Woodard & Curran

Automated Calibration Workflow for the GW-DLL

Sercan Ceyhan, PhD

Ali Taghavi, PhD, PE

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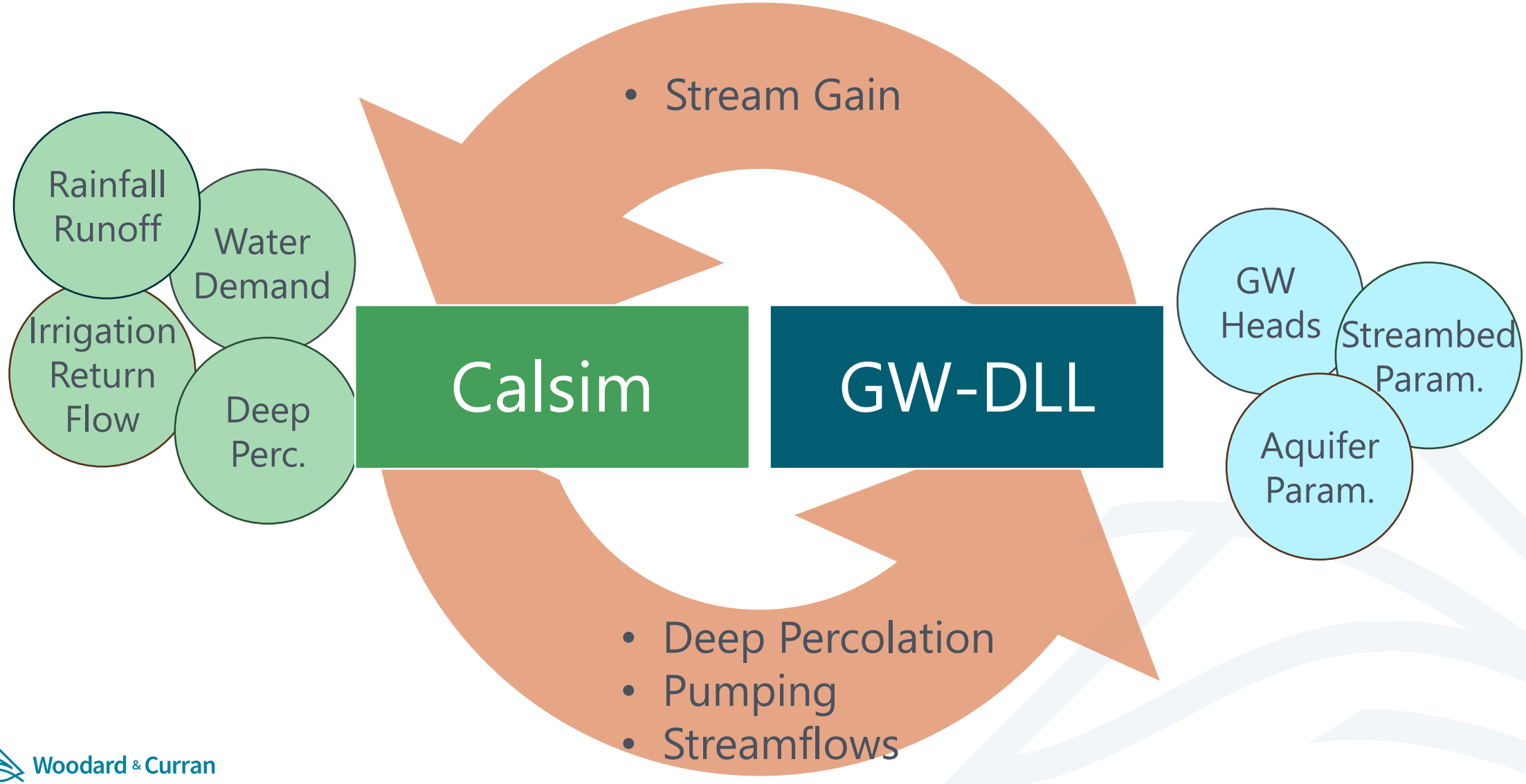
BUREAU OF RECLAMATION

Stantec

Flows and reservoir conditions simulated by Calsim are directly influenced by the GW conditions simulated by GW-DLL



Previous Calsim versions used the GW-DLL parameterization from C2VSimCG

- C2VSimCG and IWFM got updated over time.
- Those changes were implemented in the GW-DLL currently being reviewed.

- There are differences between the land surface conditions in Calsim and C2VSimCG.
- GW-DLL in Calsim needs to be independently calibrated.
- Historical Mass Balance version of Calsim was developed for GW-DLL calibration purposes.

Outline

- Calibration Philosophy
- Automated Calibration Workflow
- Next Steps

What is calibration?

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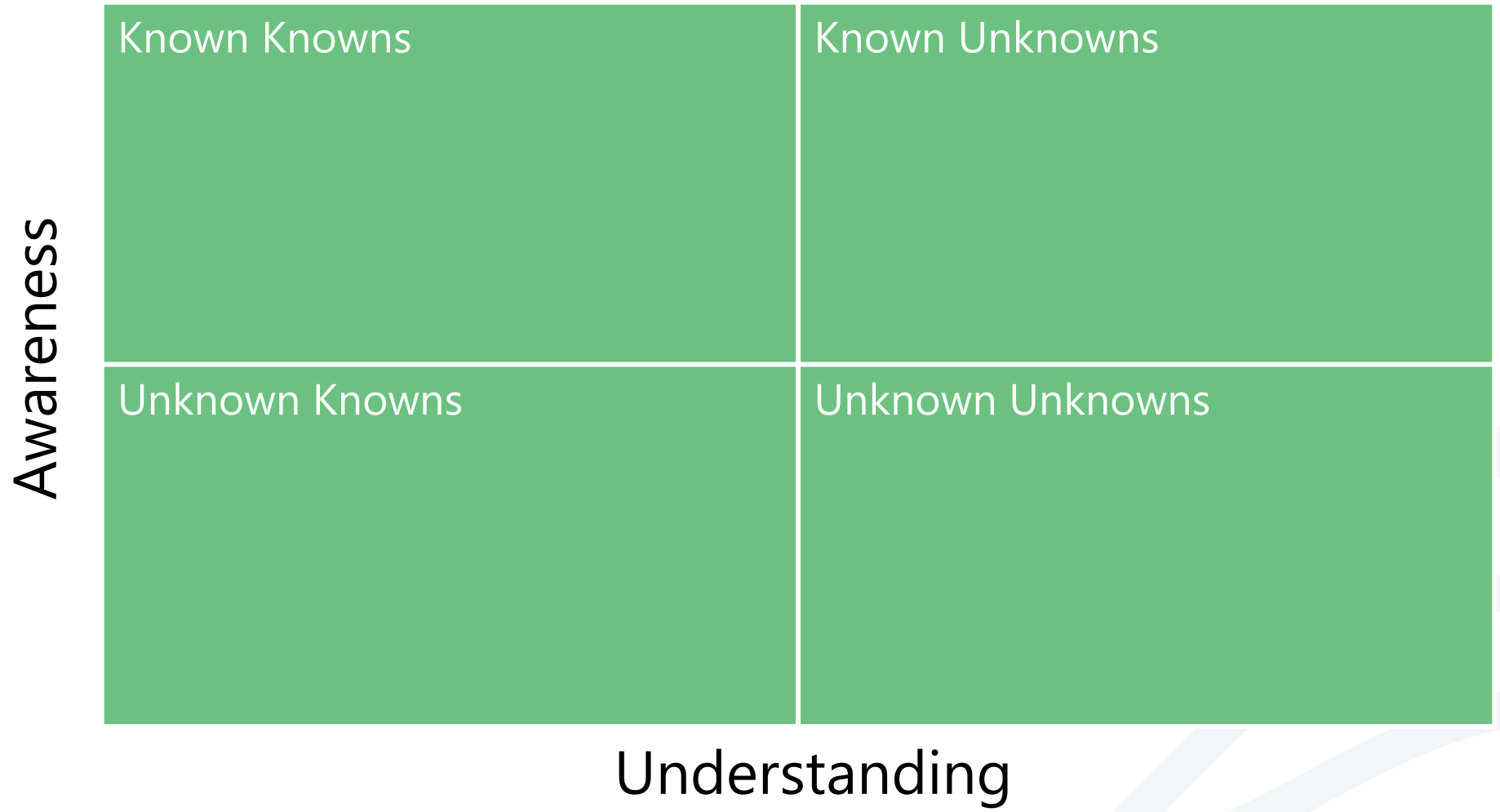
Model Calibration

