Ground Water Flow in Pierce, Polk and St. Croix Counties, WI

Funding by:

Polk County

St. Croix County

Pierce County

USGS science for a changing world

With assistance from:

UW Extension WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

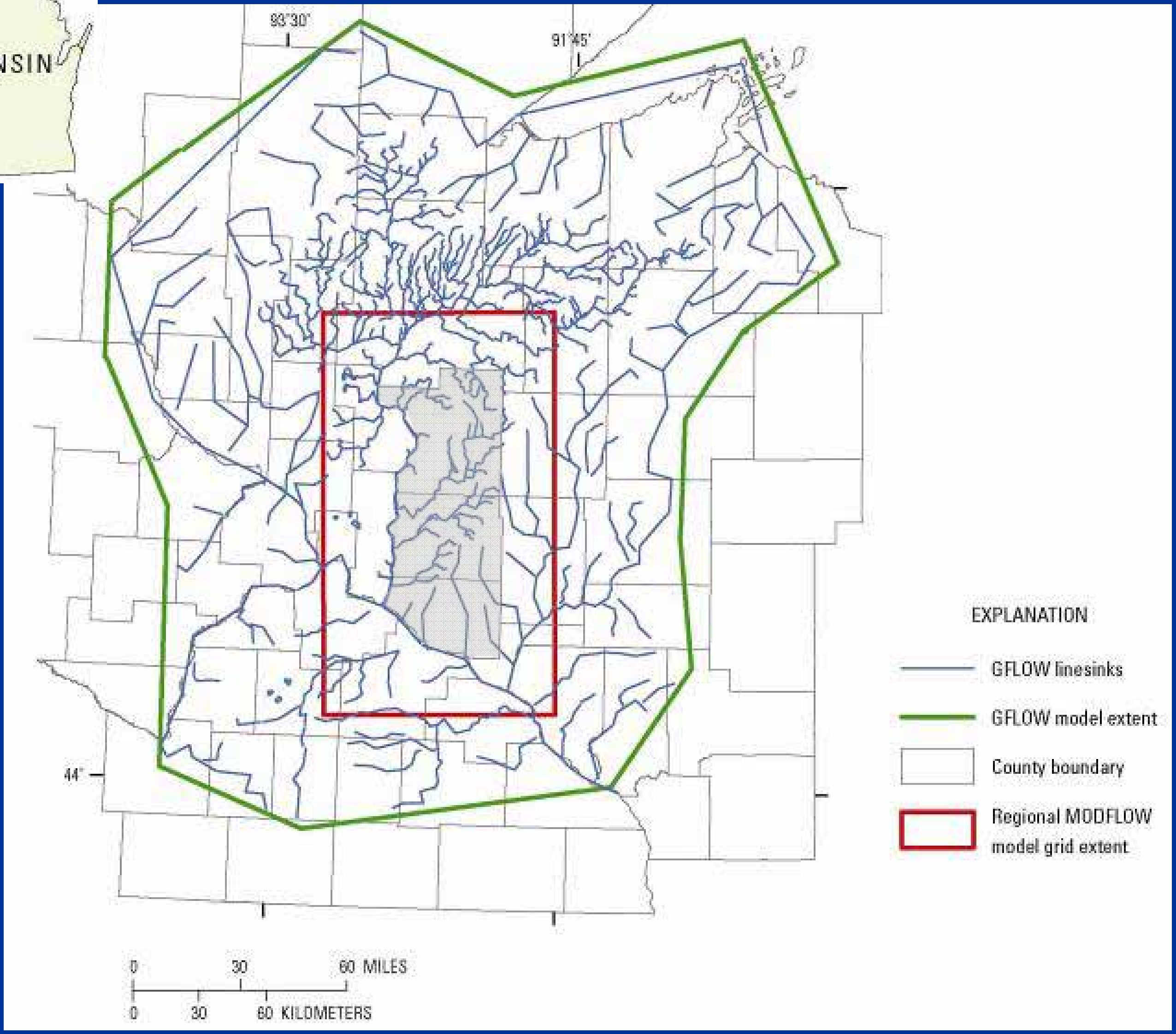
UNIVERSITY OF WISCONSIN MADISON

Objectives

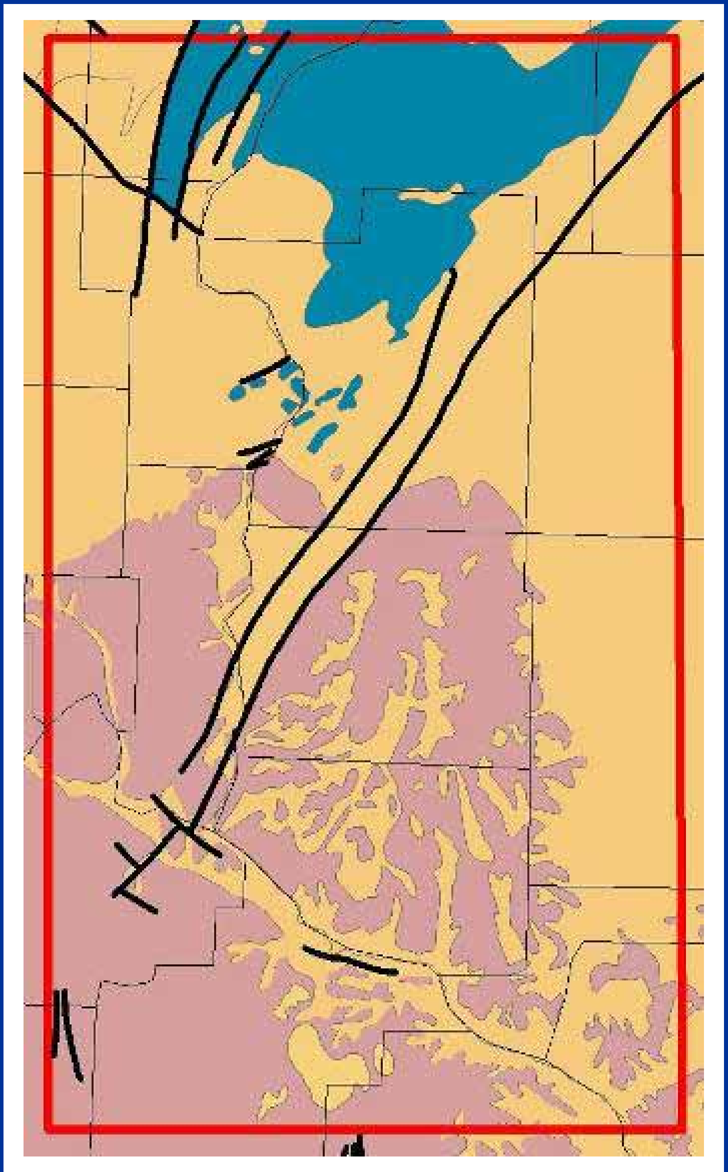
- Improve understanding of ground-water flow and surface-water/ground-water interactions in Pierce, Polk and St. Croix counties
- Provide a quantitative tool for evaluating regional management options
- Provide a framework from which to integrate regional flow patterns into more detailed local simulations

