COASTAL & HYDRAULICS LABORATORY

ERDC
Engineer Research and Development Center

Distributed Hydrologic Model Simulations for Forecasting Stream Flows and Reservoir Storage

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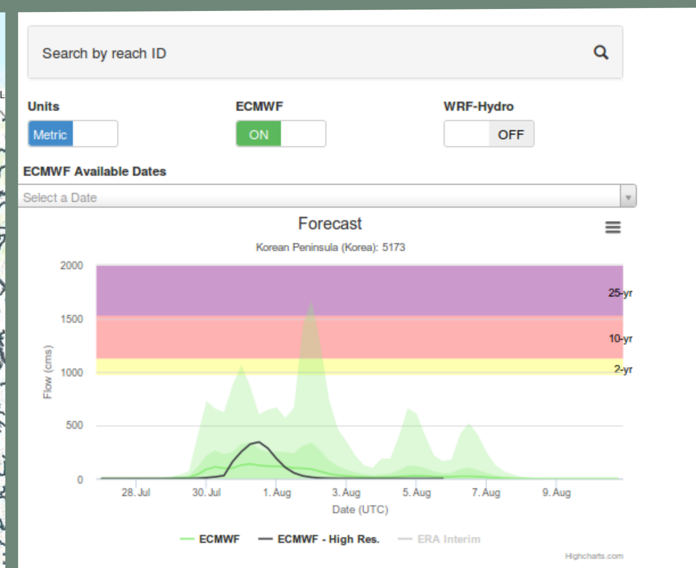
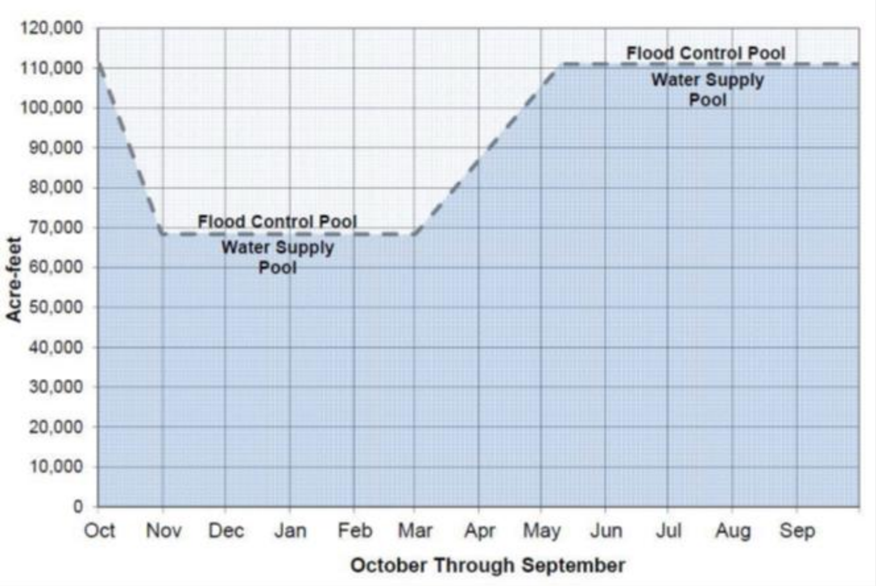


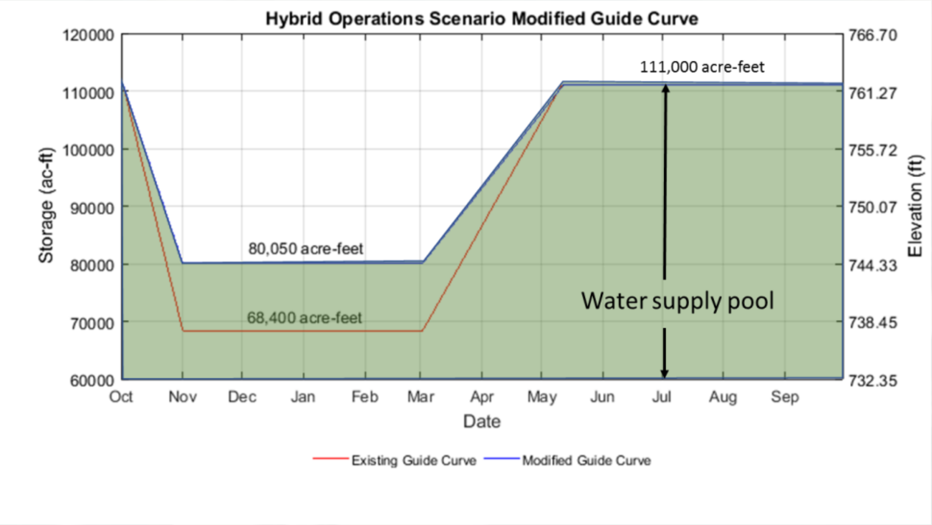
2018 FIRO Workshop
August 1, 2018

Ultimate Goal

- Utilize coupled weather and hydrologic forecasts to allow more flexible operations to enhance secondary reservoir benefits without harming flood protection.



Lake Mendocino Rule Curve



Alternate Mendocino Rule Curves Accounting for Forecast Runoff

What Would it Take to Do That?

- Ability to adequately predict the probability of an AR occurring with enough lead time to adjust reservoir operations, 3-7 days for Lake Mendocino.
- Ability to adequately simulate the amount of rainfall in the basin due to an AR.
- Ability to adequately simulate the runoff from the watershed to the reservoir.
- Ability to adequately simulate the reservoir response to the inflow and reservoir operations.

