Session G2: Salinity

Room 308-310

09:00 - 10:30

Assessing Salinity Sources and **Baseflow Constraints** in the **Pecos River Basin** using **SWAT+** *gwflow*

Seonggyu Park,
Scott Collins,
Shane Walker,
Eric Bernard,
Texas Tech University
Ryan Bailey,
Colorado State University
Celray James Chawanda,
Arun Bawa,
Jeff Arnold
Texas A&M AgriLife

2025 SWAT International Conference
Fort Collins, Colorado, October 21-24, 2025

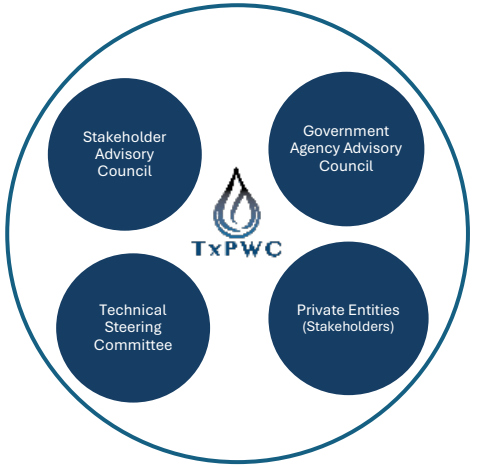
Texas Produced Water Consortium

Outline

- TxPWC Overview & Texas Water Challenges
- SWAT+ gwflow Modeling Approach
- Pecos River Case Study & Expected Results
- Conclusions & Next Steps

Texas Produced Water Consortium (TxPWC)

- Established by SB601 (2021) to study technical and economic aspects of beneficial reuse of treated produced water
  - Leadership team at Texas Tech University
  - Legislative reports: 2022 (link), 2024 (link)
  - Active and diverse stakeholder membership:
    - agriculture, landowners, O&G upstream, midstream, environmental, governmental, consultants, etc.

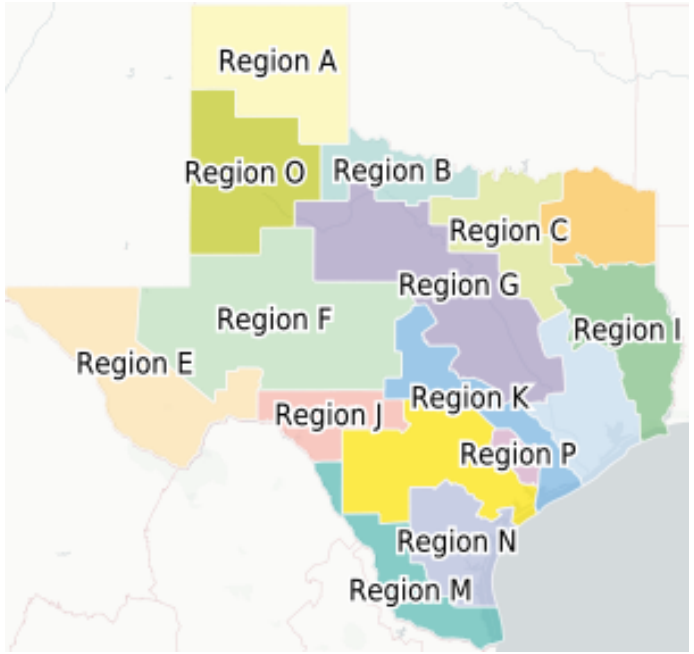


MEMBERS

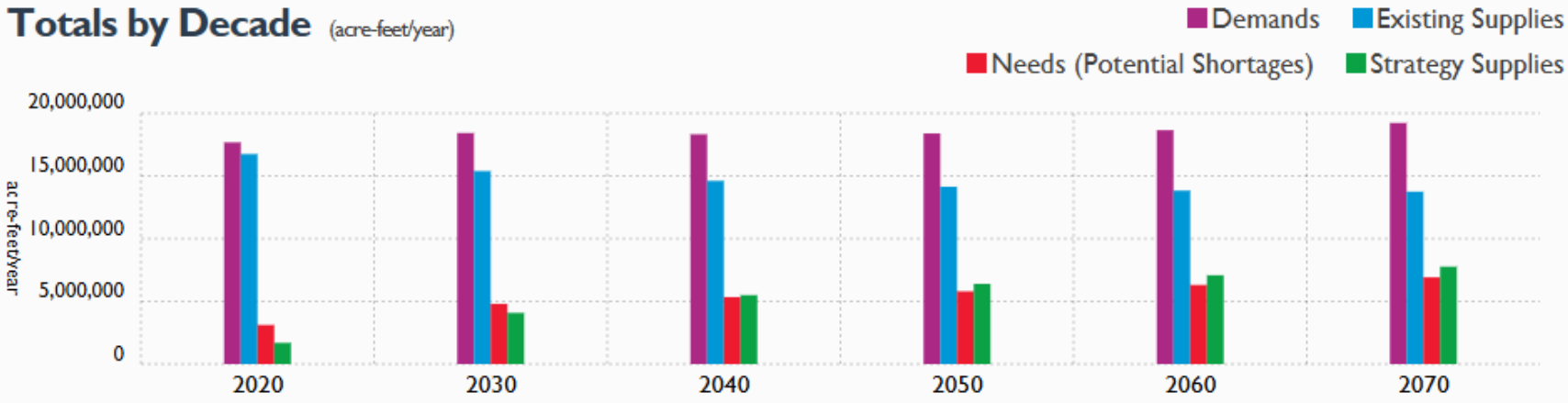
Aris Water Solutions LLC
Bachtel Leeds
BadWater Alchemy
Bar Lazy V
Carollo
Chemical Injection Partners
Chevron
ConocoPhillips
Diamondback Energy
Environmental Defense Fund
Fasken Oil and Ranch
Gulf Coast Authority
Layne Water Midstream
Meadows Center
NLB Water
Occidental Oil & Gas Corporation
Permian Basin Petroleum Association
Resource West Inc.
Select Water Solutions
Sierra Club Lone Star Chapter
Texas American Water Works Association
Texas Desalination Association
Texas Pacific Water Resources
TETRA
TETRA TECH
Texas Oil and Gas Association
WaterBridge Operating LLC
Western Midstream Partners

Challenges: TWDB – State Water Plan

- 2020-2030 statewide water demand: **~18M ac-ft/yr**
- Growing needs: **4.8M ac-ft/yr** (2030) to 6.9M ac-ft/yr (2070)



Totals by Decade (acre-feet/year)



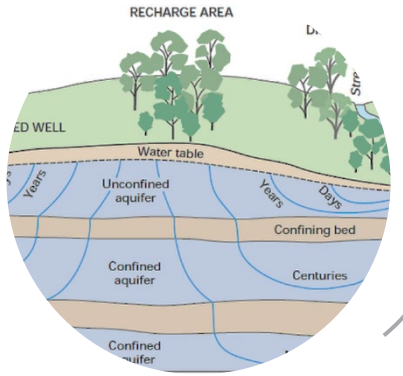
	2020	2030	2040	2050	2060	2070
Demands	17,680,444	18,426,781	18,326,558	18,394,477	18,647,792	19,230,876
Existing Supplies	16,748,029	15,394,457	14,615,947	14,142,237	13,834,633	13,750,315
Needs (Potential Shortages)	3,116,143	4,802,730	5,339,768	5,798,441	6,307,209	6,917,609
Strategy Supplies	1,690,192	4,081,861	5,497,295	6,398,116	7,083,691	7,766,984

https://2022.texasstatewaterplan.org/, accessed 2025-MAR-02

Objective

- The overall objective of this project is to identify the major hydrological and ecological processes during and after the release of treated produced water.
    - To simulate key hydrological and ecological processes
    - To track the fate of released desalinated water
    - To assess impacts on streamflow and ecosystems
    - To capture spatial and temporal variability
    - To support safe and informed water reuse decisions

Why SWAT+gwflow?