Model Area


MINNESOTA
WISCONSIN


93°30'
91°45'
44°
EXPLANATION
GFLOW linesinks
GFLOW model extent
County boundary
Regional MODFLOW model grid extent
0
30
60 MILES
0
30
60 KILOMETERS

Geology



Explanation

Model Boundary

Counties

Geology

Vertical Faults

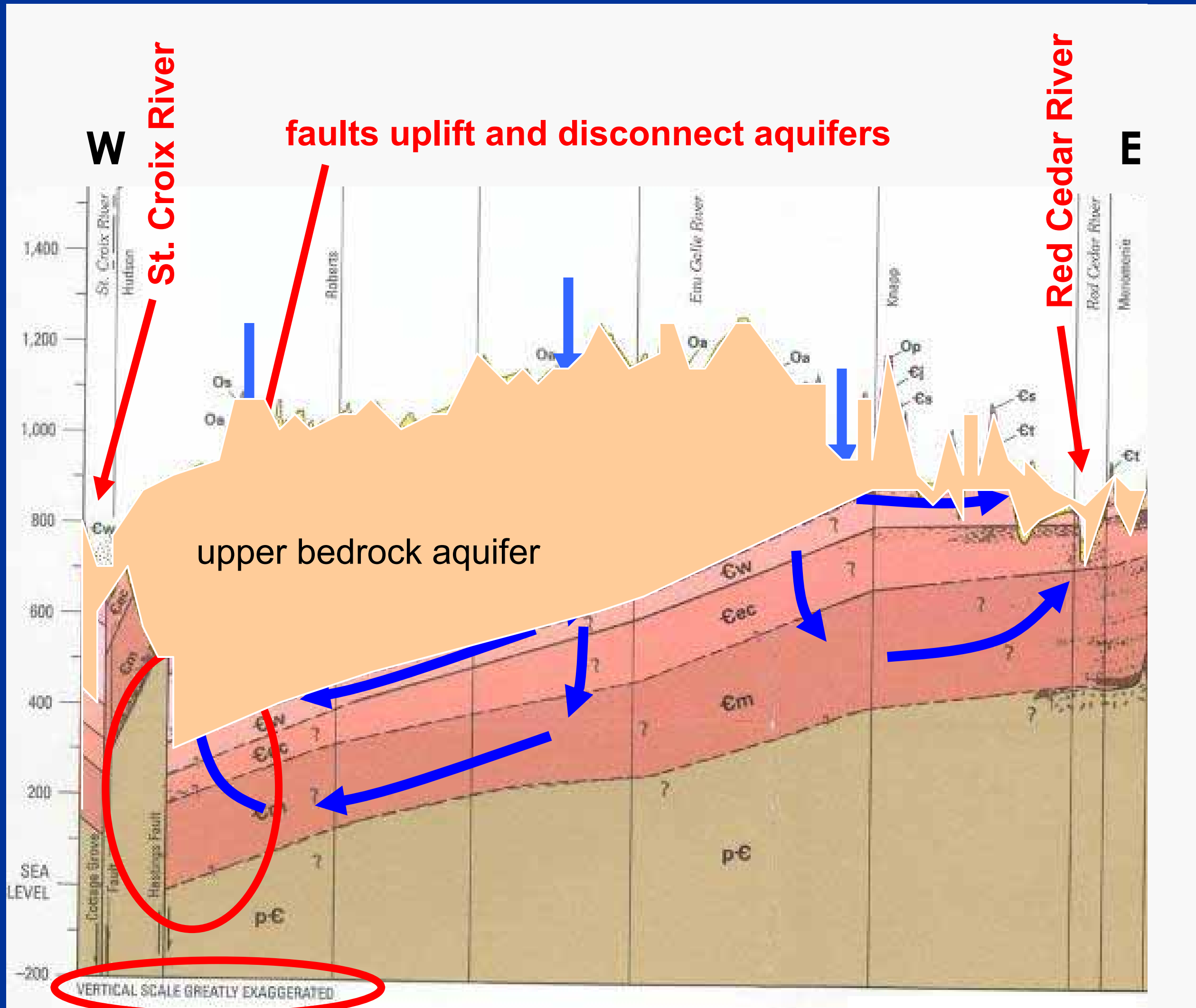
Crystalline rocks (basalt = "trap rock")

Sandstone rocks

Carbonate rocks (limestone)

