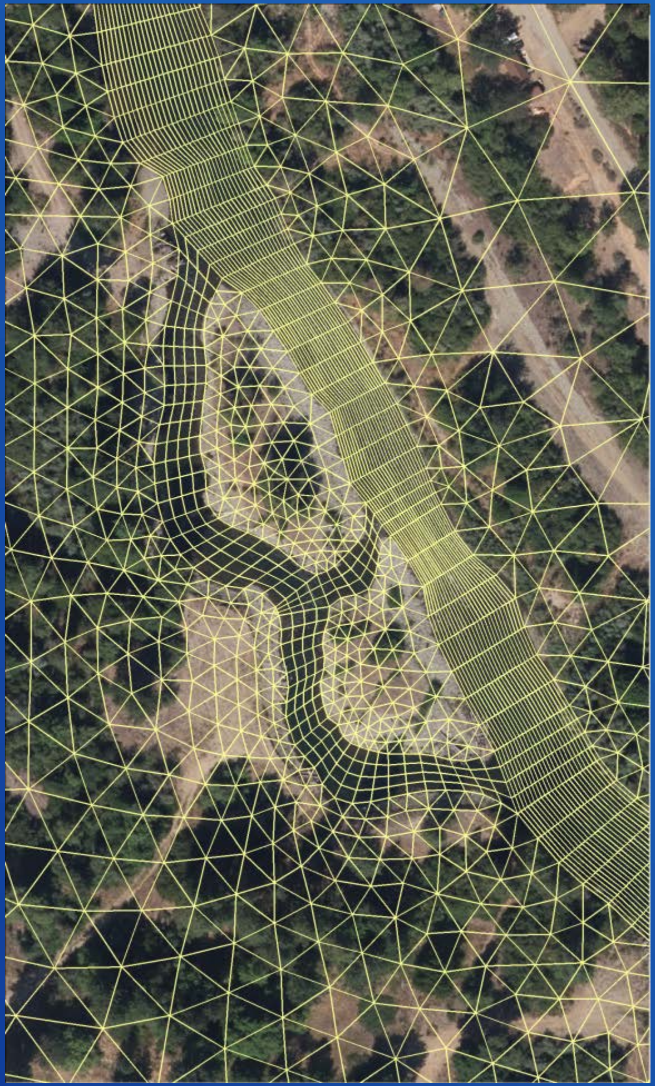
Solves the depth-averaged Navier-Stokes equations

(aka St. Venant equations)

Model mesh represents terrain

Boundary conditions:
Inlet flux, outlet WSE

Tune roughness to adjust water surface elevation to match observations



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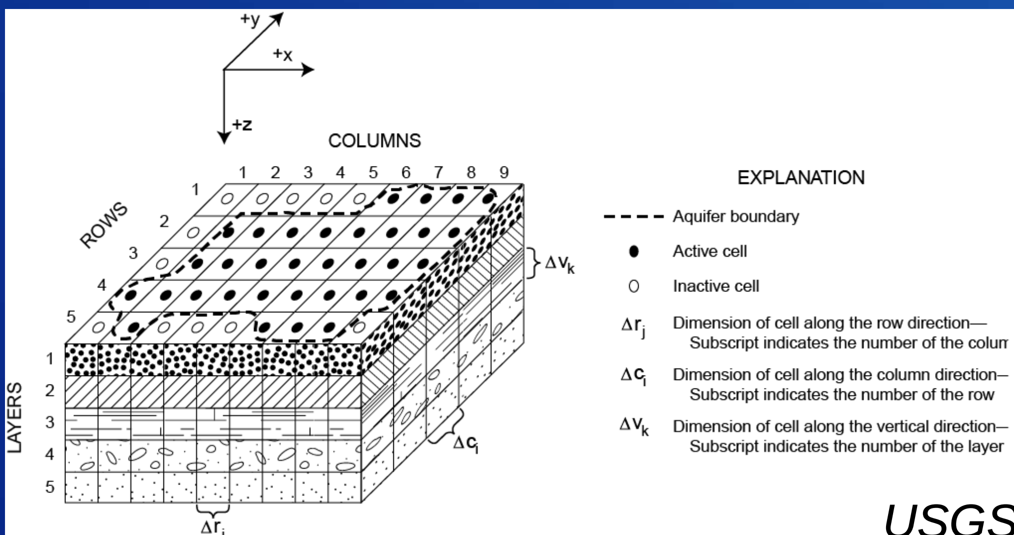
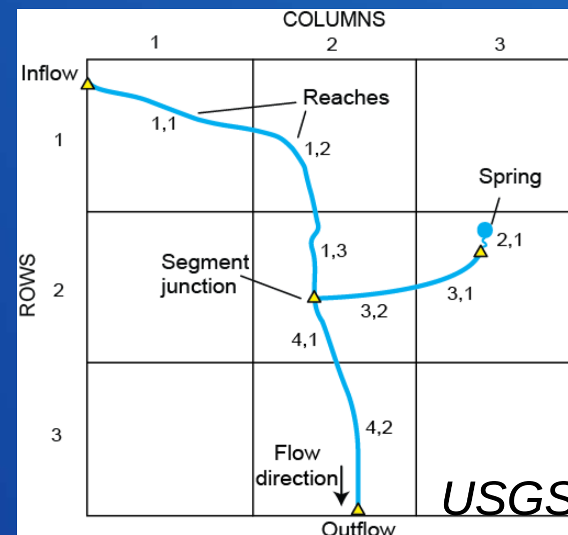
MODFLOW