DayCent
DSSAT
EPIC
DNDC

Crop

Surface

Subsurface

MODFLOW
FEFLOW

- *10–15 used at watershed scale*
- *~ 20 global models used in climate-hydrology research.*

(Sources: EGU European Geosciences Union, MDPI, Wikipedia)

SWAT / SWAT+
APEX
HEC-HMS
PRMS-V
HEC-RAS

SWAT+*gwflow*

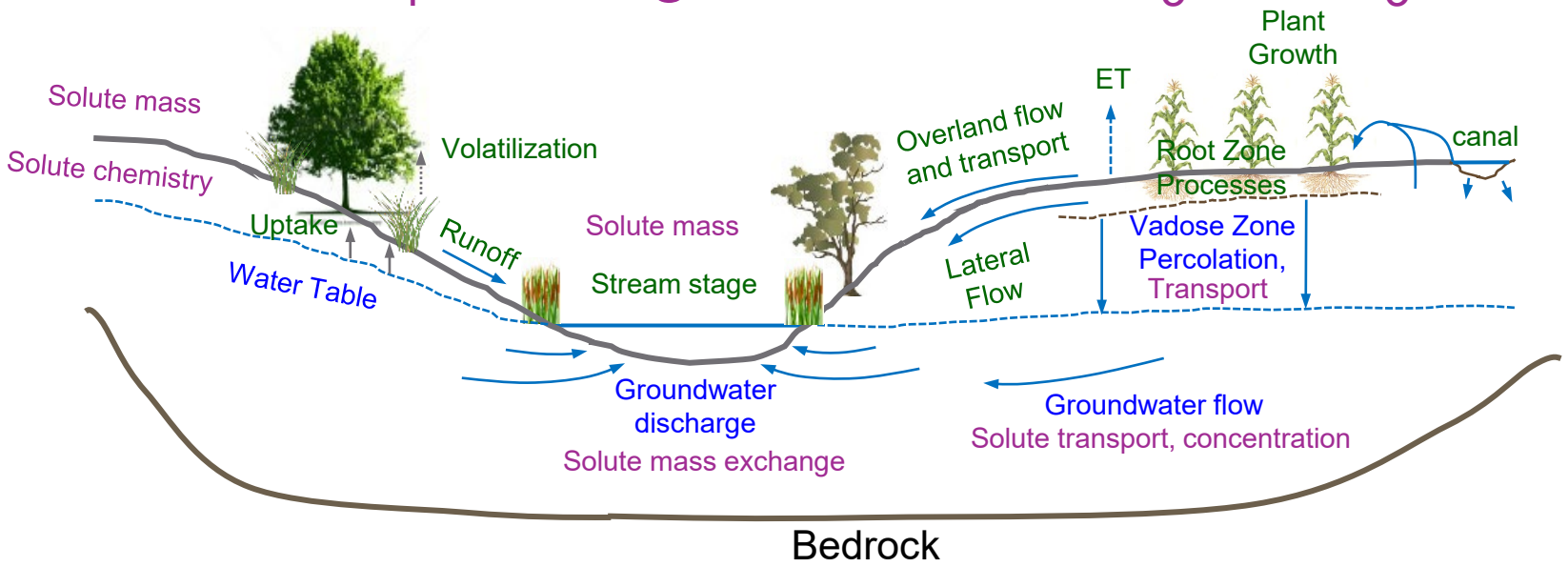
SWAT(SWAT+)-MODFLOW
APEX-MODFLOW-RT3D-Salt
ParFlow
GSFLOW
MIKE SHE

Why SWAT+gwflow?

Method: Enhanced SWAT+ (Salt and river dynamics) *gwflow*

Watershed Solute transport in Enhanced SWAT+*gwflow* (Bailey at al., 2020)

Solute = SO_4, Ca, Mg, Na, Cl, K, CO_3, HCO_3 , NO_3, P, NH_4^+

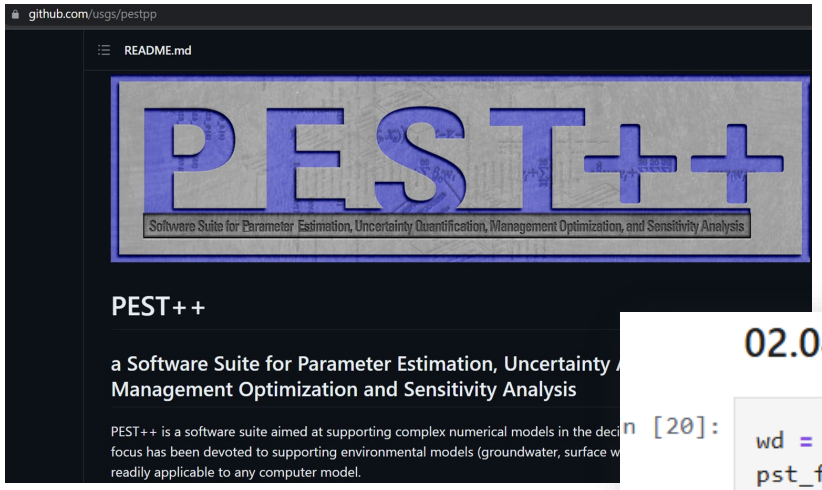


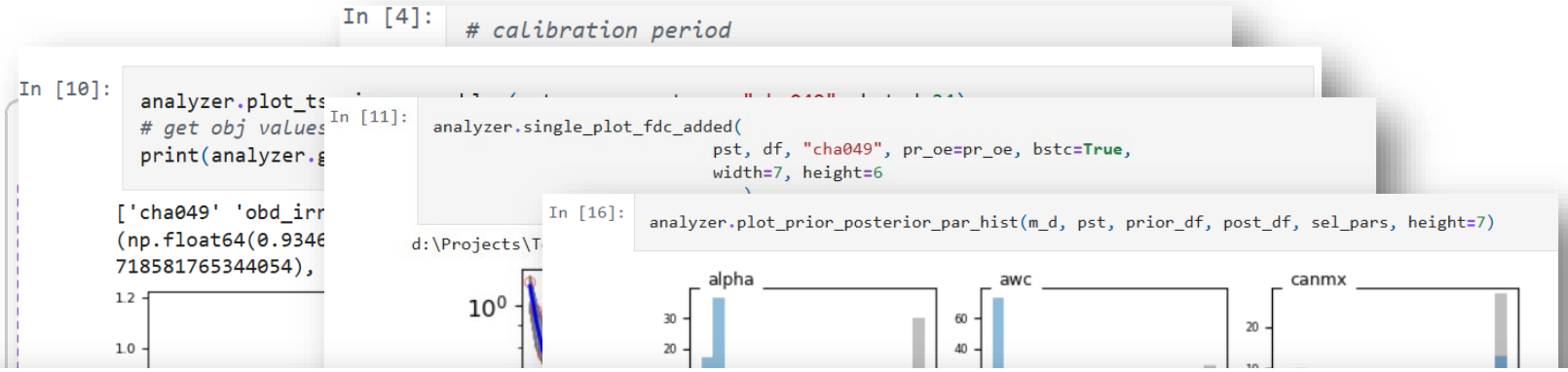
- Key Advantages
  - Comprehensive solute tracking (12+ constituents)
  - Explicit GW-SW coupling
  - Management scenario testing

- Integrated Hydrologic Process
  - GW/SW interaction
  - Water Availability
- Management
  - Water Allocation
  - Land application (irrigation)
  - In stream

Texas Produced Water Consortium

Uncertainty & Scenario Analysis

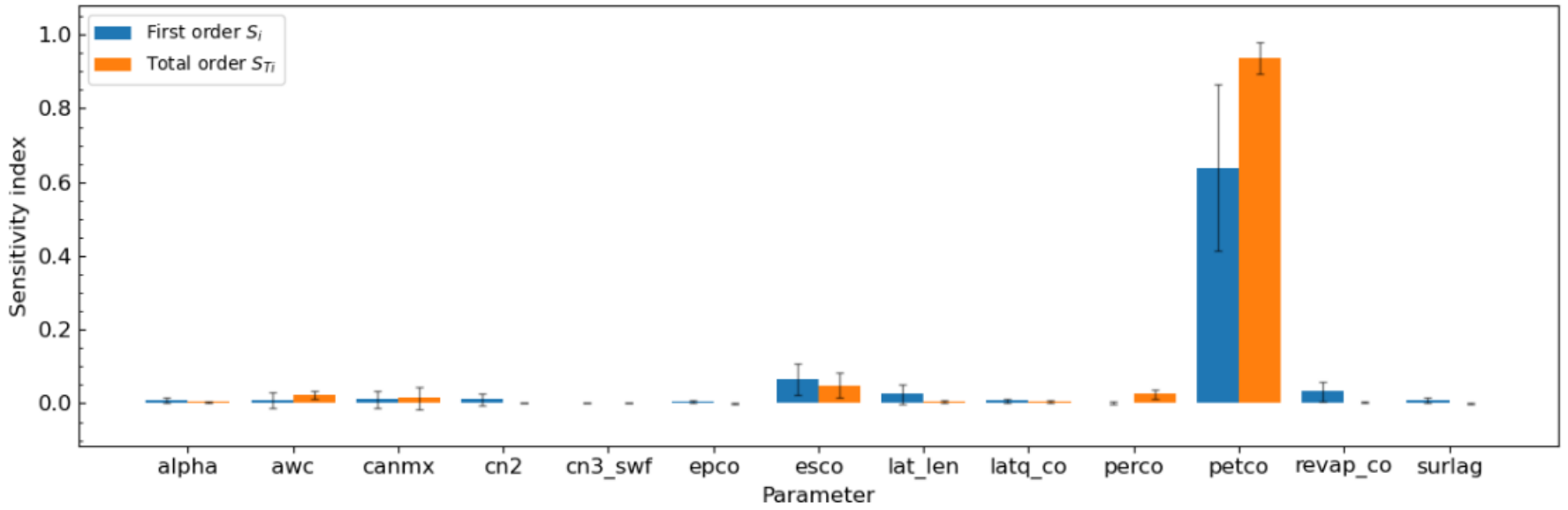




02.04 Sensitivity Analysis

In [20]:

```
wd = "D:\\Projects\\Watersheds\\Albufera\\2nd\\alb_rw_sobol"
pst_file = "alb_rw_sobol.pst"
analyzer.plot_sen_sobol(wd, pst_file)
```