Conceptual Model

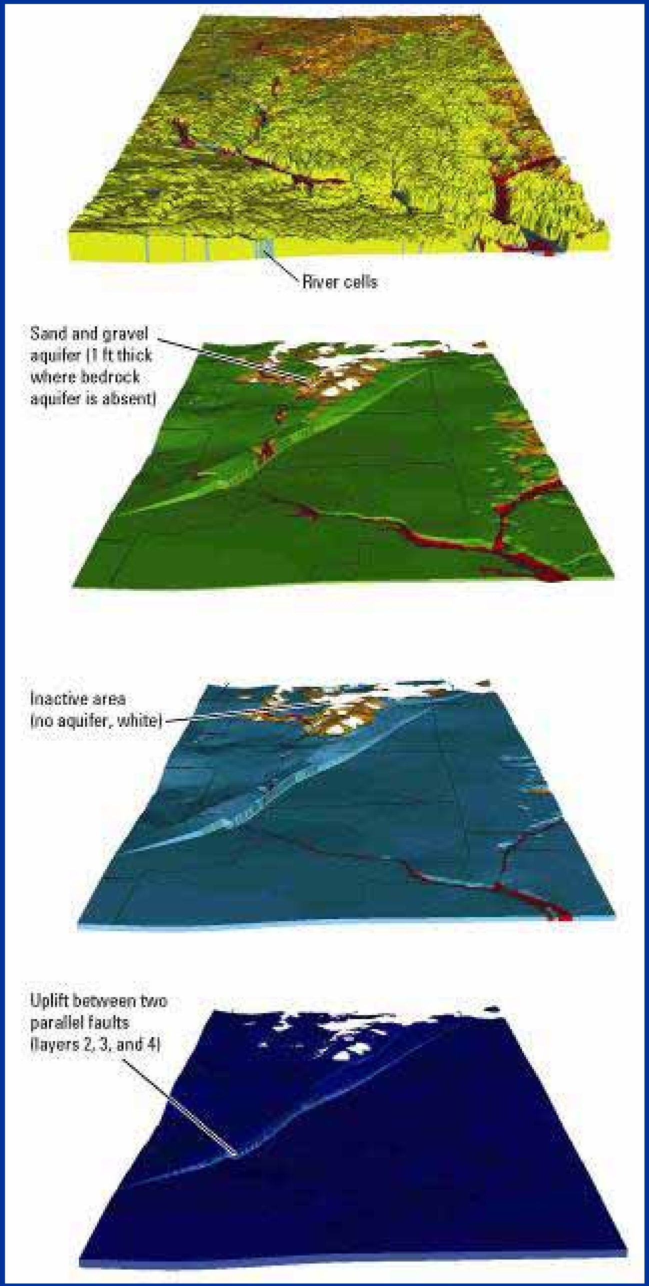
central & southern study area – St. Croix & Pierce



Hydrologic Atlas 731

How Models Work:

- Golden Rule: "water can not be created or destroyed"
- Plumber's Rule: "water flows down-gradient"
- Numerical equations representing real world entered into the computer *(geologic properties, surface-water bodies, pumping)*
- Calibrate *(data requirements can be large - "results are only as good as the data")*



Model Development

- Construction
  - 4 continuous layers
  - Layer 1 (upper bedrock aquifer) lumps many aquifers (including karst aquifers) and confining units.
  - Sand and gravel (orange & red) aquifers are simulated where bedrock is absent ("windows" along major rivers)
  - Inactive where the aquifer is absent and replaced by crystalline rock ("trap rock")
  - Faults: uplift, permeability change, barrier where crystalline rock is adjacent to sandstone in layer 4
- Sources and sinks
  - Recharge (uniform)
  - Rivers
  - Pumping wells (average from 1994 – 2004)
- Calibration
  - Water levels
  - Stream base flows

Model Results

- Sources and sinks of water (water budget)
- Flow directions & ground-water/surface-water interaction
- Identify factors controlling flow directions (in 3D)
- Effect of current water use on water levels
- Demonstrate the use of inset models (one example)

