SWAT Soil & Water Assessment Tool

2025 Colorado SWAT Conference

Calibration of SWAT-Salt Aided by Daily Prediction Intervals

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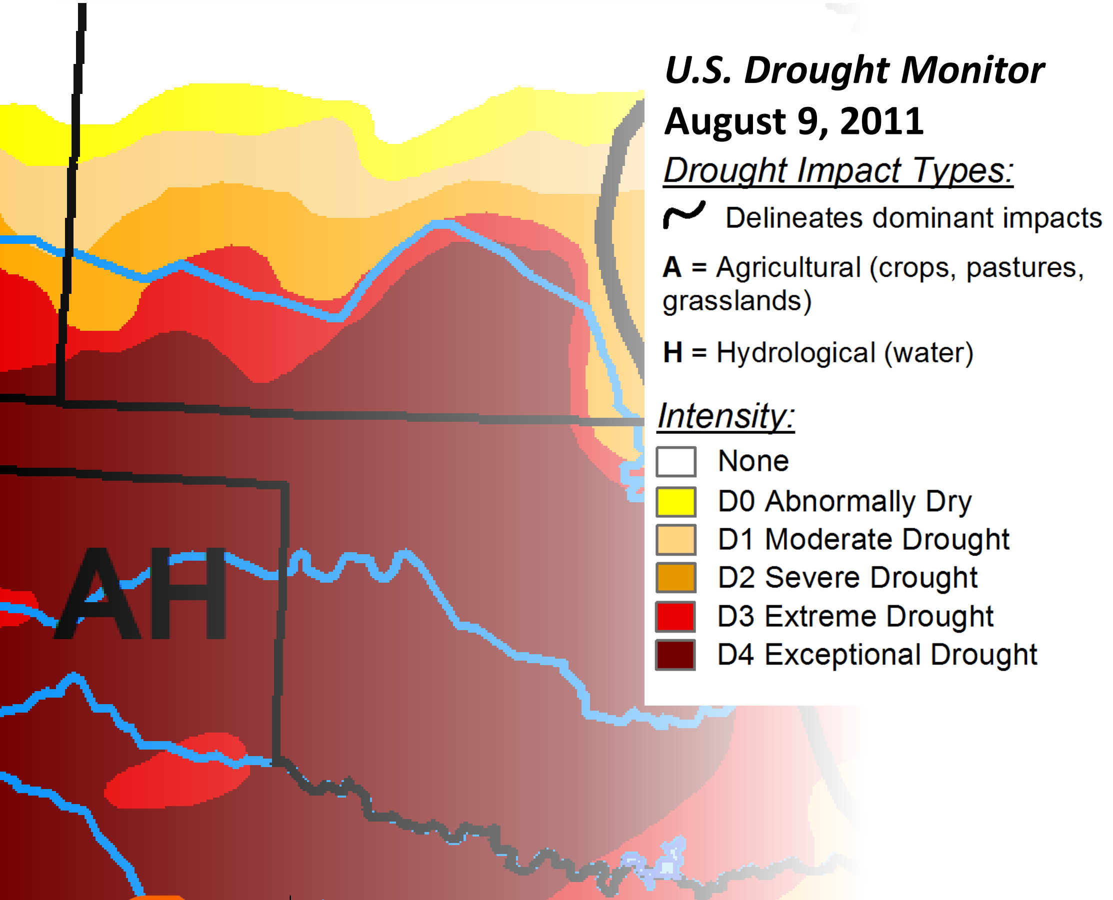
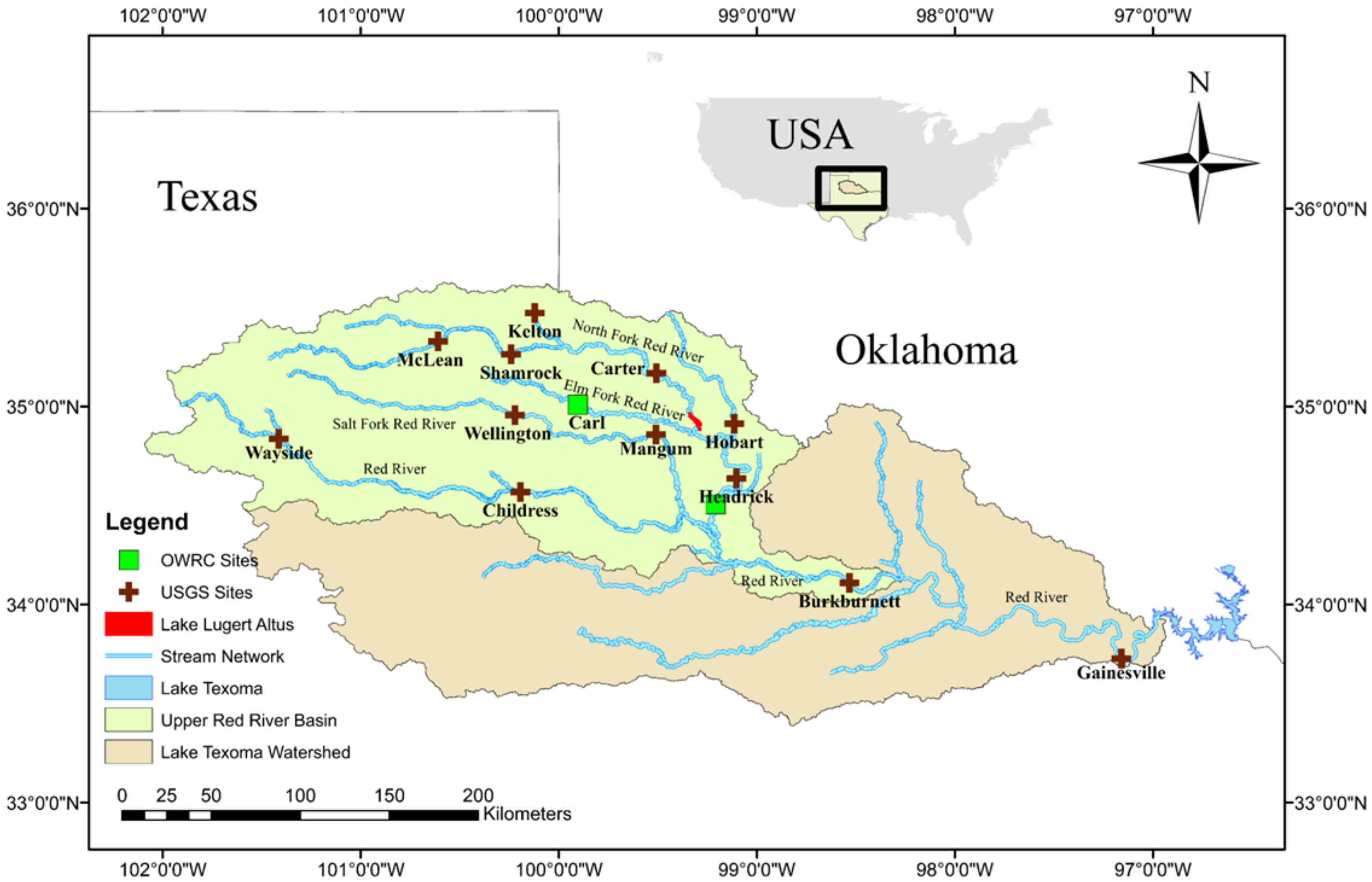
Droughts and Irrigation in Upper Red River Basin