Current Capability

- Inflows are provided by the NWS River Forecast Center (RFC) using an ensemble of rainfall forecasts with the Sacramento model to simulate runoff. USACE can use these forecast directly to make decisions, or filter them through the HEC-ResSim model.

Question

- Can research into advanced forecasting tools produce improvements to rainfall, runoff, and reservoir forecast?

Purpose

- Identify important factors and technology gaps in simulating flows and reservoir response in the Russian River Valley utilizing forecasted weather products for the purposes of assessing the effect of variations in reservoir operating rules on water supply and flood control.
- Develop tools/systems/methods that could potentially be used to improve forecasted reservoir inflows/levels and operations.

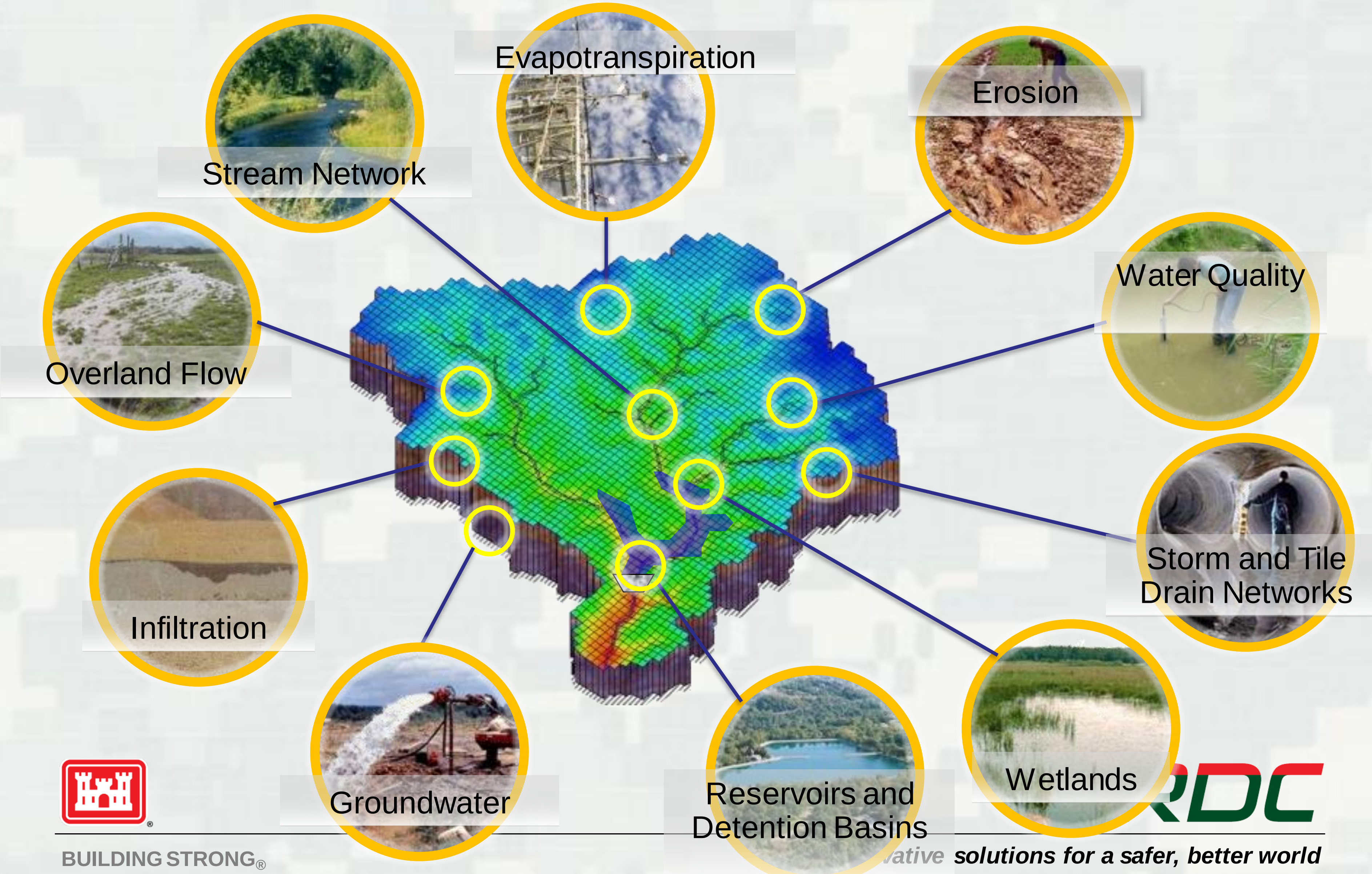
What We Are Doing

- Developing integrated physics based models of basins in the Russian River, starting with Lake Mendocino.
- Coupling the hydrologic model to West-WRF, and possibly other rainfall forecast products.
- Simulating the runoff and reservoir response with observed and forecast precipitation.
- Assessing the models ability to simulate flows and soil moistures using observed and forecasted weather products.

