Integrated modeling of surface and groundwater quality: using EC to calibrate hydrology between ET and deep percolation to groundwater

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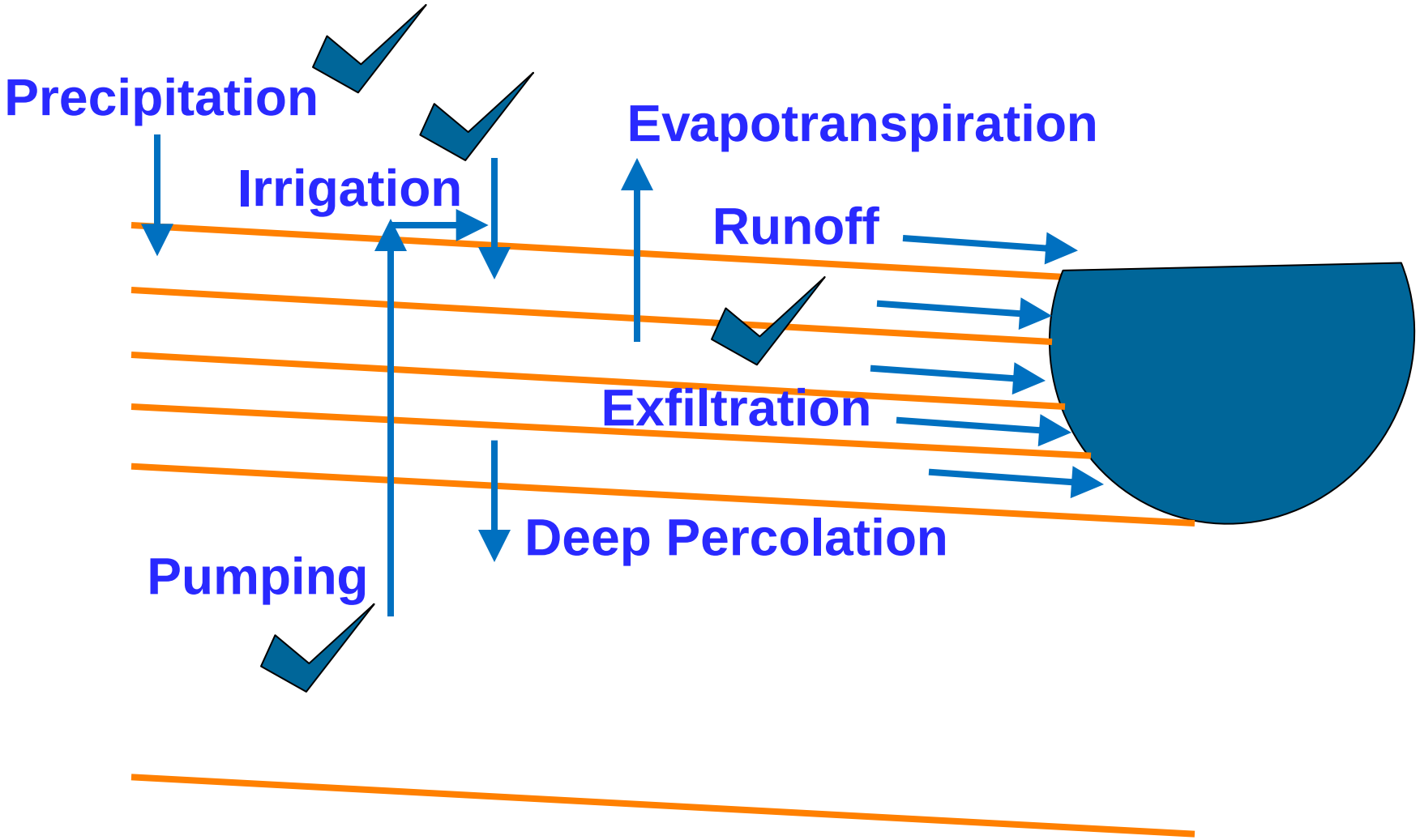
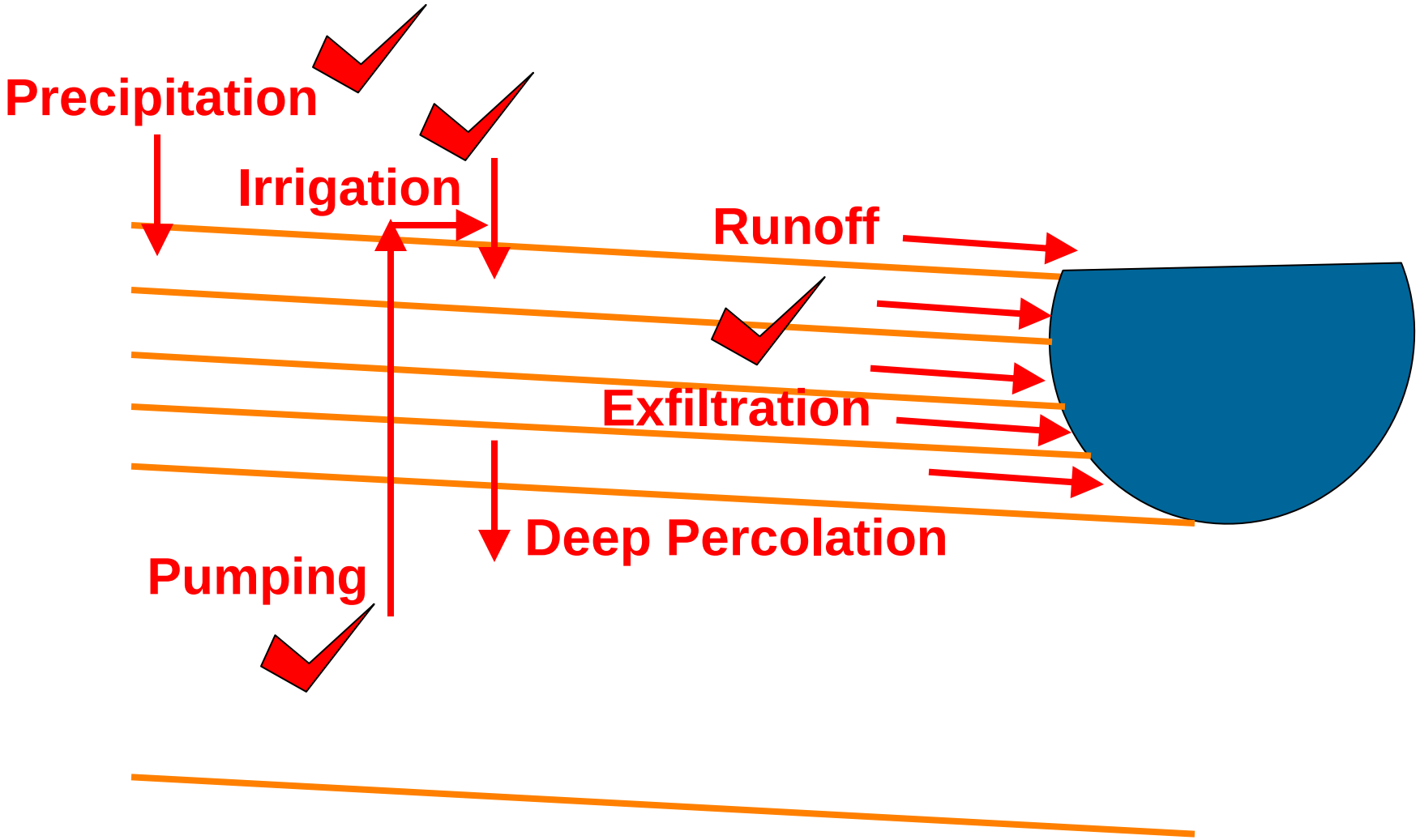
Integrating Surface and Groundwater Modeling