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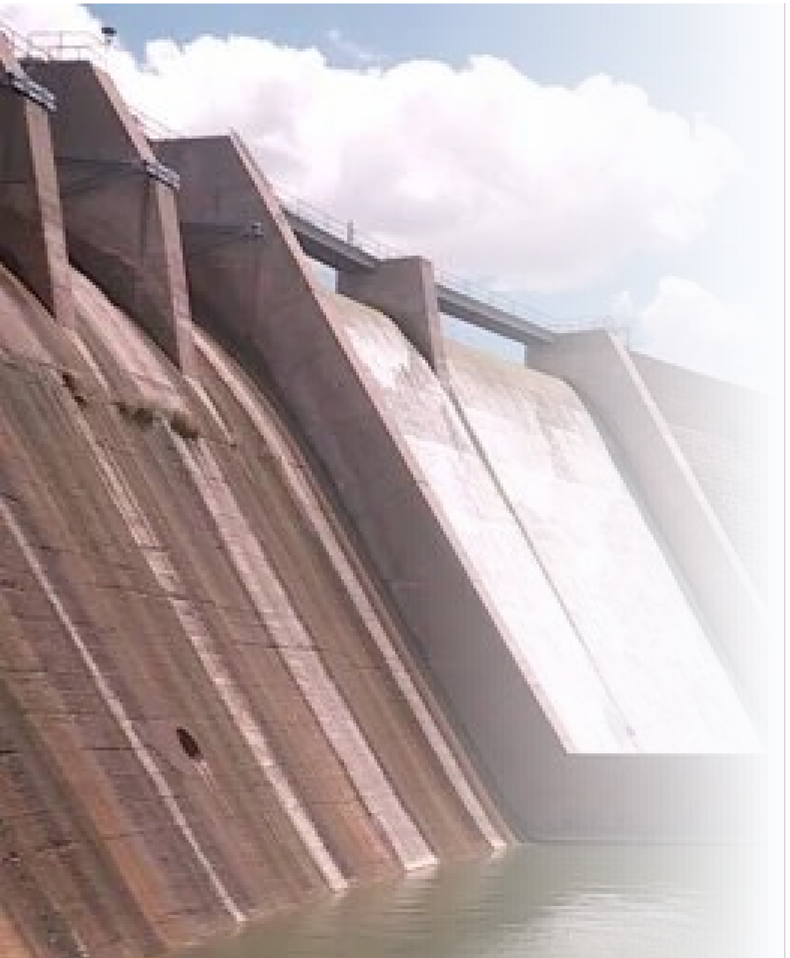
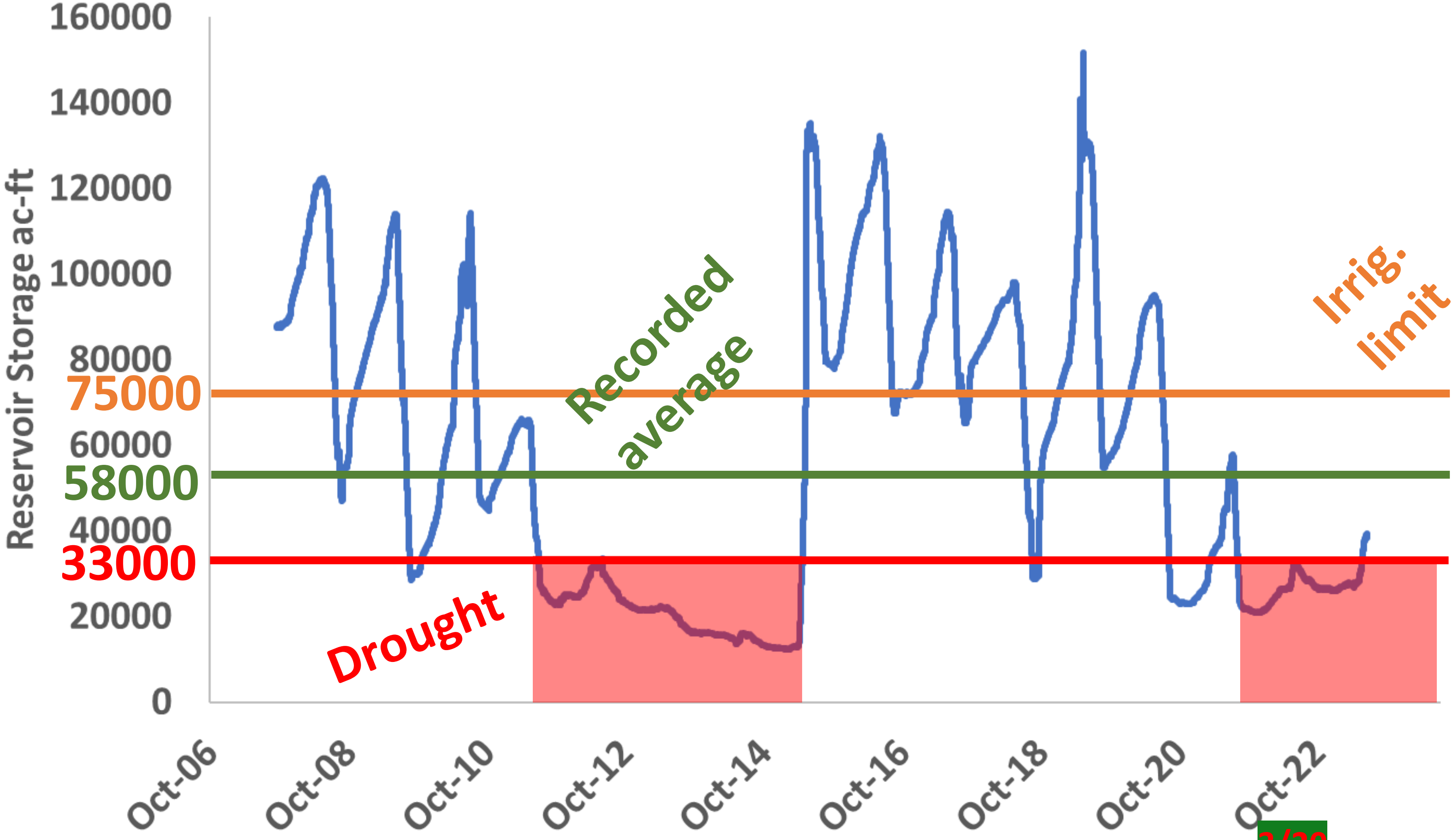
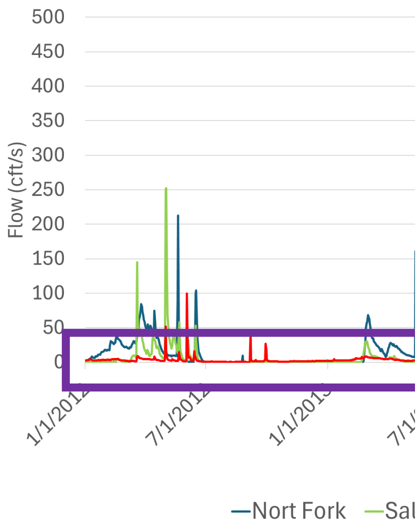




(USGS)