USGS 3D finite difference ground water flow model



MODFLOW NWT – Newton-Rhapson formulation MODFLOW-2005

Surface water routed in 1D



River (RIV) or Streamflow Routing (SFR) packages

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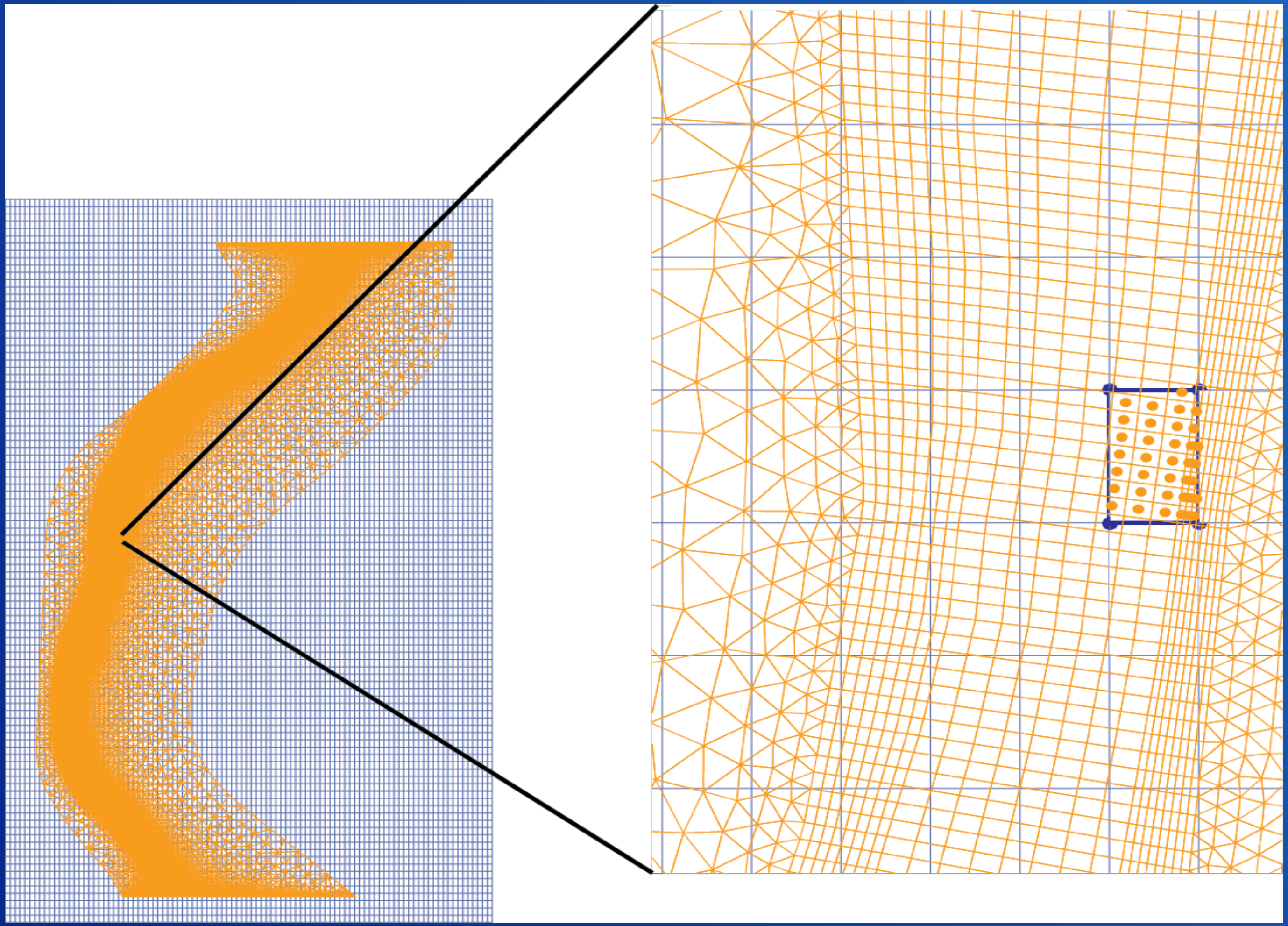
MODFLOW Grid and SRH Mesh