- Many modeling goals for tracking water quantity, quality between surface and groundwater
  - Trend in groundwater table
  - Accumulation of salt and nitrate in groundwater
  - Contributions of flow and loading from groundwater to surface water
- Many modeling approaches
  - Surface water models
  - Groundwater models
  - Hydrology models
  - Water quality models
- Modeling answers depend on approach used
  - Integrate modeling approaches to best use available information and constrain model calibration

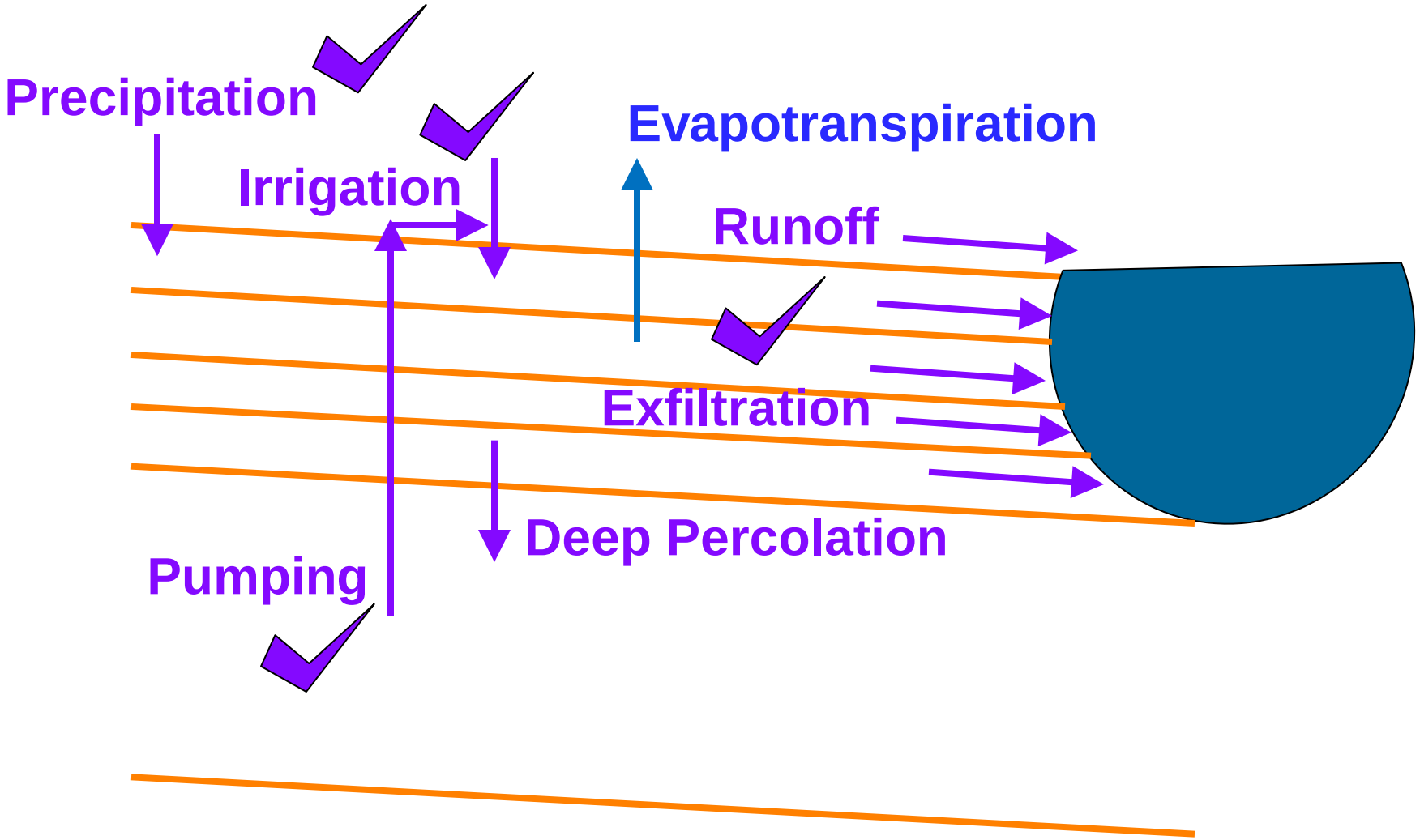
Water Balance



Salt Balance



Water and Salt Balance



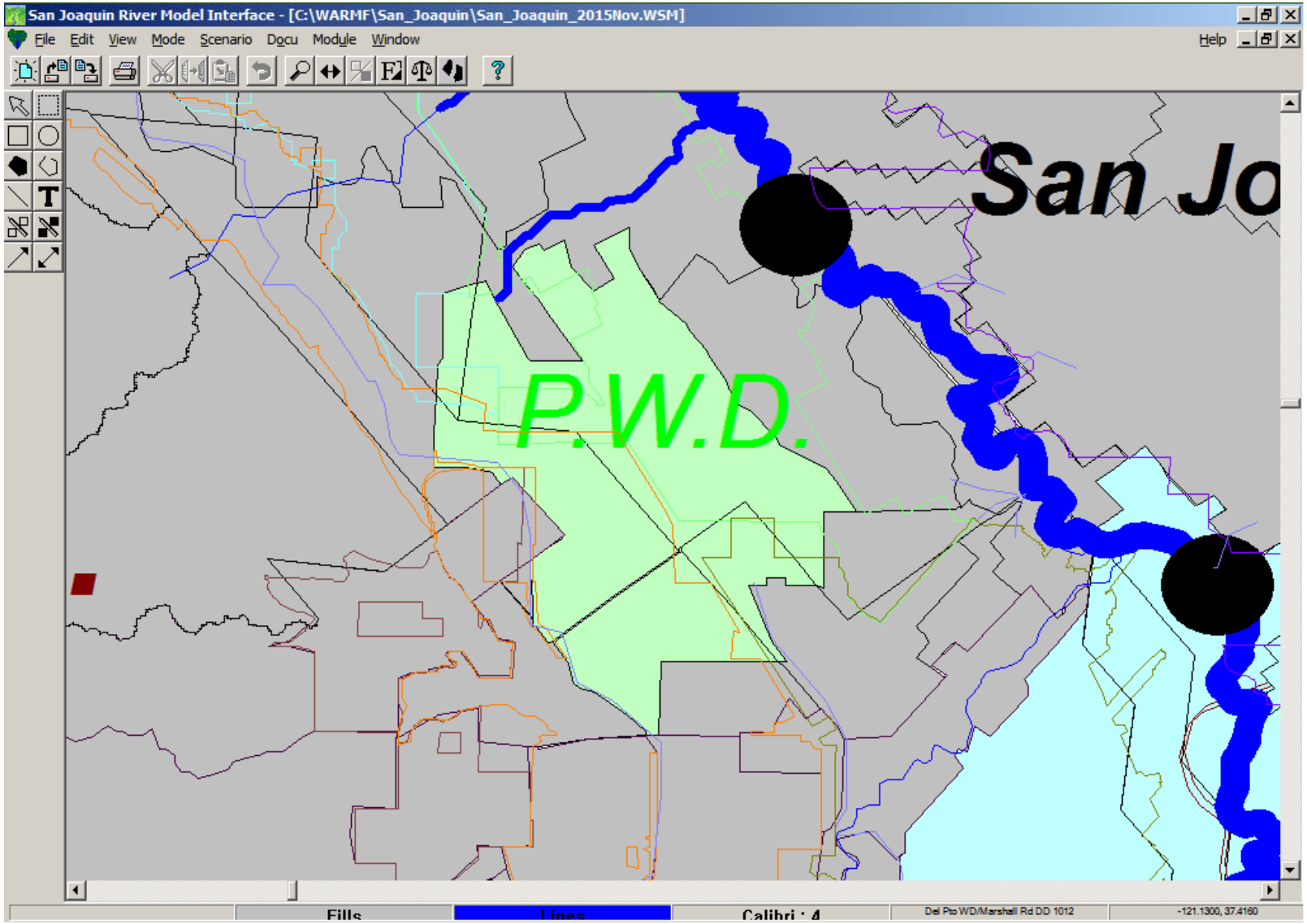
Summary of Calibration Process

1. Use continuously monitored surface water flow and EC to calibrate the watershed
2. Use measured salt load (Q x C) to calibrate deep percolation
   - Concentration to surface water is related to proportions of overland flow, flow from root zone, flow from below root zone, concentrations in each layer