Droughts and Irrigation in Upper Red River Basin



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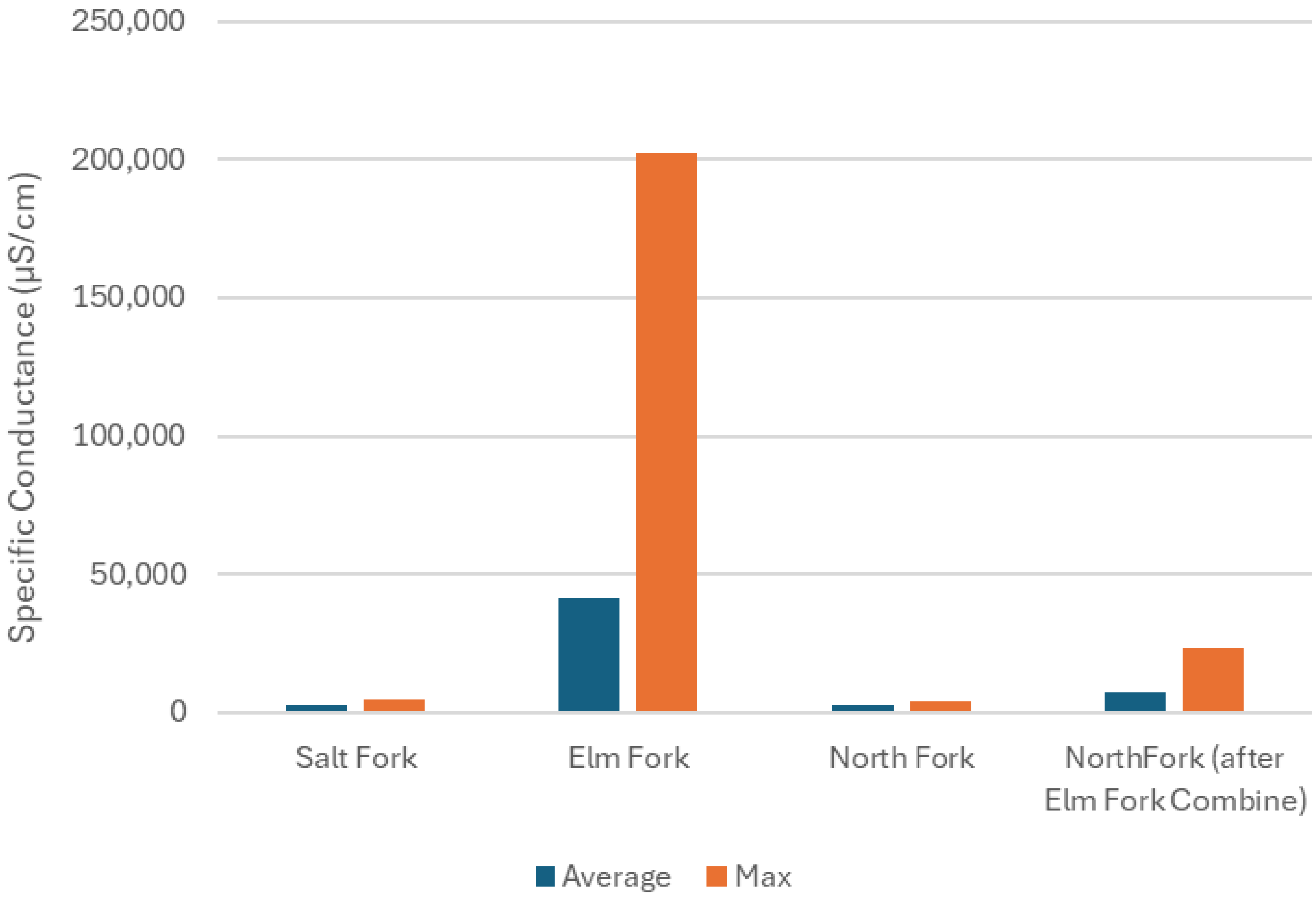
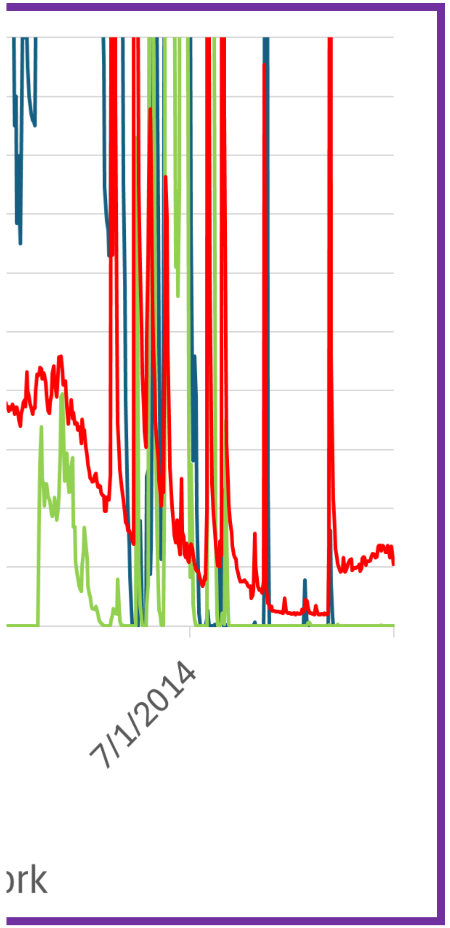
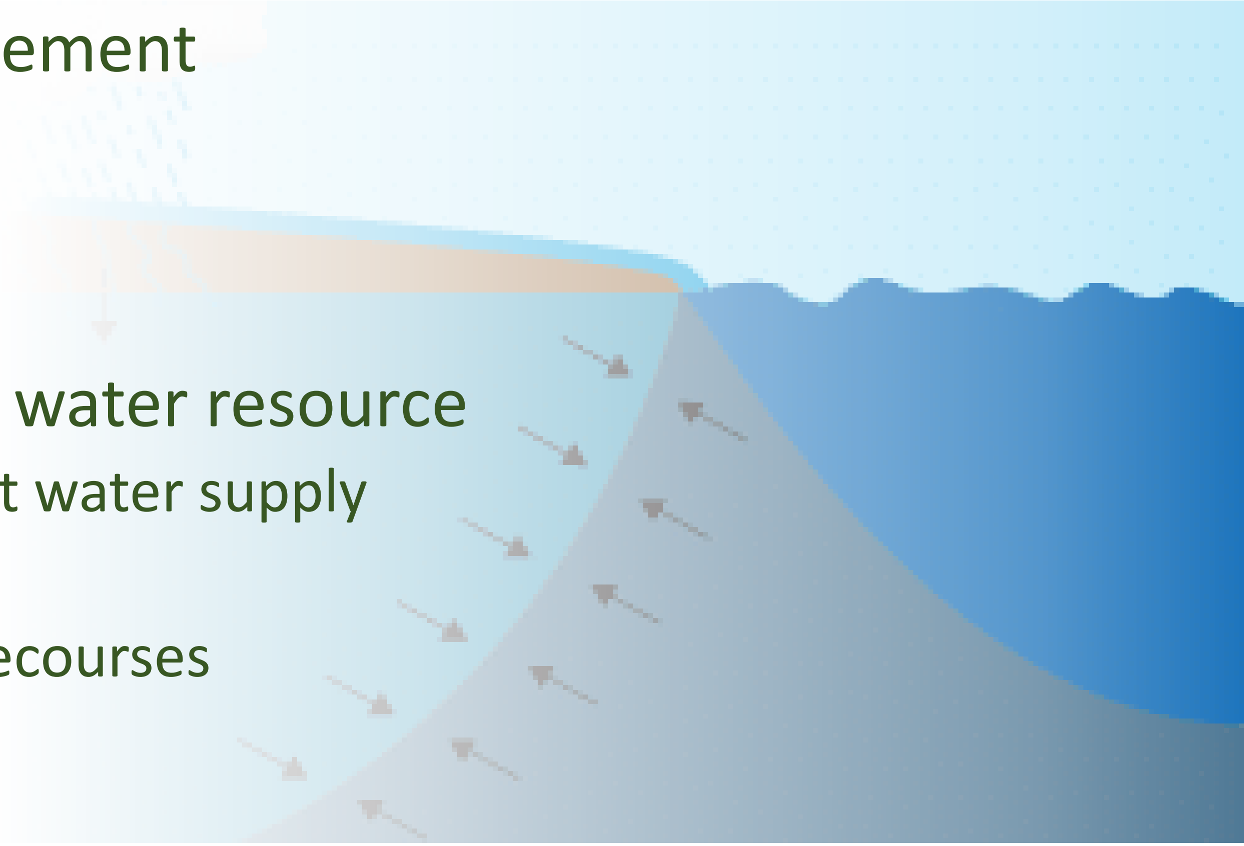




Salinity and Water Resources Management

- A threat for water resources management
  - Deteriorating water quality
  - Interrupting crop production
  - Health issues
- An opportunity as a non-traditional water resource
  - ❑Using inland saline waters to augment water supply
  - Adaptation strategy for droughts
  - Reducing the reliance of freshwater recourses



(phionics.com)

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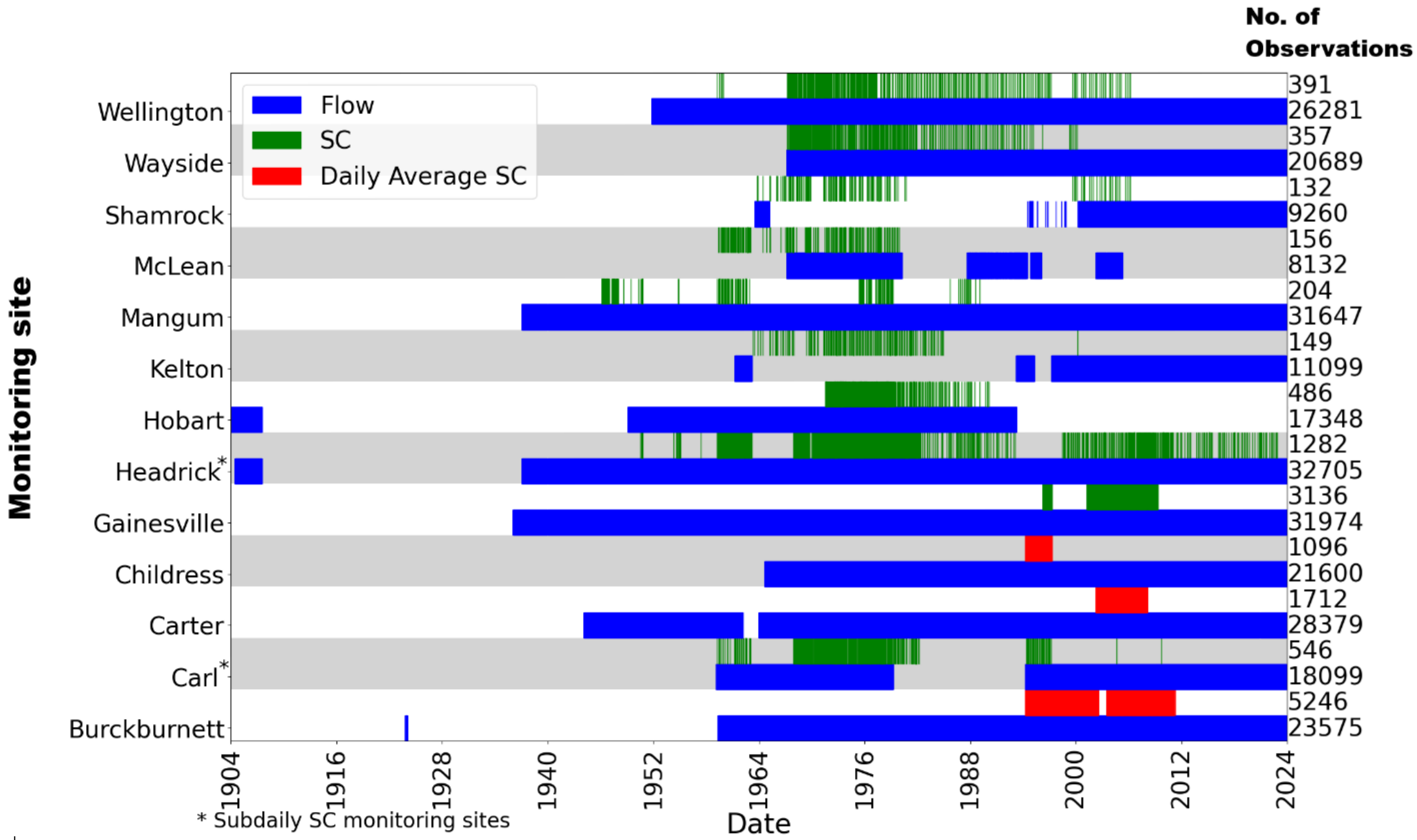
Threat or Opportunity, Must be Modeled!