Flow to Stream Cell *m*

Aquifer head above bed

$$Q_m = -\frac{K_m A_m (WSE_m - H_{ij})}{\Delta Z_i}$$

Aquifer head below bed

$$Q_m = -\frac{K_m A_m (WSE_m - BedZ_i)}{\Delta Z_i}$$

Negative flux indicates water loss from the stream

Flow to Aquifer Cell *ij*

$$Q_{ij} = \sum_{m=1}^{N} -Q_m$$

K_m Hydraulic conductivity of the stream bed $\left(\frac{L}{T}\right)$

A_m Area of cell (L^2)

H_{ij} Aquifer head (L)

ΔZ_i Bed thickness (L)

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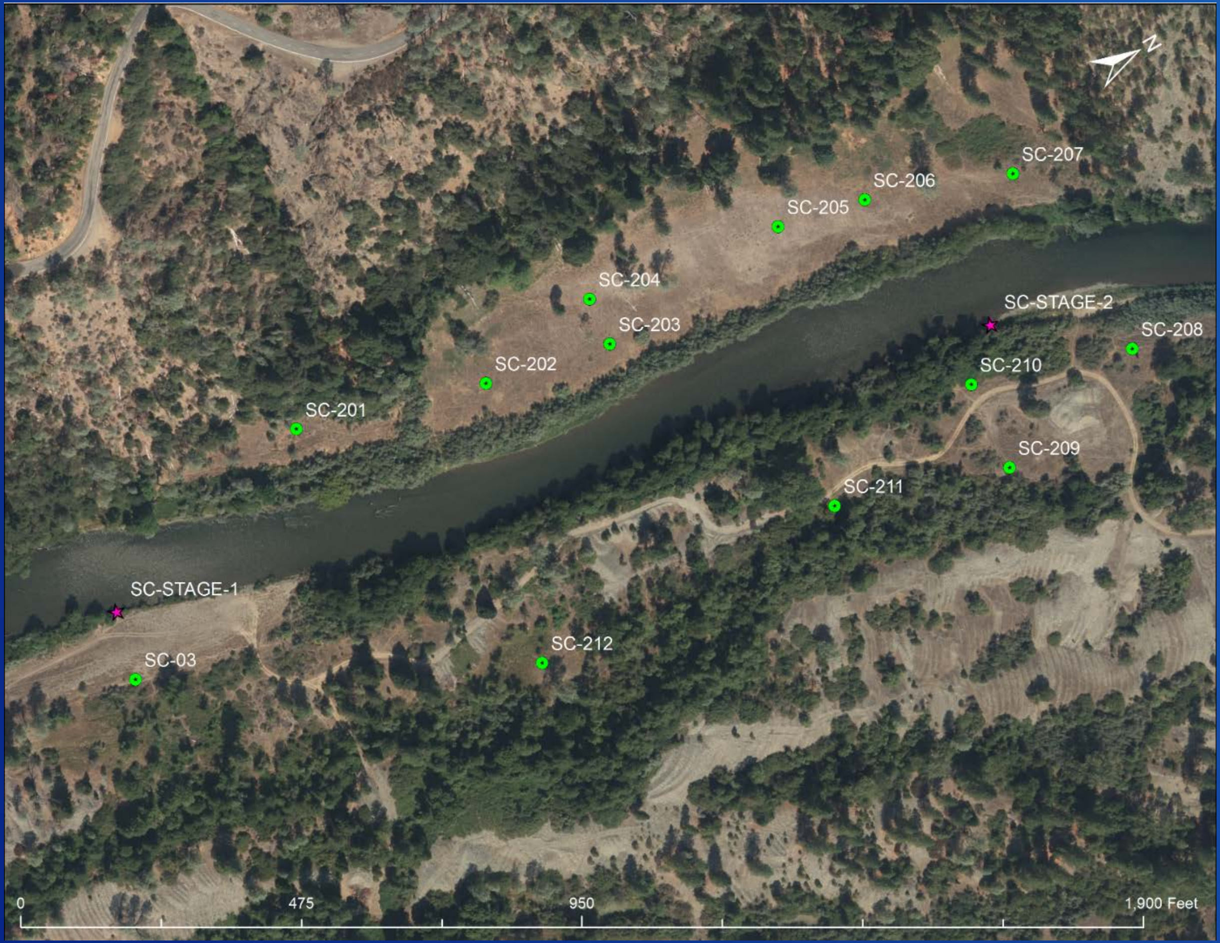
Sheridan Creek Site