Objectives

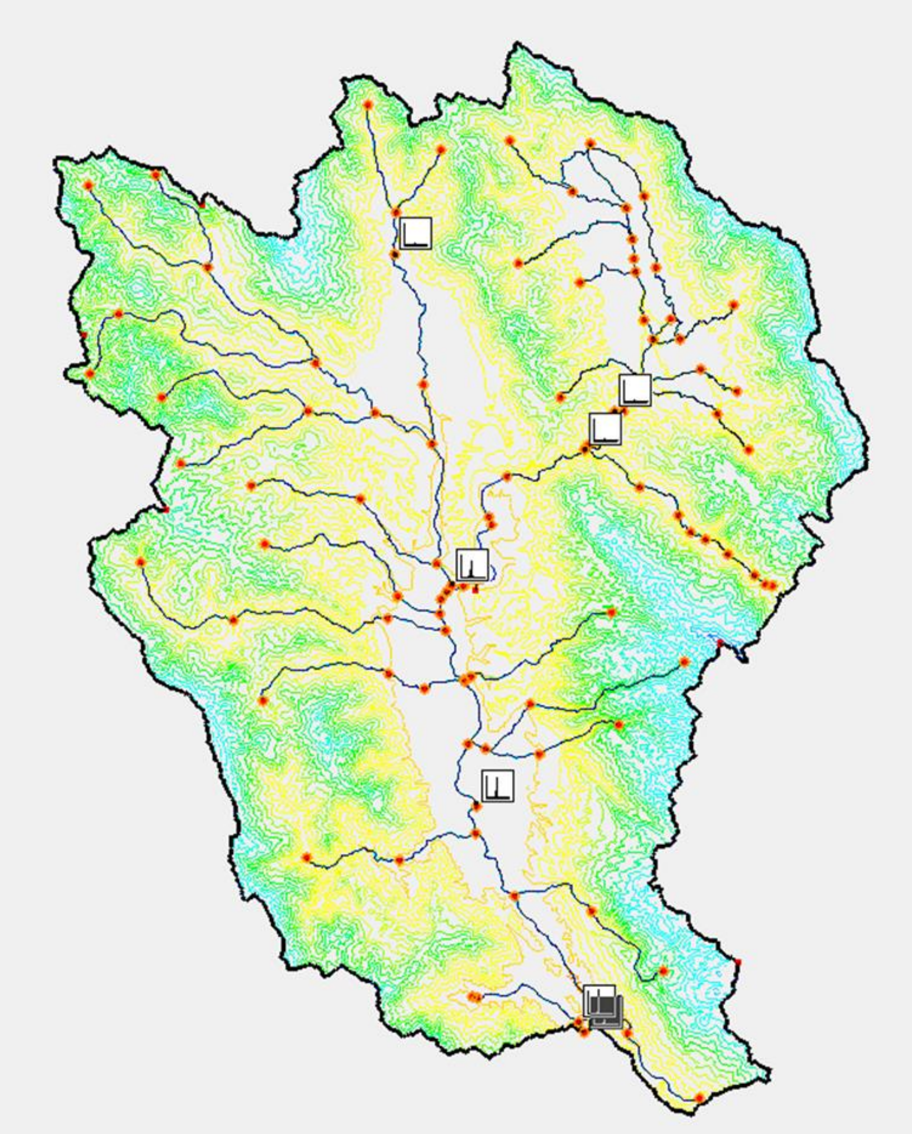
- Understand the processes that control runoff in Russian River Valley.
- Assess the ability to simulate flows and reservoir levels in the Russian River Valley with an integrated physics-based watershed model.
  - Advantages/disadvantages to standard methods
  - Effects of scale
- Incorporate forecasted weather products into the watershed model for short term, days to weeks, predictions of flows and reservoir levels.
  - Standard method for incorporation into USACE hydrologic models.
  - Assess utility of current forecast products.
  - Attempt to define required weather forecast capability with current state of the art hydrologic models.