- **Potential challenges:**
    - **Damaging crop roots and reducing the crop production rate**
    - **Adverse agroecosystem impacts**
      (e.g., altering the fish population in downstream)
- **Salinity dynamics modeling/analysis is required**

Data Availability



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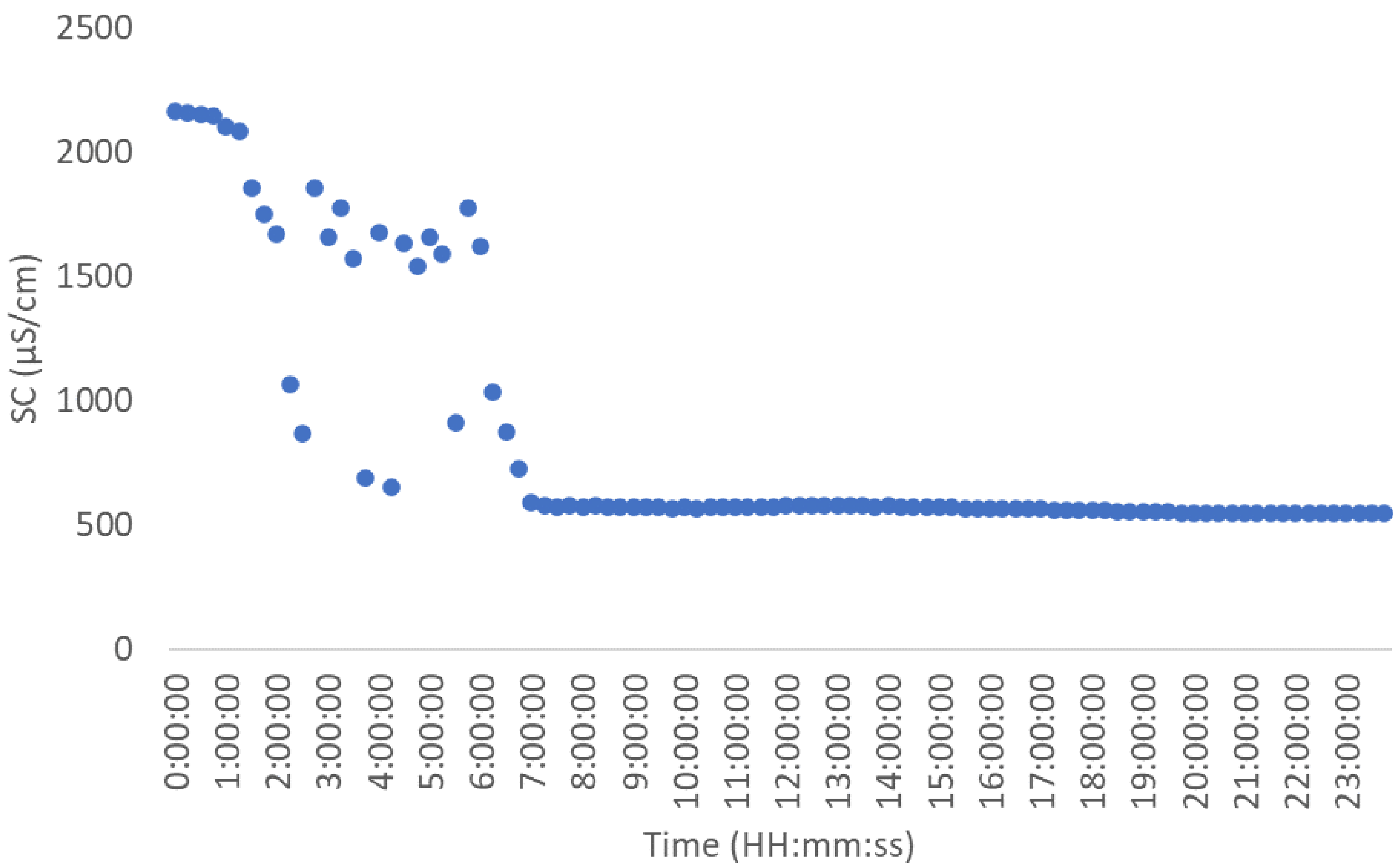
Uncertainty in Data

Collected SC data in 15-minutes interval from Elm Fork Red River, 05/26/2023



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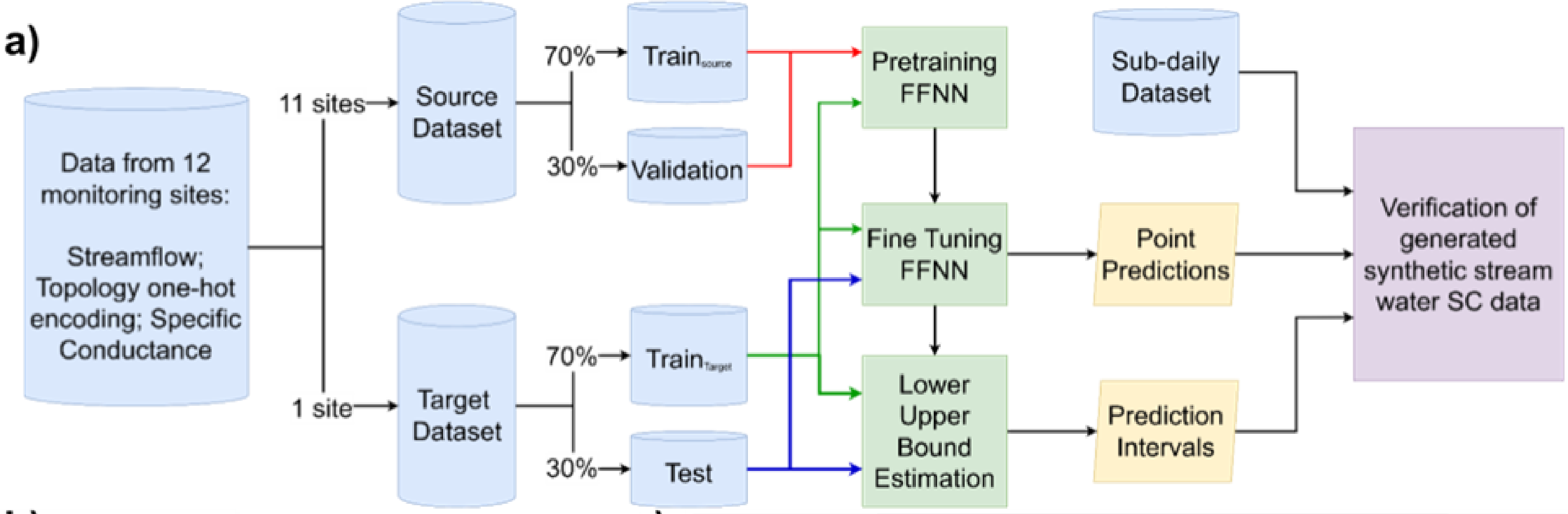
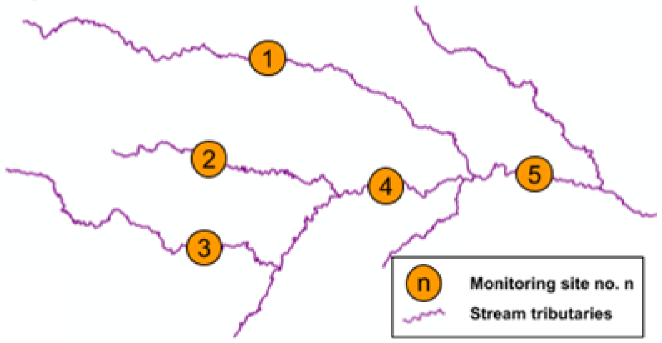
Robust Modeling Framework

a)



b)



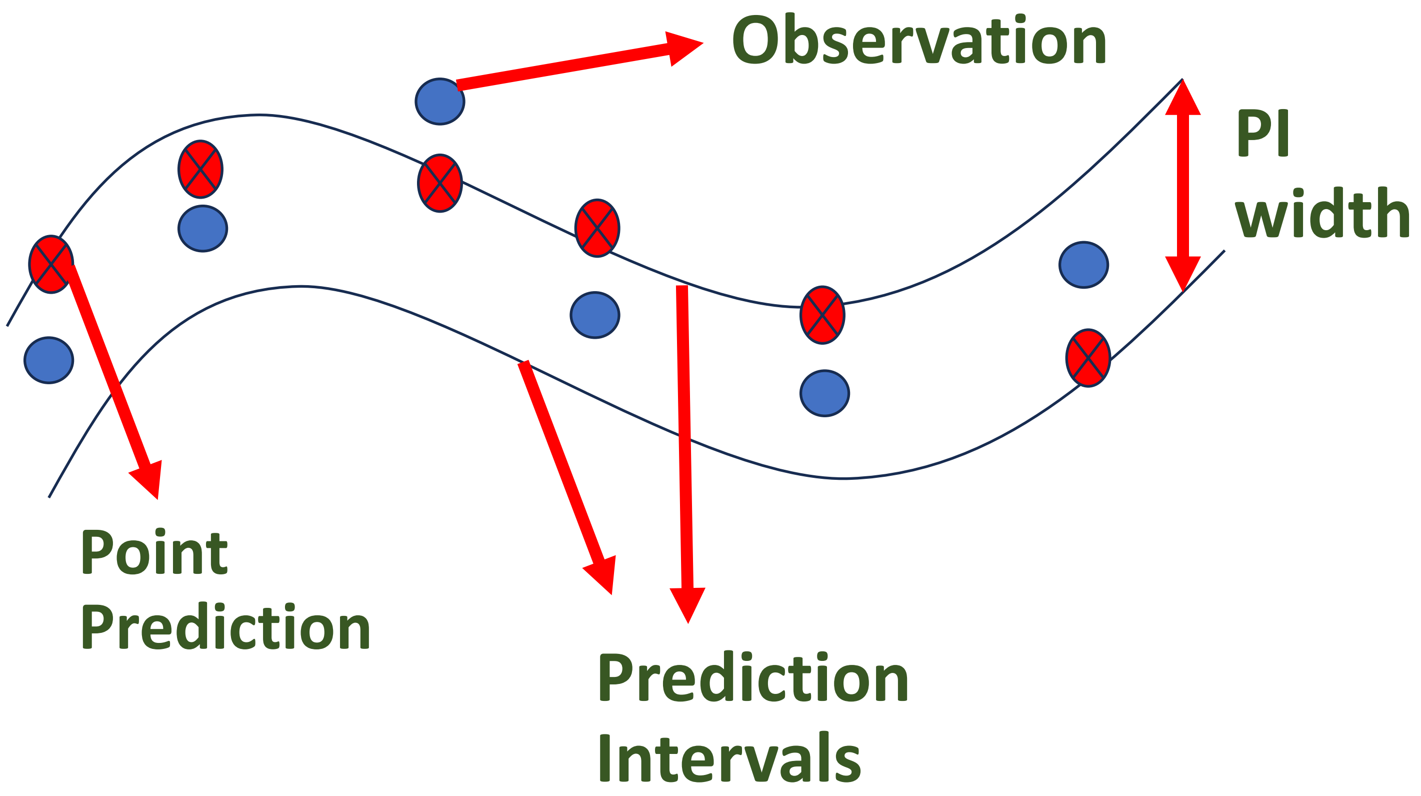
c)