13 Observation Wells

~2000 ft long

Pressure loggers recorded stage during 2016 high flow

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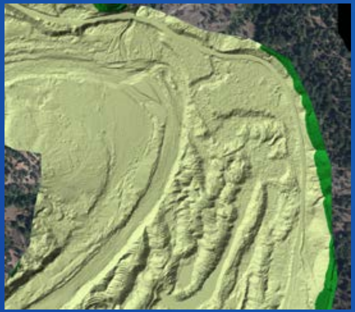
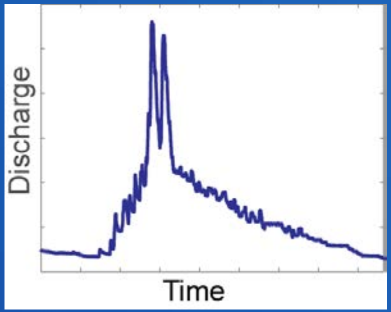
Surface Water Model

Topography from airborne LiDAR and sonar bathymetry



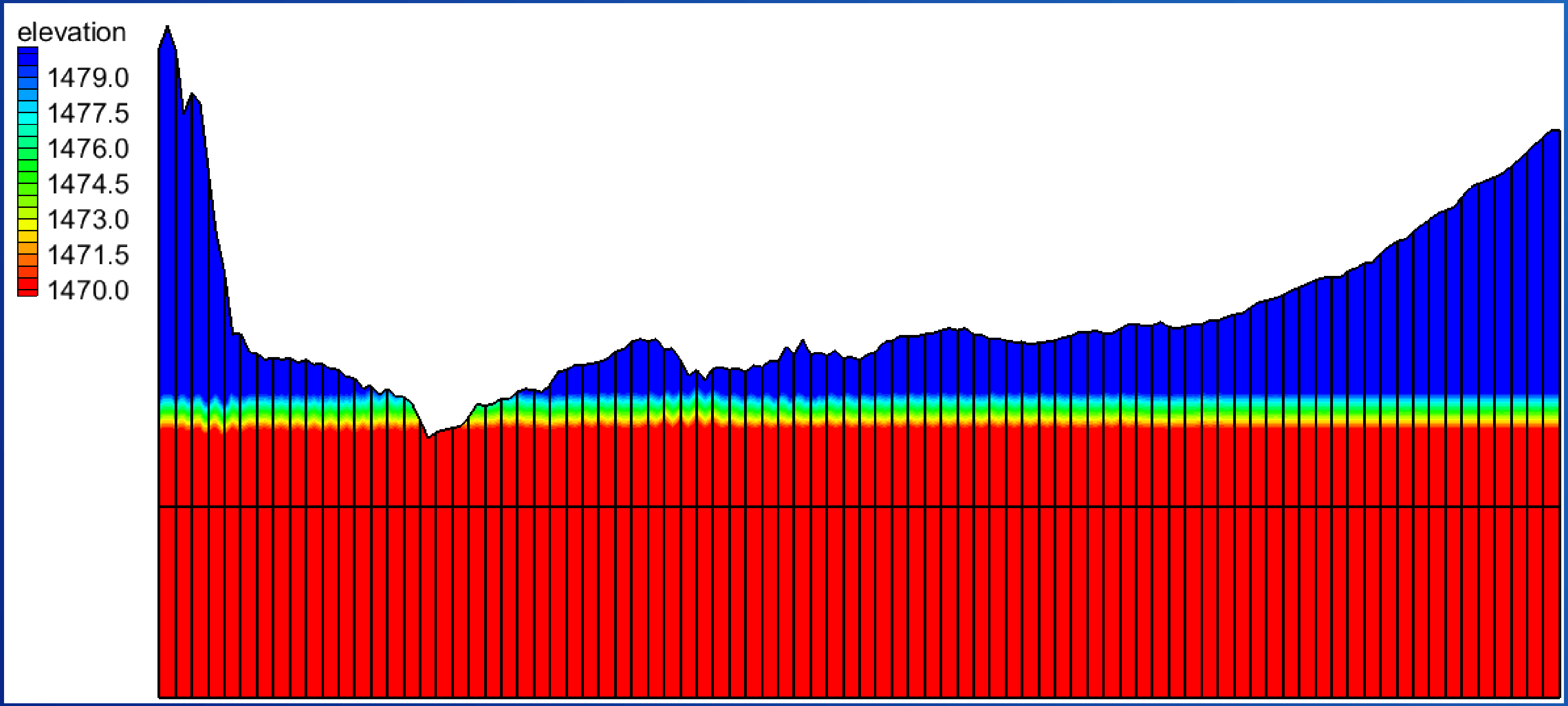