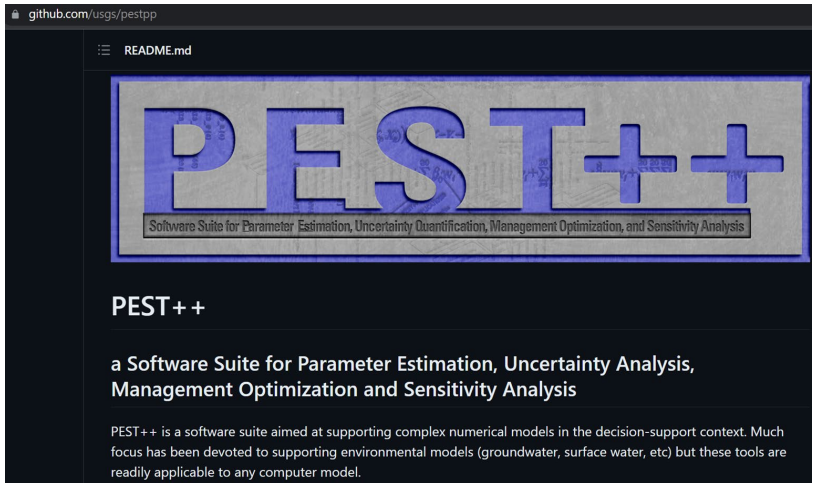


pyEMU + FloPy

- swatp_pst_wf
- swatmf (https://doi.org/10.5281/zenodo.
- apexmf (https://doi.org/10.5281/zenodo.

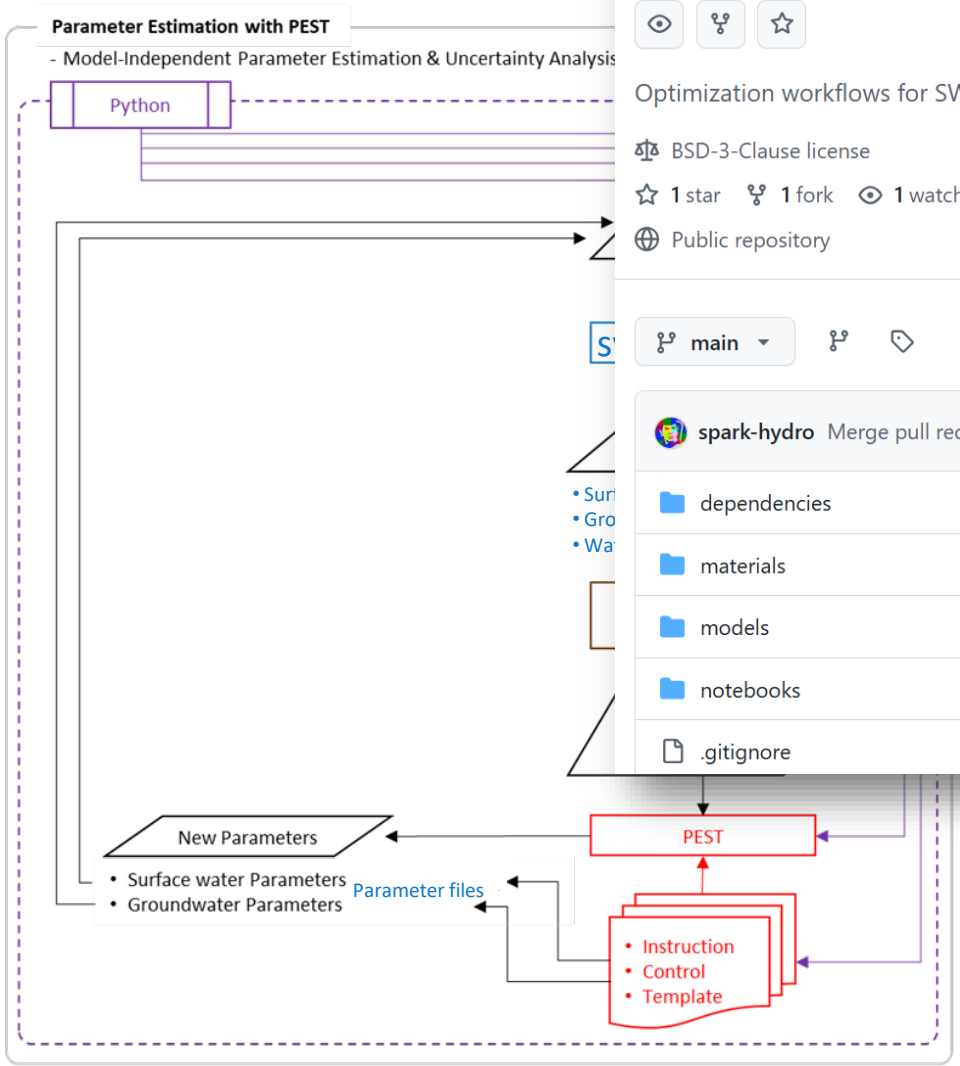
Texas Produced Water Consortium

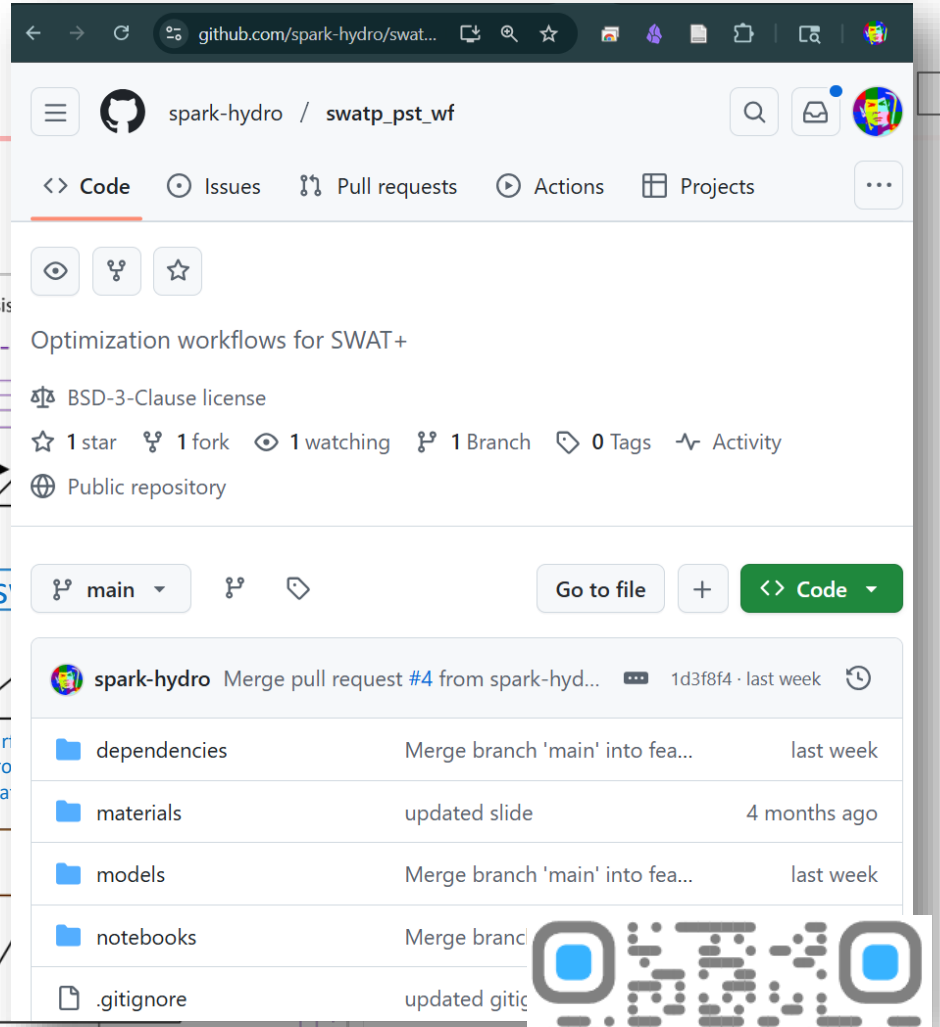
Uncertainty & Scenario Analysis



pyEMU + FloPy

- swatp_pst_wf
- swatmf (https://doi.org/10.5281/zenodo.6000645)
- apexmf (https://doi.org/10.5281/zenodo.8071033)



