



Coupled Surface-Water/Groundwater Evaluation in the Edwards Plateau



Photo: Texas Parks and Wildlife Department

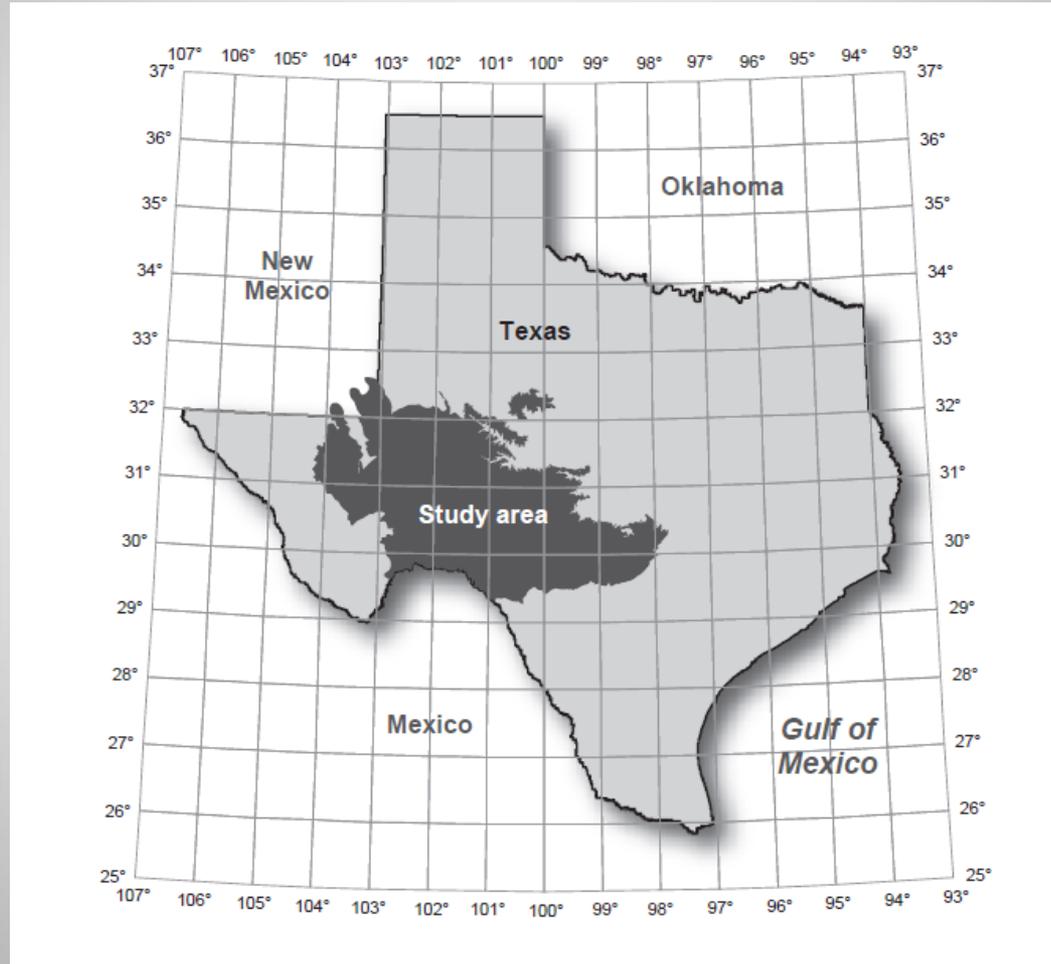
Groundwater Management Area 7 October 19, 2017

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Nathaniel Toll, and Rebecca Nunu

Southwest Research Institute®



Edwards-Trinity Aquifer



Edwards-Trinity Aquifer GAM (Anaya and Jones, 2009)



Edwards-Trinity Aquifer

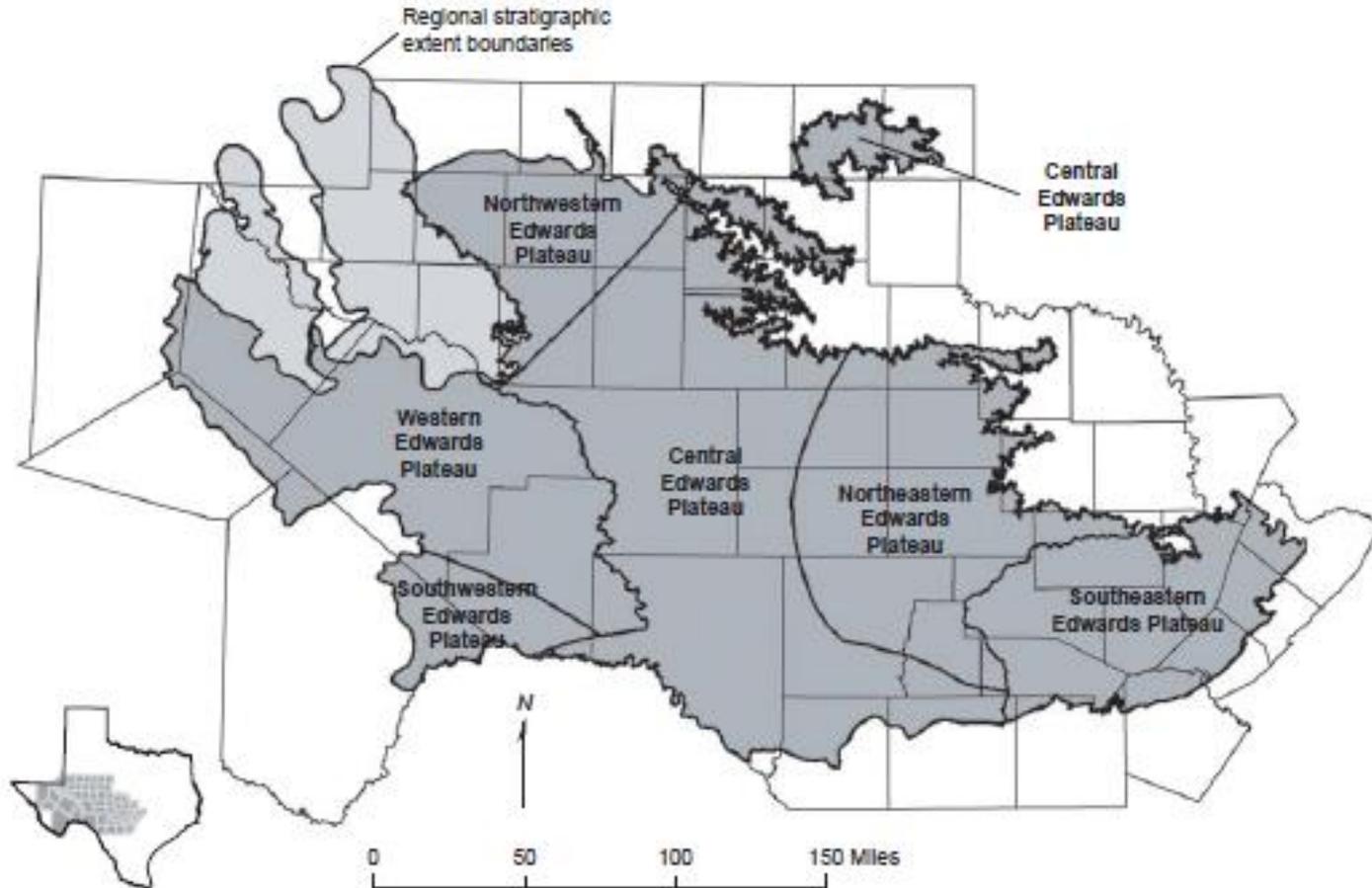


Figure 5-1. Regional extents of stratigraphic nomenclature for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity (Hill Country) aquifer systems.



Edwards-Trinity Aquifer Regional-Scale Groundwater Availability Model

Model boundaries

- Active cells
- Constant head boundary
- Drain cell boundary
- General head boundary

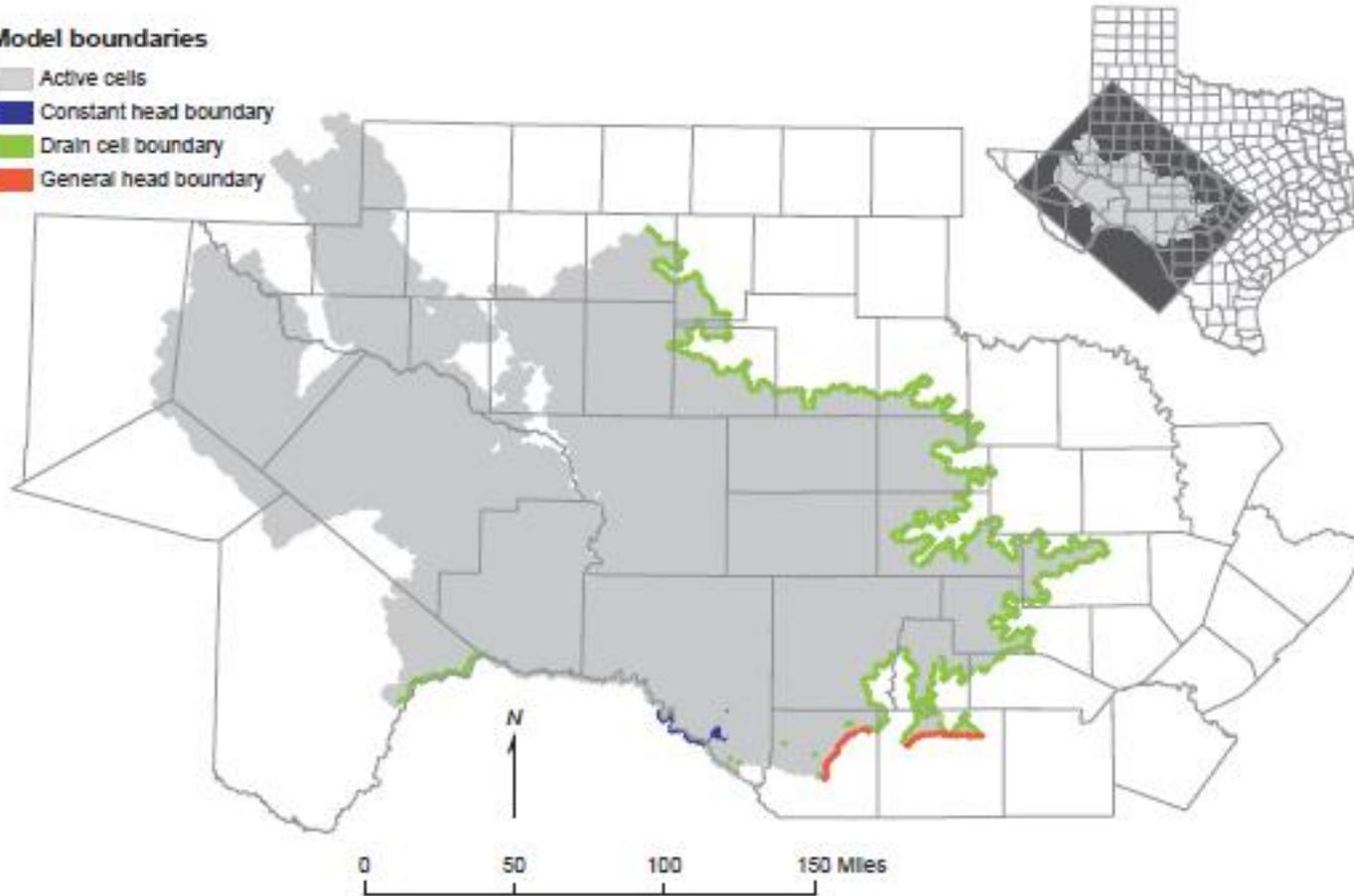
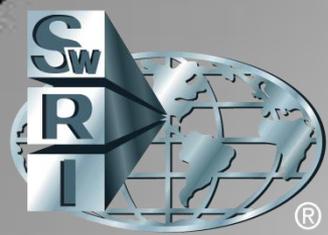
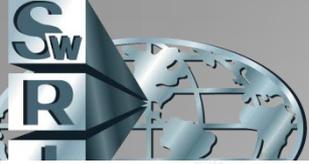


Figure 7-2. Boundary conditions for layer 1 used within model.