Flow based on downstream gage

Flow resistance estimated from observations of D84

Outlet WSE extracted from a larger Trinity model

Sheridan MODFLOW Model



Two layer, alluvium on bedrock model. Spatially uniform hydraulic properties in each layer.

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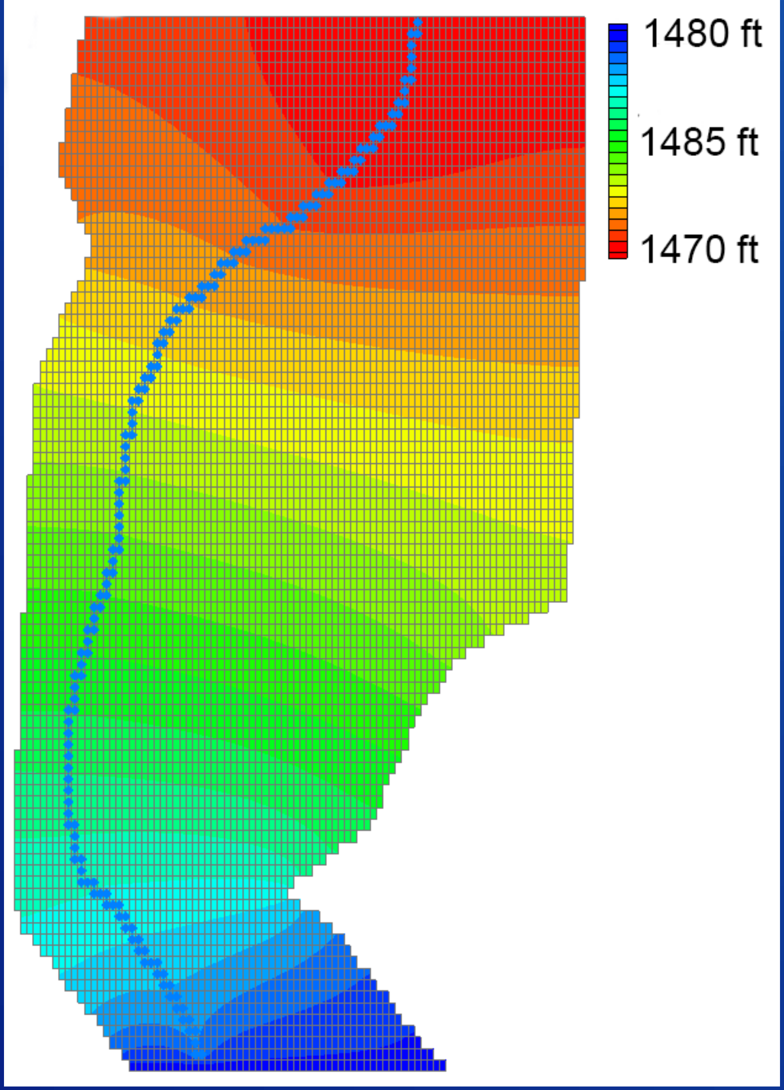
Sheridan MODFLOW Model