"Modification of input data within the reasonable limits for the purpose of making the model more closely match field conditions such as observed heads and flows."

- Amount of effort is dependent upon the intended use of the model
- Can be done manually or automatically
- Calibration process can also be a learning opportunity for the modeler

Reference: USGS SIR 2004-5038

What do we know in groundwater models?



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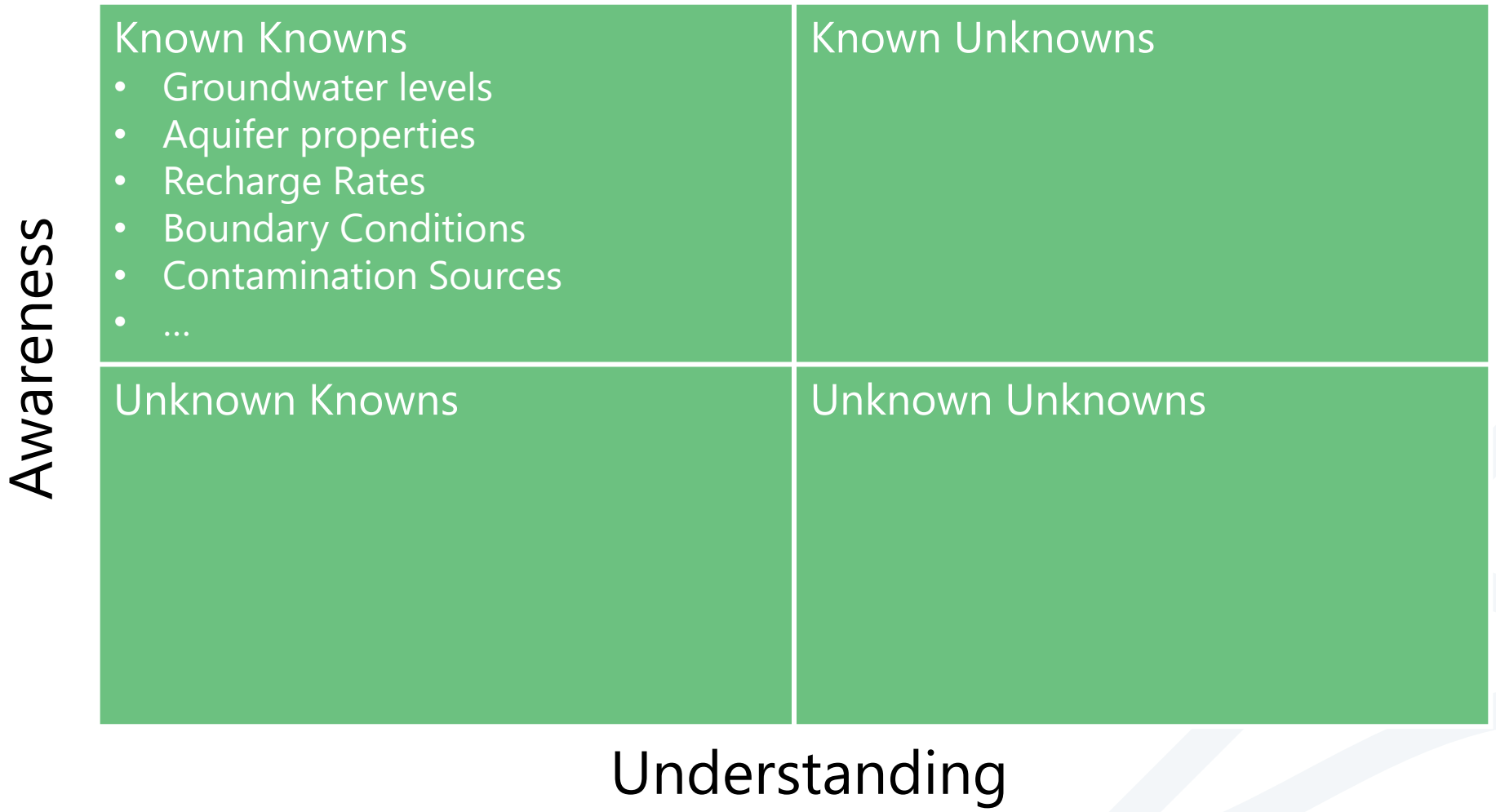