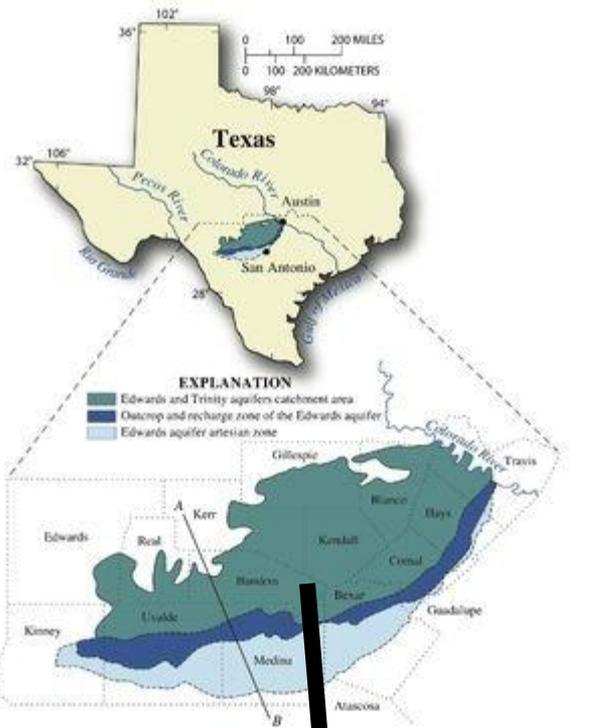


The Problem

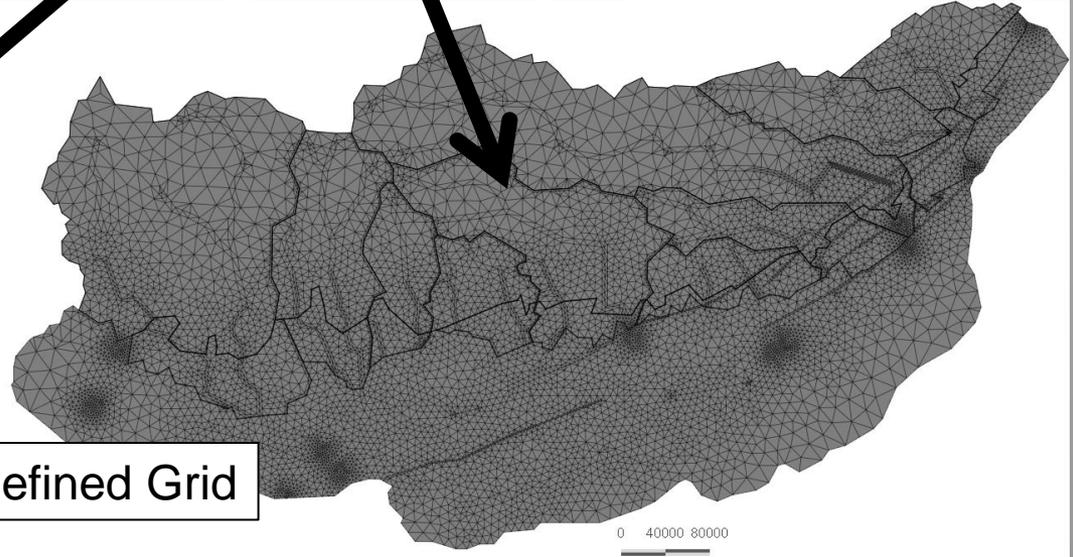
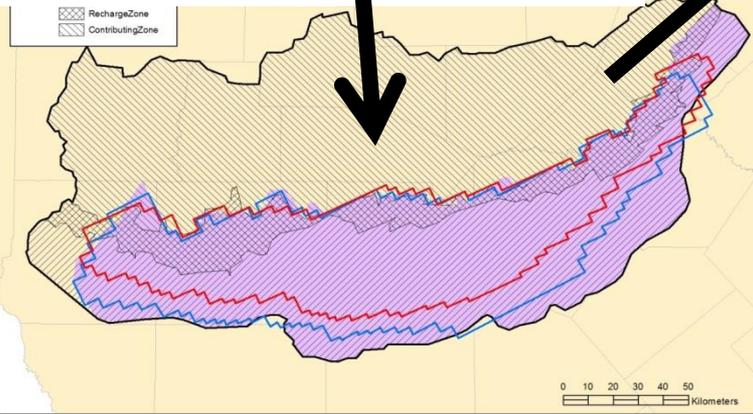
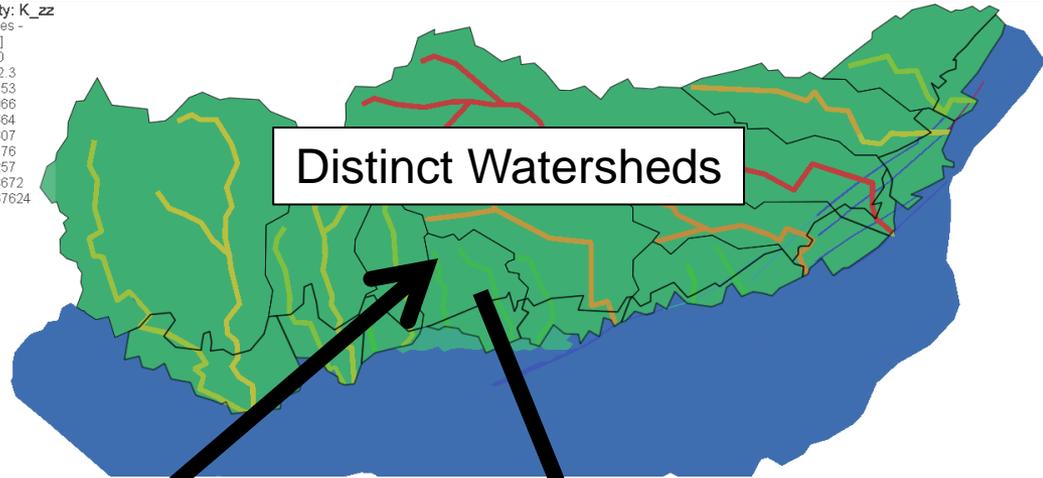
Regional-scale models not capable of replicating local-scale hydraulic features



Related Studies Provide Insight on Modeling Watersheds Independently

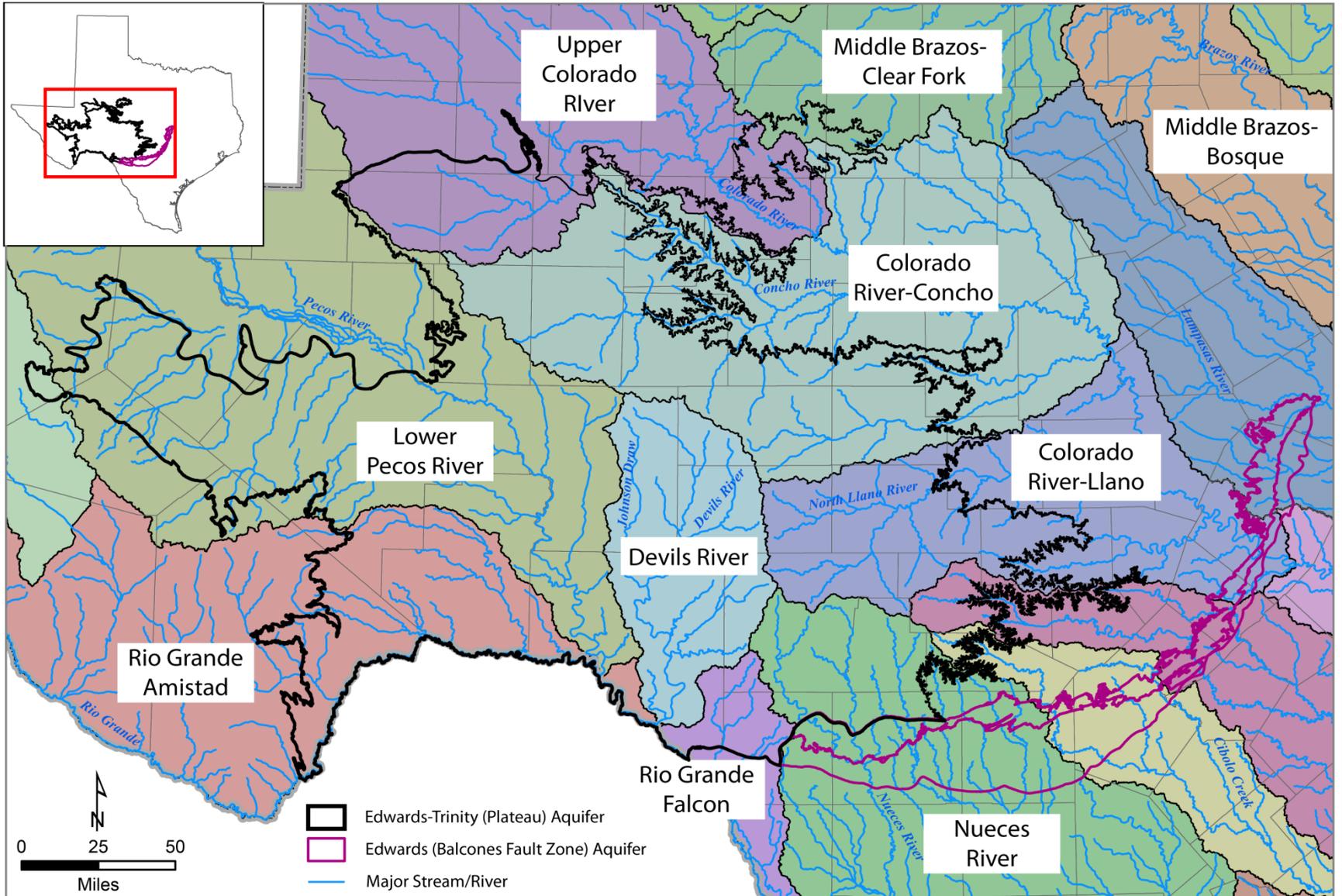


```
Activity: K_zz  
Patches -  
[ft/d]  
50000  
10692.3  
2286.53  
488.986  
104.564  
22.3607  
4.78176  
1.02257  
0.218672  
0.0467624  
0.01
```