Monitoring site	Input Vector: Topology one-hot encoding input 1	2	3	4	5	Flow input	Target
1	1	0	0	0	0	Q_1	SC_1
2	0	1	0	0	0	Q_2	SC_2
3	0	0	1	0	0	Q_3	SC_3
4	0	1	1	1	0	Q_4	SC_4
5	1	1	1	1	1	Q_5	SC_5

Q_n and SC_n denote for flow and specific conductance values at site no. n

Robustness of Generated Data

- **Potential uncertainties in the synthetic dataset**
  - **Model imperfection, error in data, regionalization, etc.**
- **Point predictions:**
  - **An average error measure.**
- **Prediction Intervals**
  - **Representing Uncertainty**
- **Ultimate Evaluation**
  - **Continuous sub-daily measurements**



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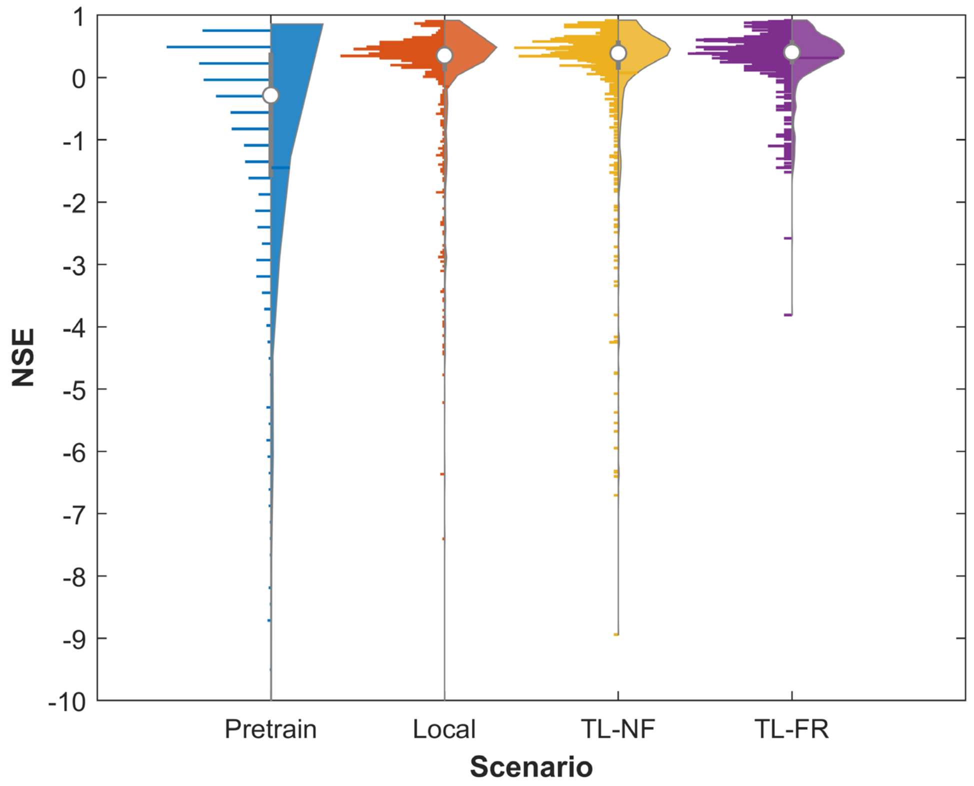
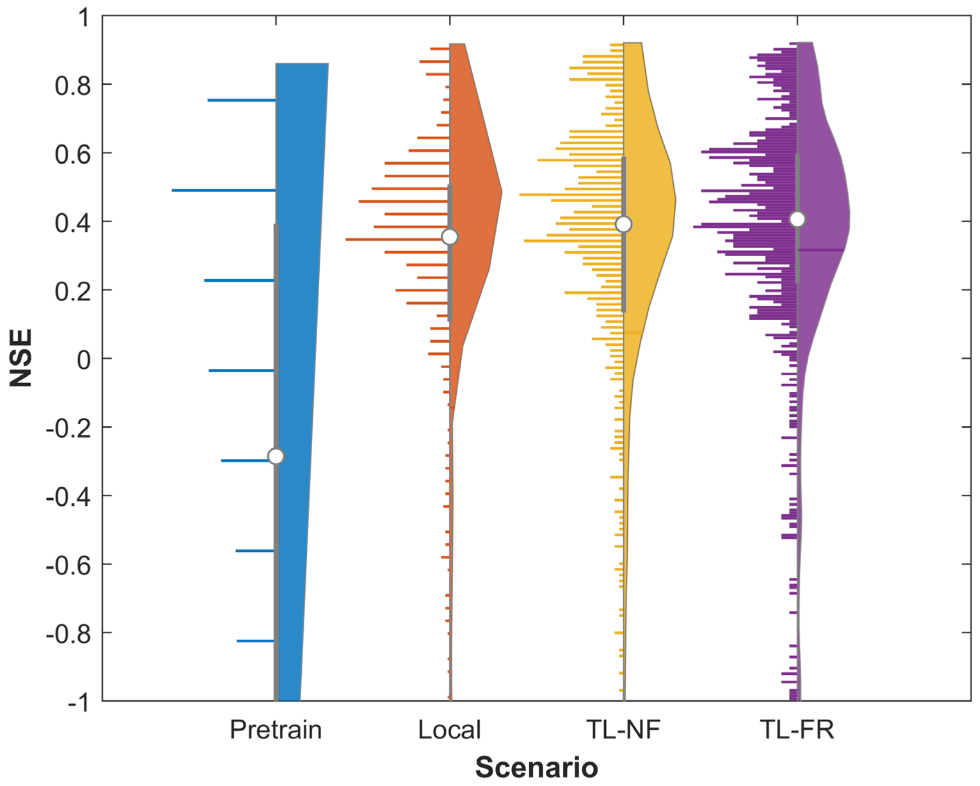
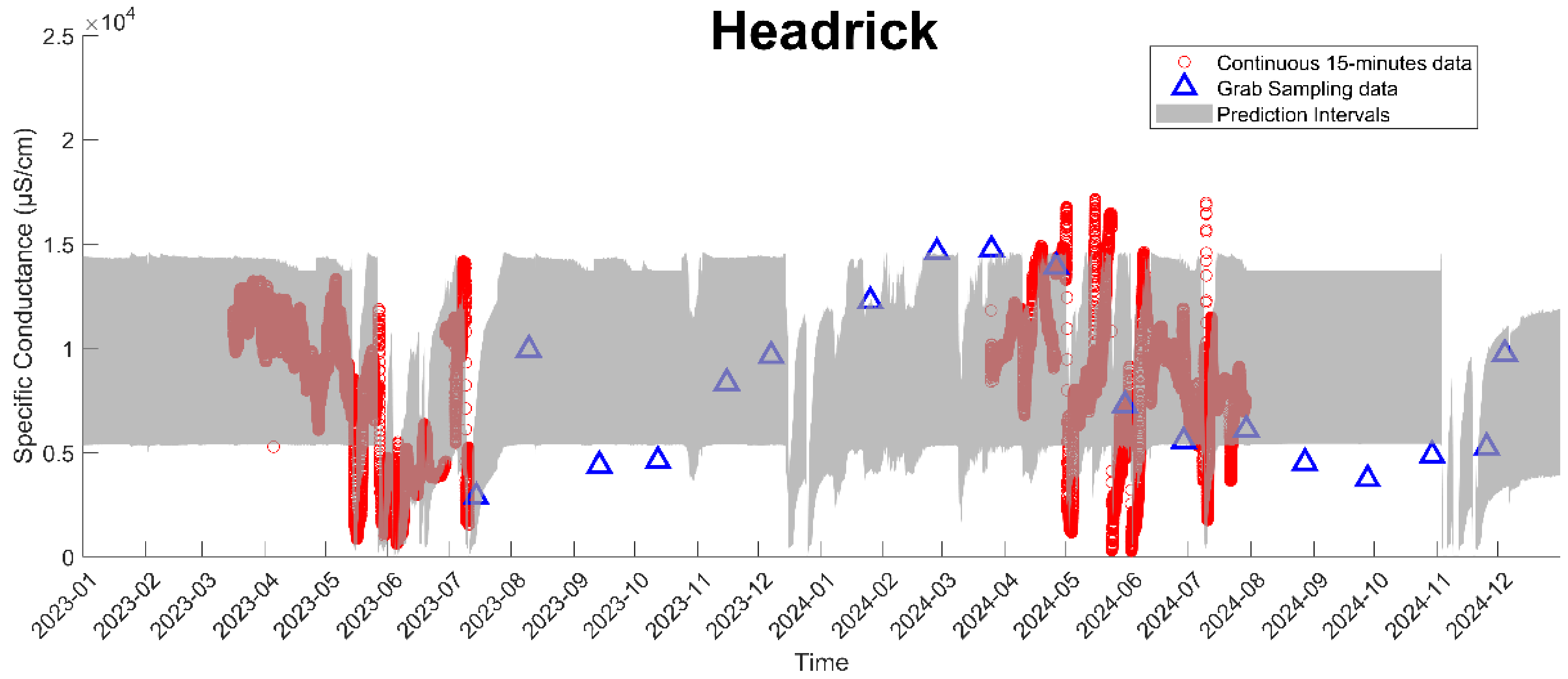
Results – Modeling