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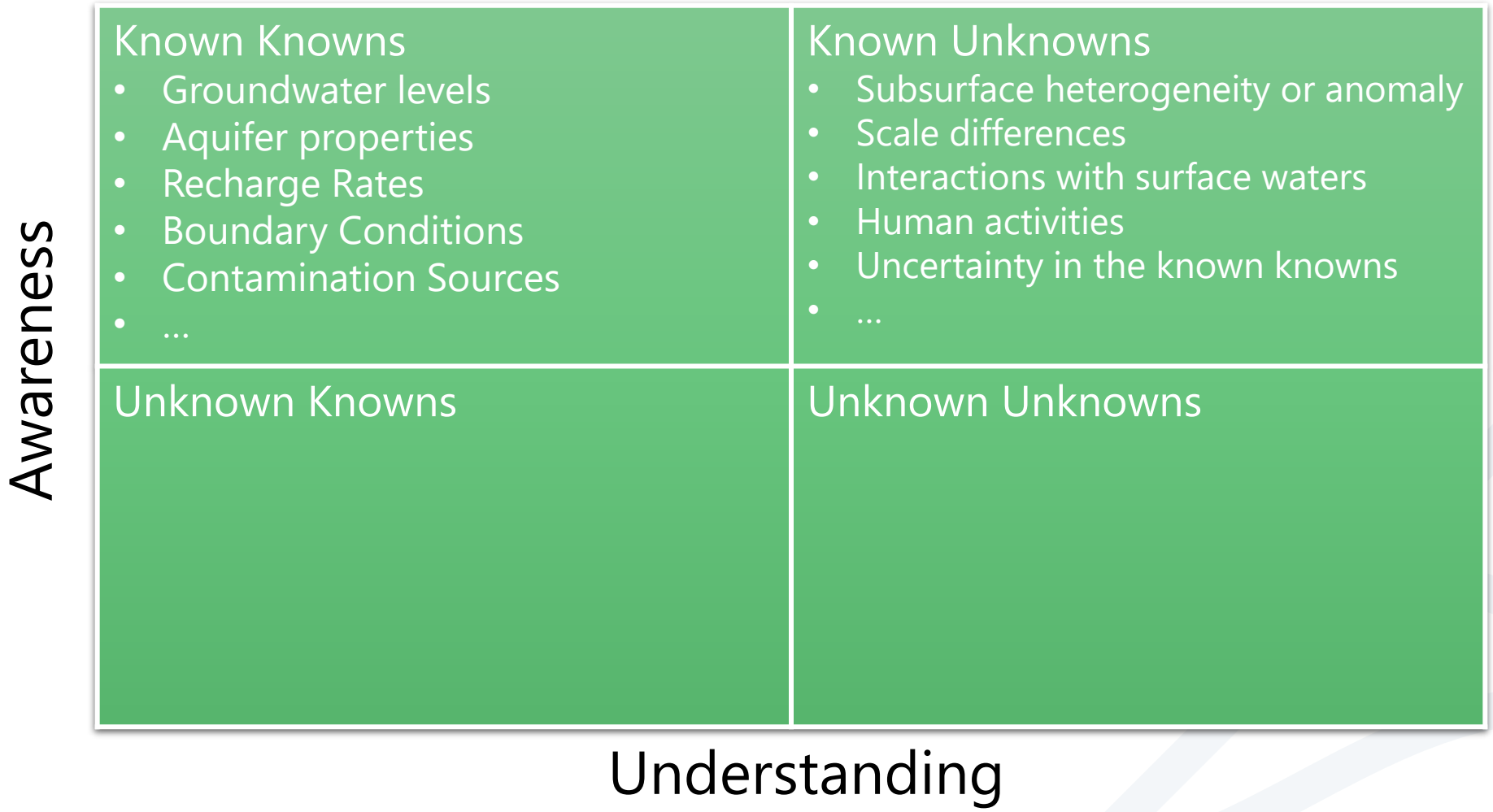

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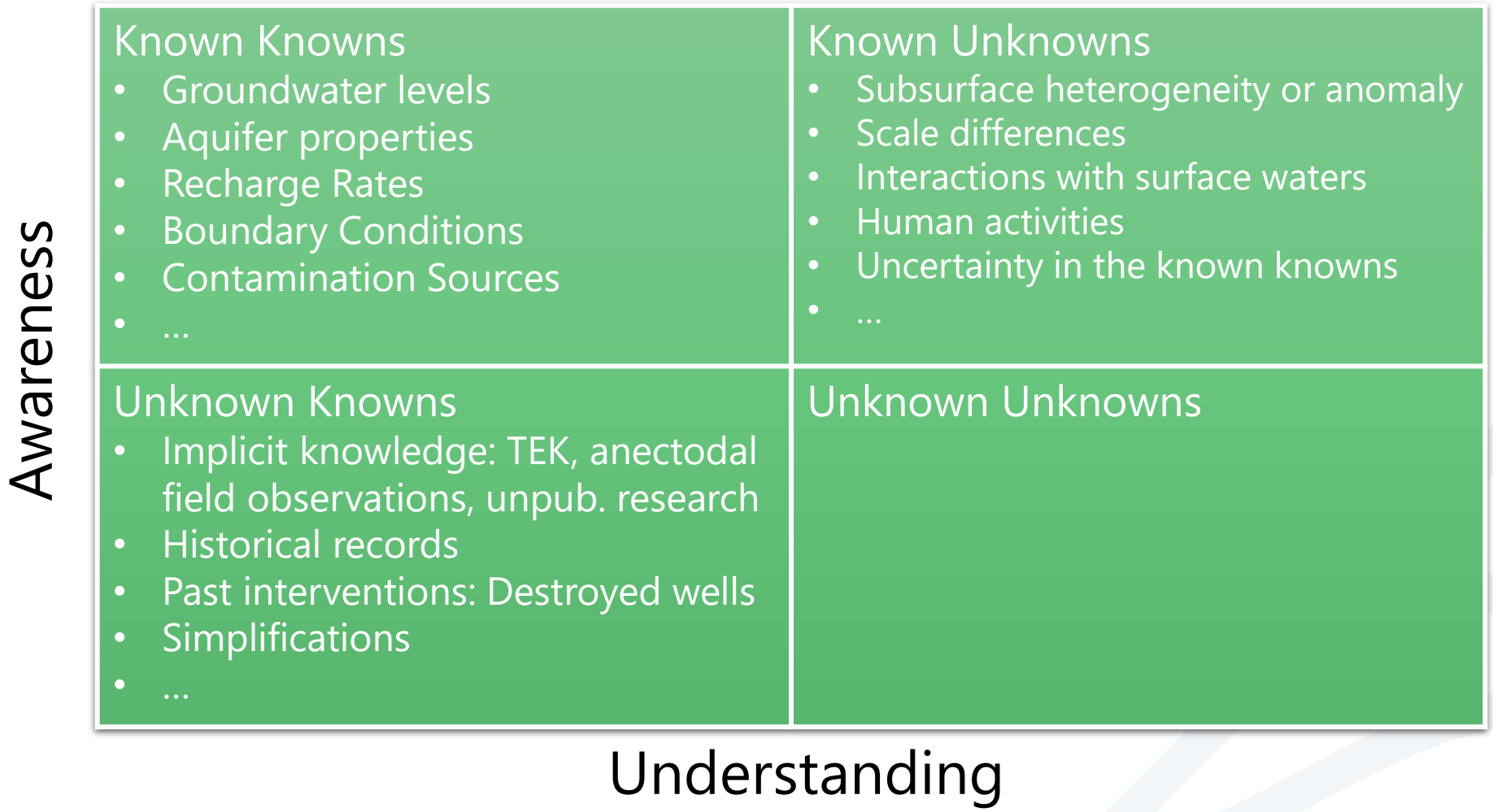