Edwards-Trinity Aquifer Major Watersheds Act Separately





Challenge: Adjoining Basins Merge at Dwindip Boundaries

Schleicher
County

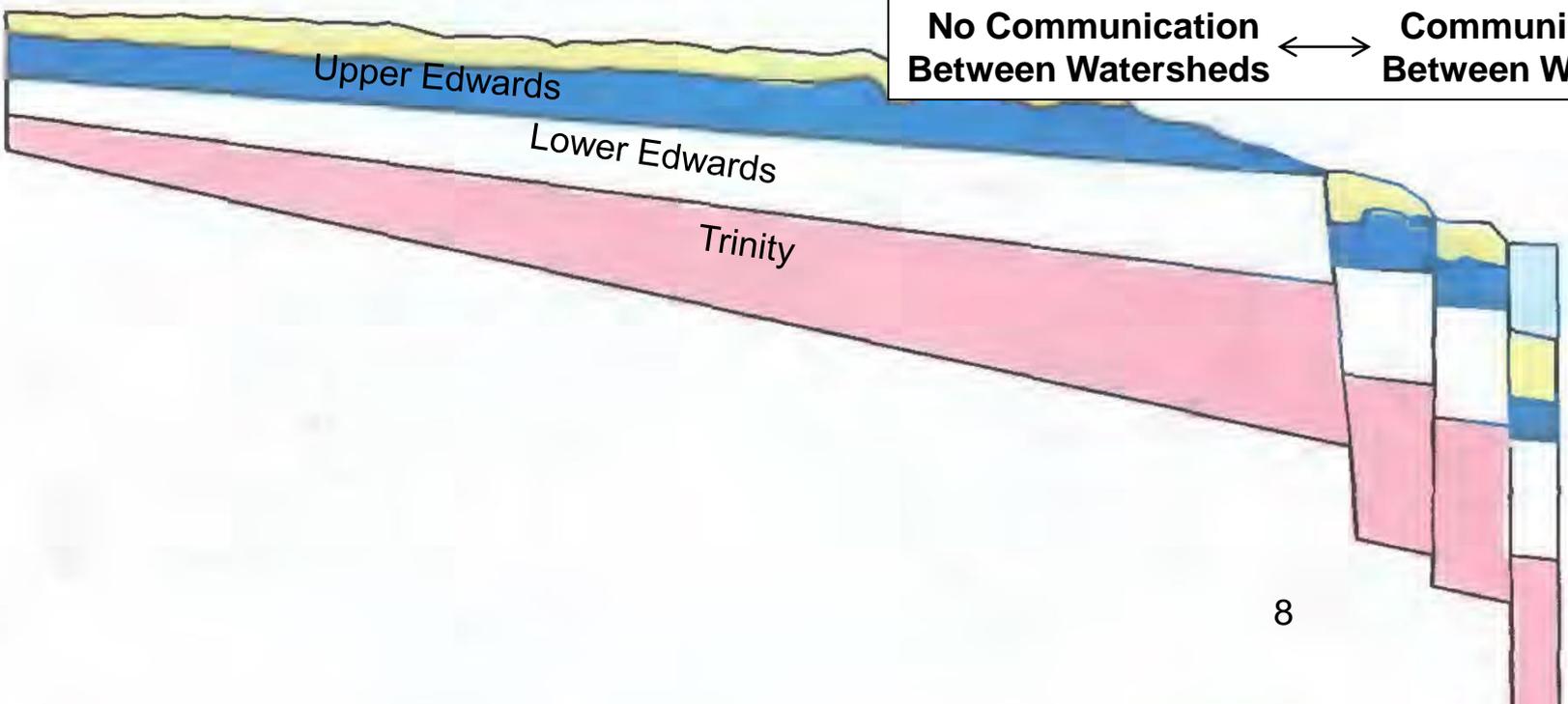
Sutton
County

Val Verde
County

Edwards Plateau

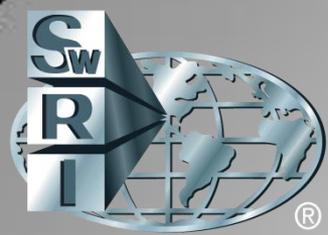
Unconfined ↔ Partially Confined ↔ Confined

No Communication
Between Watersheds ↔ Communication
Between Watersheds

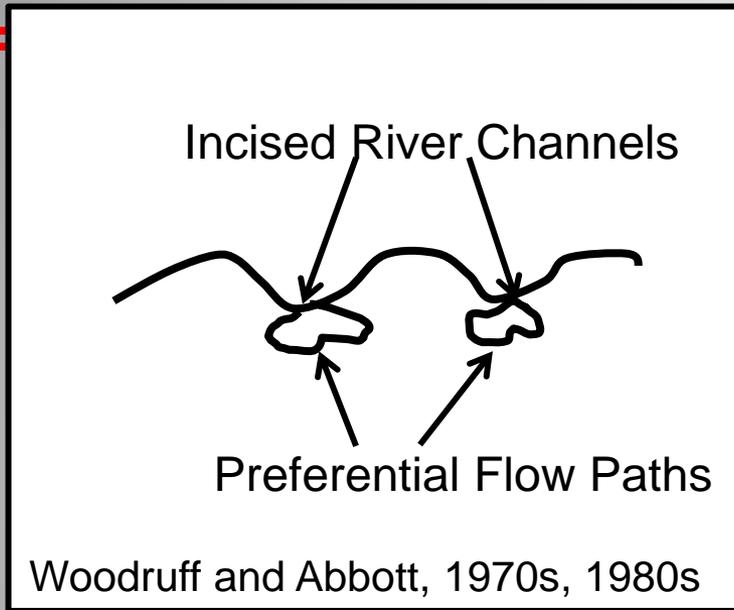




What is the nature of river and groundwater flow in the headwater areas of the Edwards Plateau?



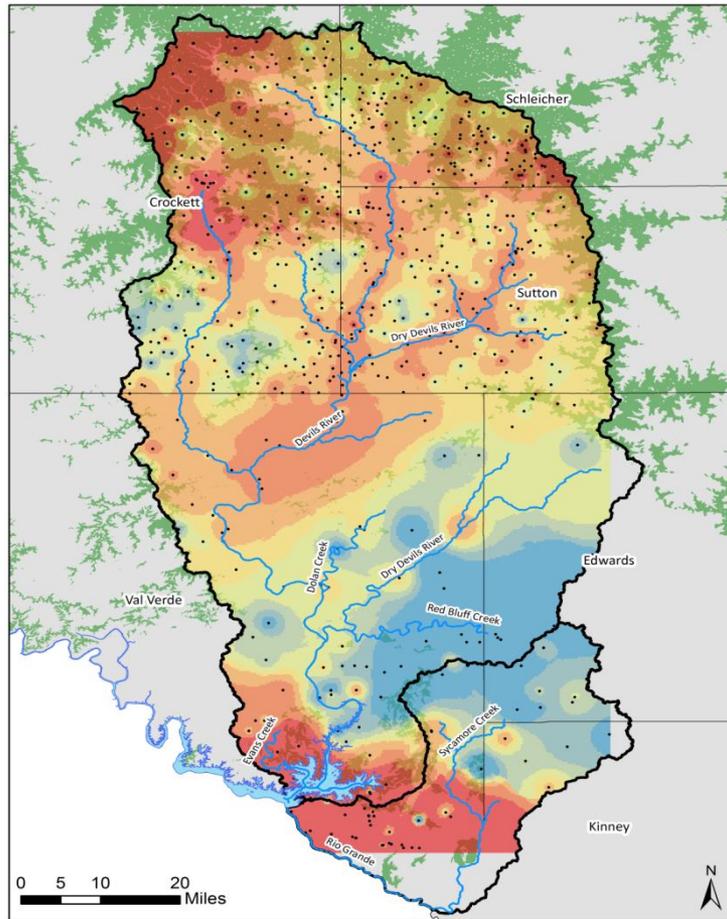
Rain Water Is Focused into River Beds and Acts as a Mild Acid That Dissolves the Limestone



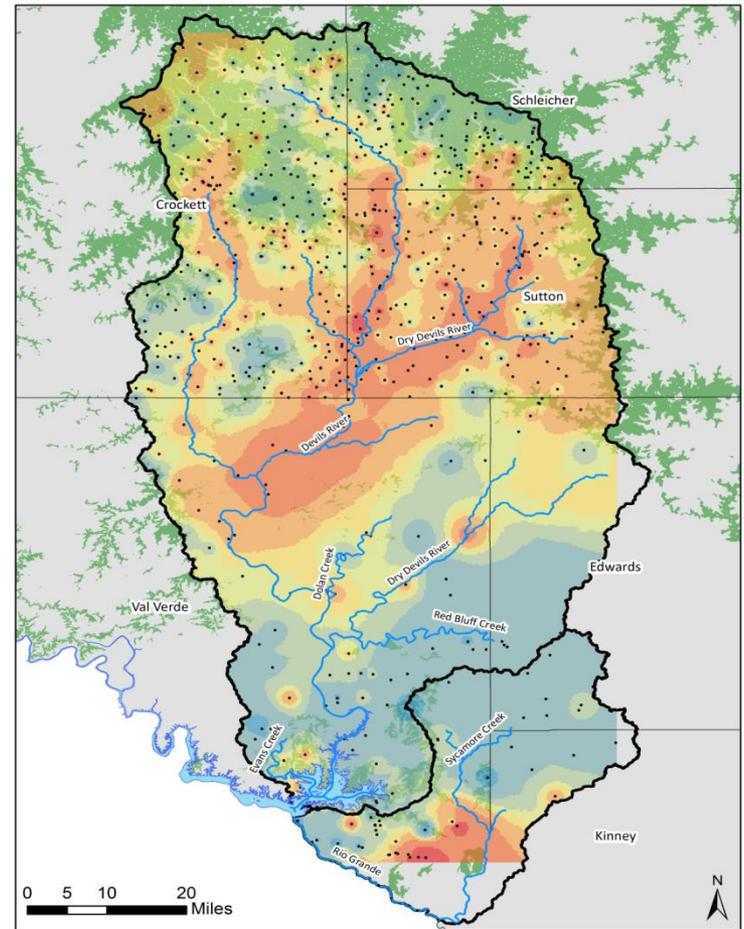
The preferential flow paths that are formed may be a “pipe”, but it is more likely the flow paths are simply zones of enhanced permeability