Results – Prediction Intervals



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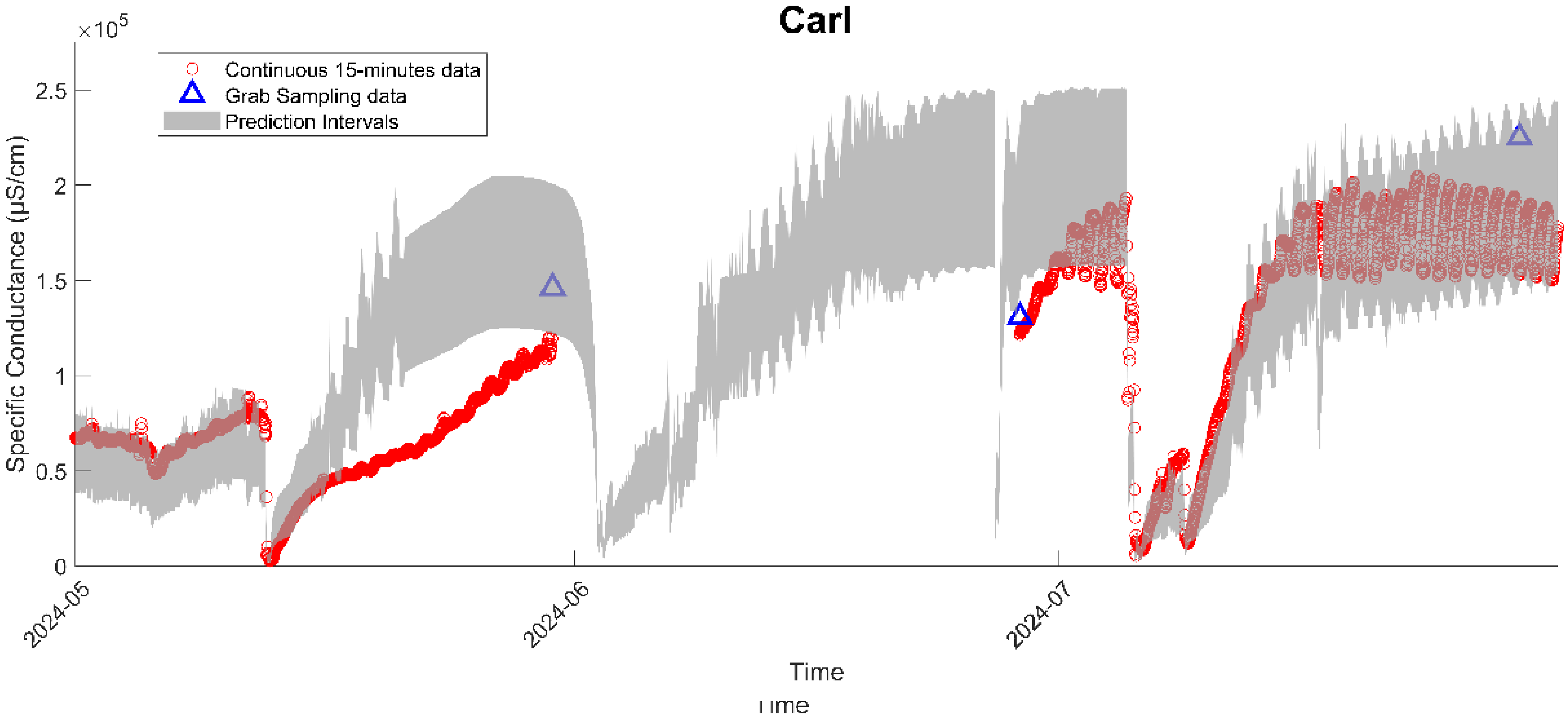
Results – Prediction Intervals



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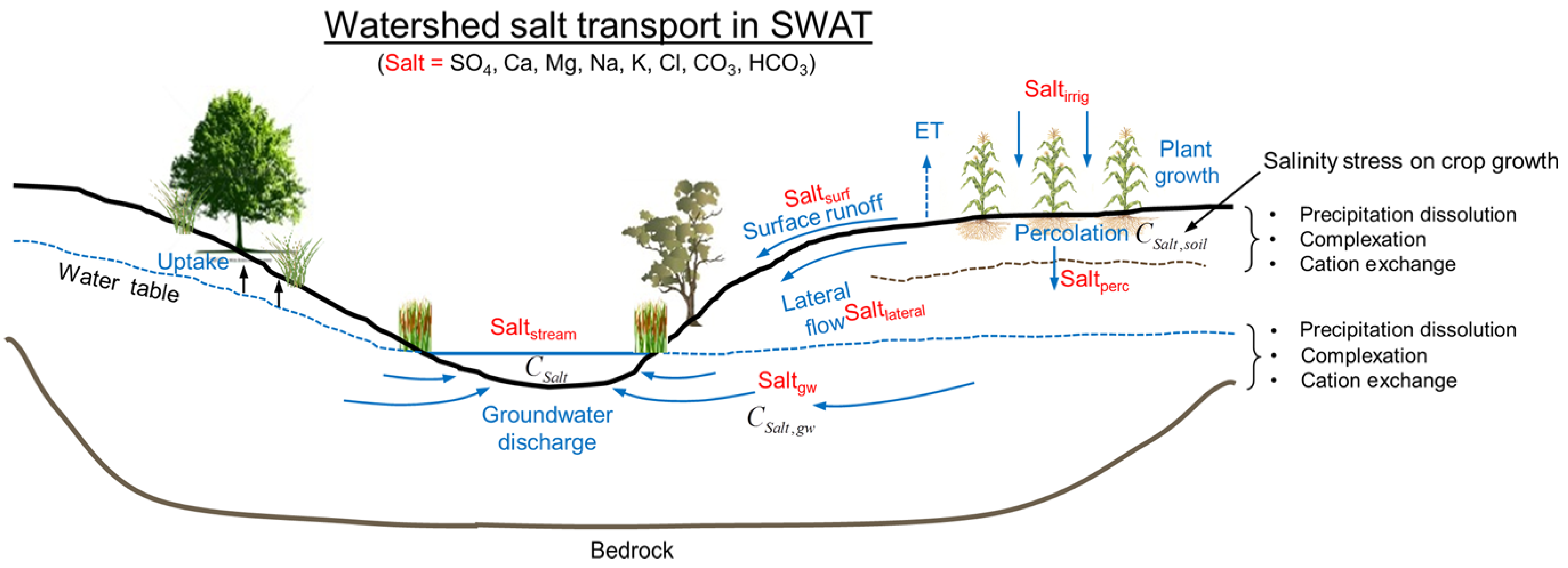
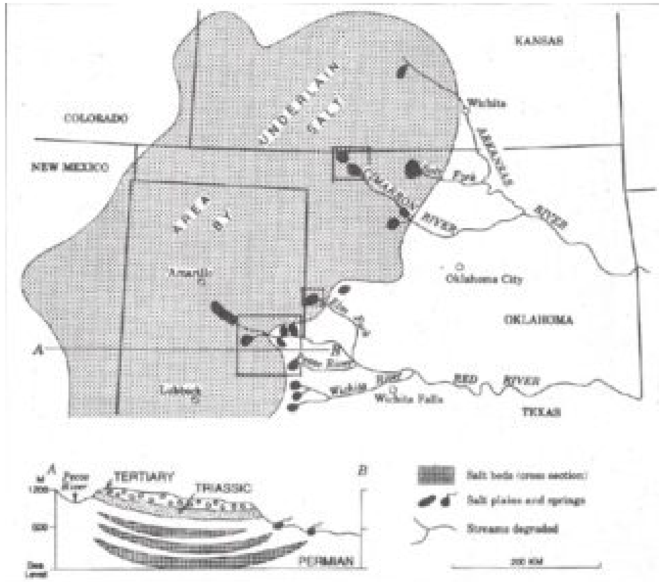
Modeling Salinity Dynamics Using SWAT-Salt



State of Knowledge on Salt Springs



ig. 2. Map and schematic cross-section showing distribution of Permian salt and sal lains in western Oklahoma and adjacent areas. *Three squares show outlines* (from north f Cimarron River, Elm Fork and Red River study areas described in this paper.