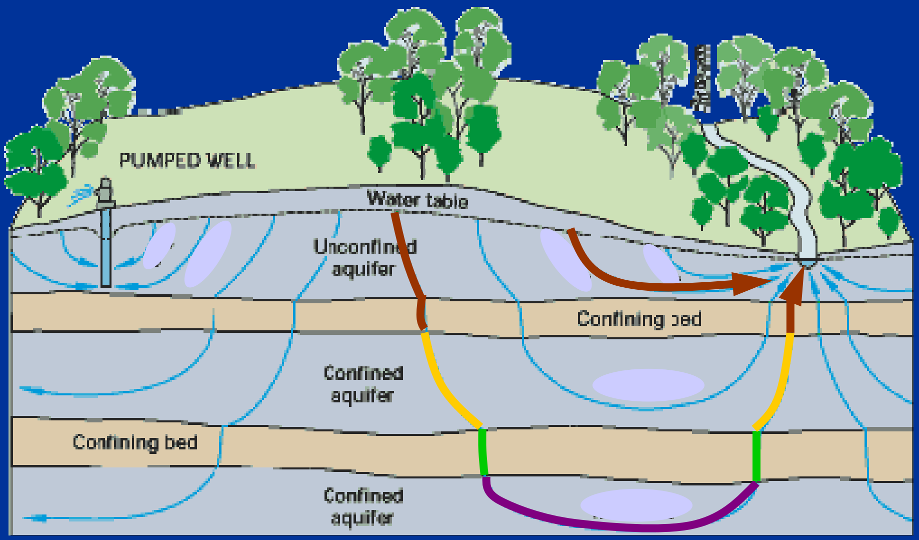
Ground Water Budget

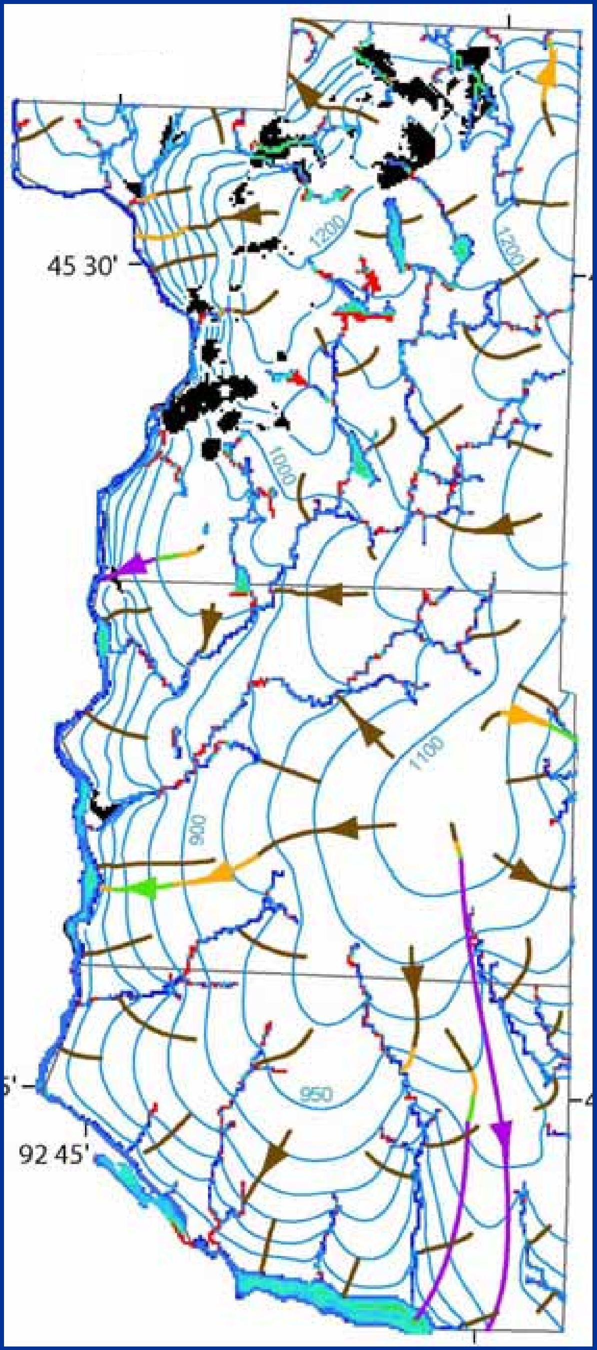
	Ground water In	Ground water Out
Recharge	82%	0%
Rivers	15%	85%
Wells	0%	1%
County boundaries	4%	14%

Flow Directions and River Gain/Loss

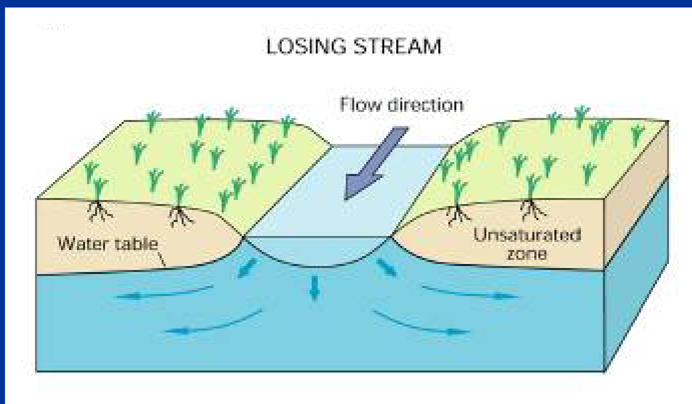
Water moving through:

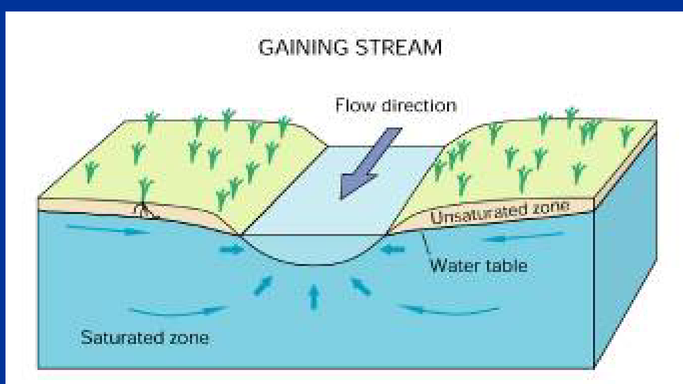
- Layer 1
- Layer 2
- Layer 3
- Layer 4





Flow Directions and River Gain/Loss





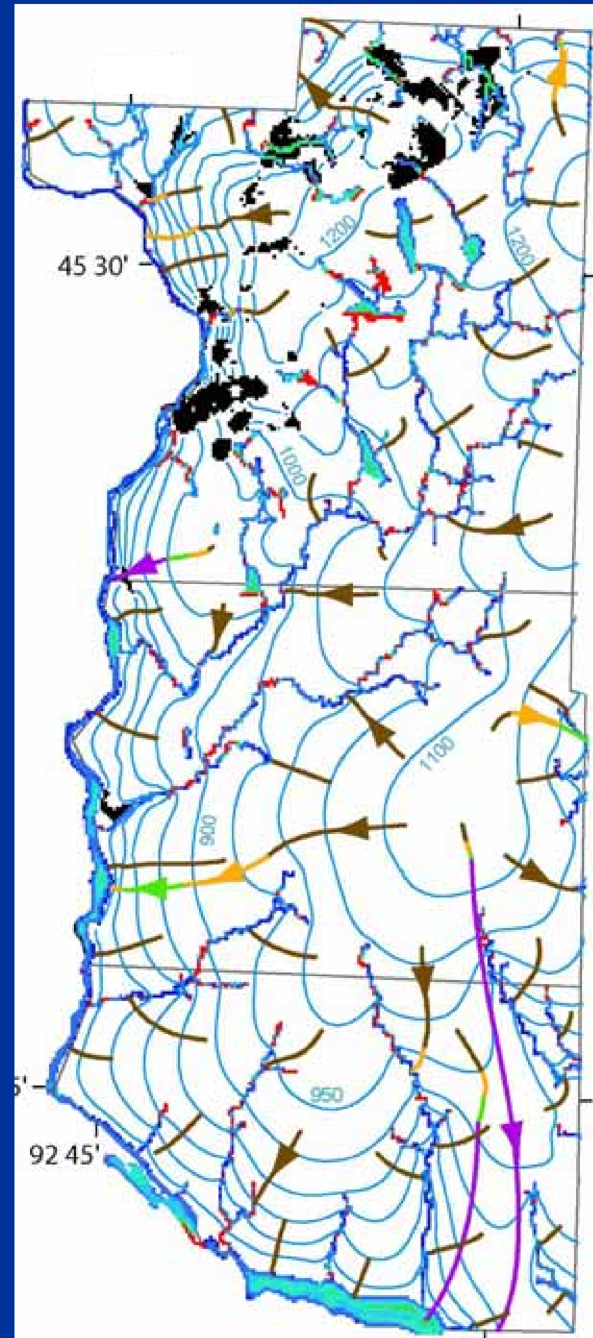
Losing Reach

Weakly

to

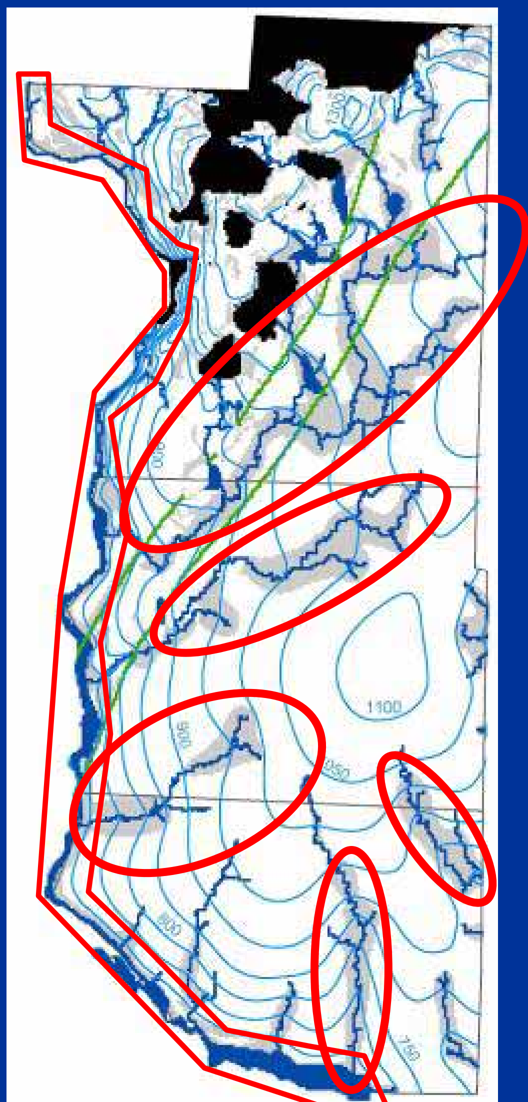
Strongly