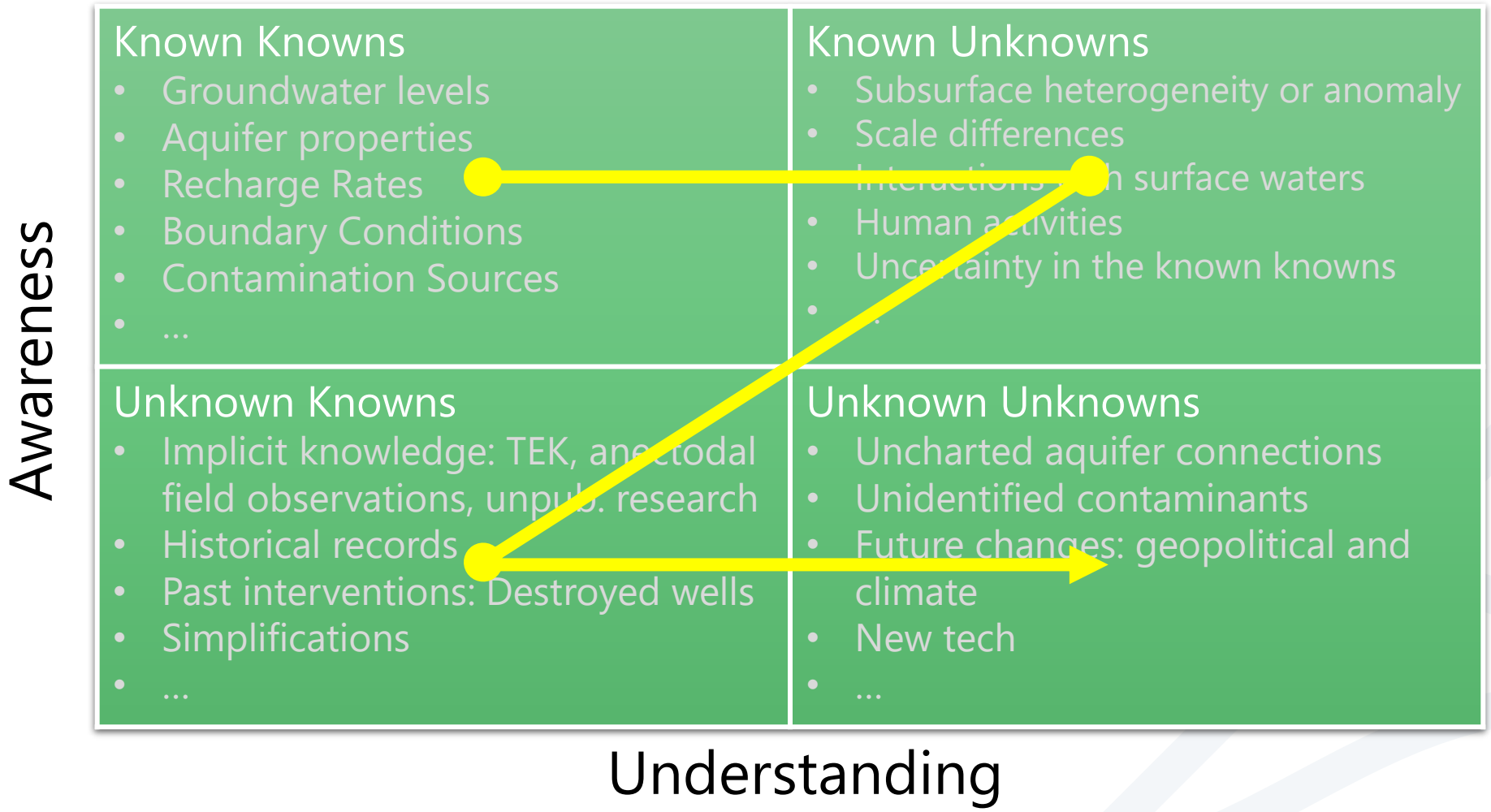
What do we know in groundwater models?

Awareness

Known Knowns • Groundwater levels • Aquifer properties • Recharge Rates • Boundary Conditions • Contamination Sources • …	**Known Unknowns** • Subsurface heterogeneity or anomaly • Scale differences • Interactions with surface waters • Human activities • Uncertainty in the known knowns • …
Unknown Knowns • Implicit knowledge: TEK, anectodal field observations, unpub. research • Historical records • Past interventions: Destroyed wells • Simplifications • …	**Unknown Unknowns** • Uncharted aquifer connections • Unidentified contaminants • Future changes: geopolitical and climate • New tech • …

Understanding

What do we know in groundwater models?



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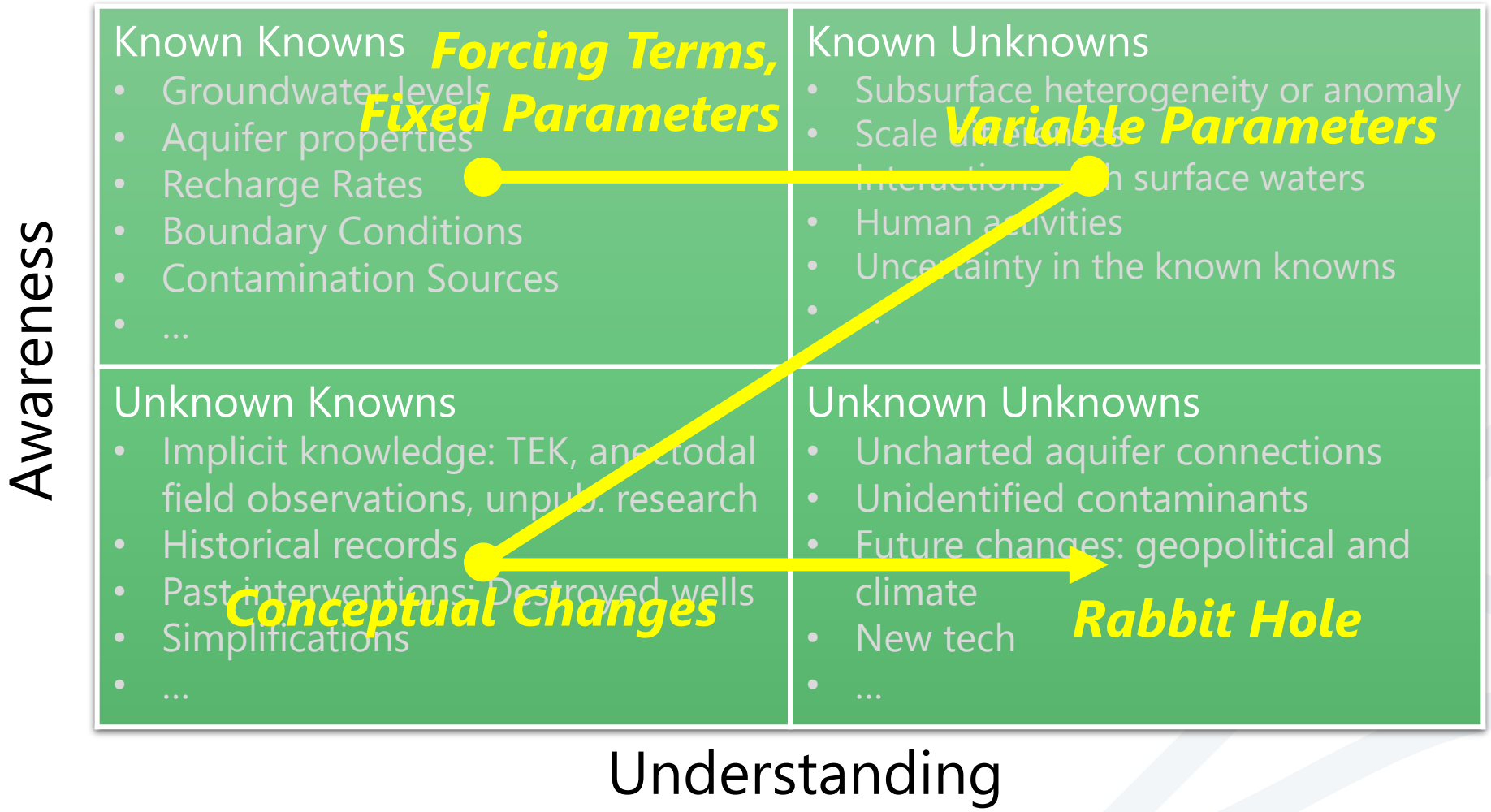