(Johnson, 1981)

Only part of the project to be built in Oklahoma is on the Elm Fork of the Red River, due west of Mangum, the largest single source of the river's pollution. Located just inside the Oklahoma-Texas line, Elm Fork springs pour forth 510 tons of salt per day. The Elm dam, pipelines, pumping equipment and evaporation ponds will cost $43.5 million.

(Nelson, 1988)

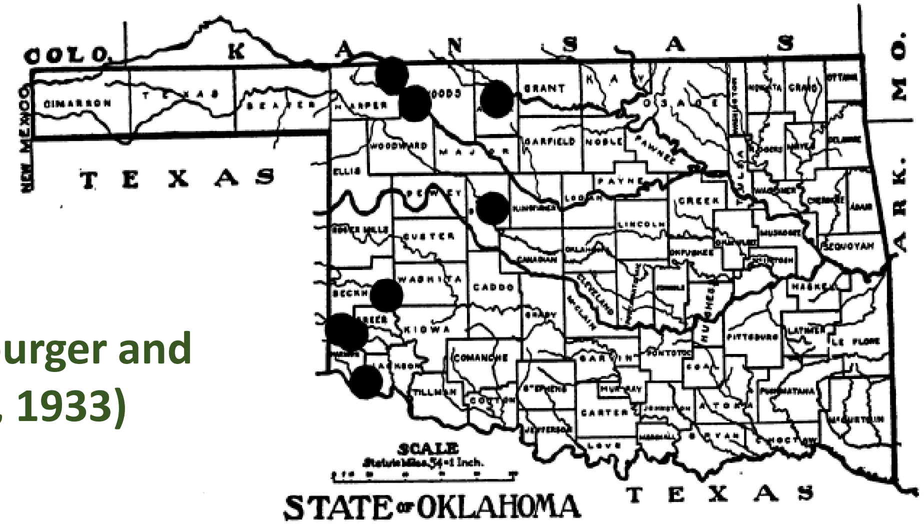
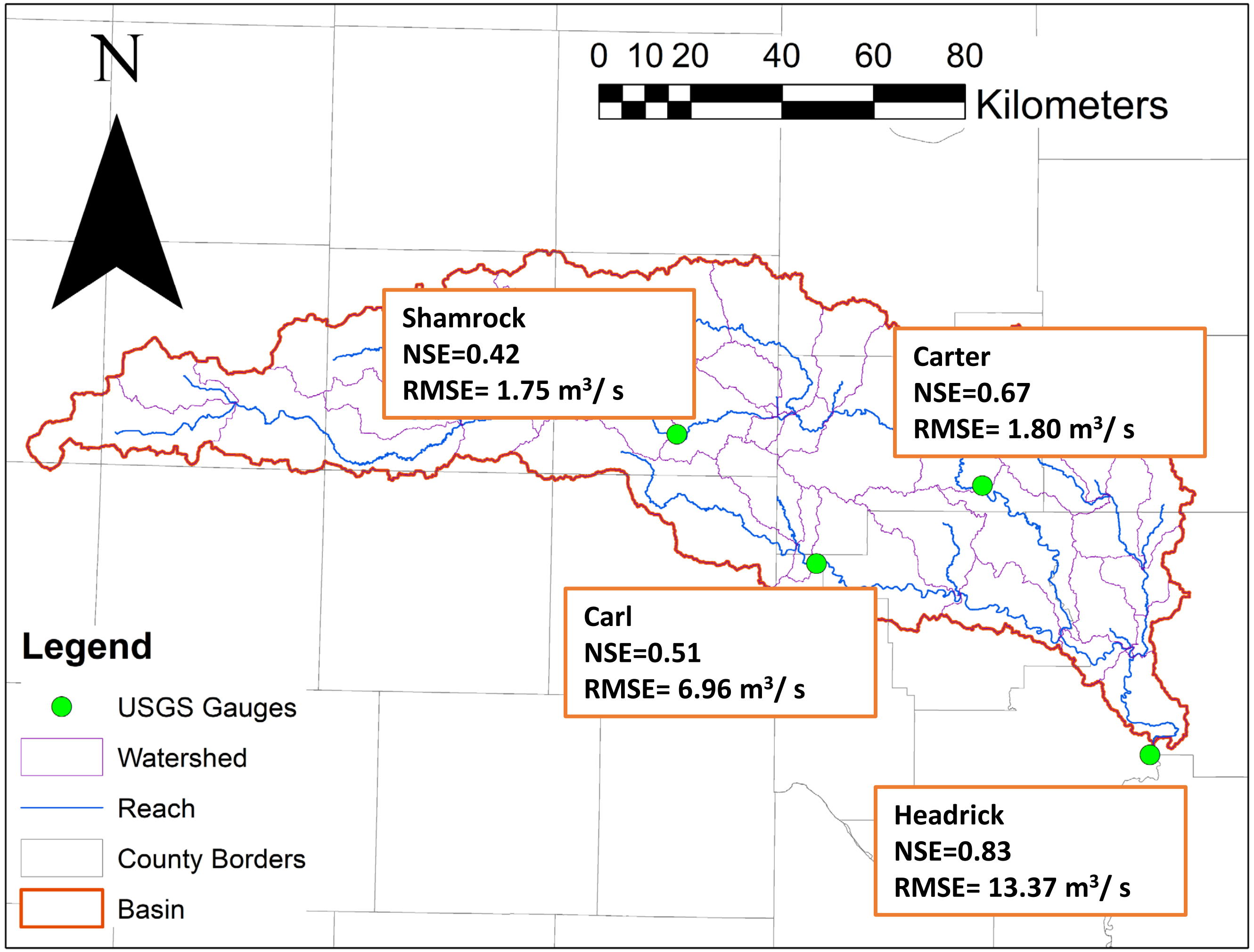


FIGURE 20. LOCATION OF SALT PLAINS IN WESTERN OKLAHOMA

(Ortenburger and Bird, 1933)

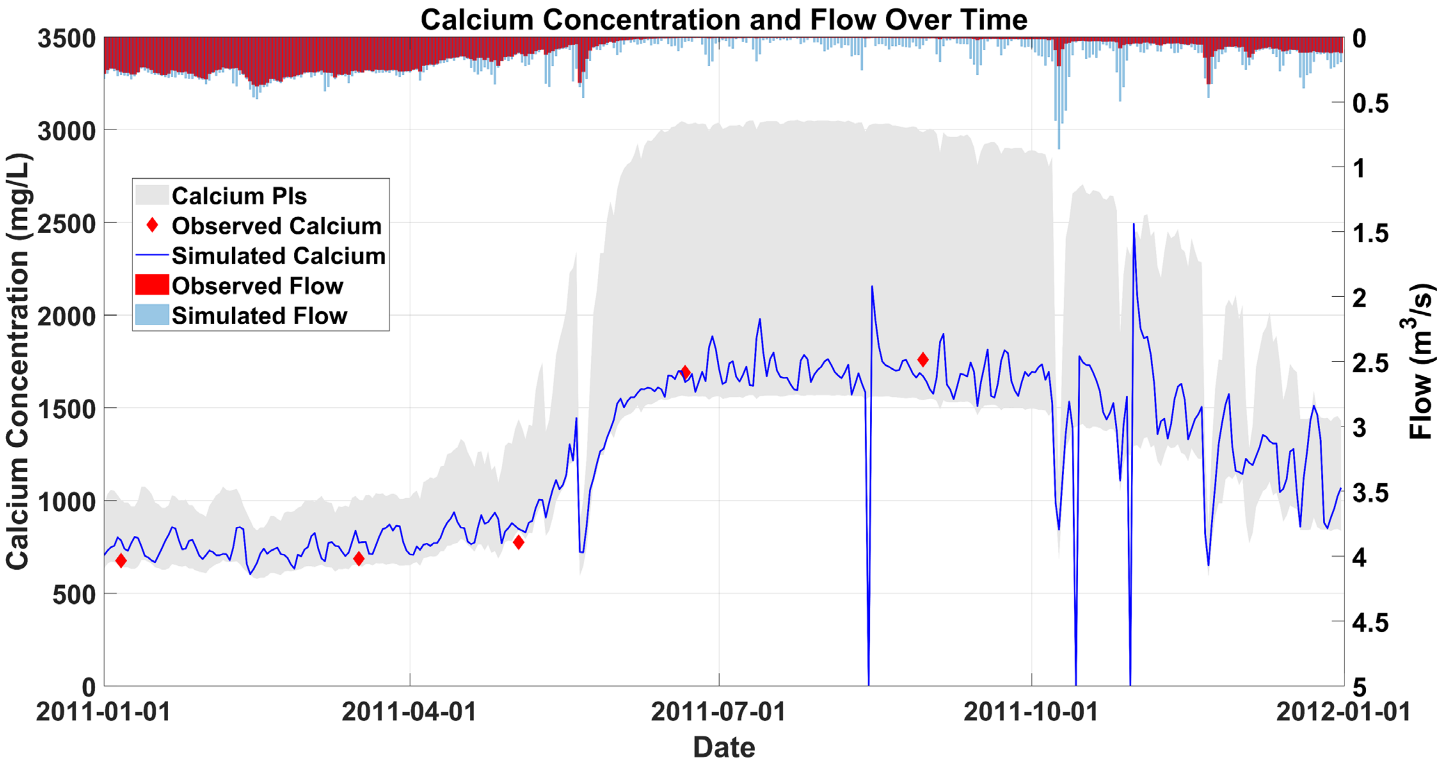
SWAT Modeling Results



Preliminary Results

- **SWAT-Salt & Synthetic PIs:**

- **SC needs to be converted to ion Concentration**
- **Model outputs for Elm Fork:**
  - **Hydrology:**
  - **NSE = 0.51**
  - **RMSE = 6.96 m^3/s**
- **80% Conf. level PIs:**