Gaining Reaches

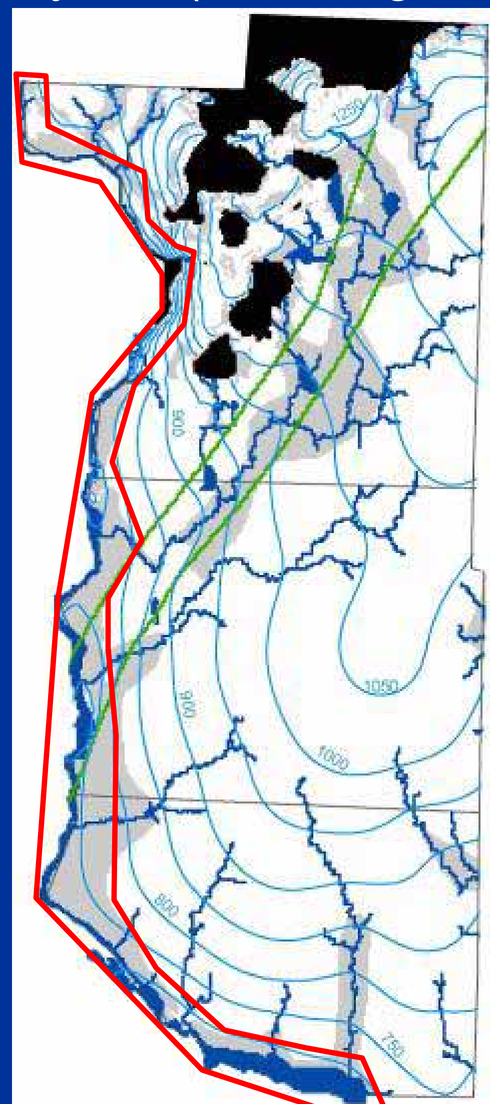


Factors Controlling Flow…Vertical

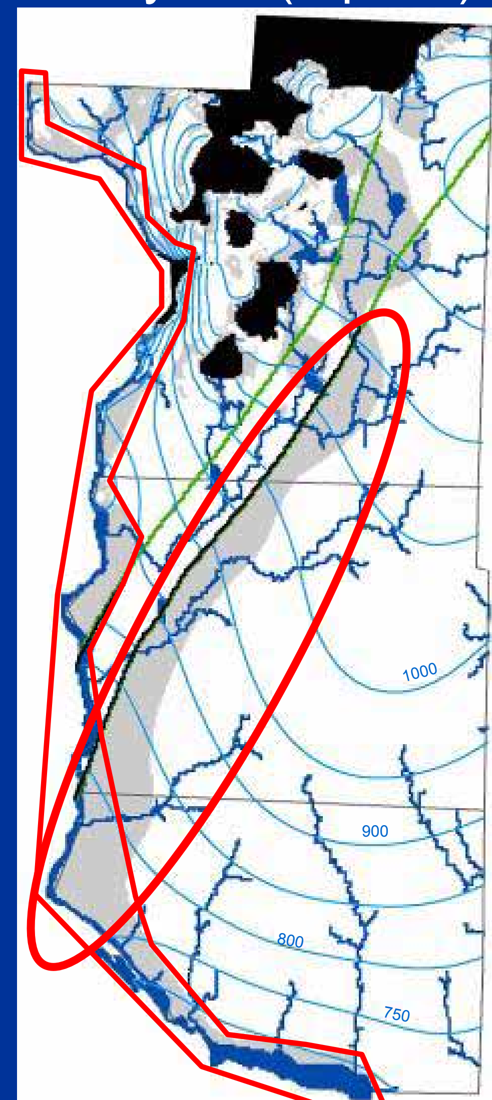
Layer 2 (aquifer)



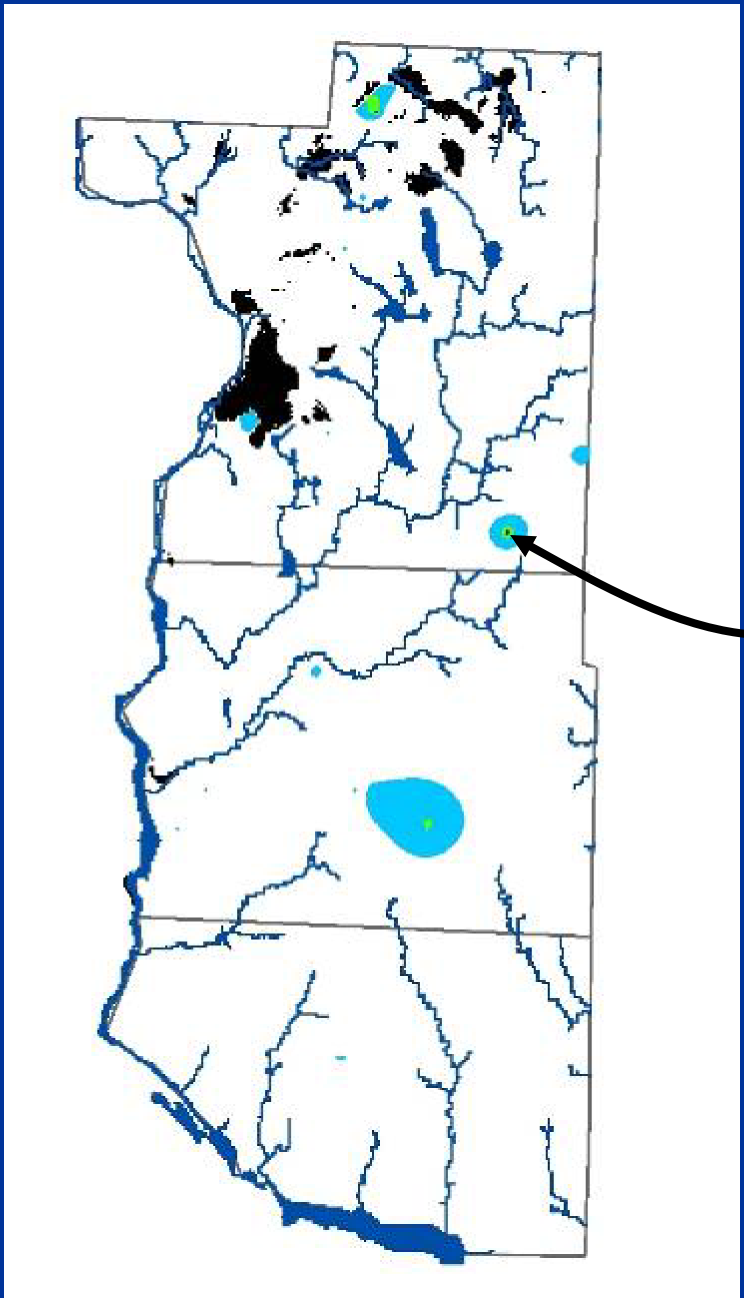
Layer 3 (confining unit)



Layer 4 (aquifer)