Groundwater Chemistry Indication of Conduit Location

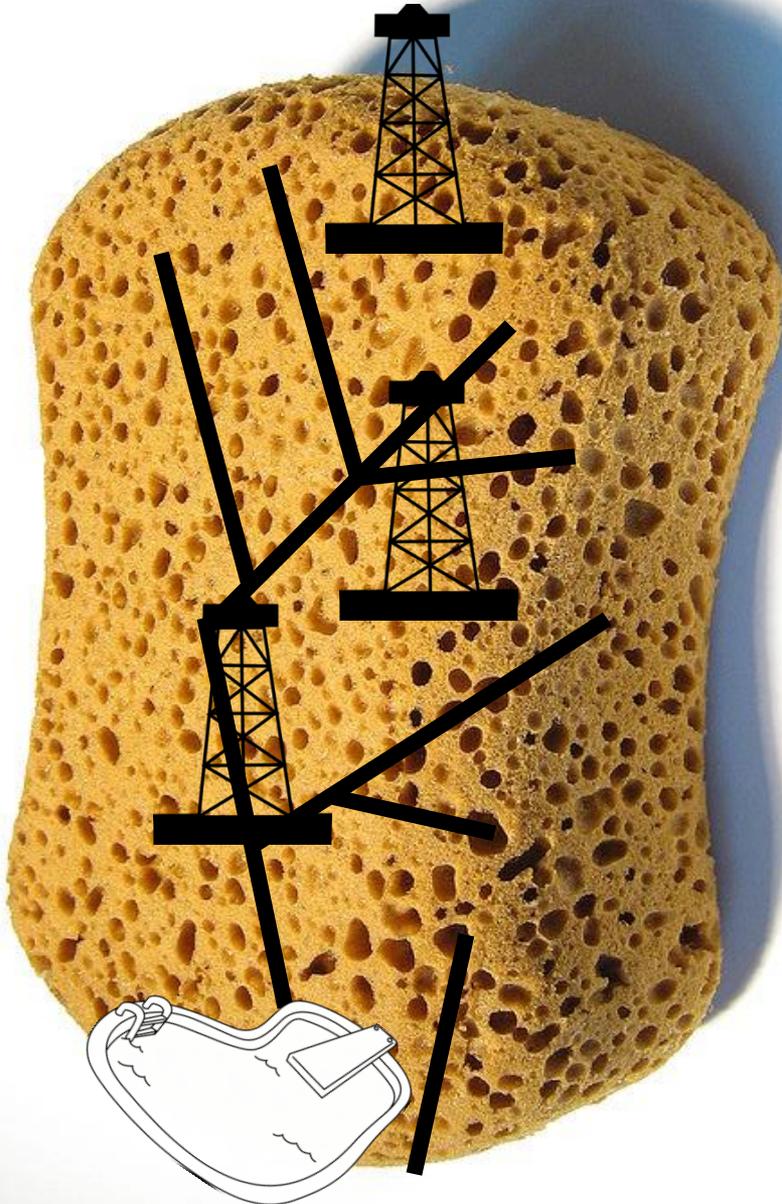


Total Dissolved Solids (mg/L)



Bicarbonate (mg/L)

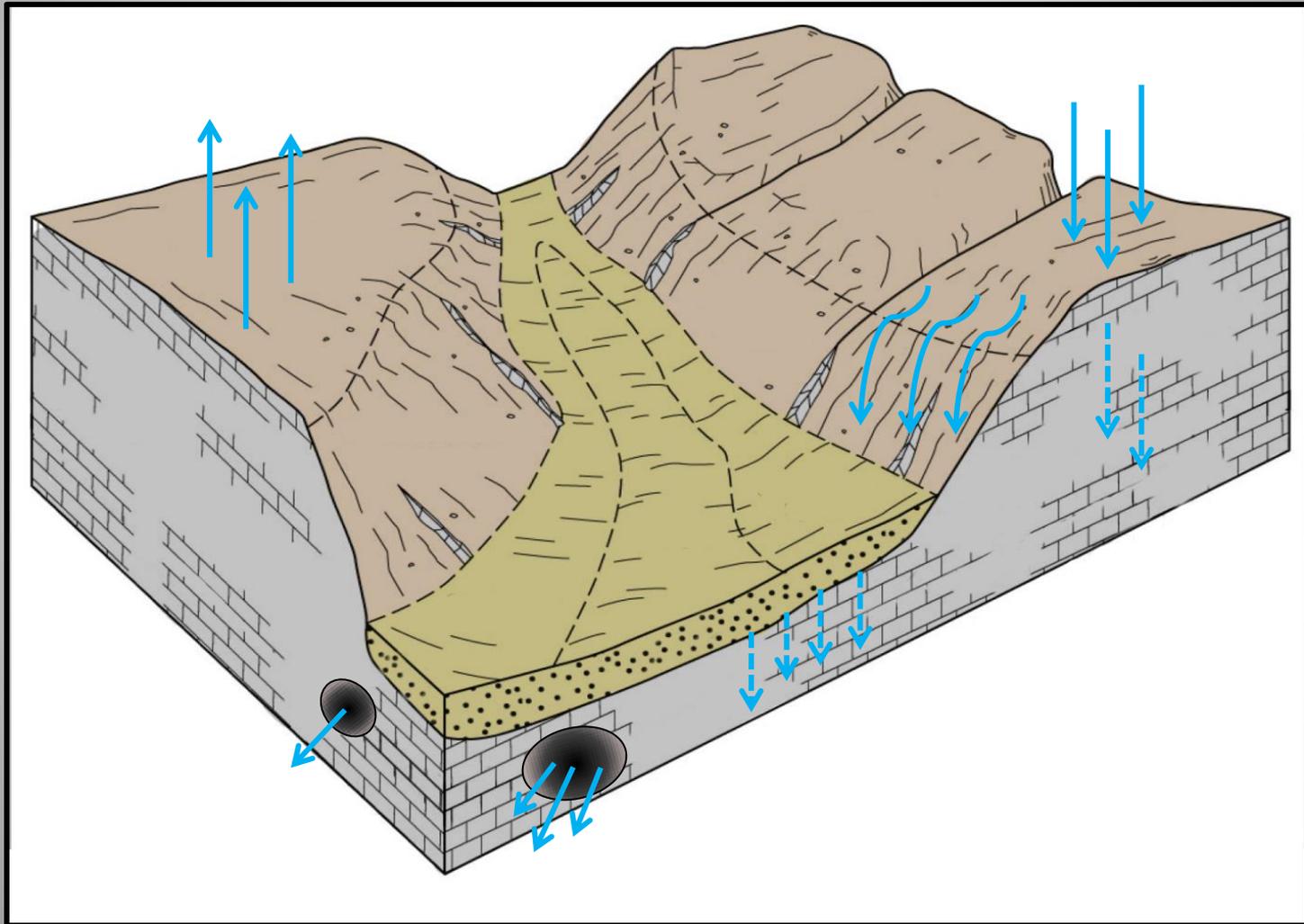


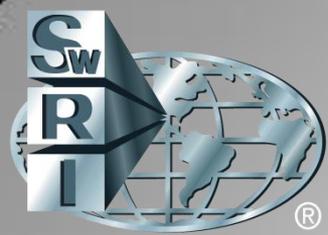


Pipes in a sponge

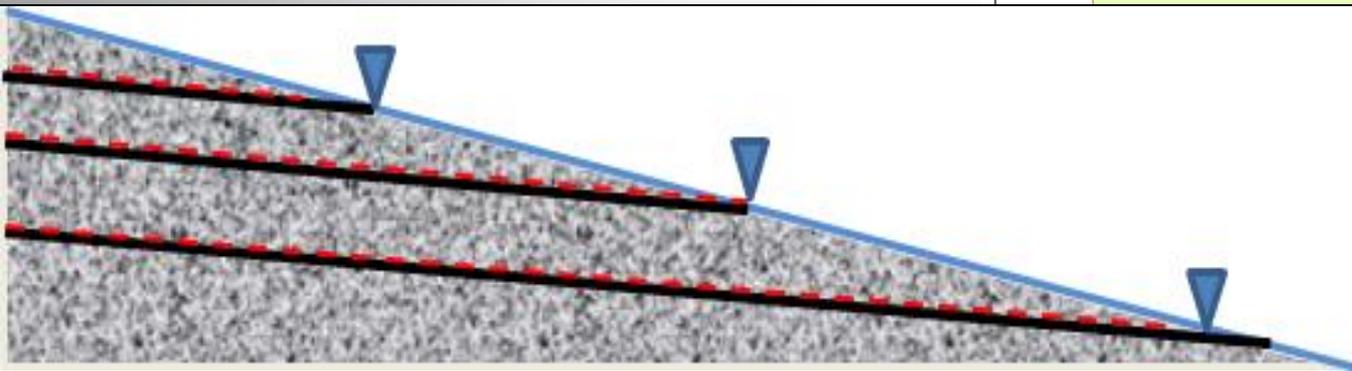
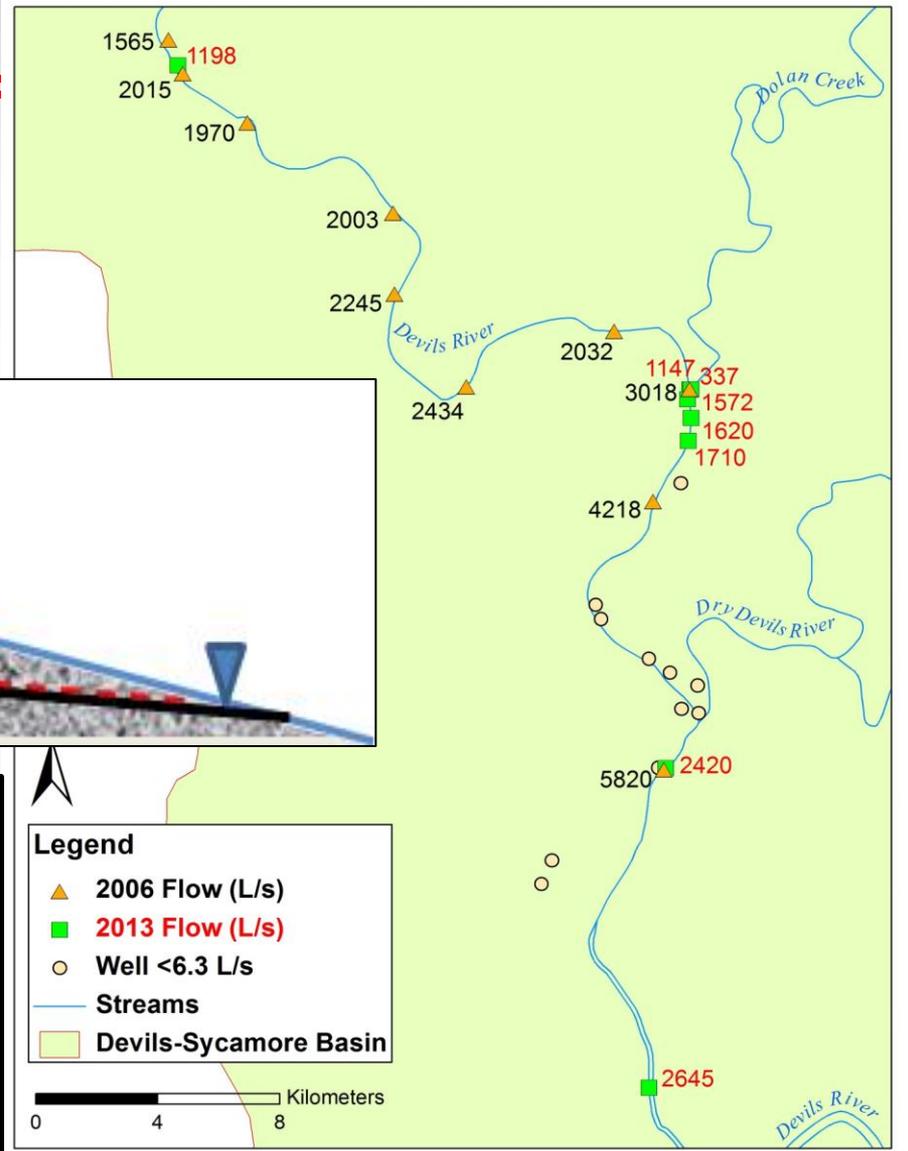