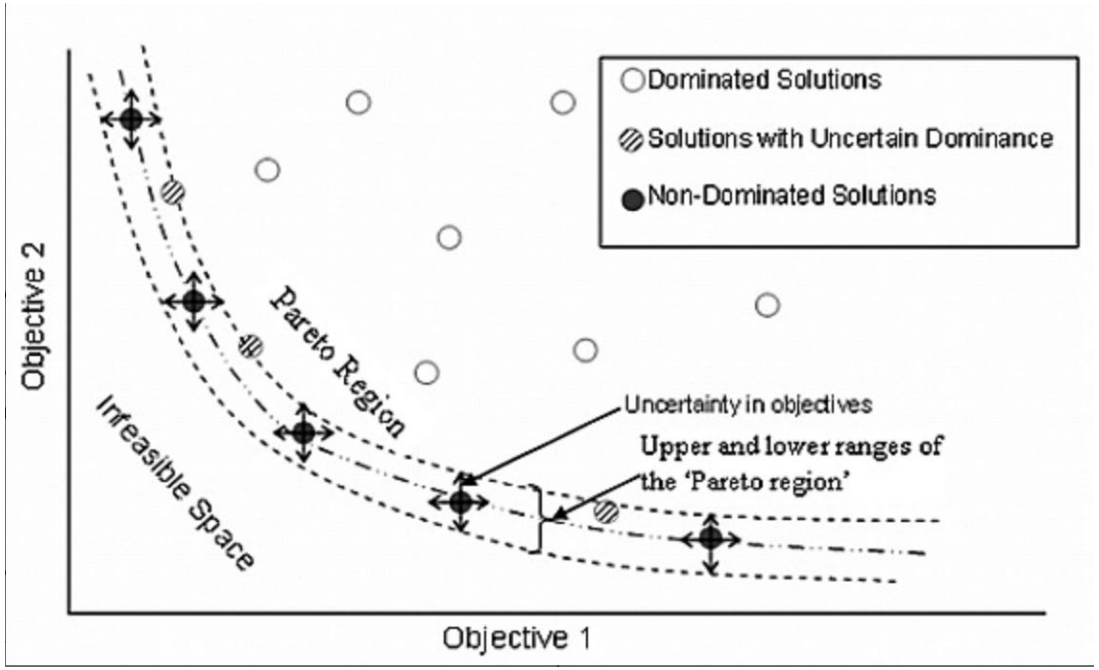


https://github.com/spark-hydro/swatp_pst_wf

Texas Produced Water Consortium

Uncertainty & Scenario Analysis

- PESTPP-MOU
  Constrained multi-objective optimization
  evolutionary/genetic global algorithms
  Chance constraints
  FOSM and stacks
- PESTPP-SEN
  - Morris (local) or Sobal (global)
- PESTPP-IES:
  - Optimization under uncertainty analysis
- PESTPP-SWP
  - Perform scenario analysis based on pre-determined parameter sets or input sets.



Pecos River Watershed

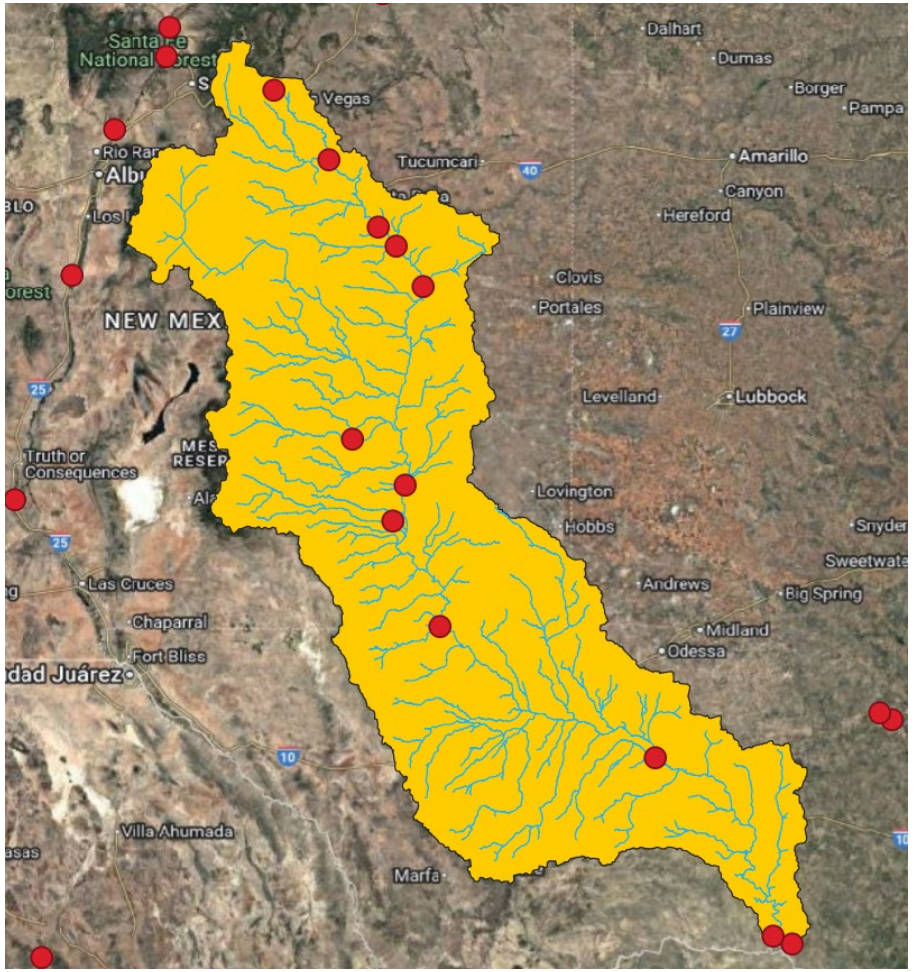
Pecos River Watershed

- CoSWAT-Framework (Chawanda et al., 2025)

CoSWAT

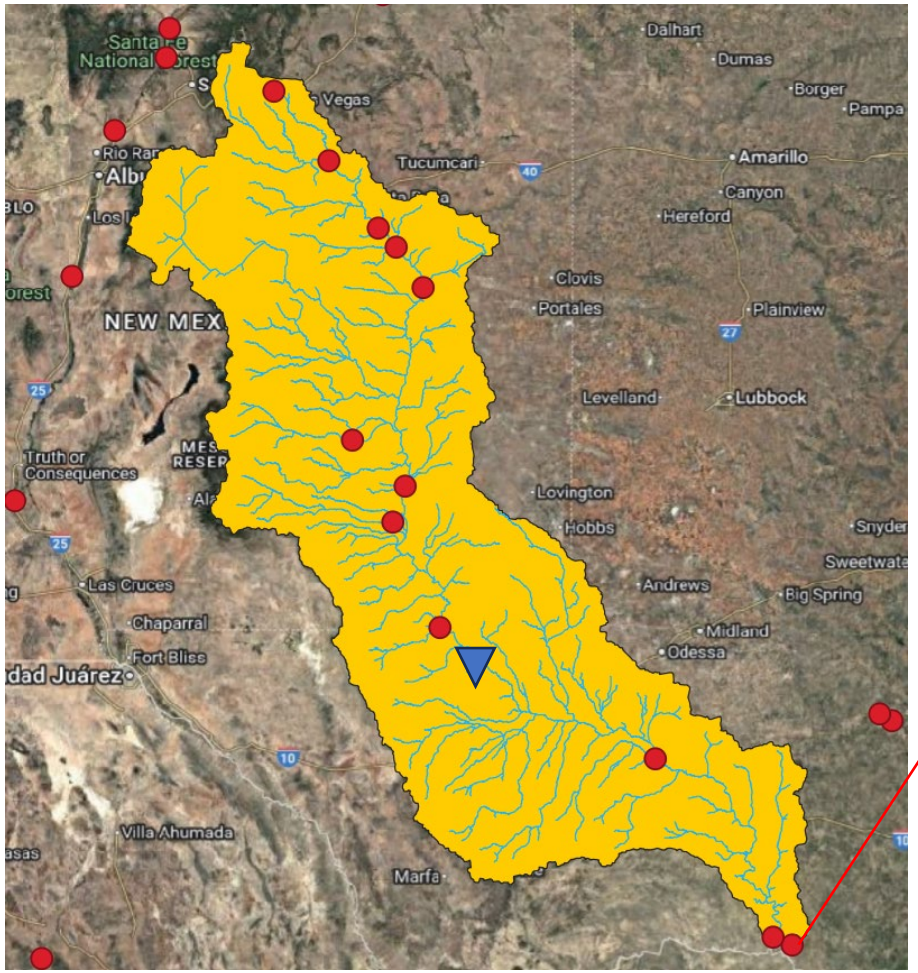
- DEM: The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) global DEM (Abrams, 2016)
- Land: European Space Agency (ESA, 2017)
- Soil: FAO soil data (Fischer et al., 2008)
- Weather: Reanalysis dataset (Lange and Büchner, 2020) through the InterSectoral Impact Model Intercomparison (ISIMIP) project.
- QSWAT+ → 3.0.6
- Editor → 3.0.8
- Run SWAT+ → 61.0.2
- Evaluation
- Prepare for Server