   - Concentration below root zone goes to deep percolation
3. Use measured flow to calibrate ET, deep percolation rate
   - Different ET changes salinity concentration
4. Iterate steps 2 and 3 until both flow and salt load are balanced

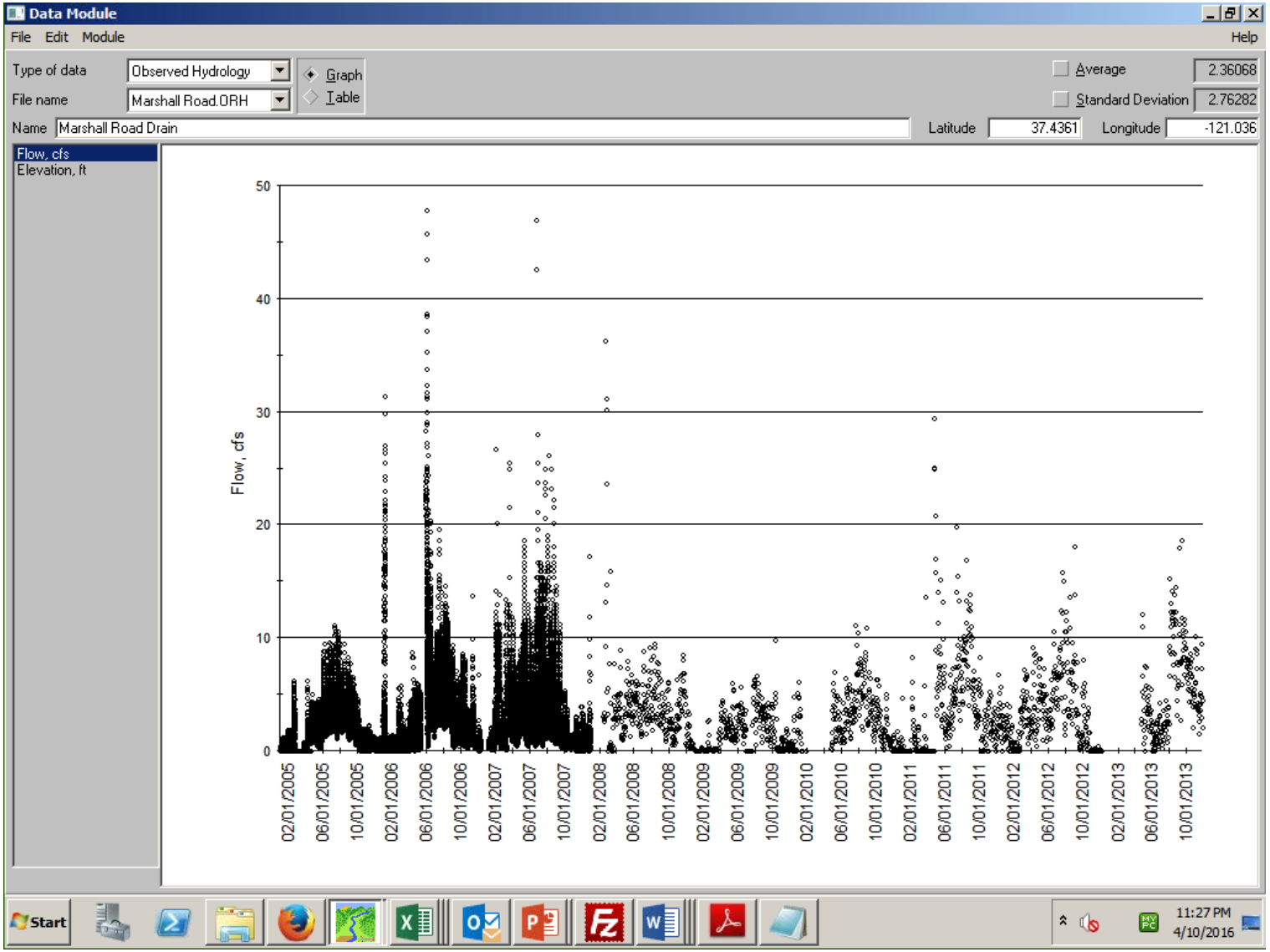
Example Calibration Using WARMF

- Surface water model
  - Divides watershed into catchments, river segments, reservoirs
  - Catchments divided into many land uses
  - Soil has 5 layers: 3 in root zone, 1 below root zone connected to surface water, 1 for unconfined aquifer
  - Calculates flow and load to aquifer, not within aquifer
- Simulates hydrology and water quality
  - Hydrology processes include precipitation, diversion, pumping, irrigation, ET, lateral flow, overland flow, deep percolation
  - Water quality processes include atmospheric deposition, chemical reactions, adsorption, cycling through vegetation, advection
  - Water volume and chemical mass balance maintained through every model element
  - Salt mostly conservative