Hydraulic couplings are more complex than just SW ↔ GW





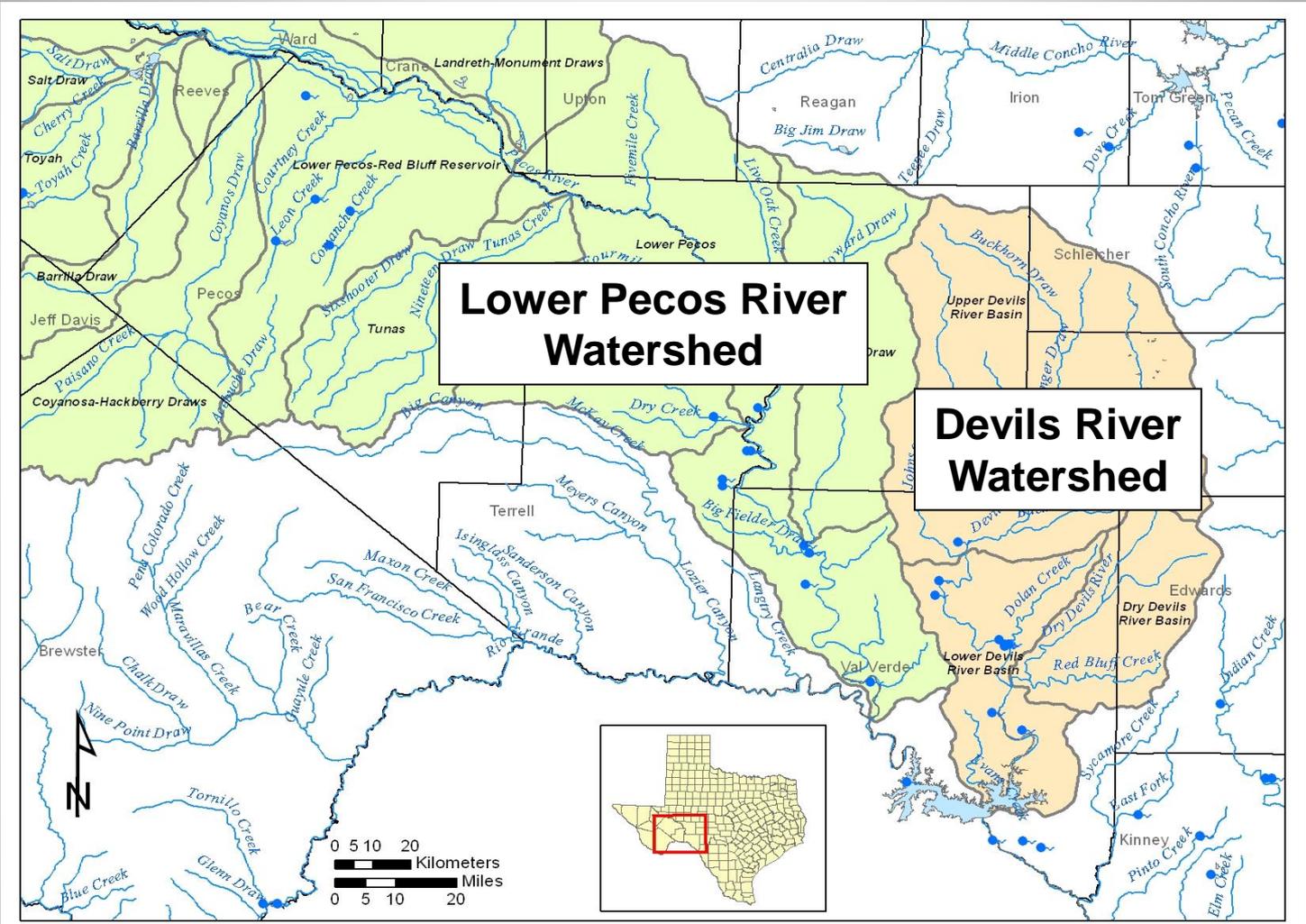
Headwater Streams are Mostly Gaining



2006 – TCEQ
2013 – Jeff Bennett/NPS; Marcus Gary/EAA; Ron Green/SwRI; Kevin Urbanczyk/Sul Ross; students

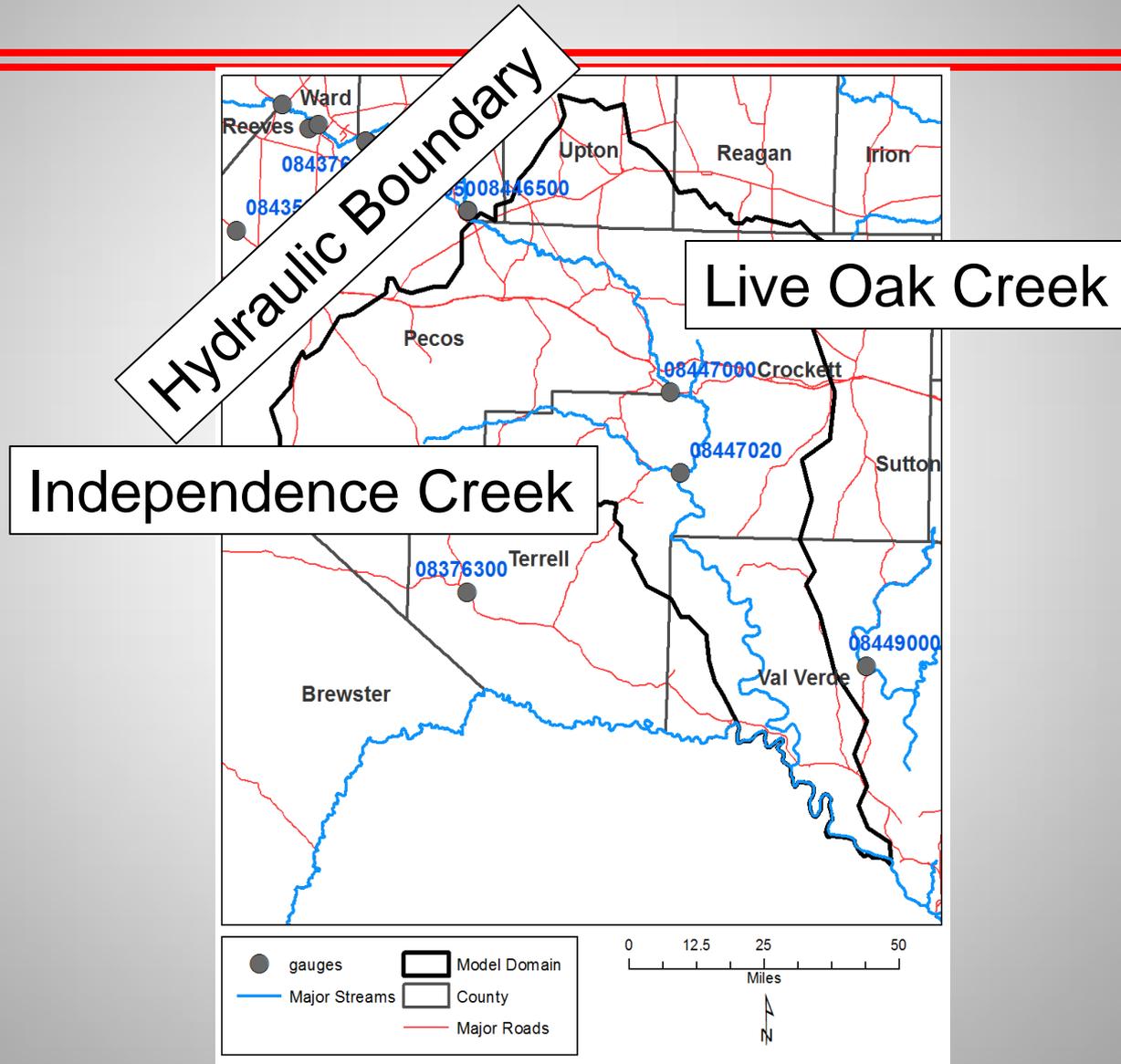


Watershed-Scale Studies

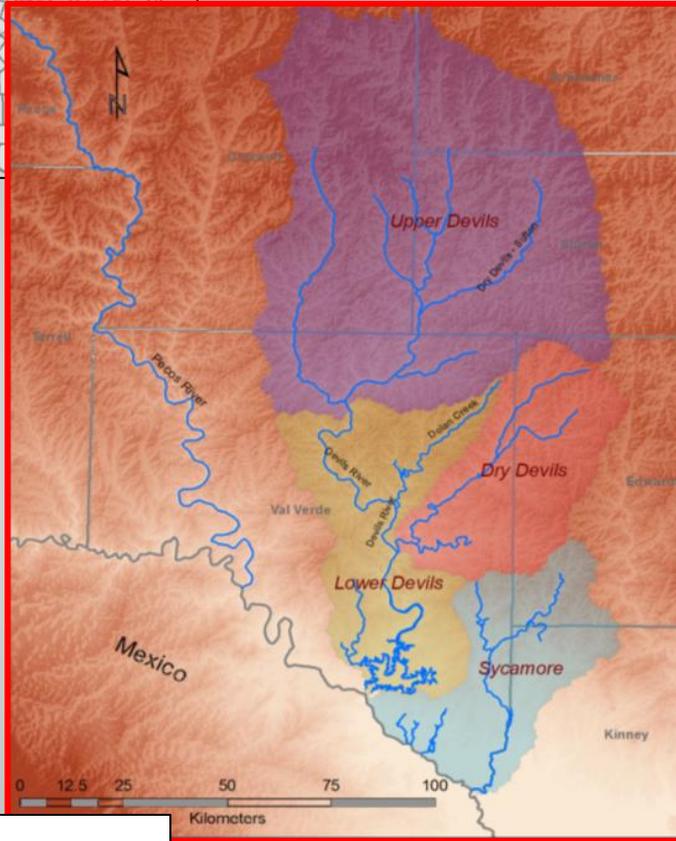
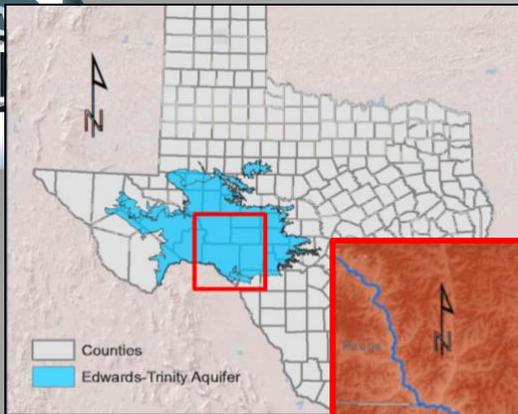




Parsing Out the Lower Pecos River Watershed



Devils River Watershed

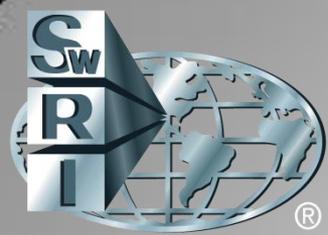


Drains southward off Edwards Plateau

Devils River watershed has features that make it difficult or impossible to model with just any SW-GW software.