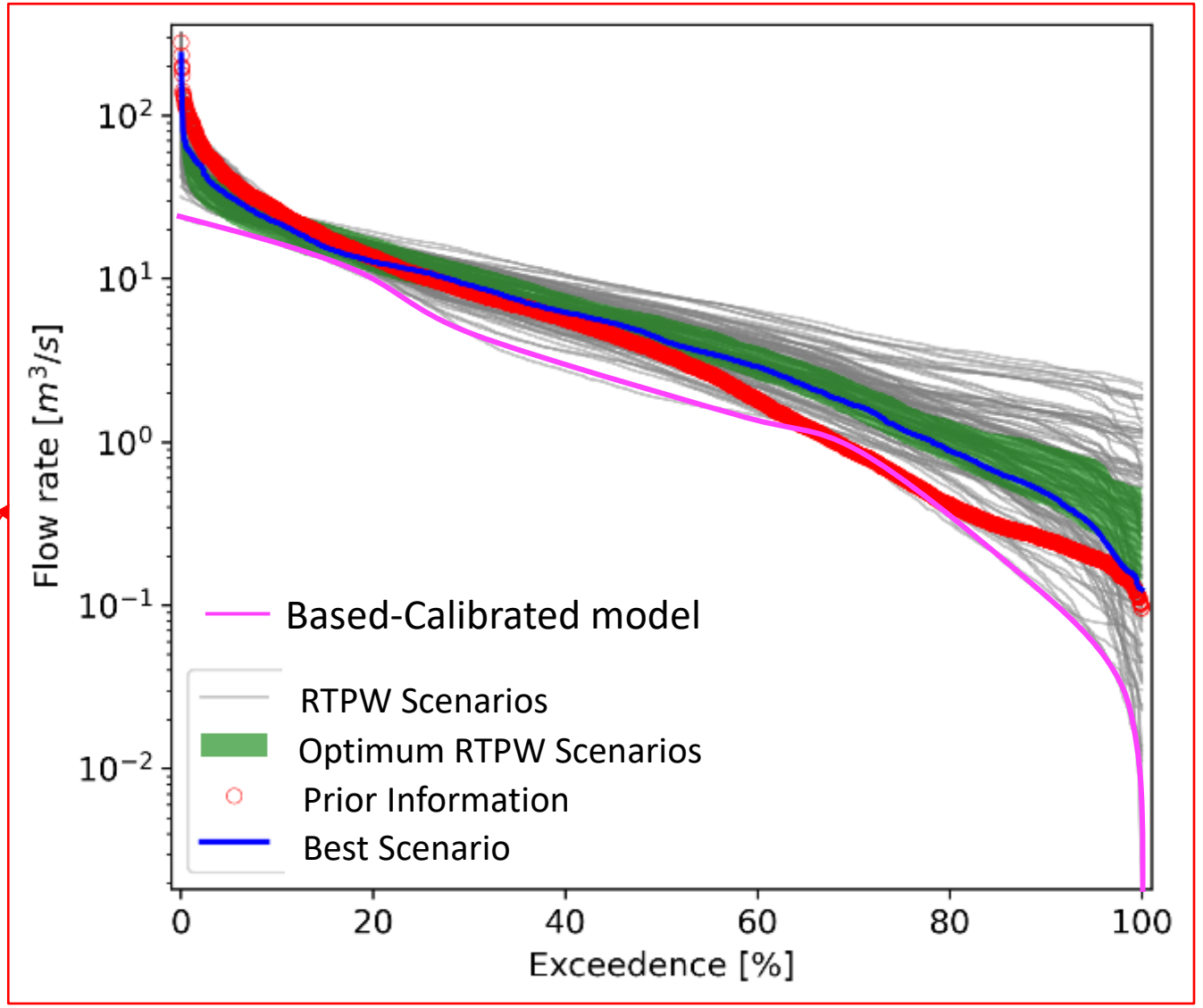
Pecos River Watershed



- Size: 161,070 km^2
- HRUs: 2,874
- Subbasin: 460

Pecos River Watershed

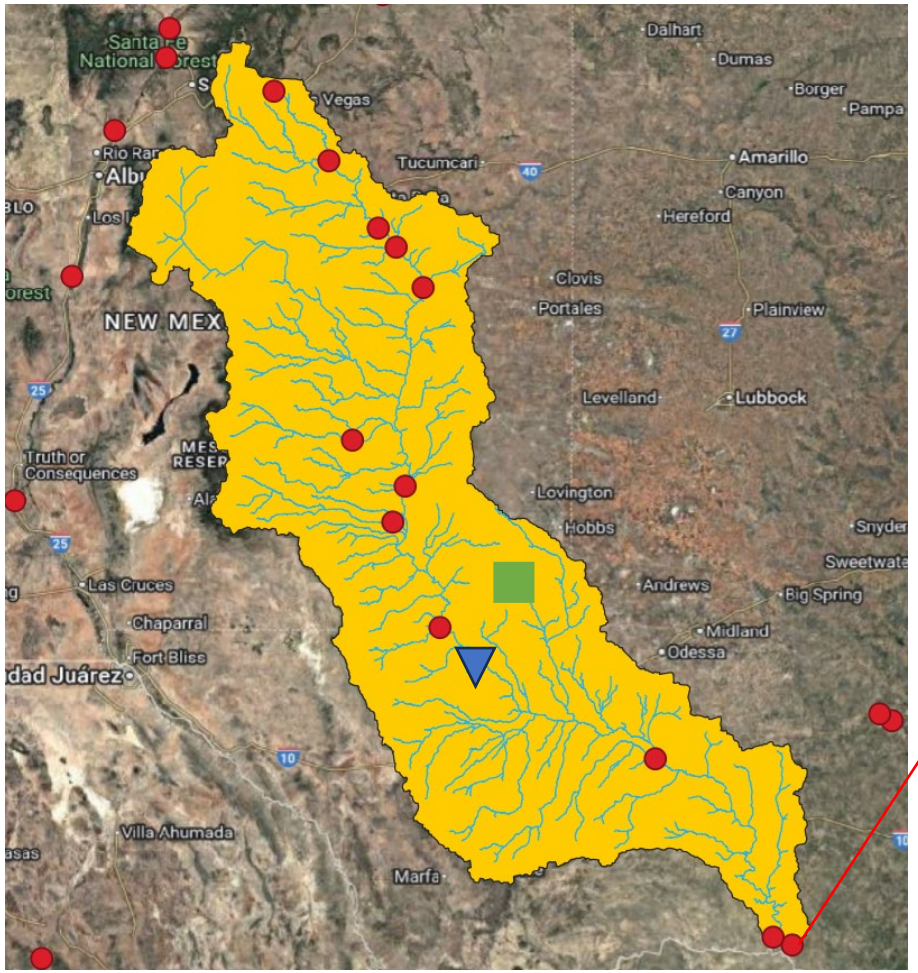


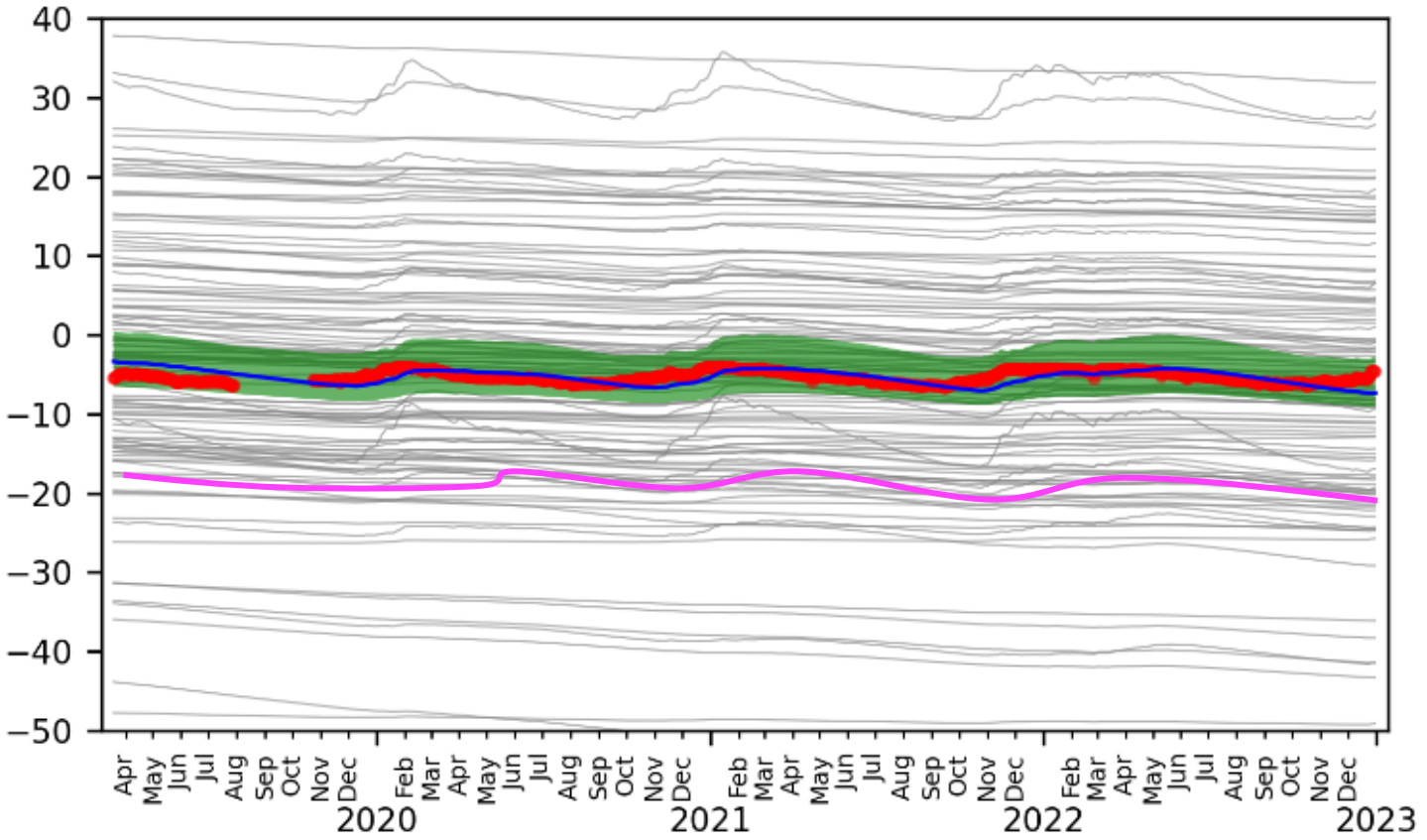


▼ NGL Water Solutions: up to 16.9 million gpd
Texas Pacific Water Resources: up to 840,000 gpd