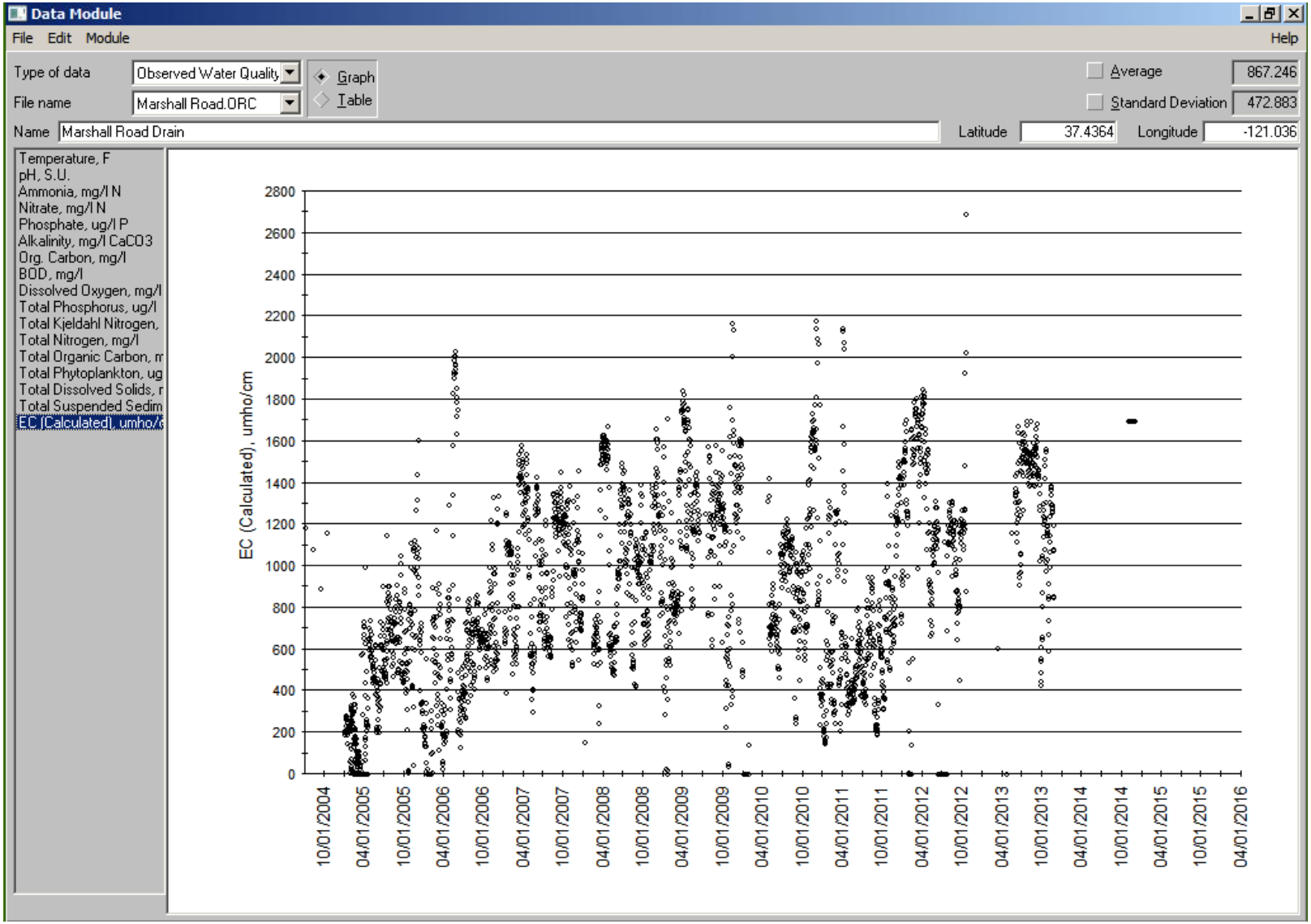
Calibrating Marshall Road Drain



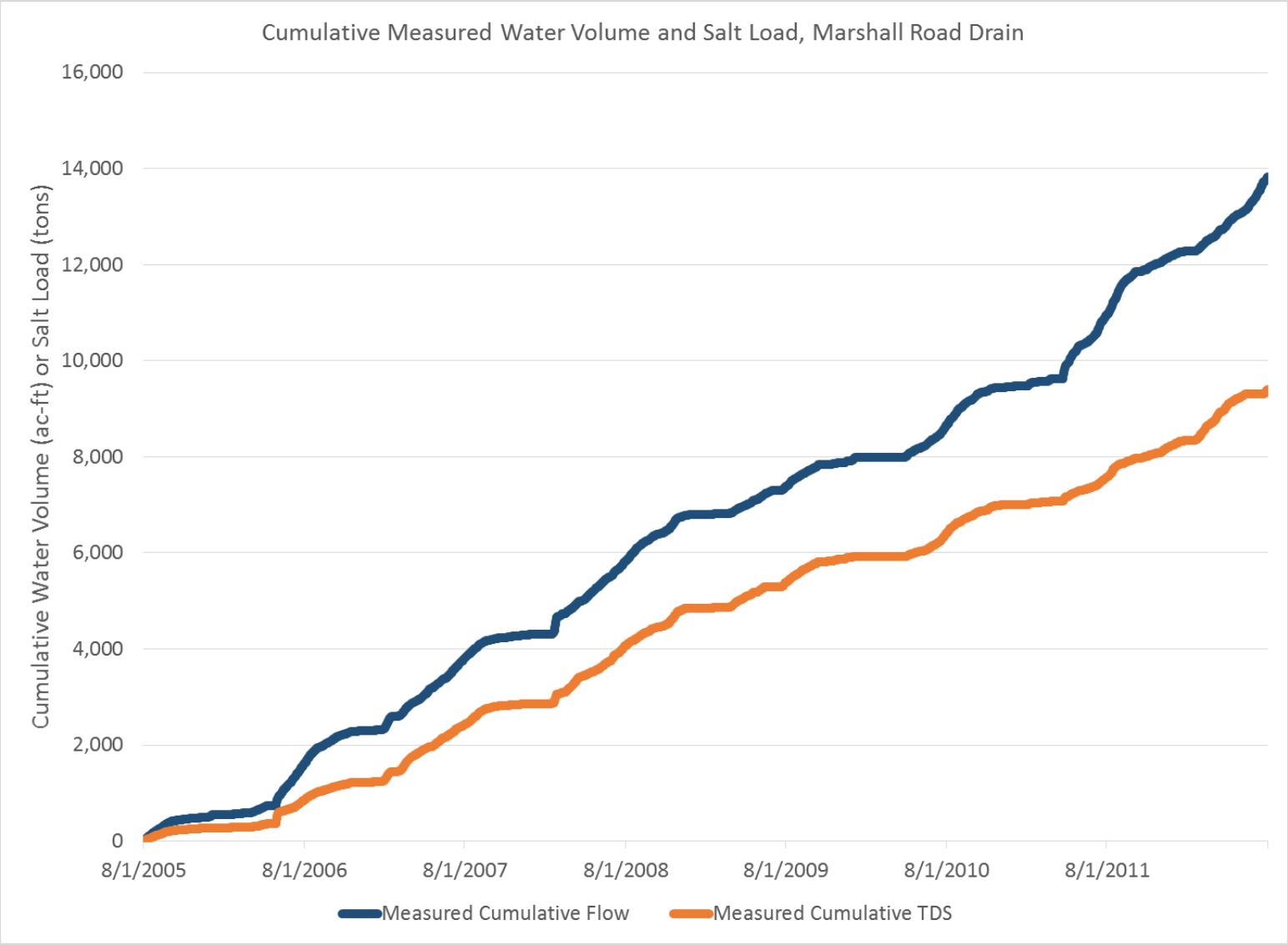
Marshall Road Drain Flow Data



Marshall Road Drain EC Data



Calibration Approach: Cumulative Flow and Salt Balance

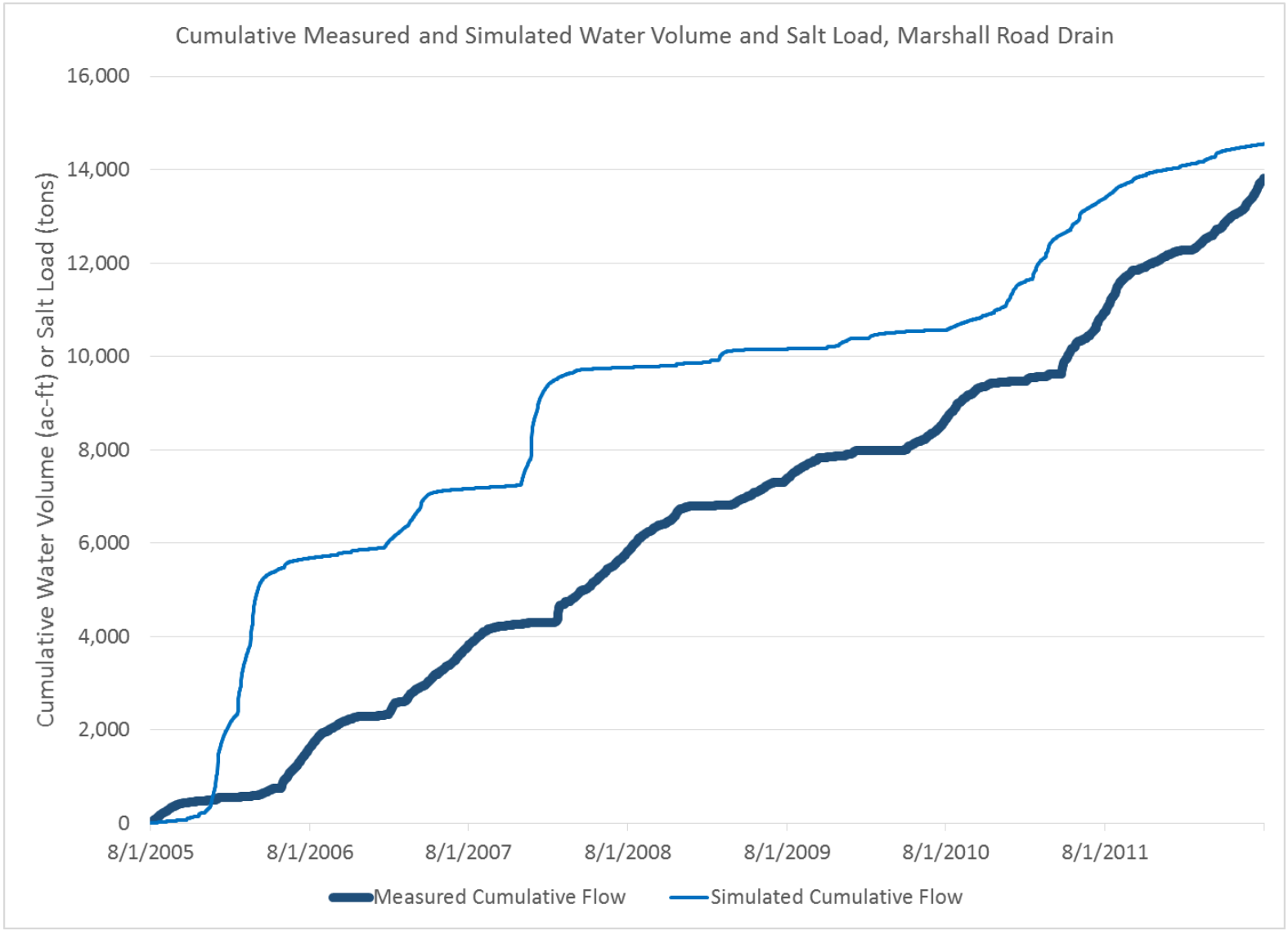


Calibration Parameters

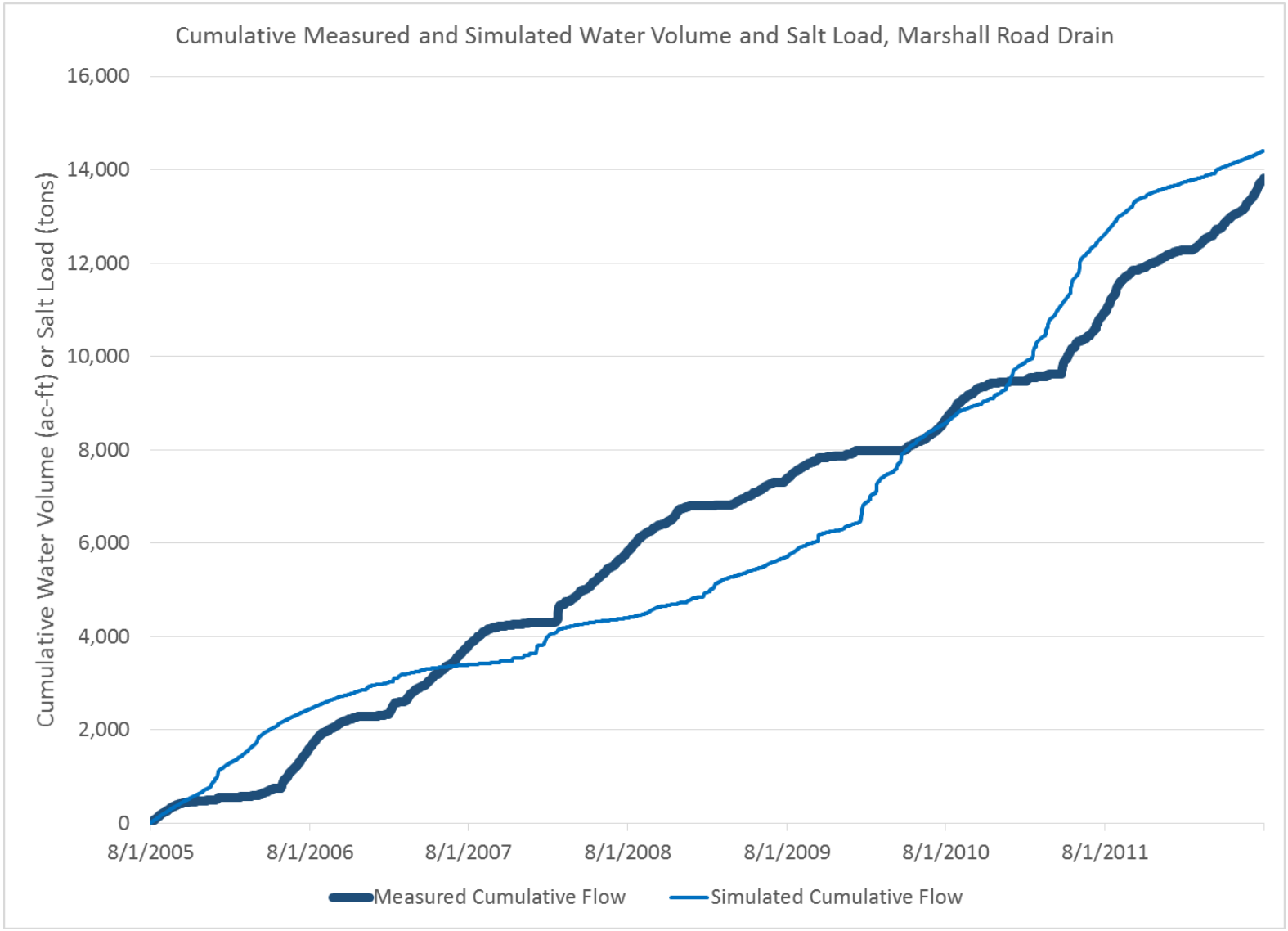
- Initial soil moisture of each soil layer
- Maximum infiltration rate of each soil layer
- Horizontal hydraulic conductivity of each soil layer
- Thickness of fourth soil layer (below root zone connected to surface water)

- Coarse calibration performed for demonstration: mostly long-term flow, salt balances