Legend

- Streams
- Counties
- Digital Elevation Model
- Meters
- High : 1998.92
- Low : 218.746
- Modeled Basins
- Sub-Basins
- Dry Devils
- Lower Devils
- Sycamore
- Upper Devils



The Problem

- **Accurately predicting impact of groundwater pumping on surface flow or depletion of surface water on groundwater recharge** requires modeling interdependent surface and subsurface processes.
- **Integrated models are available, but not well developed**, particularly for challenging environments such as semi-arid karstic watersheds.
- TCEQ **WAM** is **not coupled** with TWDB **GAM**



Surface Water

Owned by the State

Governed by TCEQ

Administered using WAMs

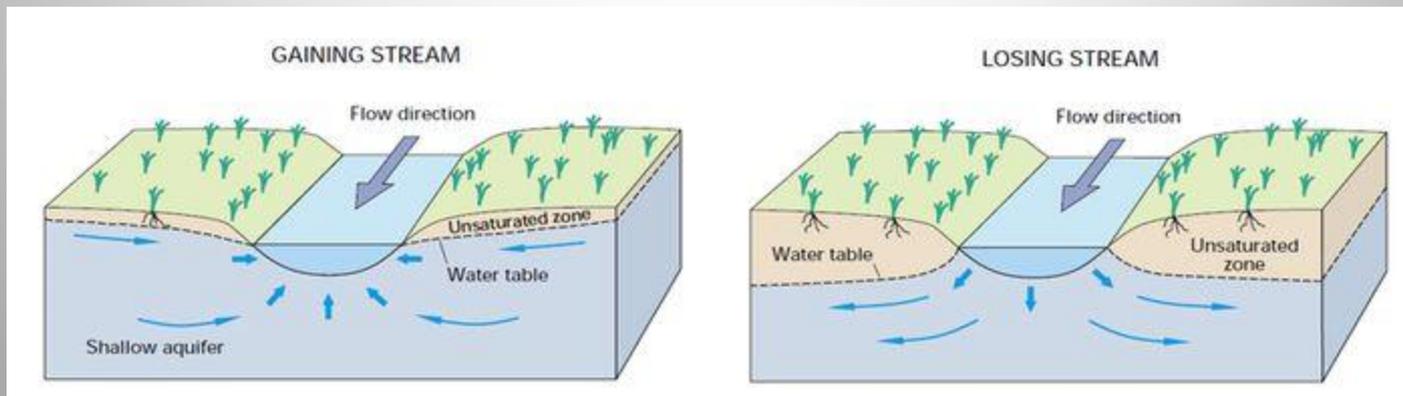
Groundwater

Owned by Land Owners

Governed by

TWDB/GMAs/GCDs

Administered using GAMs



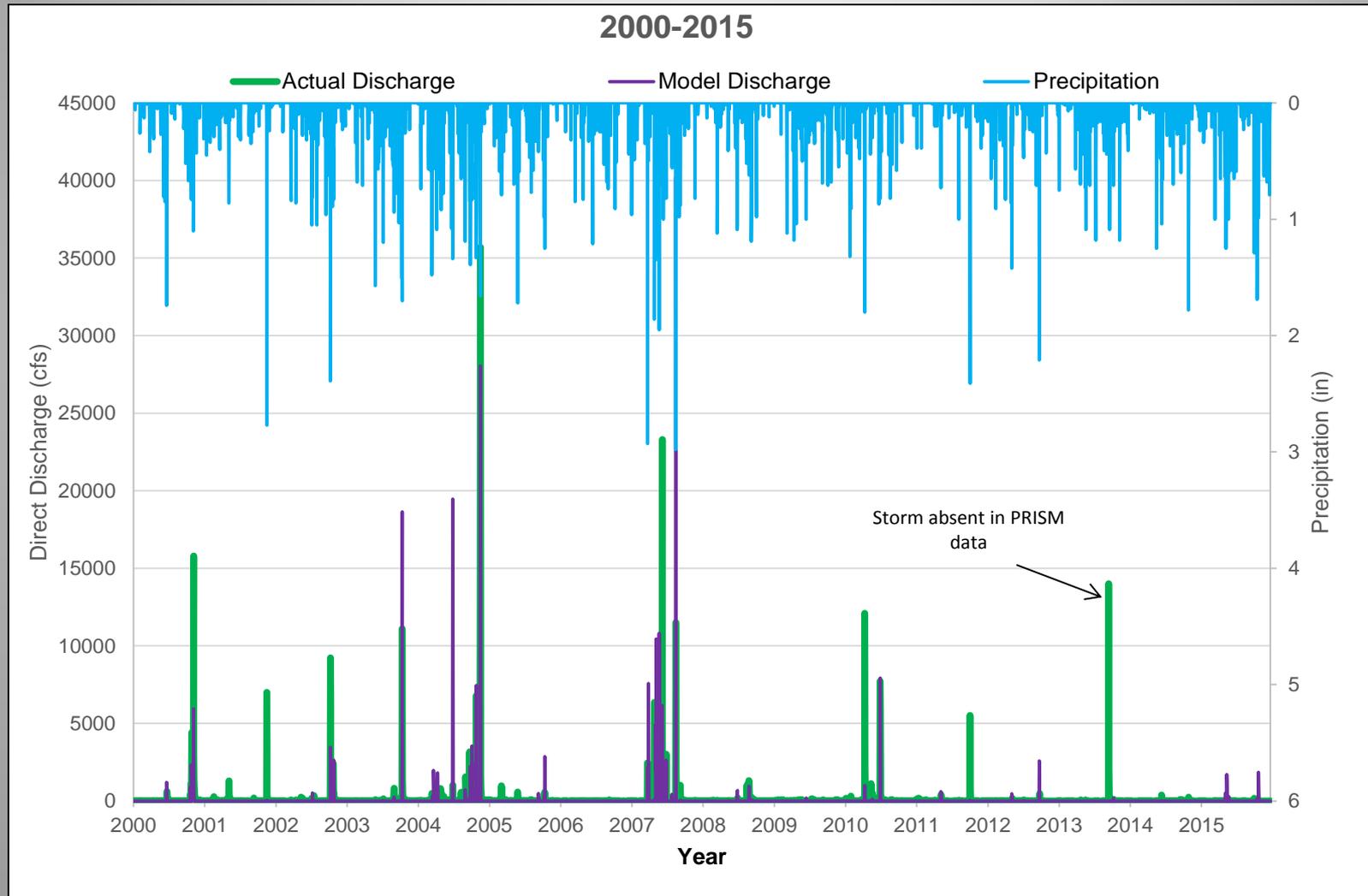
(Winter et al., 1998)



Surface-Water Model



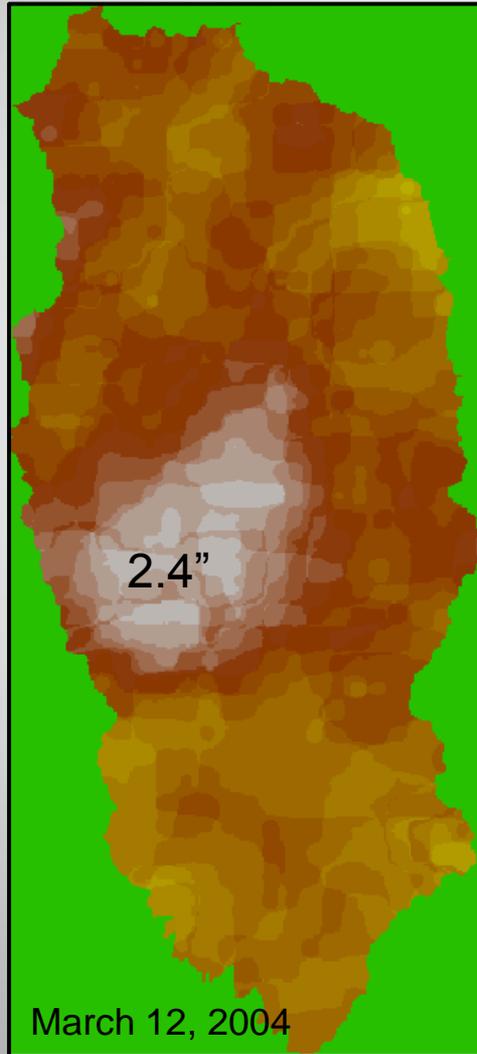
Long-Term Calibration 2000-2015



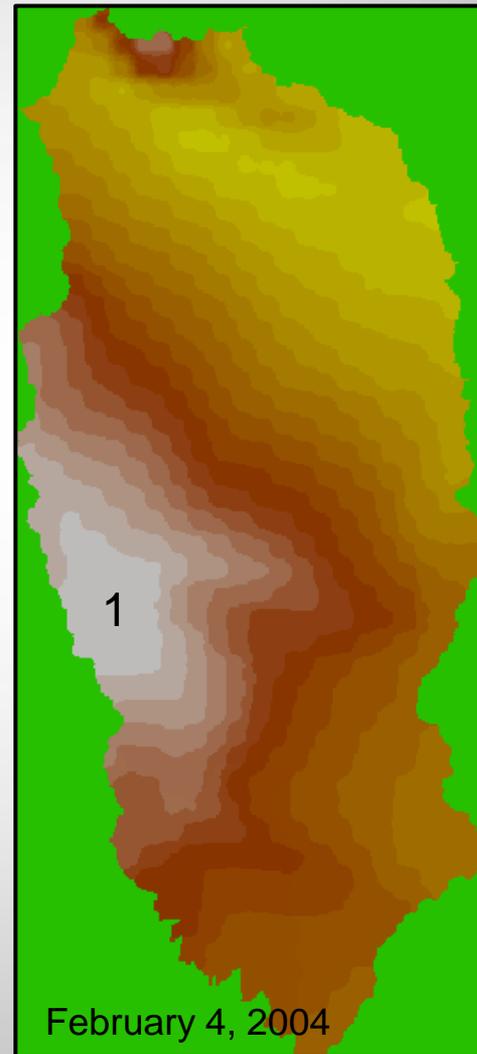


Percolation is Calculated by Surface-Water Model and Imported into the Groundwater Model