Texas Produced Water Consortium

Pecos River Watershed





Based-Calibrated model

RTPW Scenarios

Optimum RTPW Scenarios

Prior Information

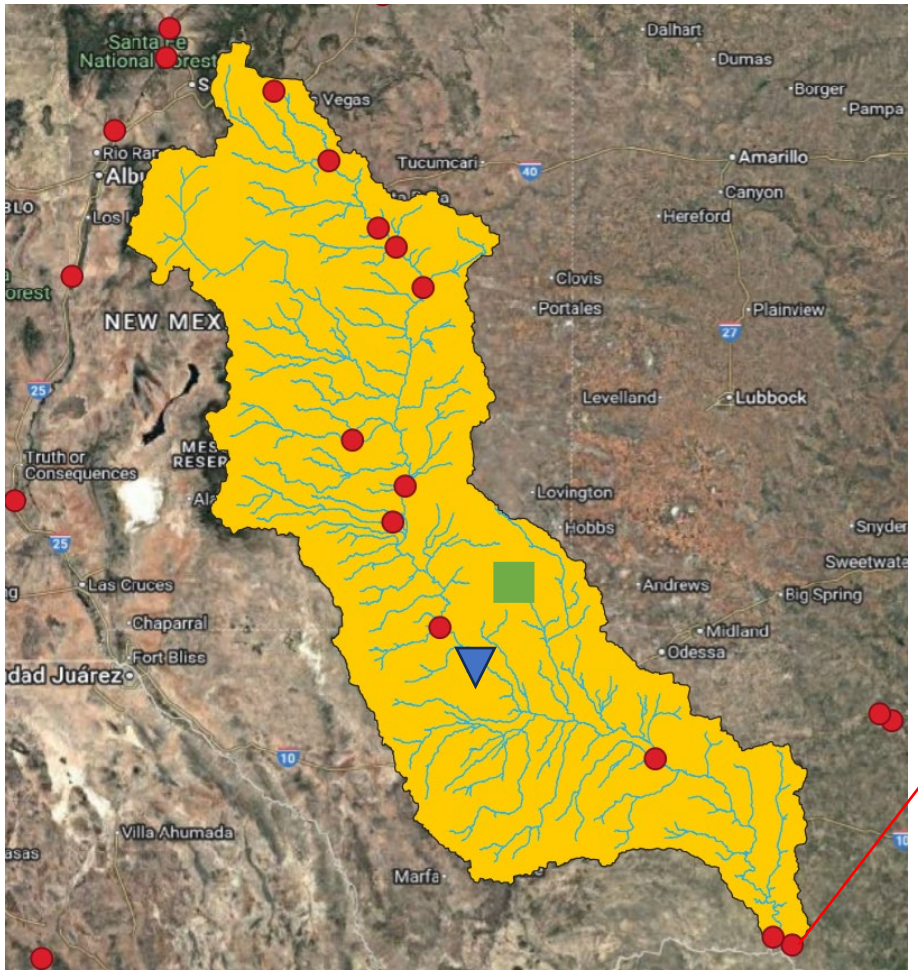
Best Scenario

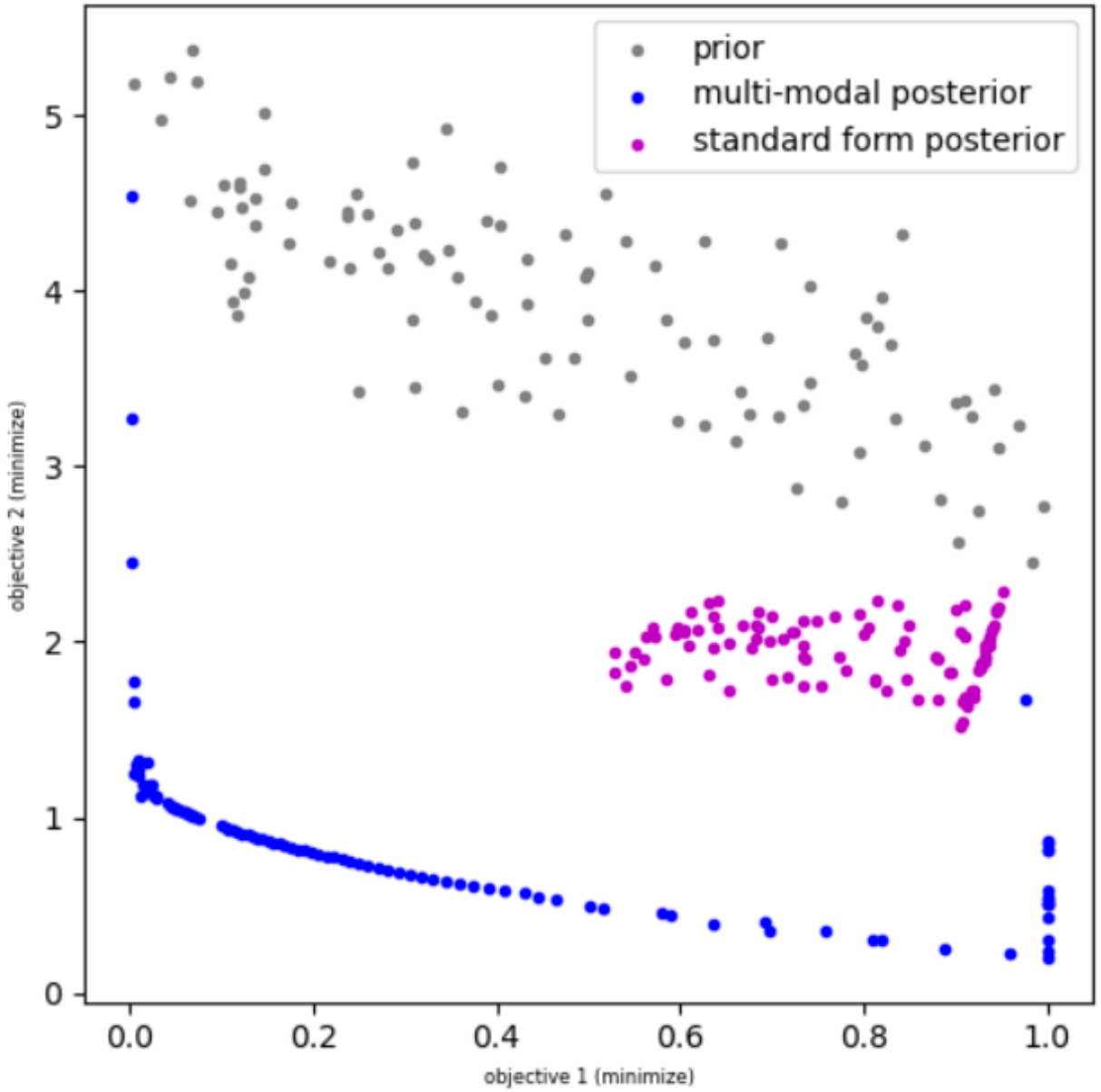
NGL Water Solutions: up to 16.9 million gpd