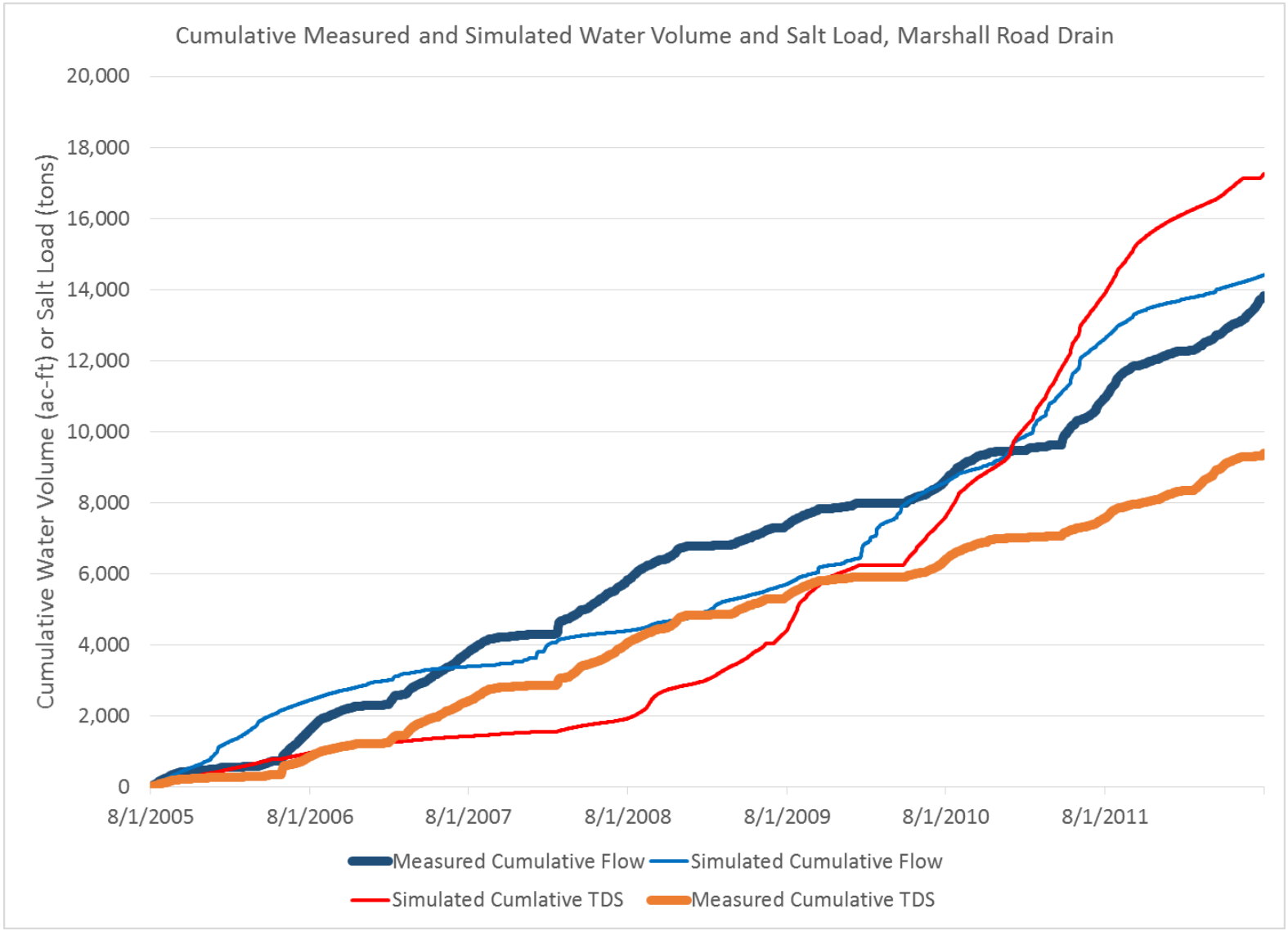
Uncalibrated Model



Initial Calibration Ignoring EC



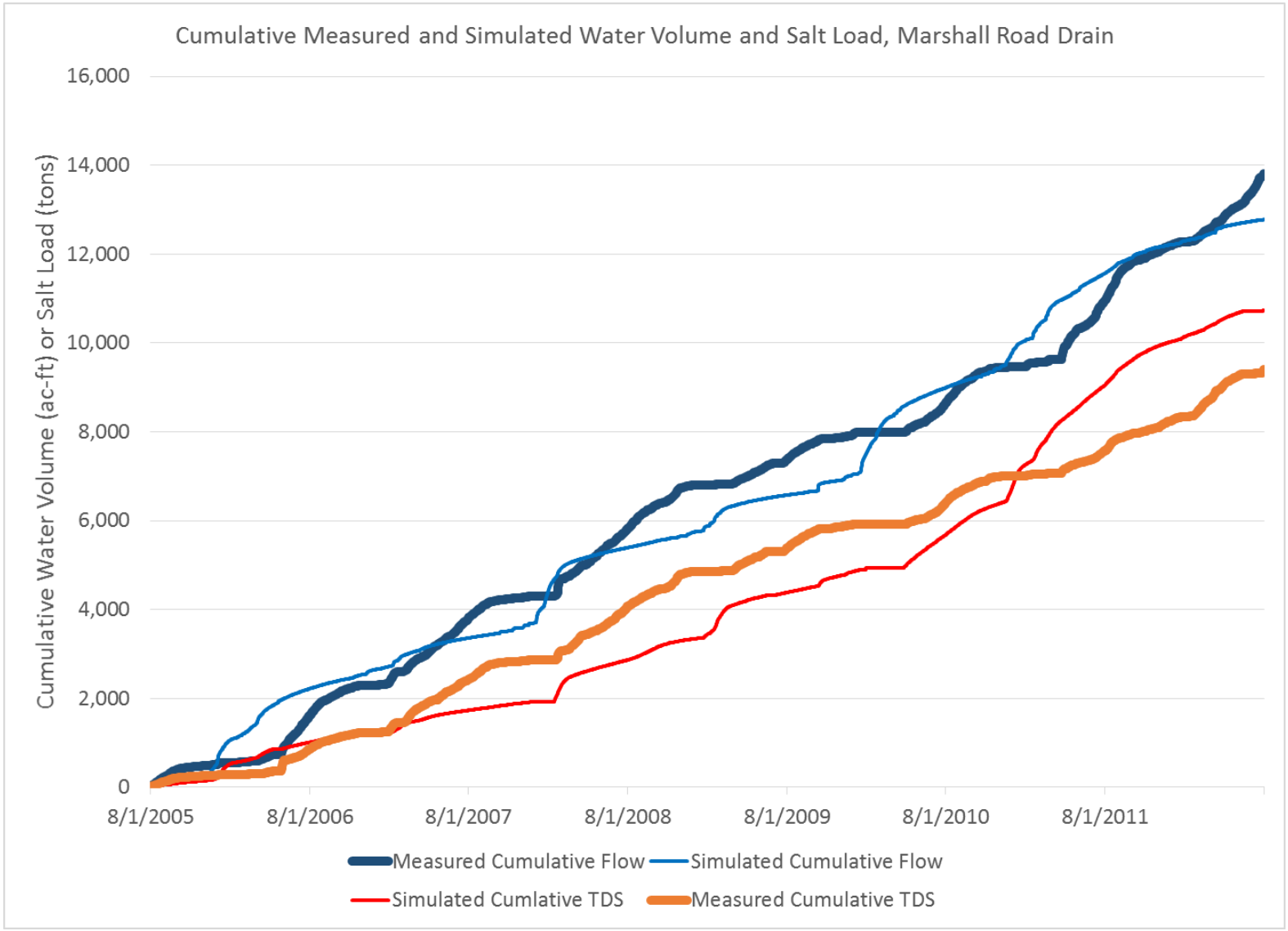
EC Balance of Calibration Ignoring EC



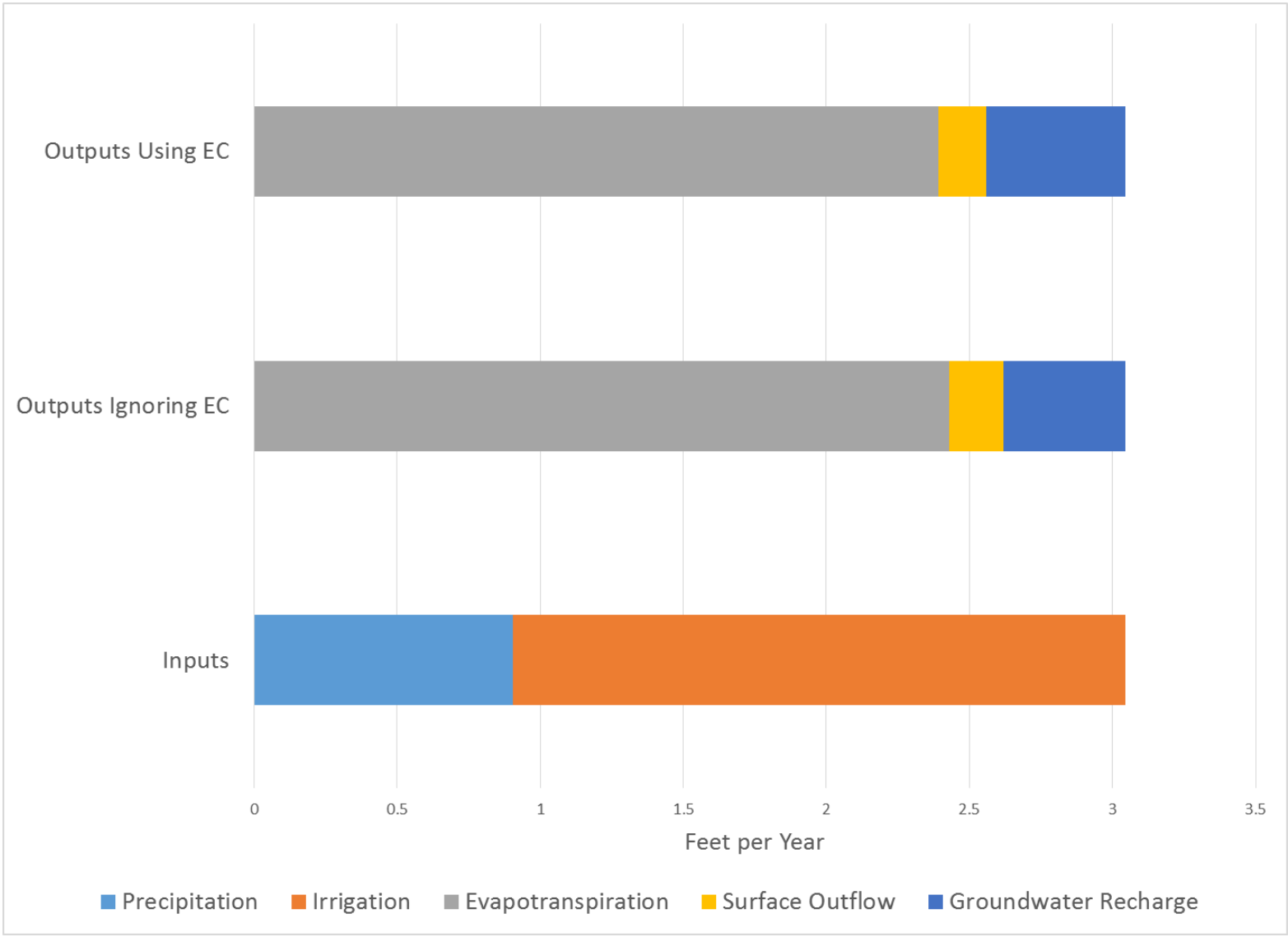
Calibration Ignoring EC

- Initial flow calibration
  - Some year-to-year imbalance, but volume balanced over long-term
  - twice as much salt load as measured
  - Simulation has too much ET, not enough percolation to deep groundwater
- Reduce salt to drain by increasing salt load in deep percolation to groundwater
  - Calibrate EC using hydrology parameters only