Downstream General Head Boundary (GHB)

Upstream variable head boundary (CHD) tracks observed water surface elevation

Starting head driven by SFR

Sides are no-flow boundaries

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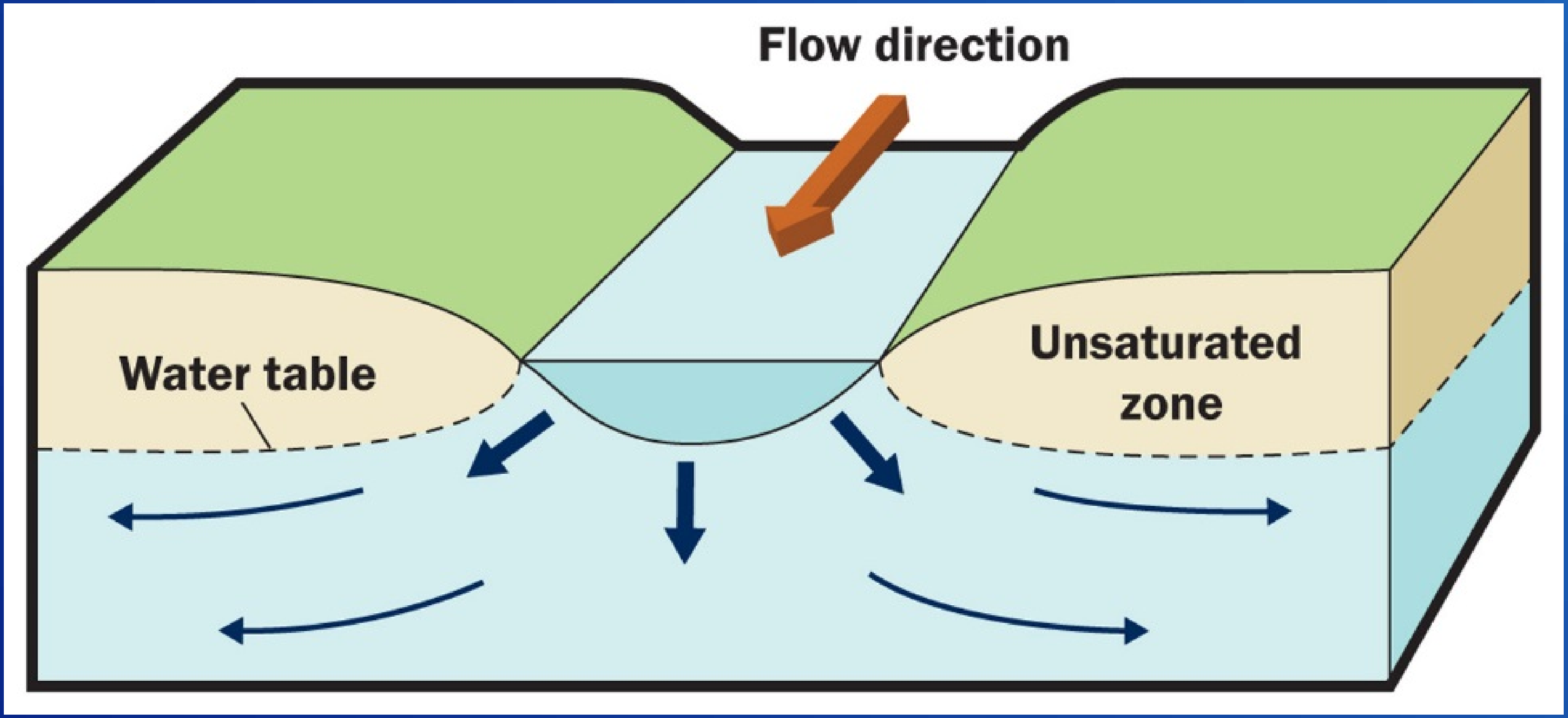
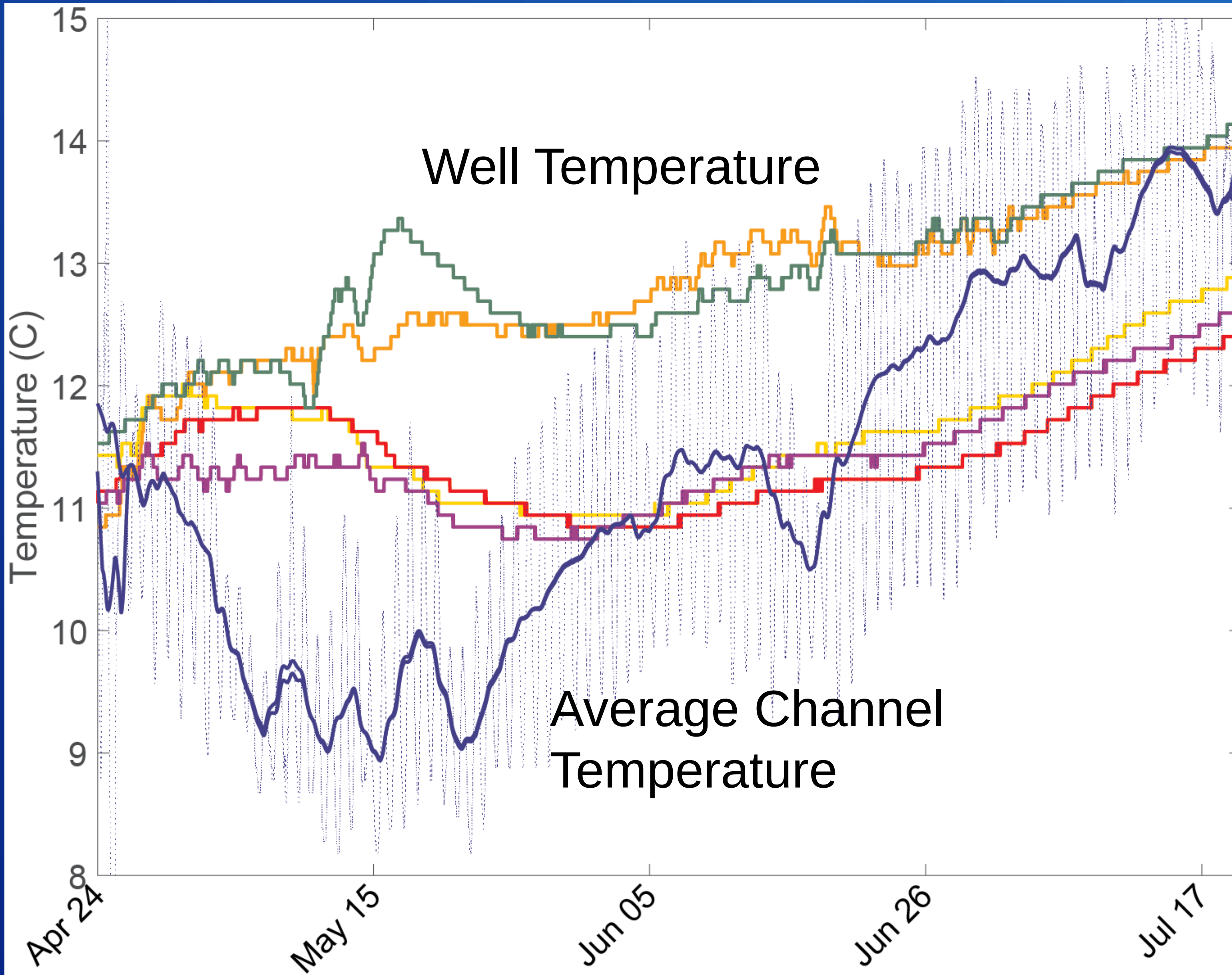
Current Status