Infiltration



Saturated Fraction



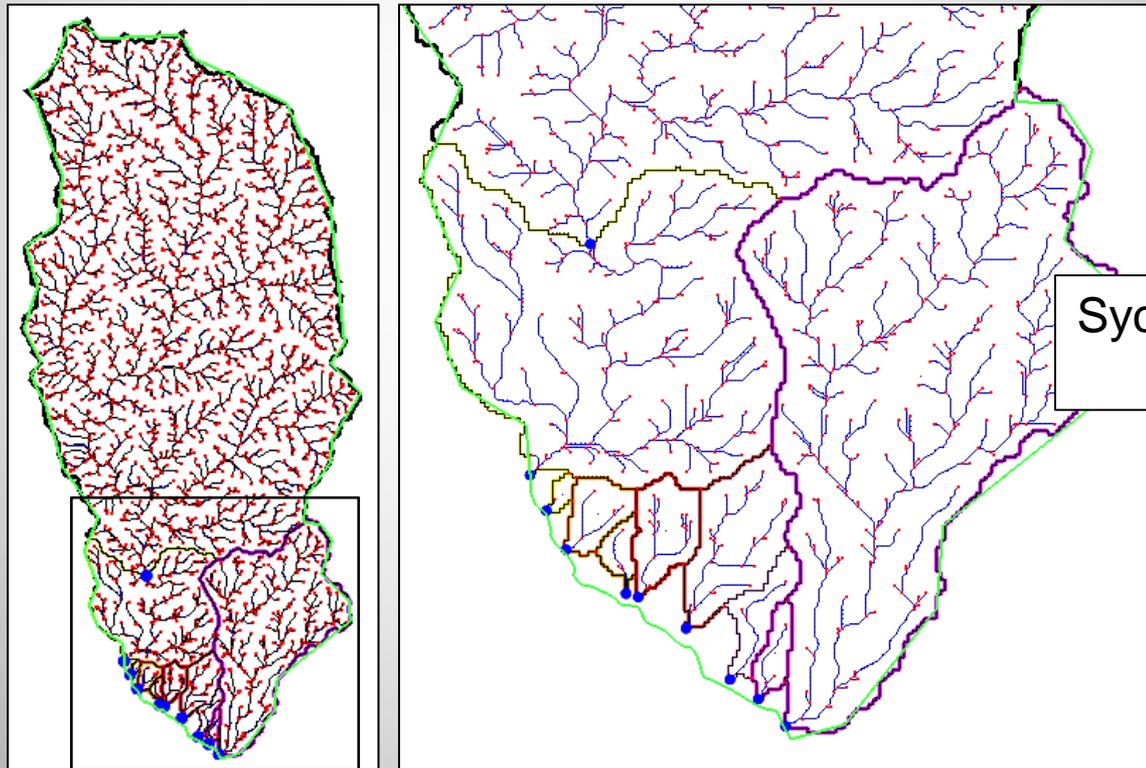


Groundwater Model Refinement



Groundwater Model Mesh Refinement

Mesh refinement at areas where the surface-water flow accumulation has selected stream channels



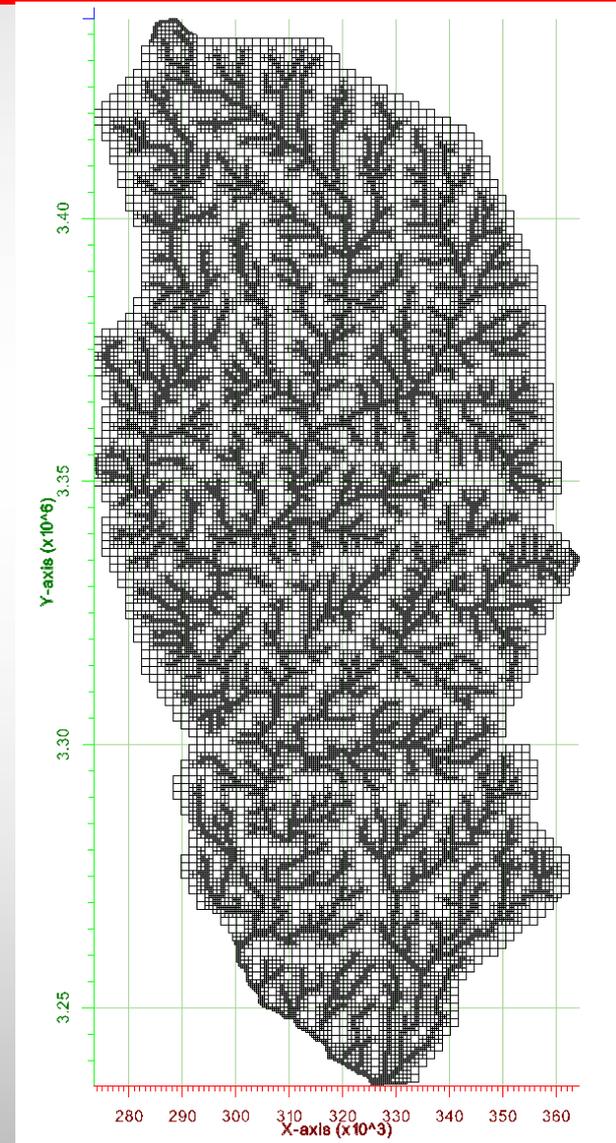
Sycamore Creek
Watershed



Groundwater Model Mesh Refinement

Quad-Tree mesh
refined along stream
centerlines

Significantly reduces
mesh density while
preserving complexity

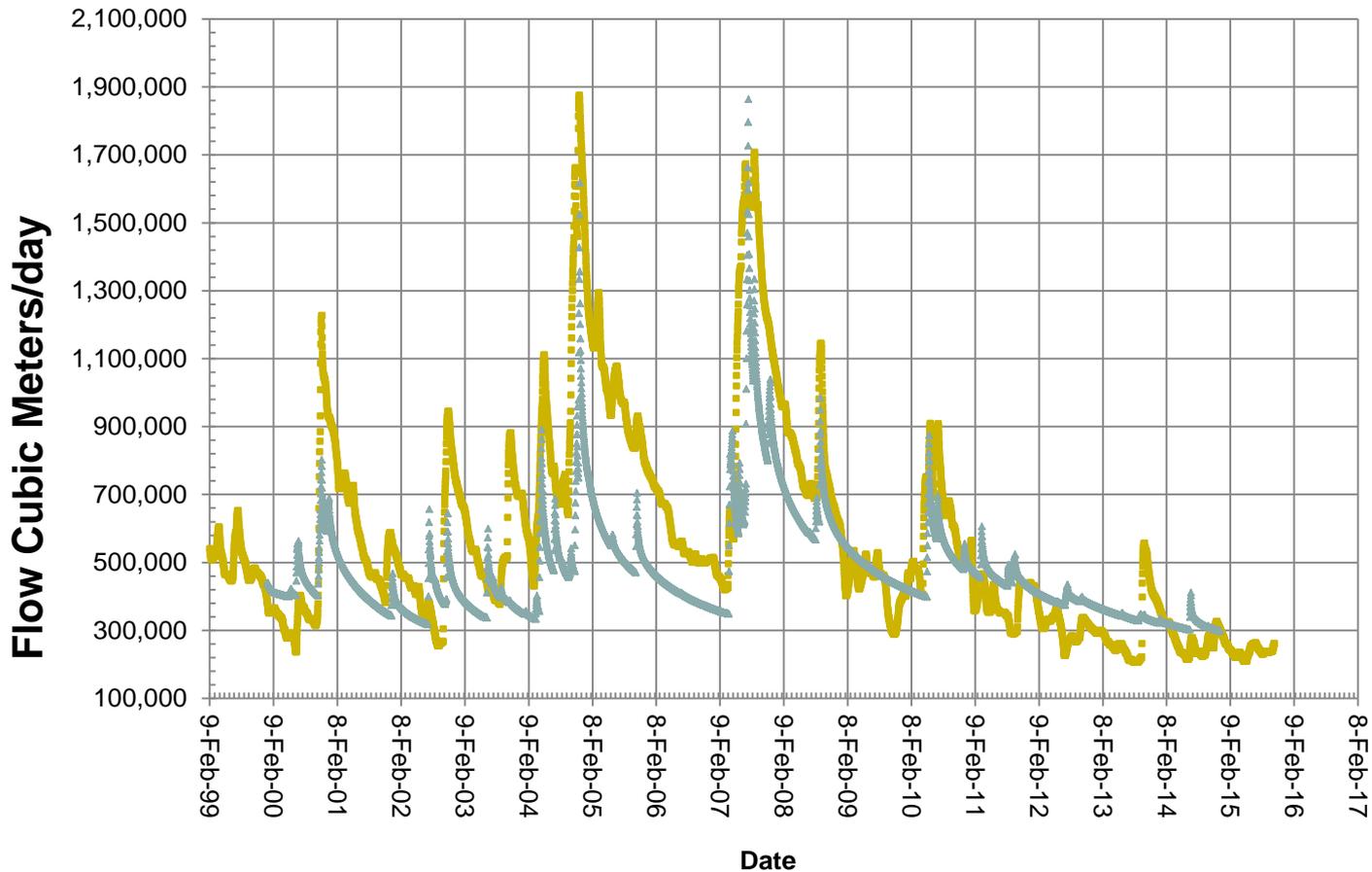




Groundwater Model Performance



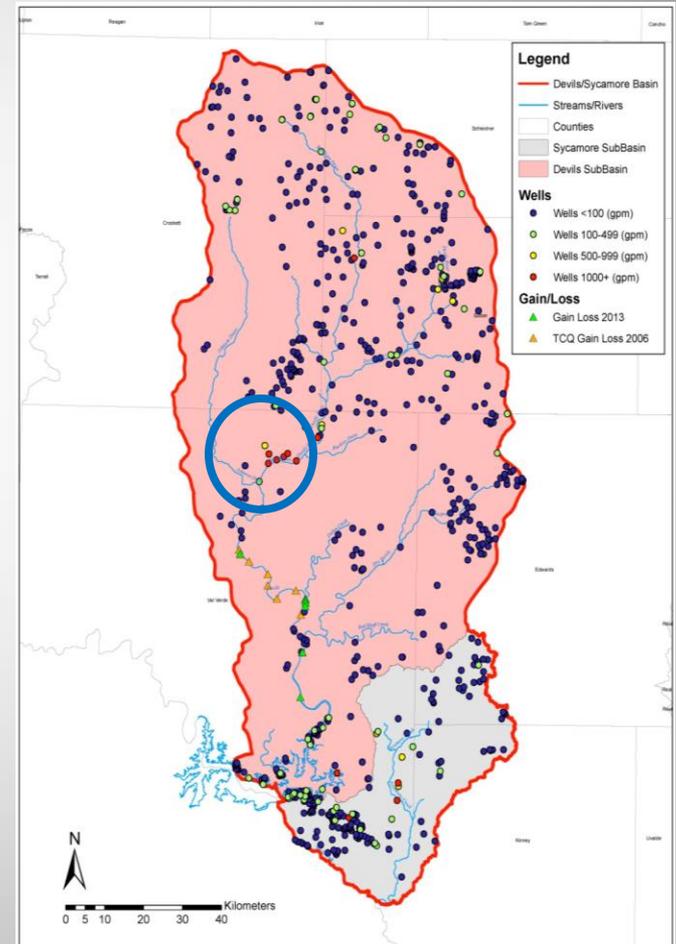
Groundwater Model River Discharge: Pafford Crossing