Automated Calibration Workflow

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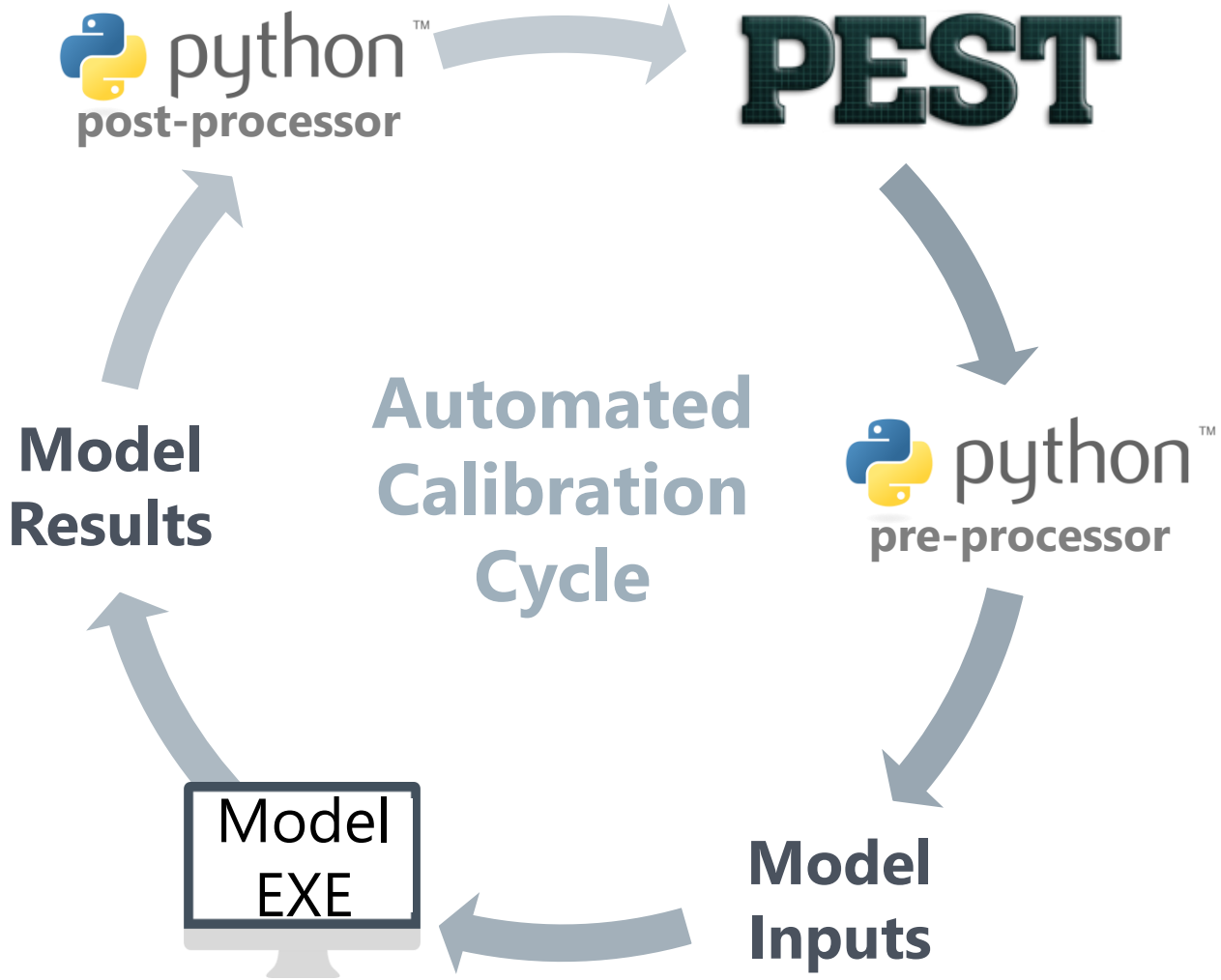
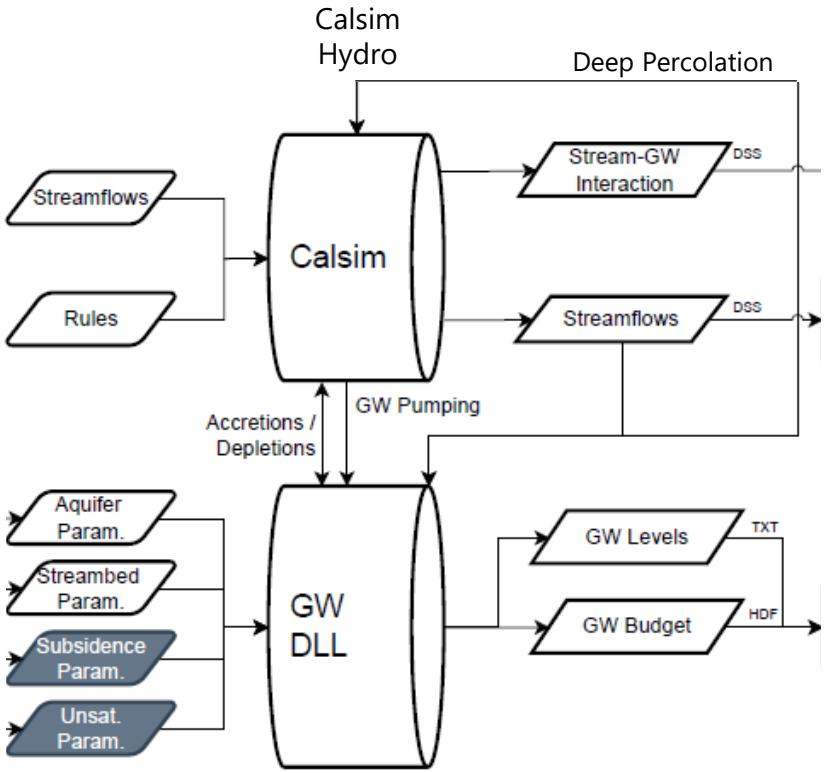
PEST: Model-Independent Parameter Estimation and Uncertainty Analysis

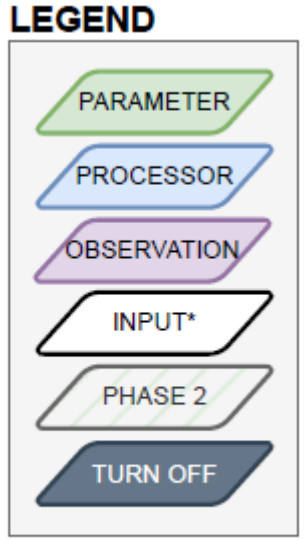


PEST++-IES:

- Iterative ensemble smoother implementation of GLM (based on the work Chen and Oliver 2013) with support for generic localization (local analysis and/or covariance localization)
- Runtime is not limited by the number of parameters, but limited by the ensemble size and number of iterations.