Texas Pacific Water Resources: up to 840,000 gpd

Texas Produced Water Consortium

Pecos River Watershed

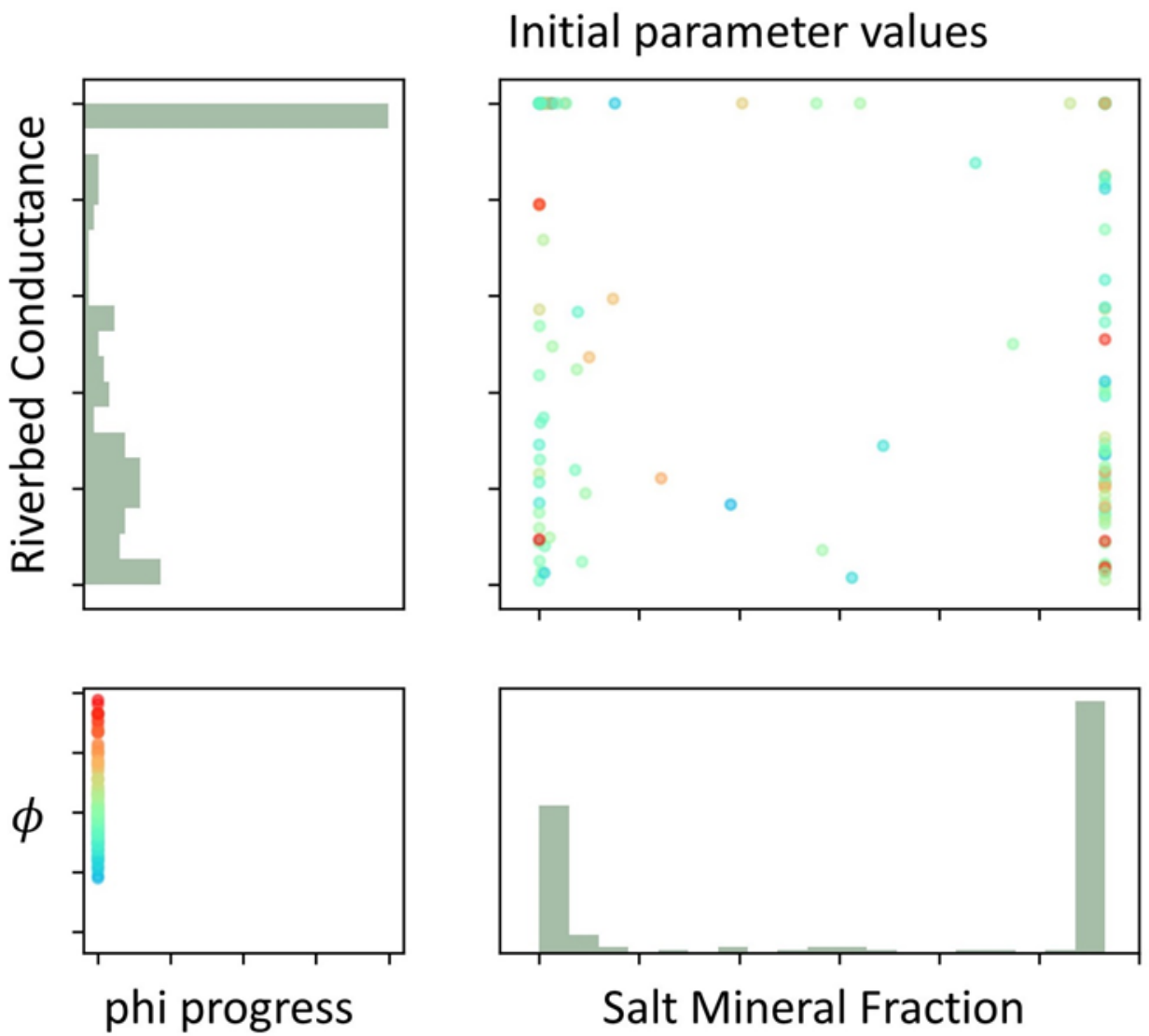


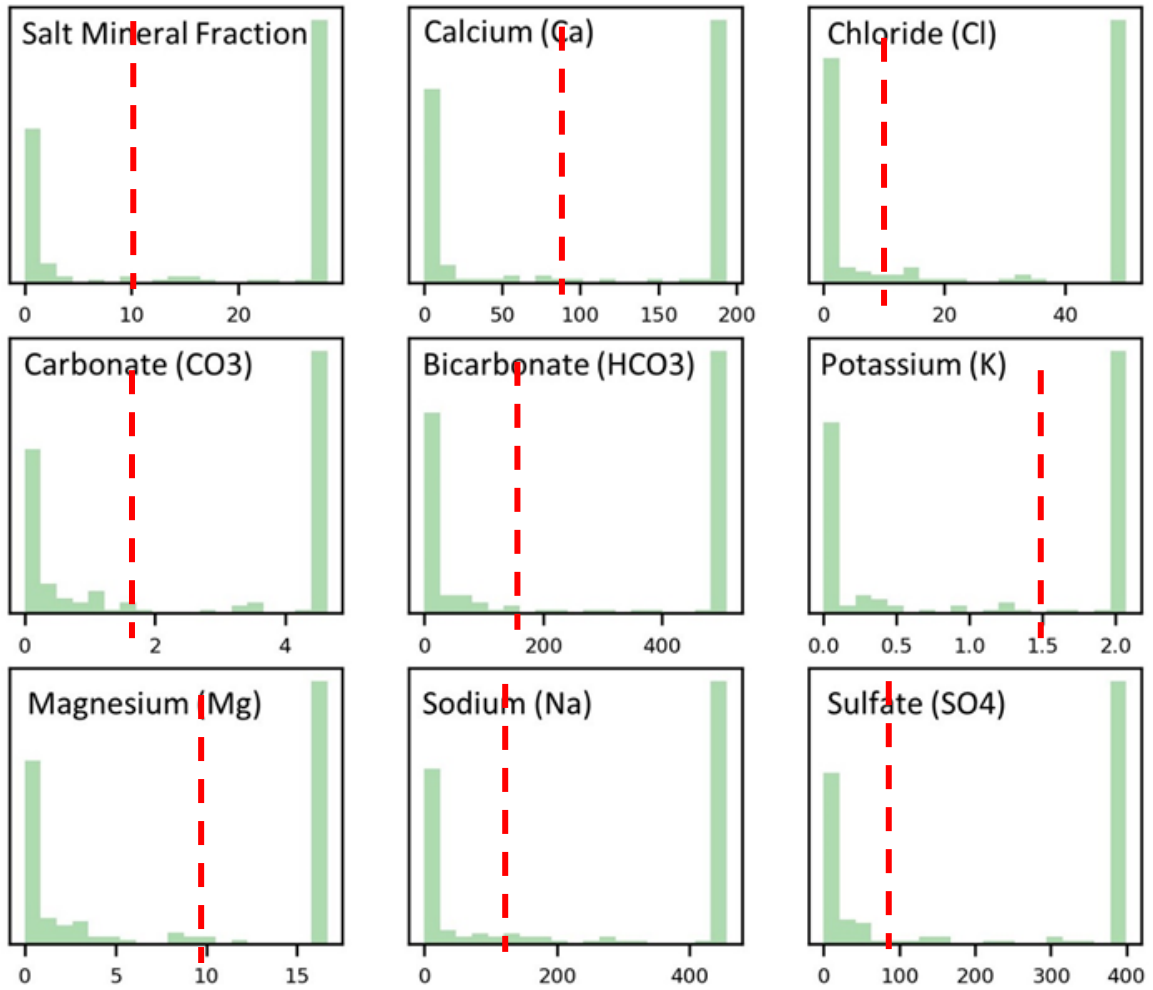


▼ NGL Water Solutions: up to 16.9 million gpd
Texas Pacific Water Resources: up to 840,000 gpd