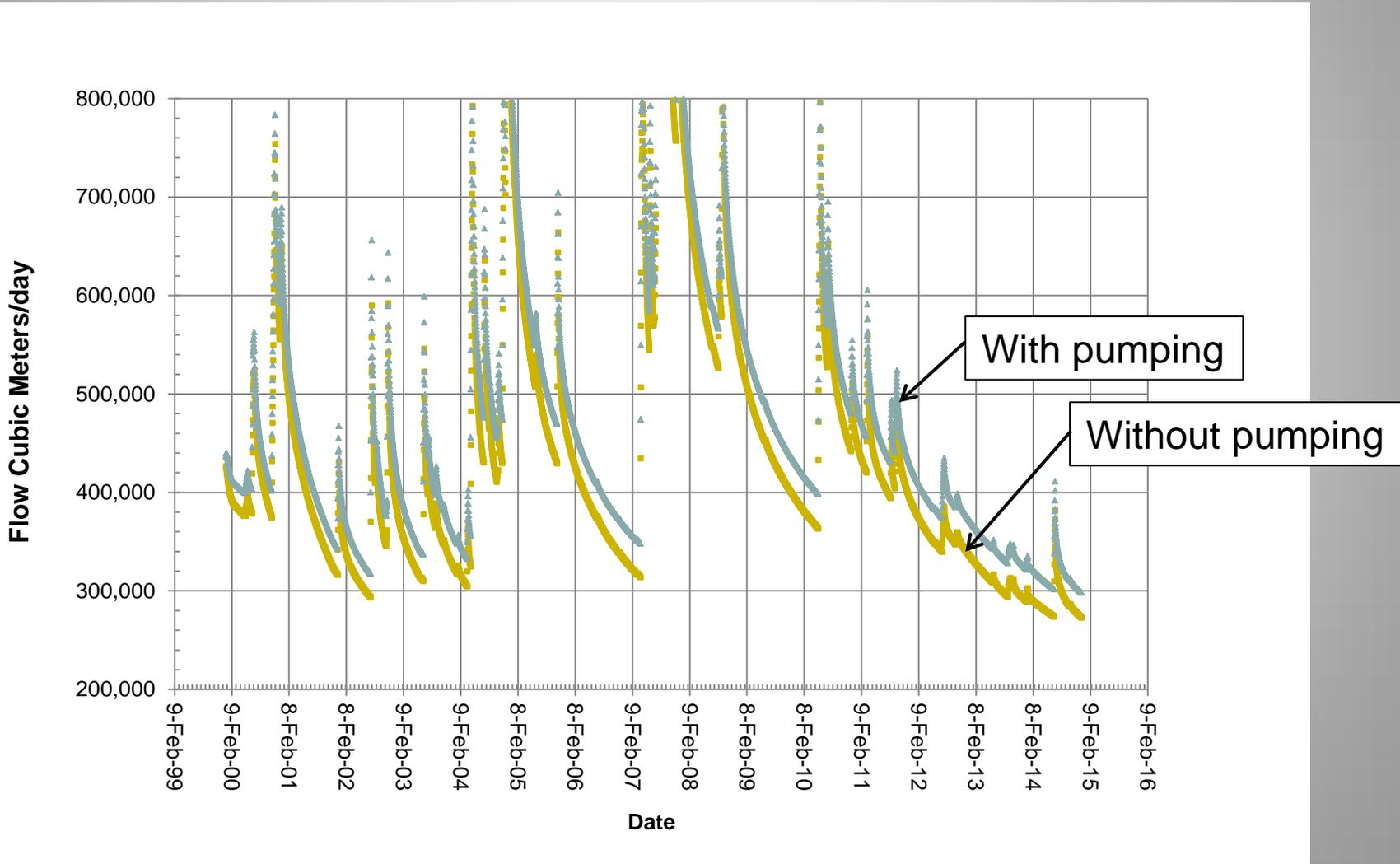
Groundwater Pumping Scenario

- Well field located near Juno
- Cumulative pumping of 8,000 gpm (12,800 acre-ft/yr)
- What is the effect on baseflow to the Devils River?



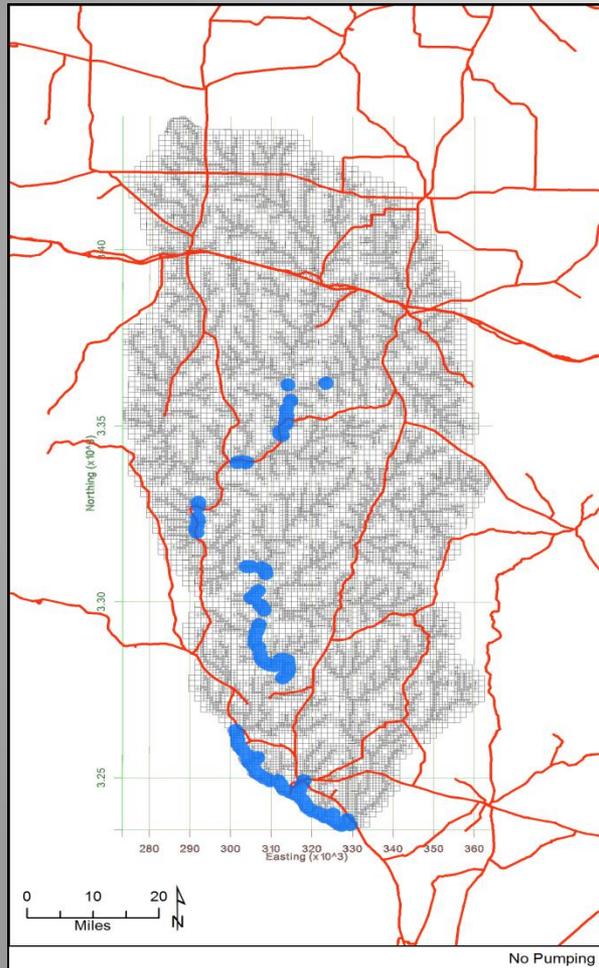


Groundwater Pumping Scenario 8,000 gpm at Juno



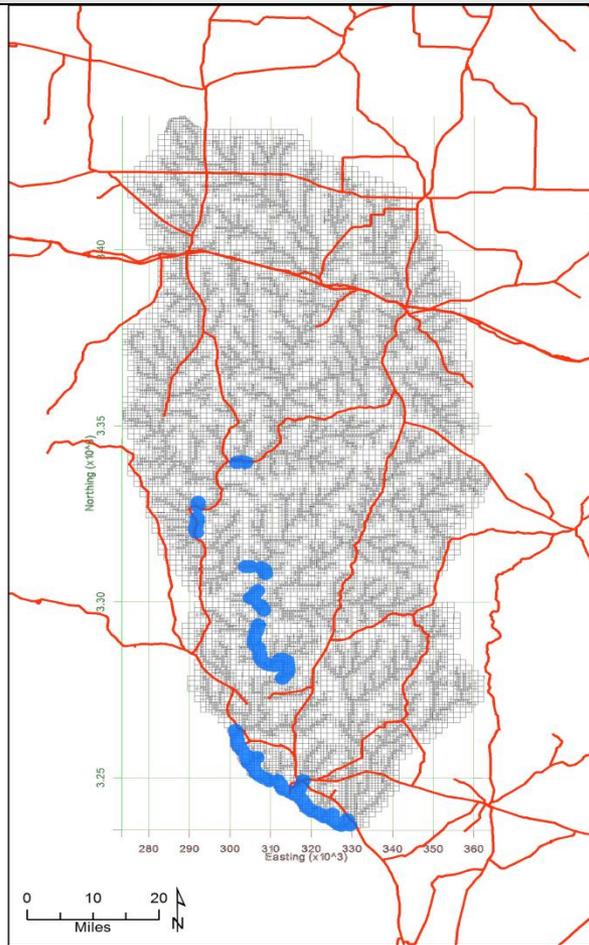


Self Selecting Spring Locations



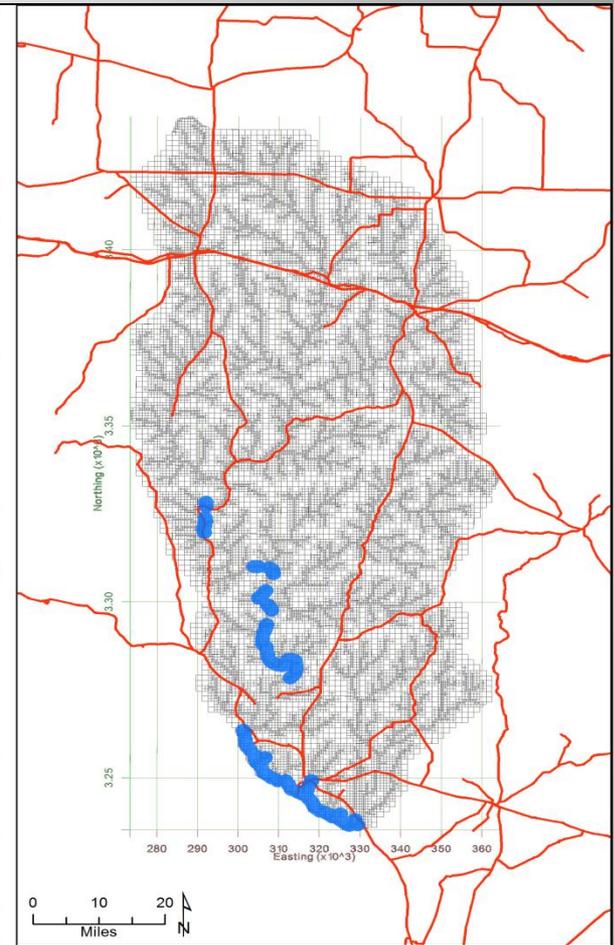
No Pumping

Pre-Development



Sutton, Val Verde, and Schlecher Pumping

Current Conditions



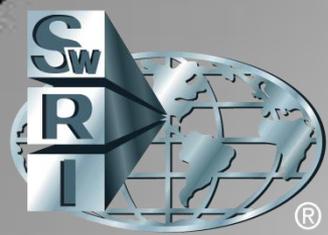
Additional 10,000 gpm pumping near Juno

With Juno Wellfield



Major Observations

- Improved insight on water resources provided when evaluating coupled surface water and groundwater.
- Individual watersheds in the Edwards Plateau can be evaluated and modeled separately.
- Groundwater flow controlled by the morphology of the area more than the hydraulic properties of the rocks. Model is relatively insensitive to assignment of hydraulic properties.
- Recharge in the Edwards Plateau is modest.
- Pumping of groundwater in basin will result in proportional reduction of flow in the Devils River. Impact is most pronounced during low flow conditions.
- Relatively modest pumping in upper Devils River watershed has shifted live water ~10 miles south.



Acknowledgements

- **Regional reconnaissance water-resource evaluation – Six Edwards Plateau counties & Del Rio: (2009-2010)**

- **Devils River Watershed**
 - **Field studies – Coypu Foundation: (2012-2013)**
 - **Groundwater Model – Nueces River Authority: (2014-2015)**
 - **Surface-Water Model – Devils River Conservancy: (2016-2017)**

- **Lower Pecos River/Devils River Watersheds**
 - **Field studies – Coypu Foundation: (2015-2016)**



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