Detailed Calsim-PEST Setup

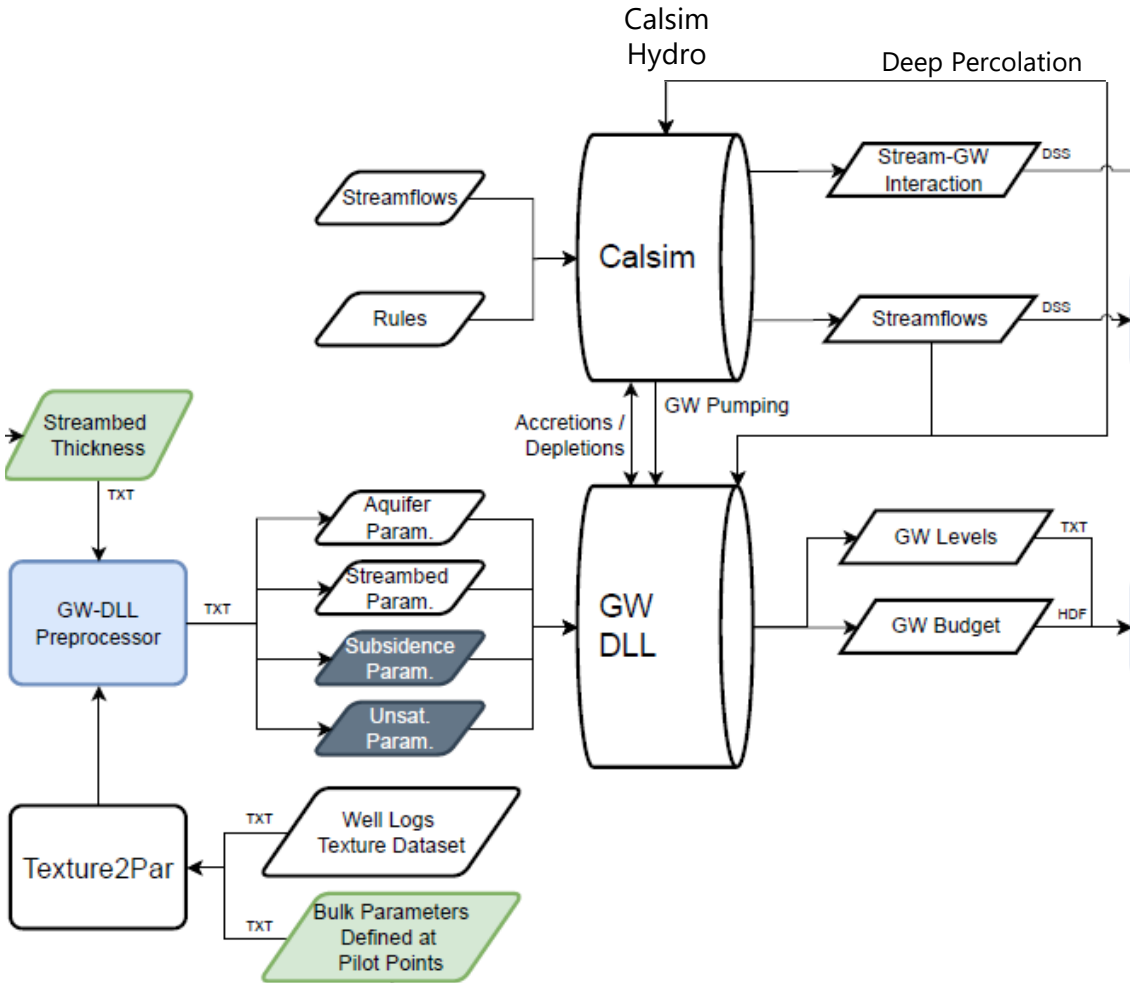


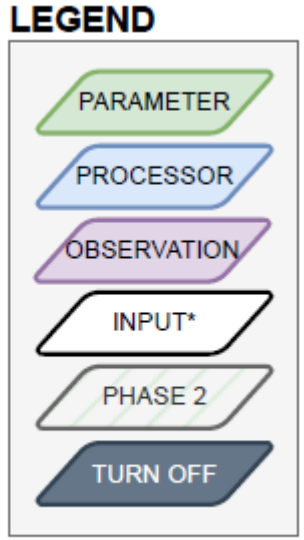


* A selected subset of inputs and outputs are shown in this chart.

- Historical Calsim: 2000-2020
- No operations, purely based on observed flows

Detailed Calsim-PEST Setup





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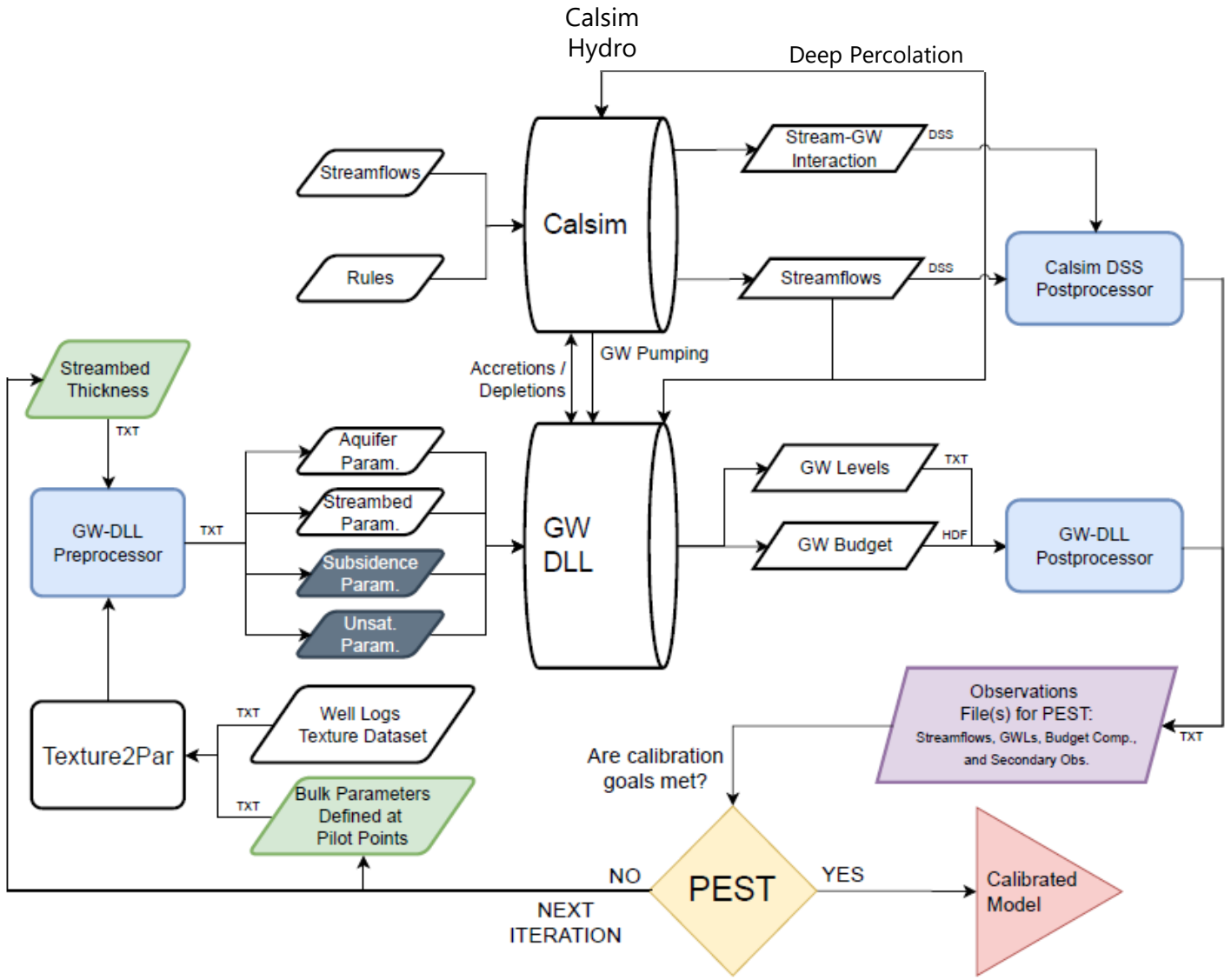