Watershed Modeling Capabilities

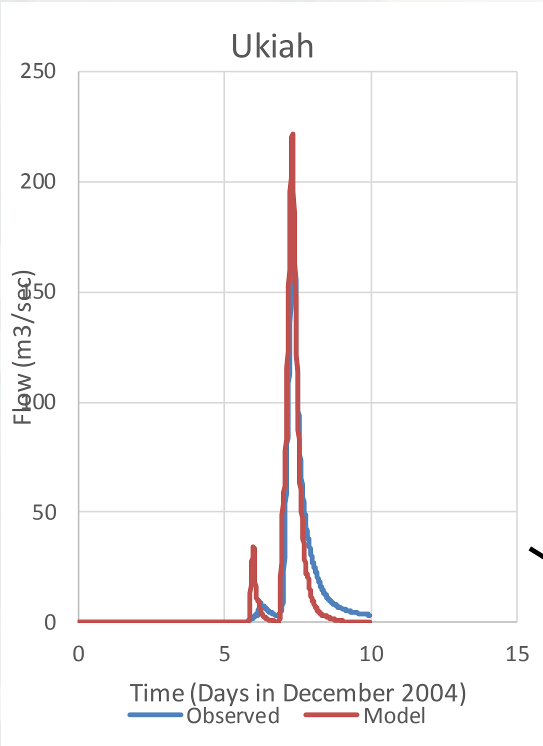


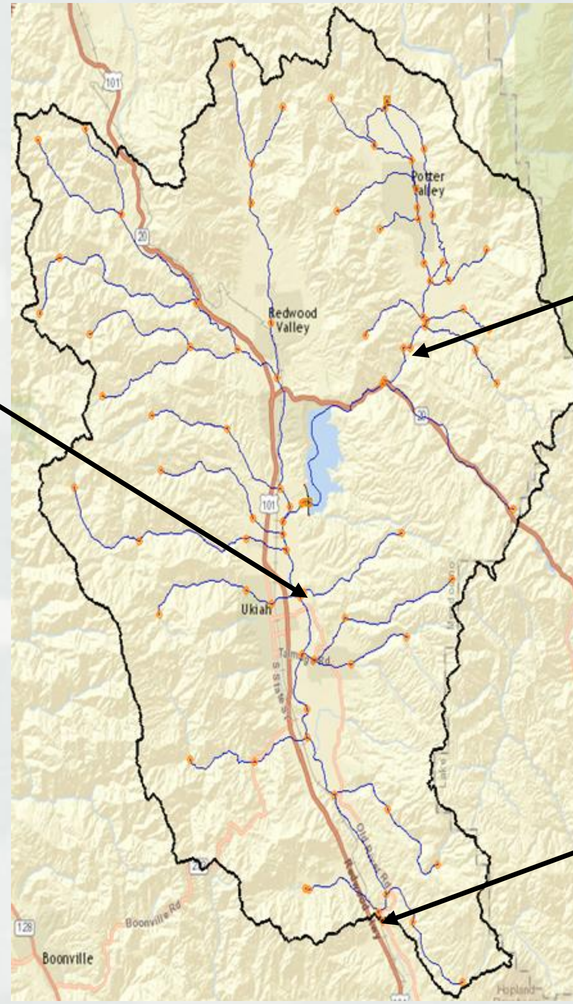
Initial Watershed Conceptualization

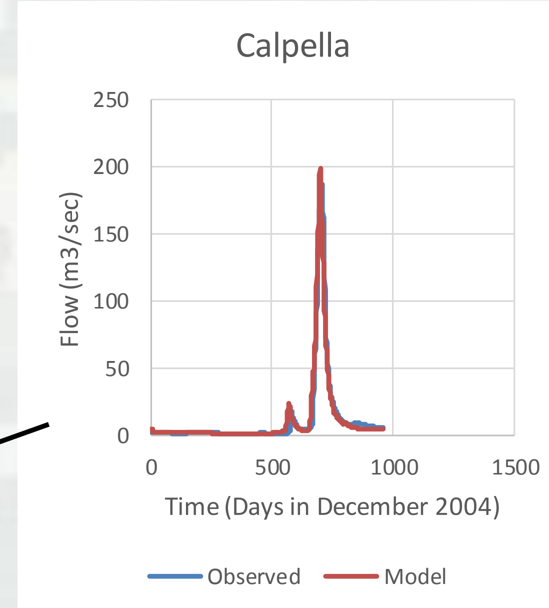
- 2D Overland flow routing with three resolutions to assess effect of grid size.
  - 30m
  - 50m
  - 270m
- 1D Stream network from 10m DEM, HECRAS and field surveys.
- Lake bottom elevations from COE surveys.
- Multi-layer Green and Ampt model to account for strong layering.
- ET – Penman Monteith
- Prescribed stream flows from Eel River diversion and Lake Mendocino discharges.