Conclusions

- **Transfer Learning improves robustness of stream salinity predictions in data scarce basins.**
- **Spatial and temporal generalizability of PIs were verified by recent, sub-daily stream salinity, measurements.**
- **PIs help with detecting drifts from calibration.**
- **Generated PIs enable salinity calibration/validation of SWAT-Salt.**

Future Improvements

- **Utilize more input data (soil type, land cover, etc.)**
- **Cross-basin Transfer Learning for stream salinity predictions.**
  - **Then we can use Deep Learning tools.**
- **Using regionalization for predicting ungauged streams.**
- **Using calibrated SWAT flow values for ungauged basins.**

Future of The CFSM Project

- ***SWAT-Salt***
- ***SWAT-MODFLOW-Salt***
- **Site suitability assessment for saline water irrigation**
- **Continues salinity data recording**
  - **Validation**
  - **Analysis**
- **Irrigation scenarios**

Acknowledgments

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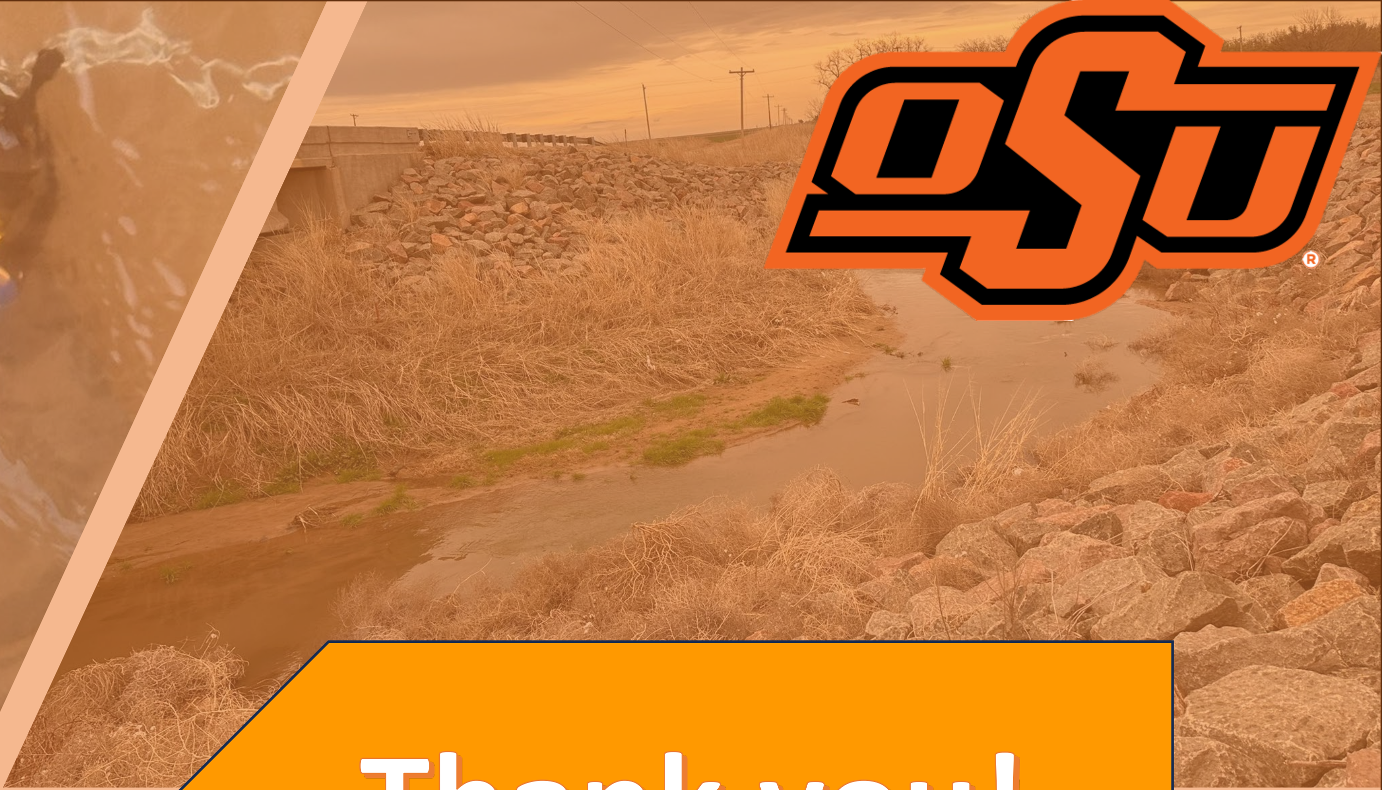
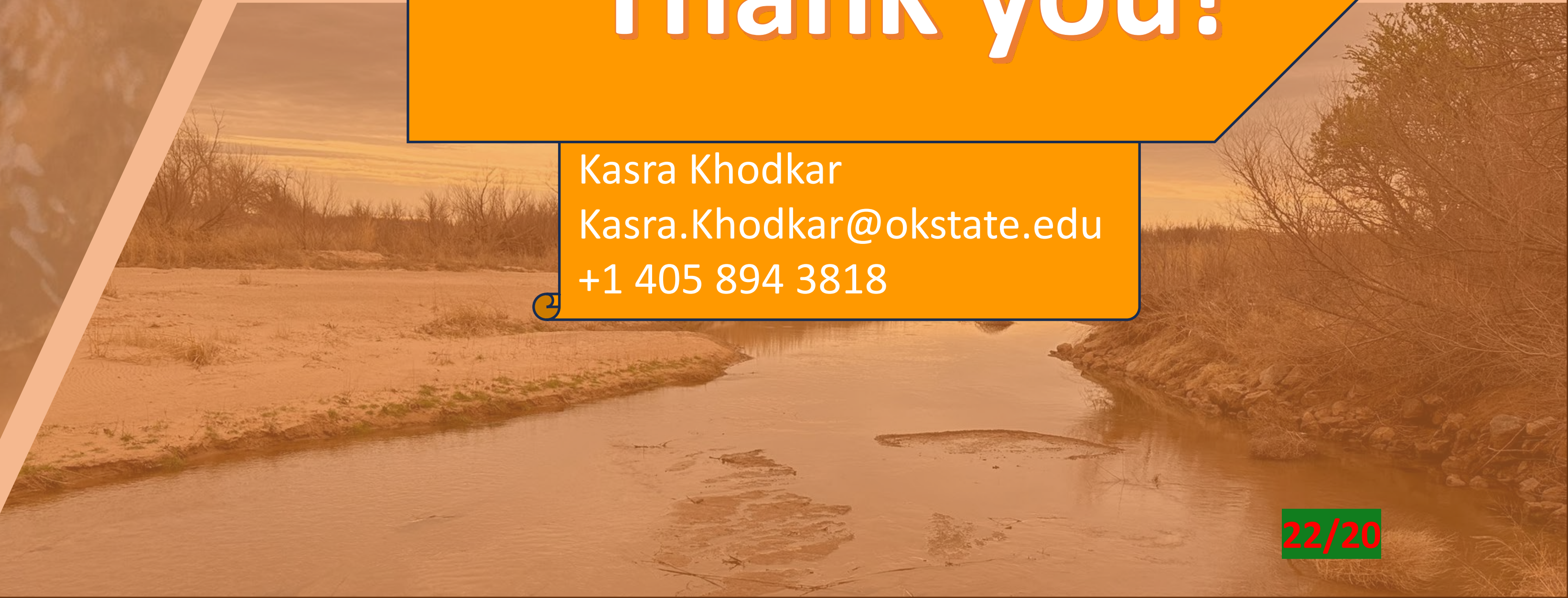
Civil and Environmental Engineering Department, Colorado State University





Thank you!

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CWC as Penalty Function

$$PICP = \frac{1}{n_{test}} \sum_{i=1}^{n_{test}} c_i$$

$$MPIW = \frac{1}{n_{test}} \sum_{i=1}^{n_{test}} (U_i - L_i) \, .$$

$$NMPIW = \frac{MPIW}{R} .$$

$$c_i = \begin{cases} 1, & t_i \in [L_i, U_i] \\ 0, & t_i \notin [L_i, U_i] \end{cases}$$

$$\gamma = \begin{cases} 0, & PICP \geq \mu \\ 1, & PICP < \mu . \end{cases}$$

$$CWC = NMPIW \left(1 + \gamma \, (PICP) \, e^{-\eta (PICP - \mu)}\right)$$