Texas Produced Water Consortium

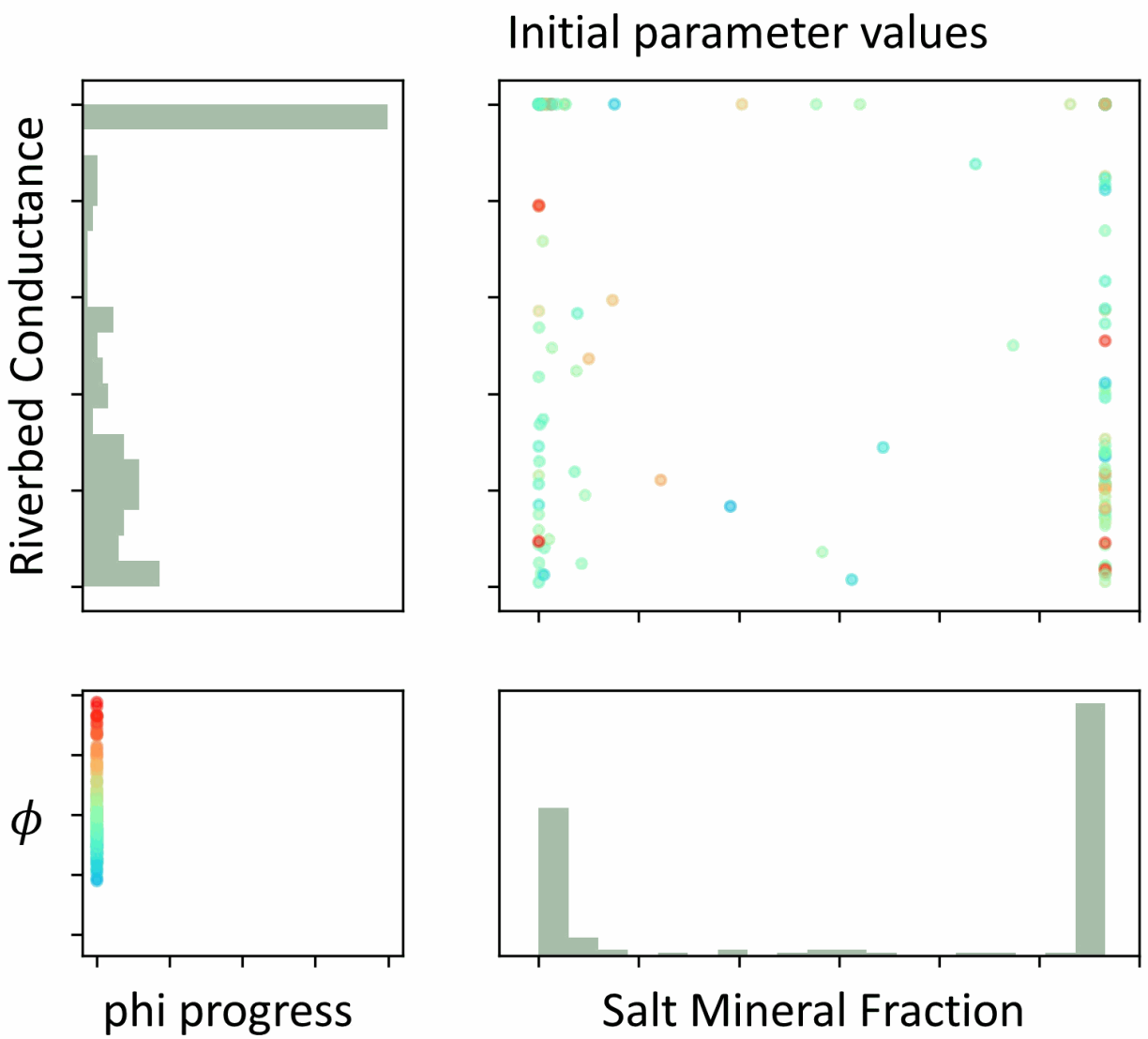
Pecos River Watershed

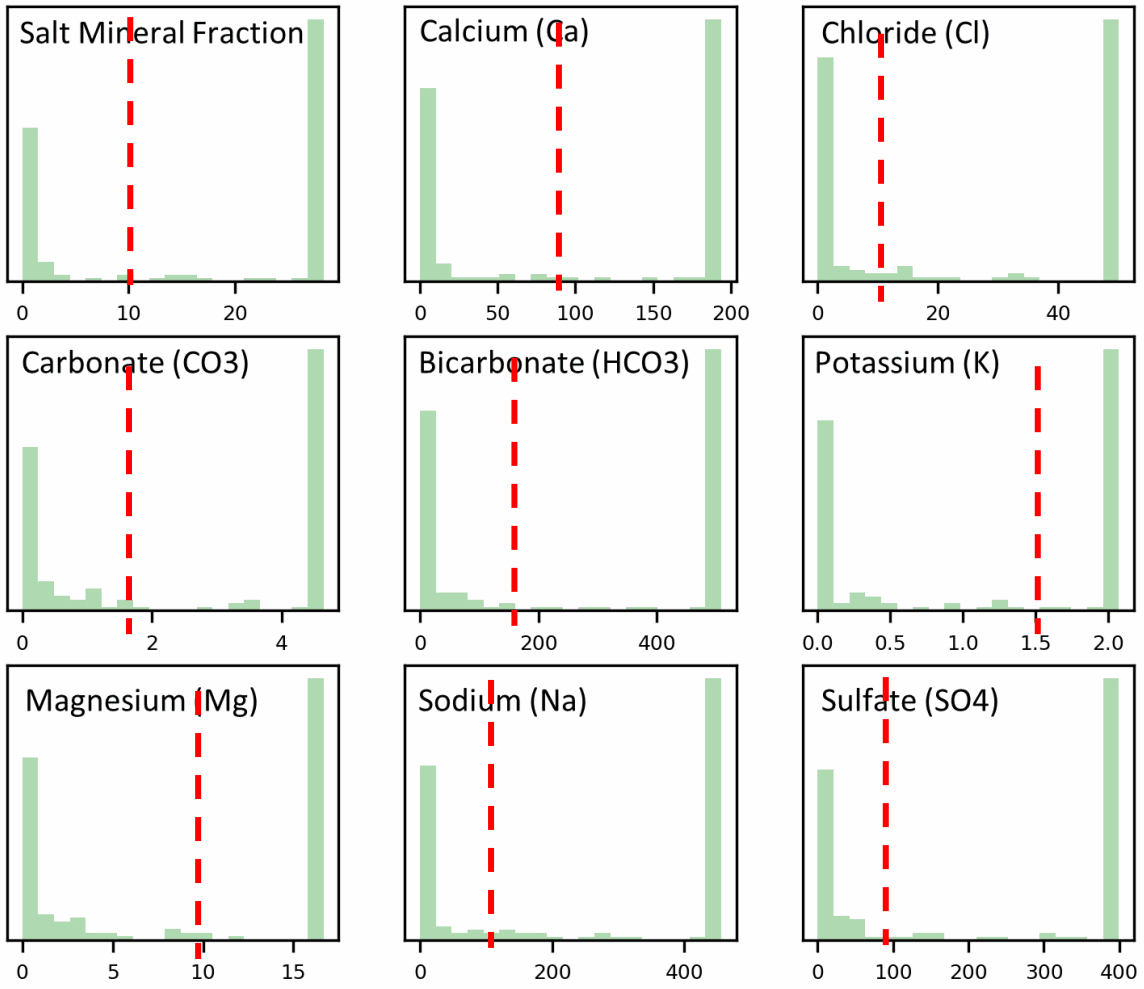




Texas Produced Water Consortium

Pecos River Watershed





Texas Produced Water Consortium

Conclusions and Key Takeaways

- ✓ SWAT+ gwflow provides integrated framework for produced water reuse assessment
- ✓ Model capabilities:
  - Coupled surface-groundwater-solute transport
  - Multiple application scenarios (stream discharge, irrigation)
  - Uncertainty quantification for decision support
- ✓ Pecos River case study evaluates real permit applications
- ✓ Full results expected 2026

Thanks!

questions **?**

Contact information

- seonggyu.park@ttu.edu