# Implications of Refining Vertical Resolution of Hydraulic Conductivity in the Numerical Modeling of Groundwater Flow to Surface Water, NAS Whiting Field, Florida

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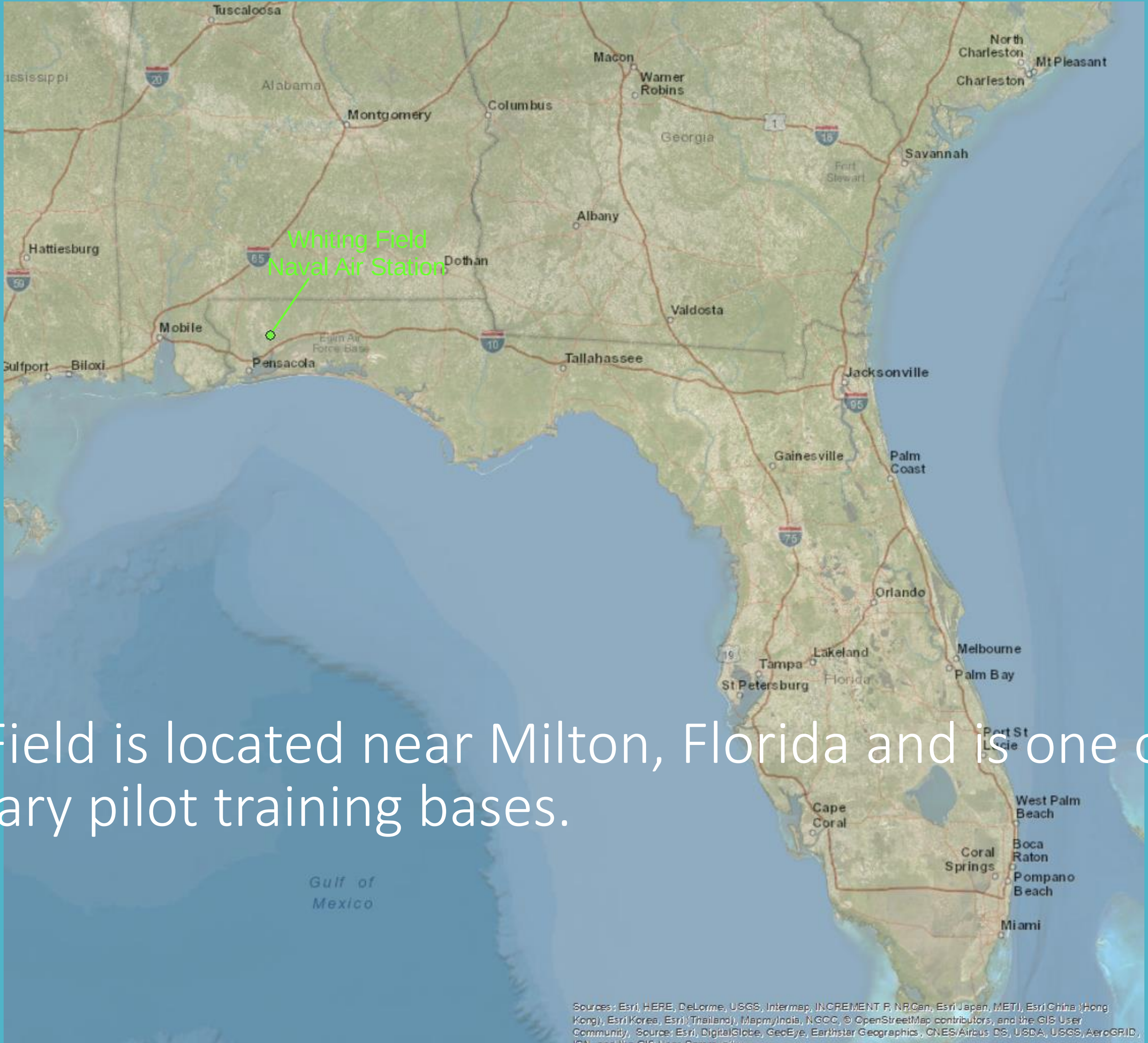


Whiting Field is located near Milton, Florida and is one of the Navy's two primary pilot training bases.