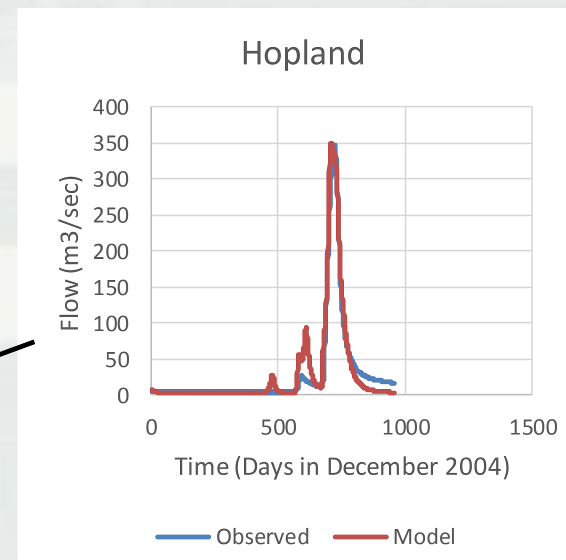


Single Event Calibration – Surface Water Only



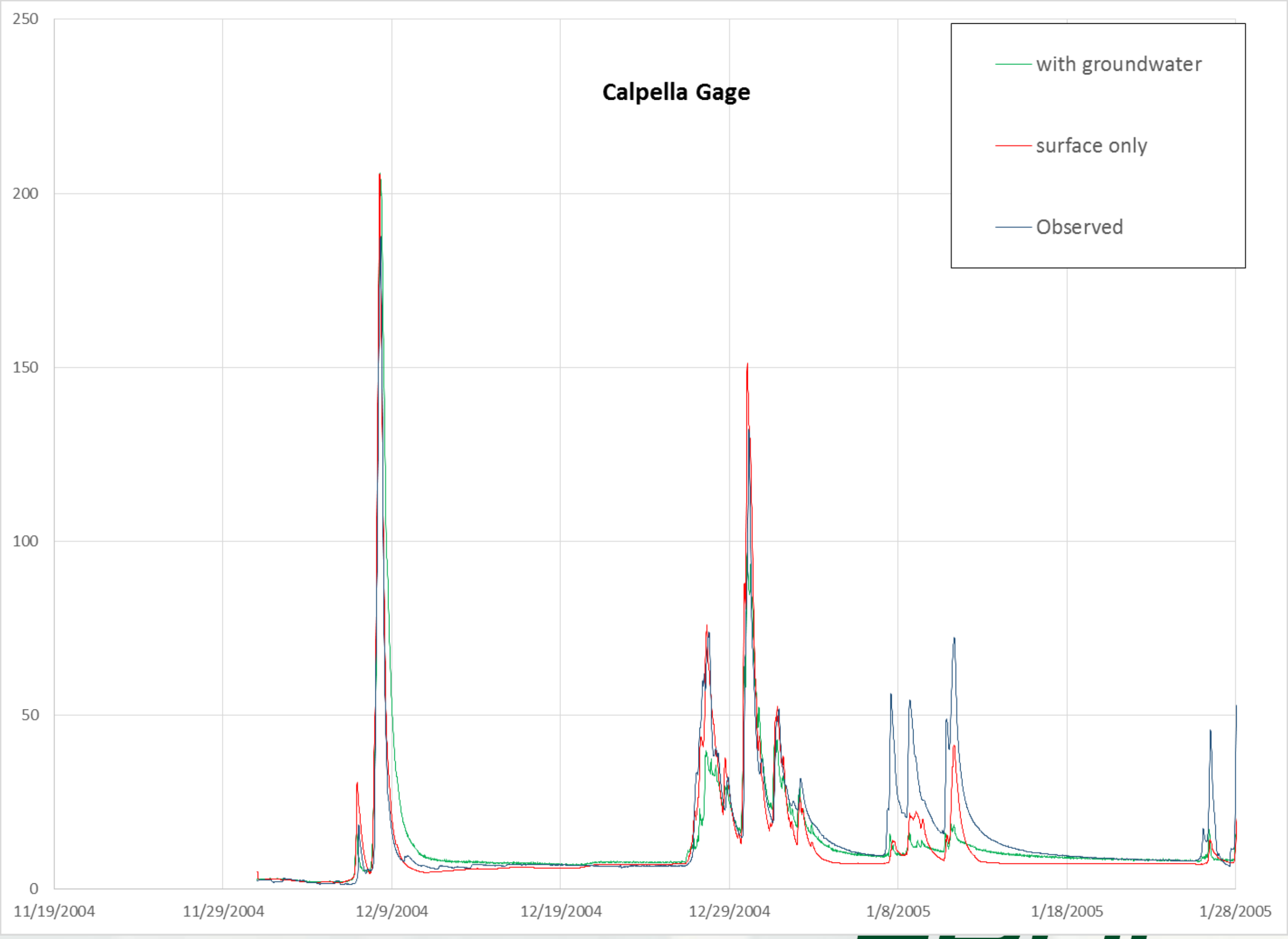




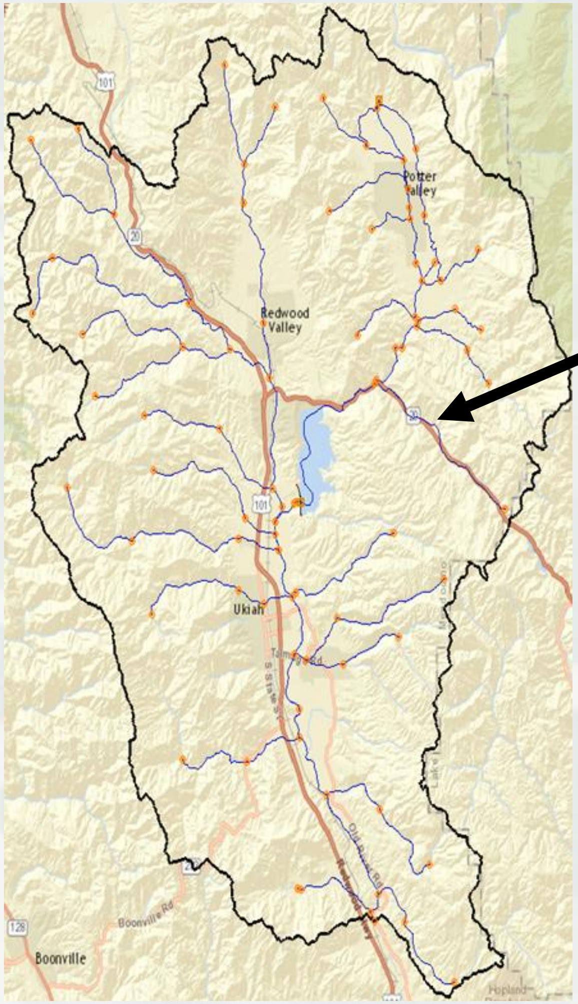