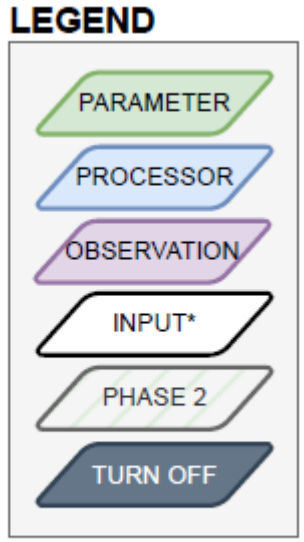

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Observation Datasets

For calibration (non-zero weighted):

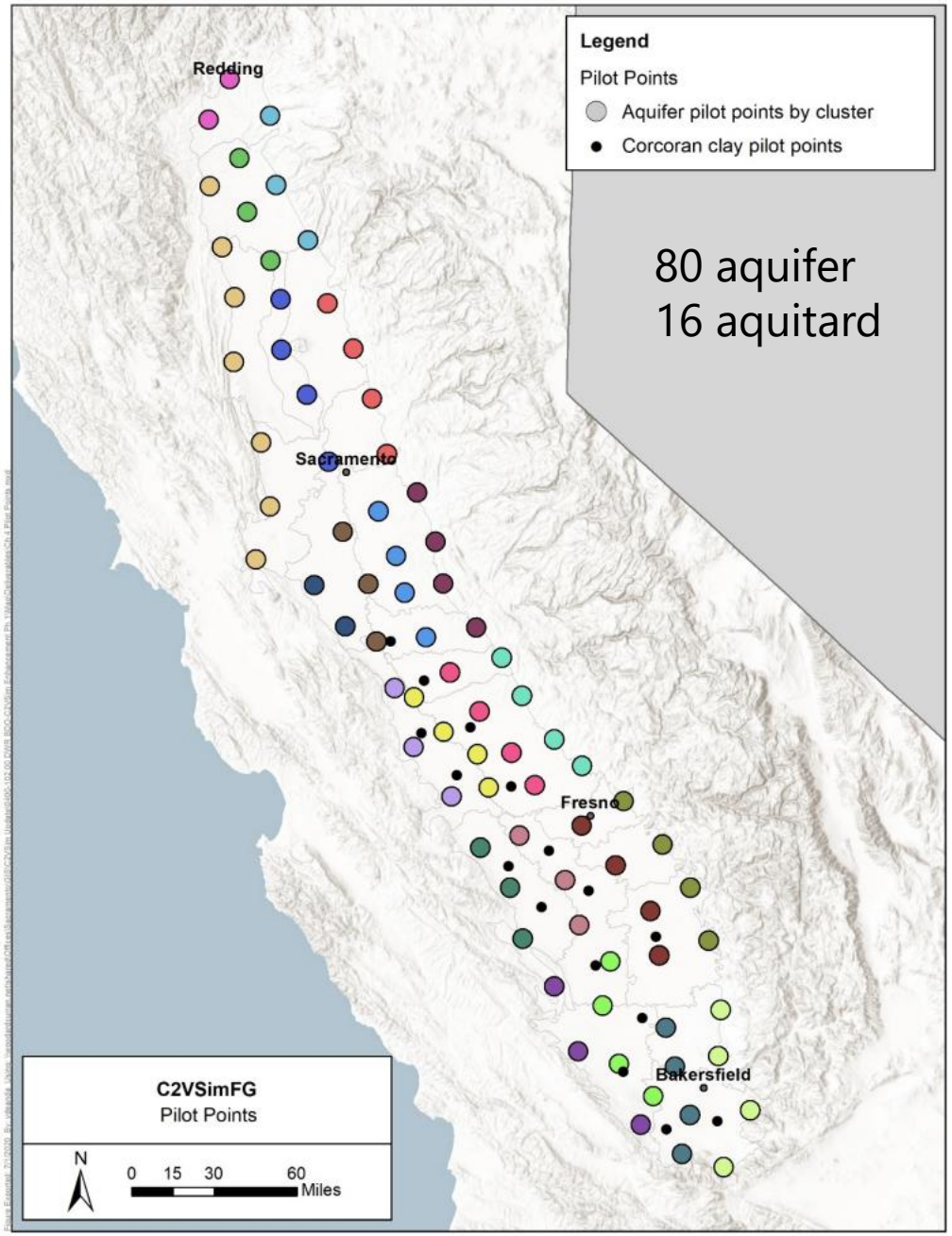
- GW Heads:
  - 2,150 Locations
  - 117,000 Primary Obs.
  - 25,000 Secondary Obs.
- Closure Terms: 15 Locations x 252 time steps

For tracking (zero weighted):

- Channel Flows: 17 Locations
- Stream Gain: 939 Locations
- GW Storage Change: 21 Subregions

During Automated Calibration

1. Start from 1 pilot point, all parameters and gradually increase the number of pilot points
   a) Understand the spatial heterogeneity captured by Texture2Par
   b) Identify the parts of the domain that behave differently