- Observations of well water levels indicate that the aquifer responds rapidly to changes in river stage.
- Very high river bed hydraulic conductivity is need to mimic the observed response in a 1D model
- Similar rates of water exchange in the 2D coupled model cause numerical instability. Expected to be resolved in the coming weeks.

Conceptual Models of Interaction





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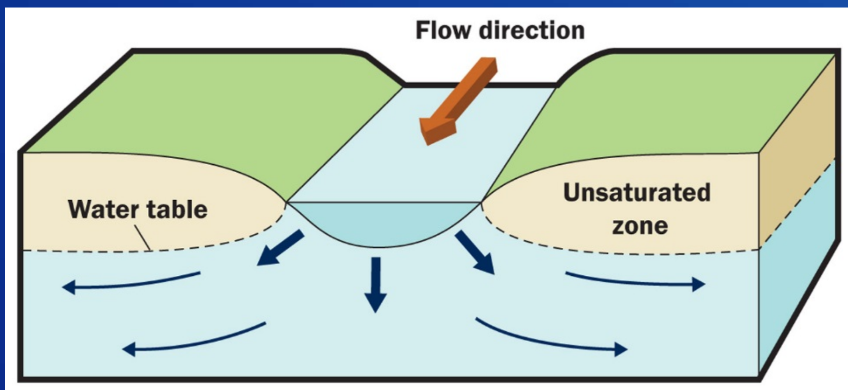
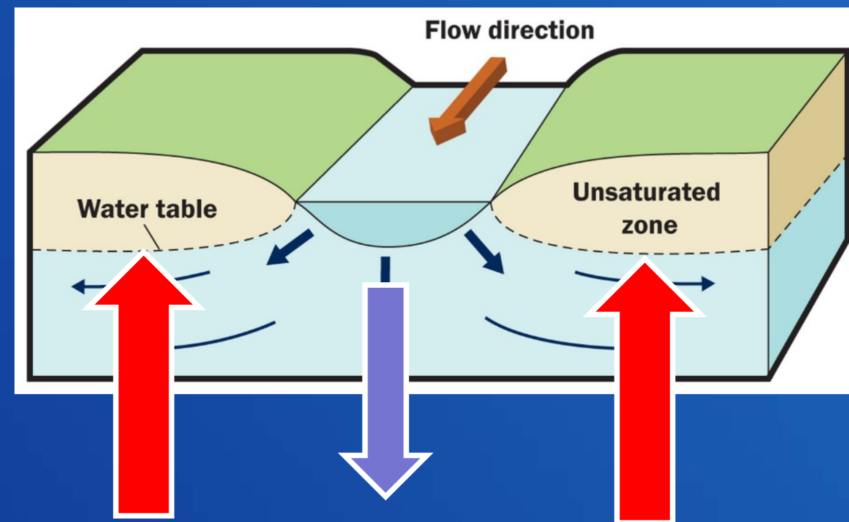
Conceptual Models of Interaction





The groundwater flow model should be able to show which concept is correct

Summary

- Riparian habitat restoration can be improved with a better understanding of groundwater response to river flow.
- USBR is coupling SRH-2D to MODFLOW to improve the design of environmental flows (the trailing limb of the hydrograph)
- The model can improve our intuition about groundwater flow paths and understanding of thermal regime and nutrient exchange.

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