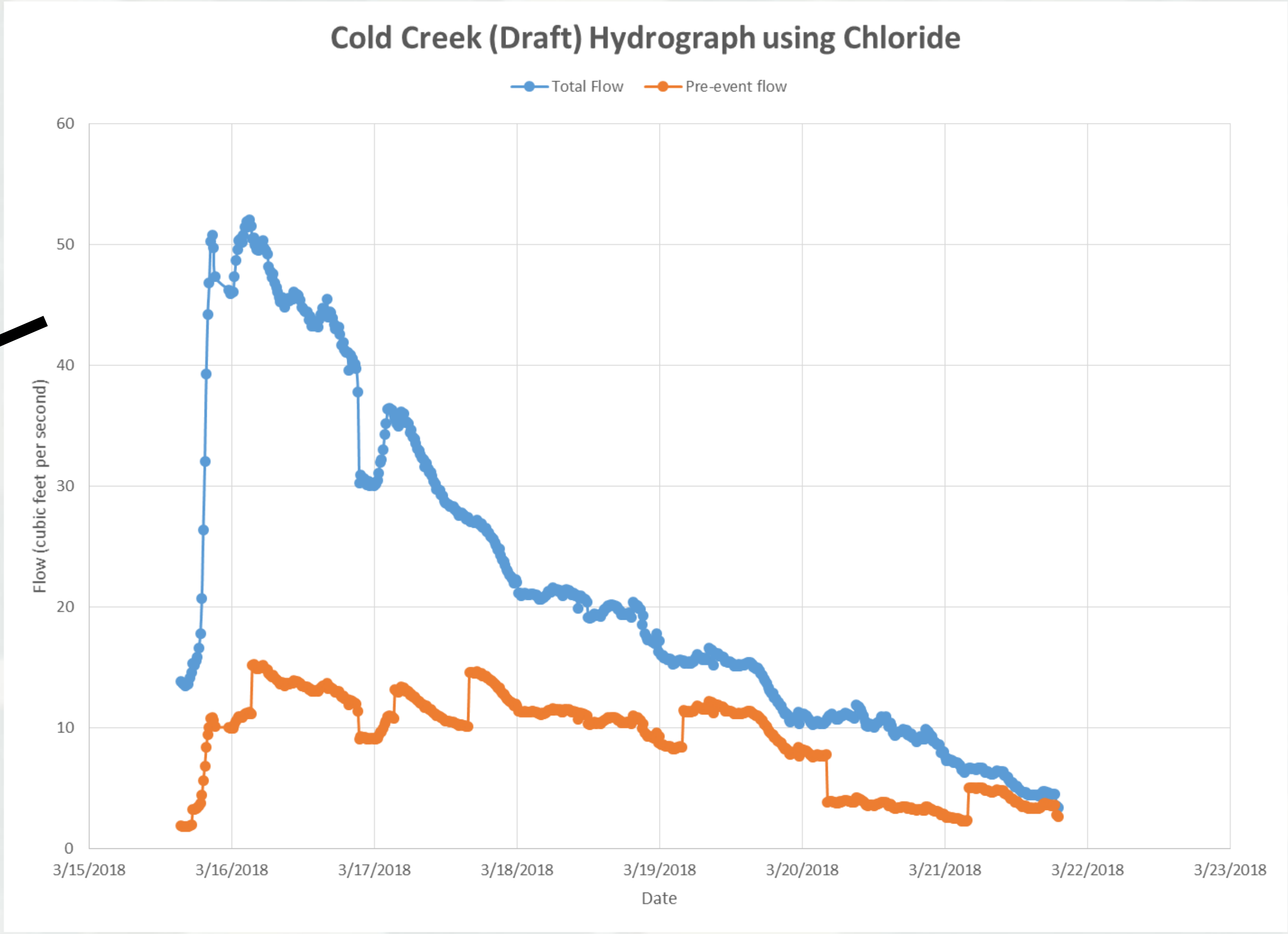
Effect of Groundwater

- Although the model does an excellent good predicting flow in dry conditions.
- Groundwater appears to play a bigger role in wet conditions.