Simulated Water-Table Decline



Max. decline ~8 ft

Layer 1

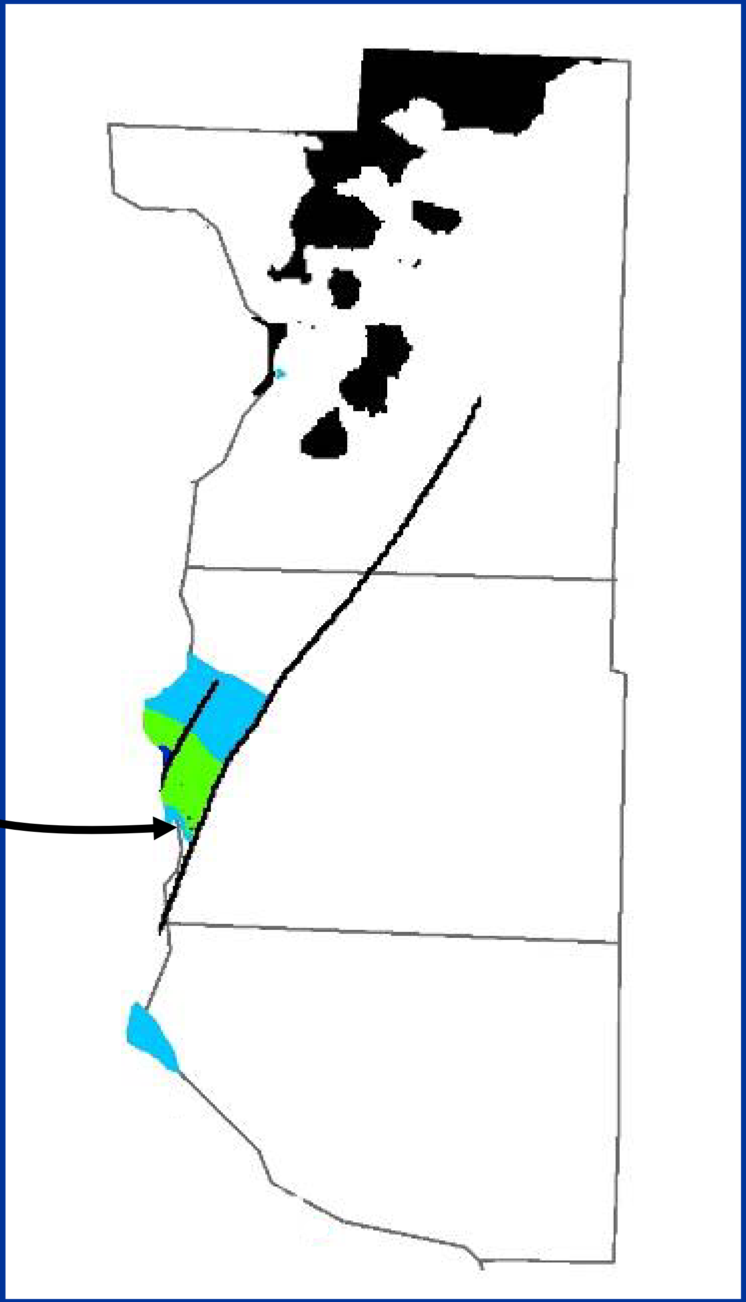
Explanation

Simulated decline:

- 2 to 4 ft decline
- 4 to 6 ft decline
- 6 to 8 ft decline

Simulated Water-Level Decline

Max. decline ~40 ft

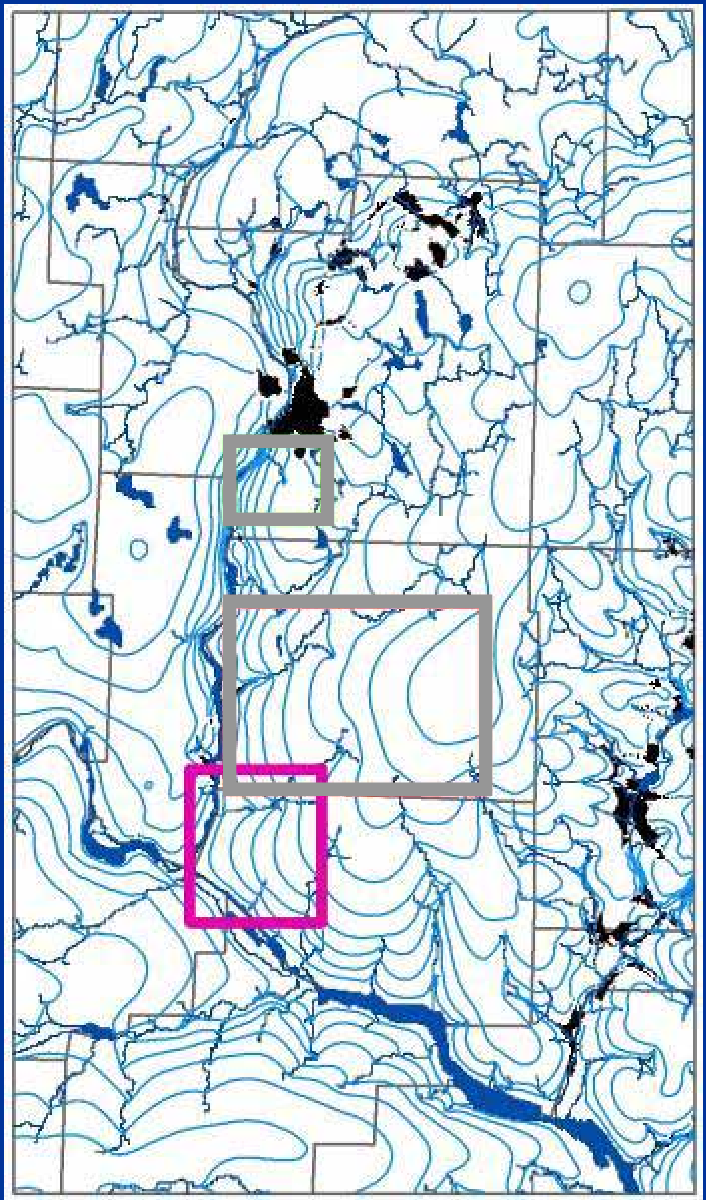


Layer 4

Explanation

Simulated decline:

- 10 to 20 ft decline
- 20 to 30 ft decline
- 30 to 40 ft decline



Regional model as a framework for inset models

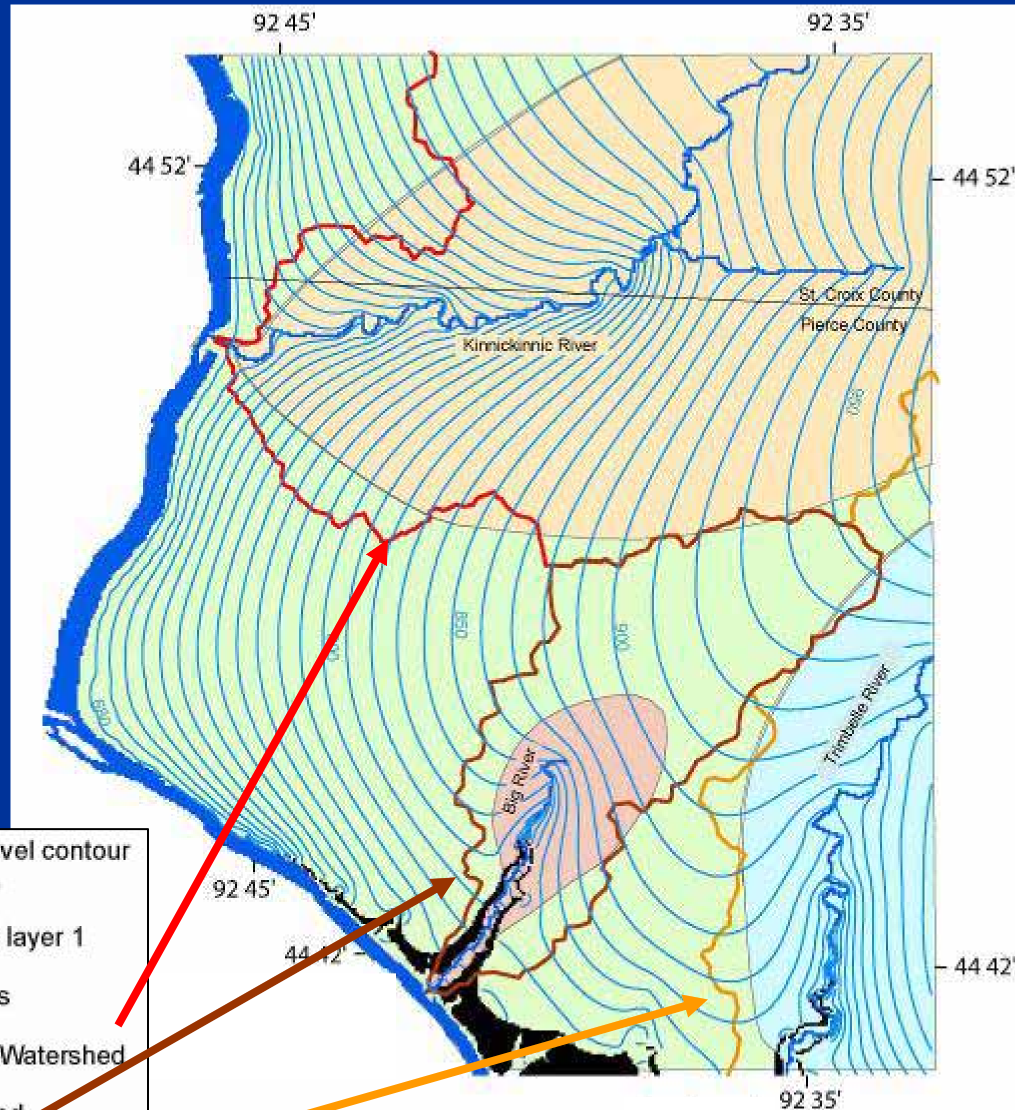
Osceola Creek:
Effect of ground-water withdrawal on seasonal baseflow

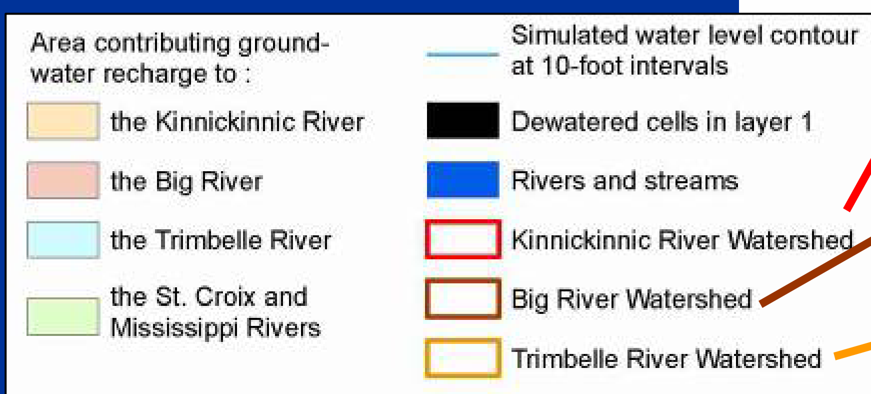
Twin Lakes:
Lake / ground-water interaction, and flow in a karst aquifer

Western Pierce County:
Ground-water and surface-water divides

Hydrologic Divides

- Ground-water and surface-water divides differ, especially at small scales
- Underflow can occur in ephemeral head-water areas





Summary

1. Most ground water is from recharge within the counties
2. Tributaries to the St. Croix River receive most ground-water discharge from the upper bedrock aquifer
3. Flow is controlled by 1) river stage & geometry, 2) properties of aquifers and confining units, and 3) faults *(limited information about karst aquifers & faults)*
4. Wells capture water that would otherwise discharge to rivers
5. Water level declines are small, but most pronounced where:
    a. high-capacity wells are clustered
    b. the aquifer is thin or isolated (faults or confining units)
6. Surface-water & ground-water divides can differ, particularly in ephemeral head-water areas
7. Inset models can improve detail…but need complimentary data