  - Change proportions of flow coming from overland flow, root zone, below root zone
  - Change deep percolation rate to groundwater aquifer
  - ET will reduce as consequence of more deep percolation

Calibration of Hydrology Using EC

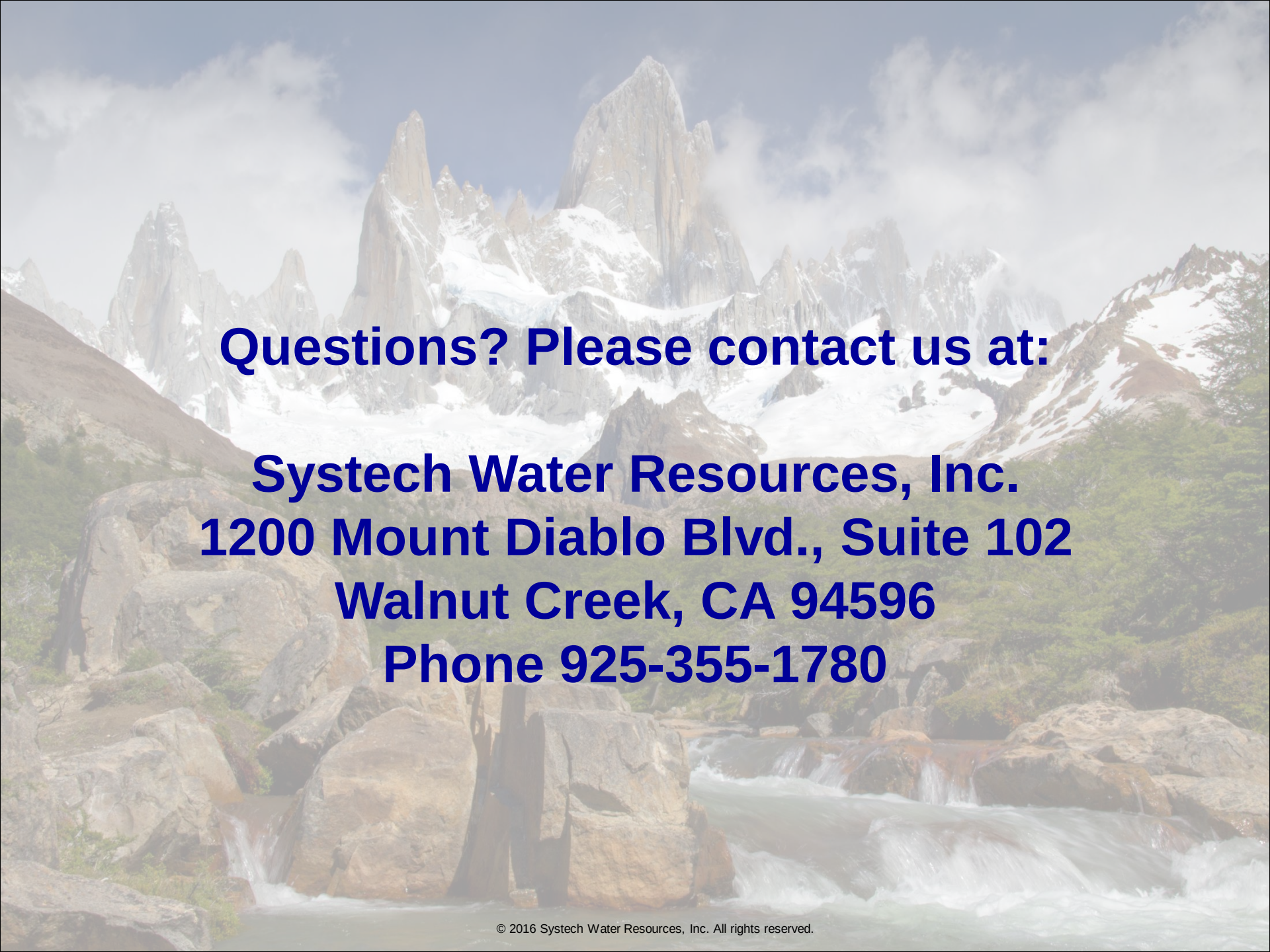


Comparison of Flow Balances: Calibrations Ignoring EC and Using EC



Summary

- Evapotranspiration, groundwater recharge
  - Key processes for modeling concerns (e.g. WT elevation, salt conc.)
  - Can't be measured directly
  - Subject to calibration of surface water or groundwater models
  - Models not well constrained between these losses when calibrating hydrology only
- Surface water data
  - Continuous monitoring of flow and EC provide water volume and salt mass from contributing watershed area
- Simultaneous calibration of surface water flow, EC
  - Constrains model: salt mass not leaving to surface water goes to groundwater aquifer
  - Salt mass is a function of deep percolation rate, concentration below root zone
  - Provides additional information for calculations of GW recharge



Questions? Please contact us at:

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