Hydrograph Separation





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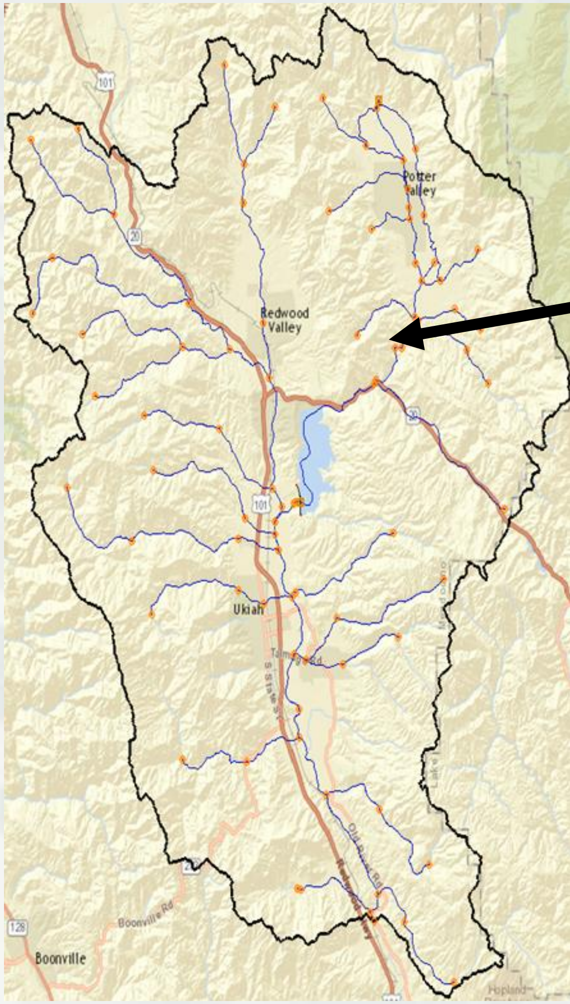
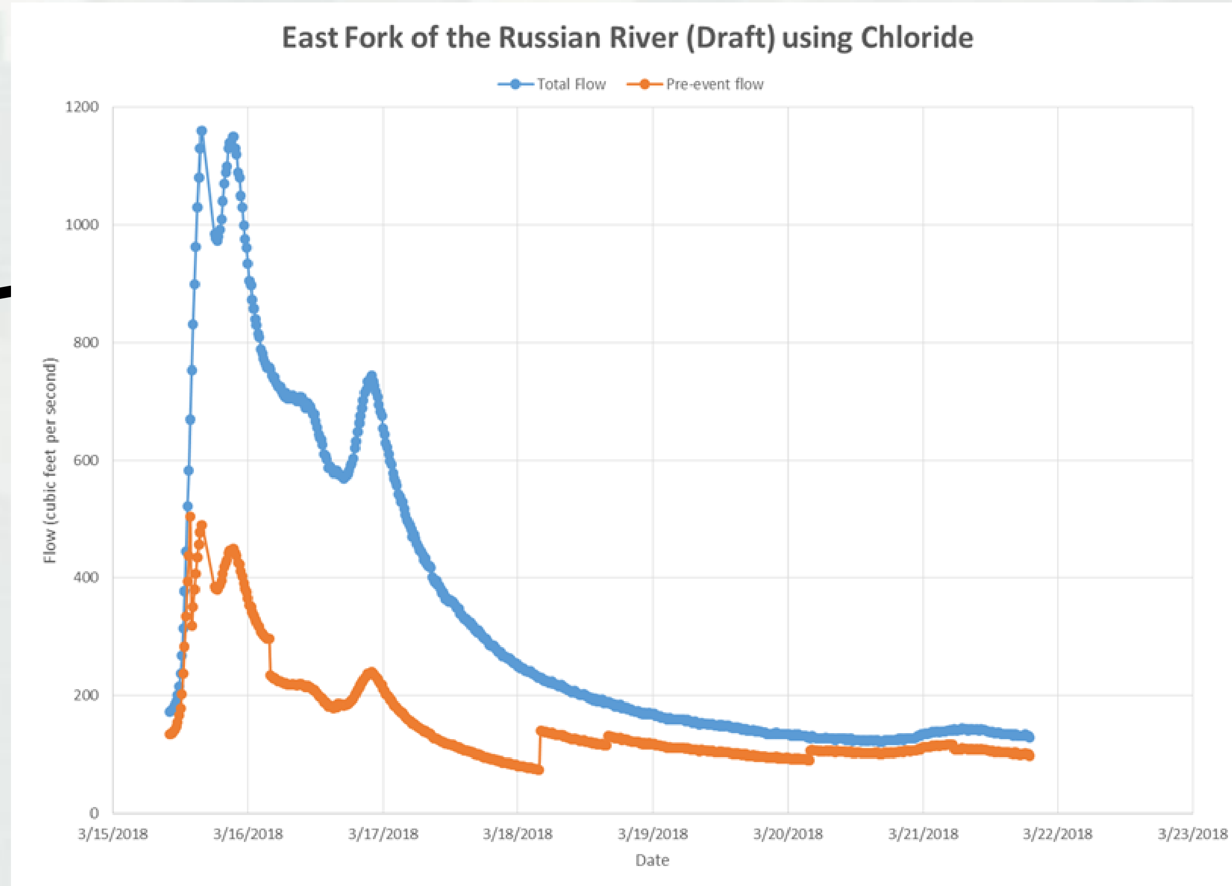
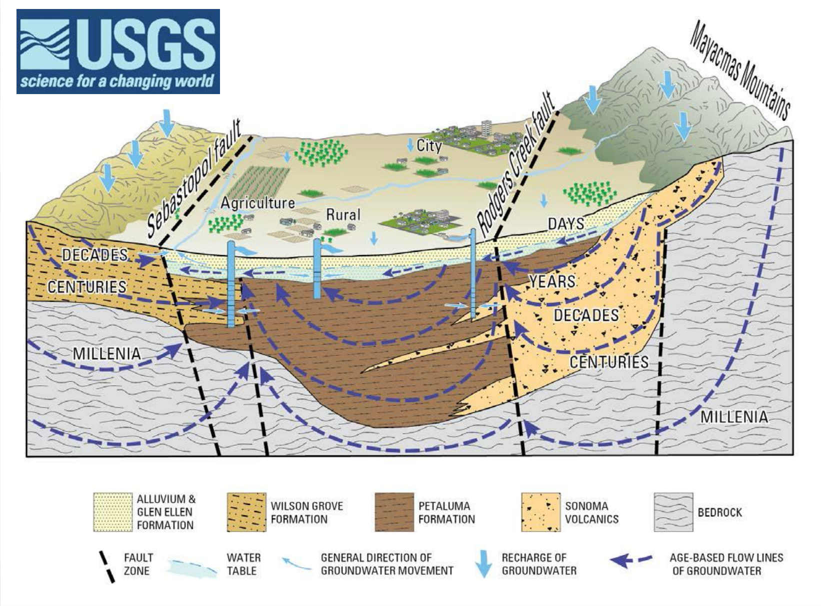
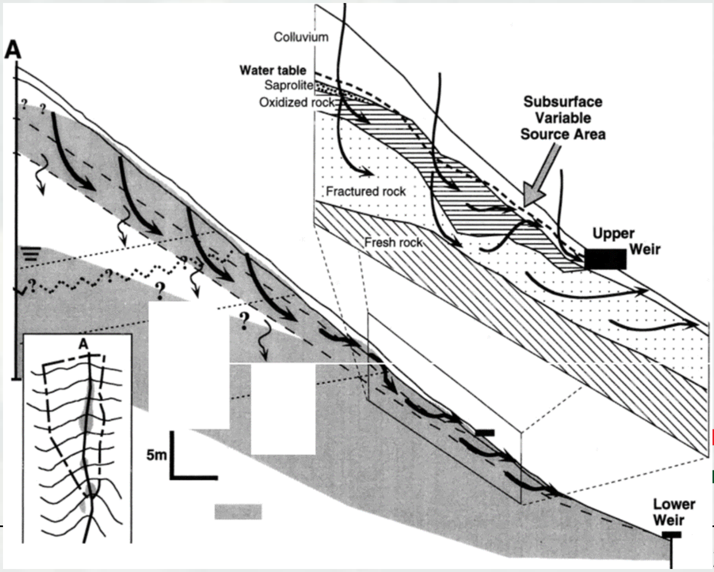