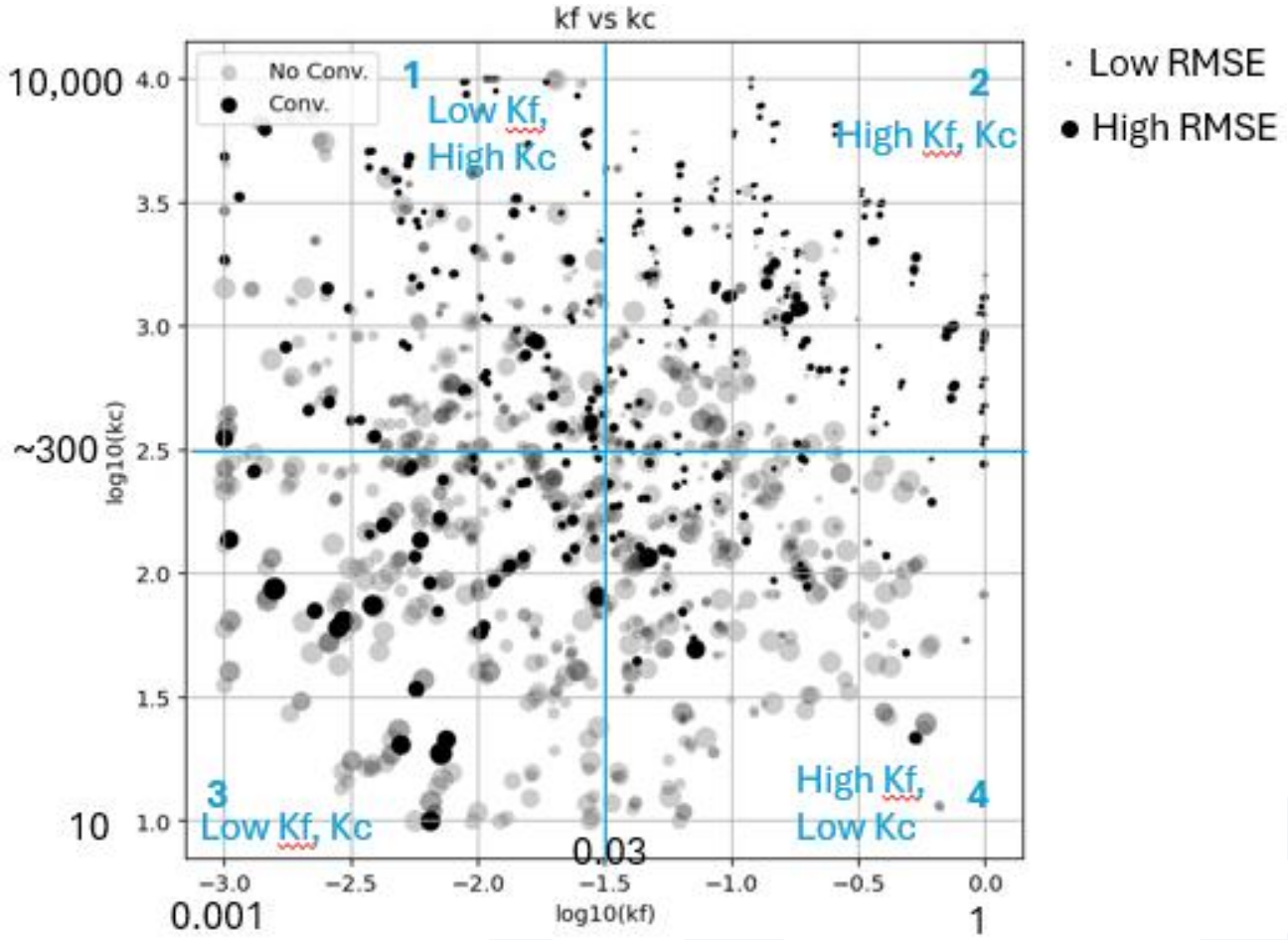


During Automated Calibration

2. Start by testing a wide range of parameter values within reasonable ranges and track the impact on residual statistics and closure terms.

   Focus on smaller ranges as calibration continues.

   Switch to another PEST version if needed.



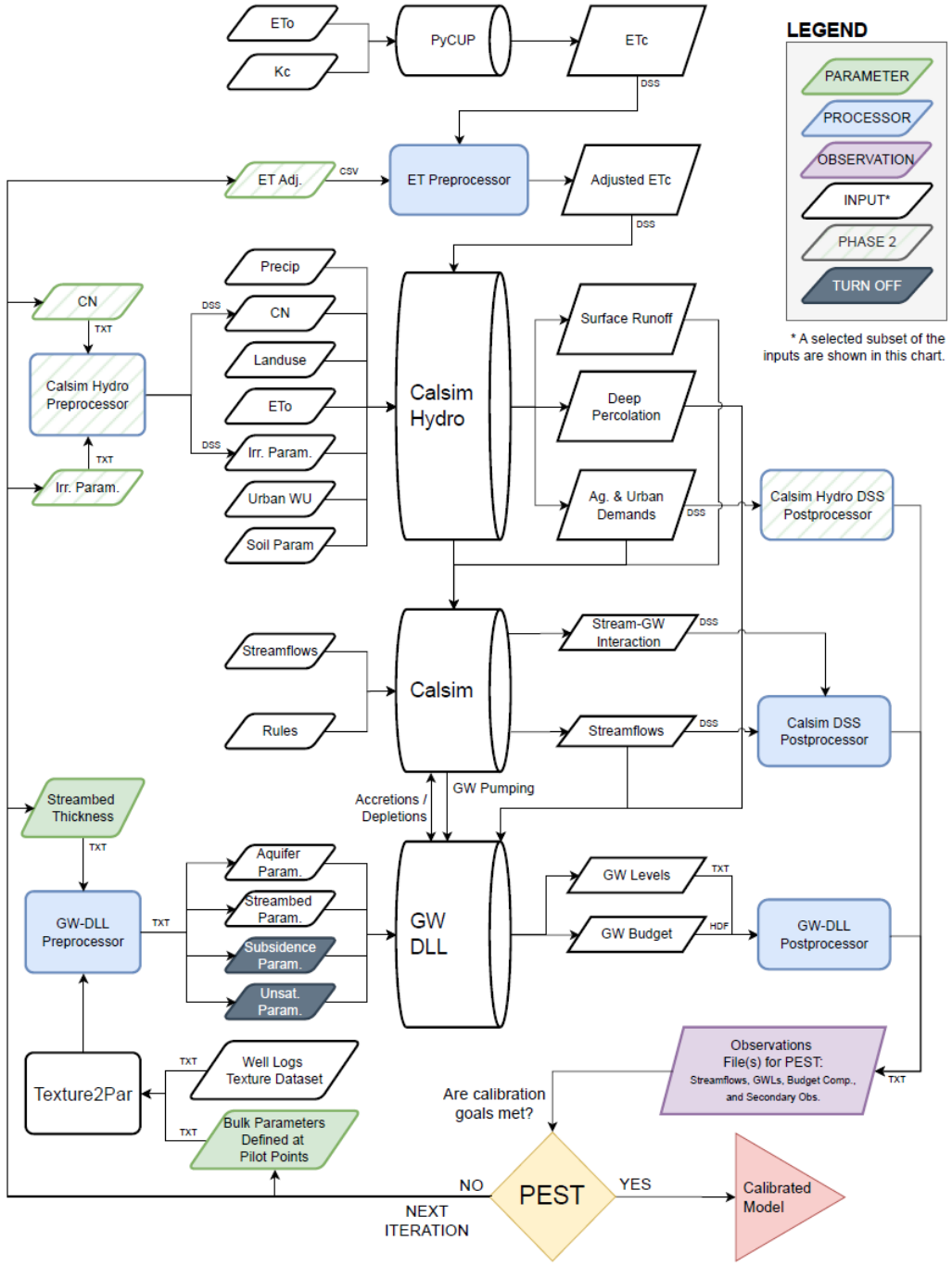
During Automated Calibration

3. Investigate the outliers in the results to identify the areas that may need conceptual and/or water budget changes.

   Make those changes and repeat.

Next Steps

- Incorporate Calsim Hydro in the process
- Investigate the impact of the land surface parameters on the closure terms and other outputs



Thank you

Project Team

Ryan Lucas
Nancy Parker
Lauren Thatch

Bridget Childs
Puneet Khatavkar

Ali Taghavi
Reza Namvar
Sercan Ceyhan

mceyhan@woodardcurran.com

www.linkedin.com/in/sceyhan