Technical Challenges of Watershed

- Groundwater discharge to streams varies greatly within each event, with calculations showing:
  - first 4 hours 10% runoff,
  - 4 to 8 hours 10 to 30% runoff,
  - 8 to 12 hours 30 to 55% runoff,
  - beyond 12 hours of the storm with 55 to 75% runoff
- The flow component on these hillslopes is a combination of overland flow and groundwater flow intermixing as shown in the following figures:





From Anderson (1997)

Impressions

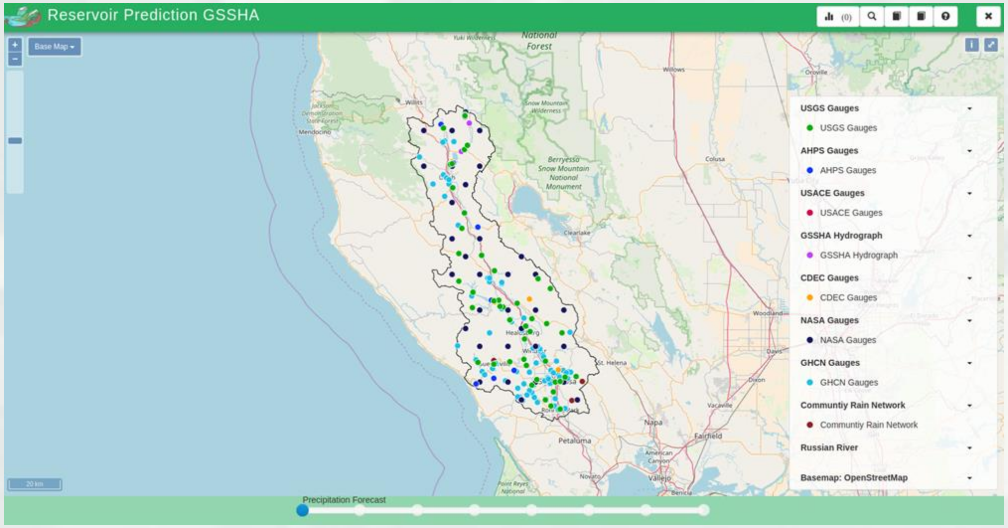
- The physics based model was able to accurately simulate runoff for dry conditions at multiple gauges.
- The model appeared to be less accurate for wet conditions, probably due to the lack of groundwater contribution.
- Combined with the enhanced data set, the model is helping the team understand the system response of the Russian River watershed to ARs.

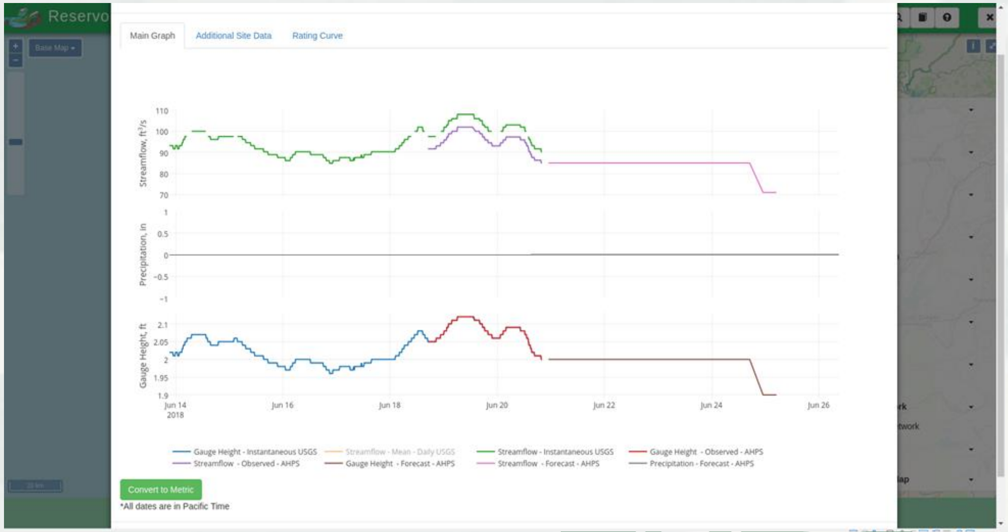
Continuing Efforts

- Model improvements
  - Adding groundwater to existing models.
  - Building additional model resolutions and domains.
  - Adding denser stream network.
  - Recalibration of models using new CW3E data set.
- Simulating West WRF forecast for last two AR seasons.
- Assessing models' ability to simulate observed soil moisture (Bob Zamora, NCAR) – This FY.
- Assimilation of flow and soil moisture data (Andy Wood, NCAR) – Next FY.
- Getting more data and users in the Russian River Data Viewer.

Russian River Data Viewer

- Web based system to display observed and simulated data in the Russian River Watershed.
- Currently includes observed flows, stages, rainfall, predictions from on-line sources, such as USGS, NWS, RFC, etc., as well as West WRF and GSSHA model output.
- Built to incorporate any type of observed or simulated data from any source willing to share.
- Hosted at ERDC, available to anyone working on the FIRO project.





Final Products

- Integrated physics-based models of the reservoirs and their watersheds in the Russian River.
  - Coupled to weather forecast products – WRF, West-WRF, etc.
  - With data assimilation – stream flow, soil moisture.
  - Assessed for stream flow and soil moisture.
- Method of coupling weather products to USACE models, GSSHApy.
- Russian River Data viewer – web based system to host information on Russian River data.