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Commissioned in 1943, historic operations at Whiting Field generated industrial wastes that contaminated soil and the water-table aquifer.

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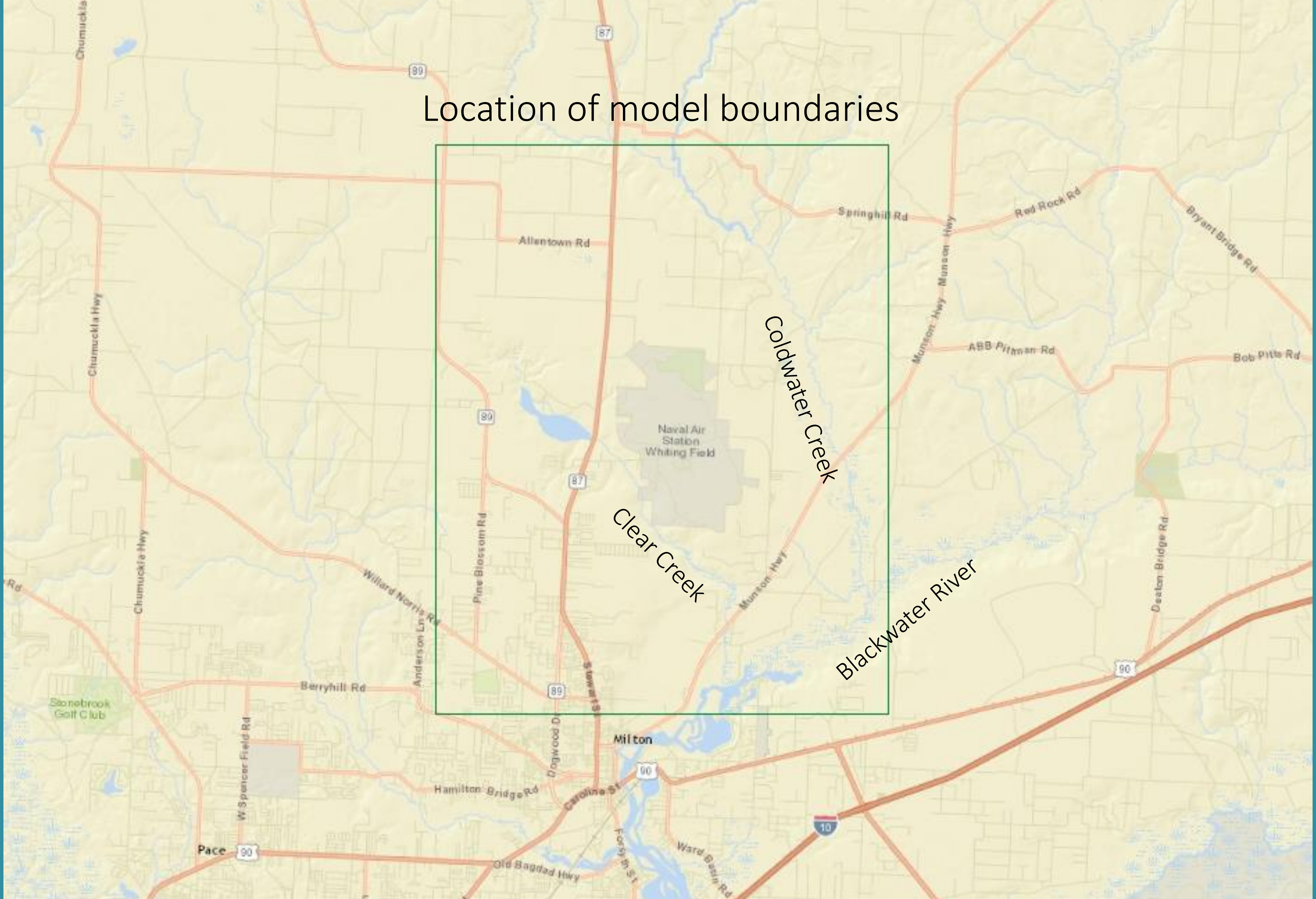
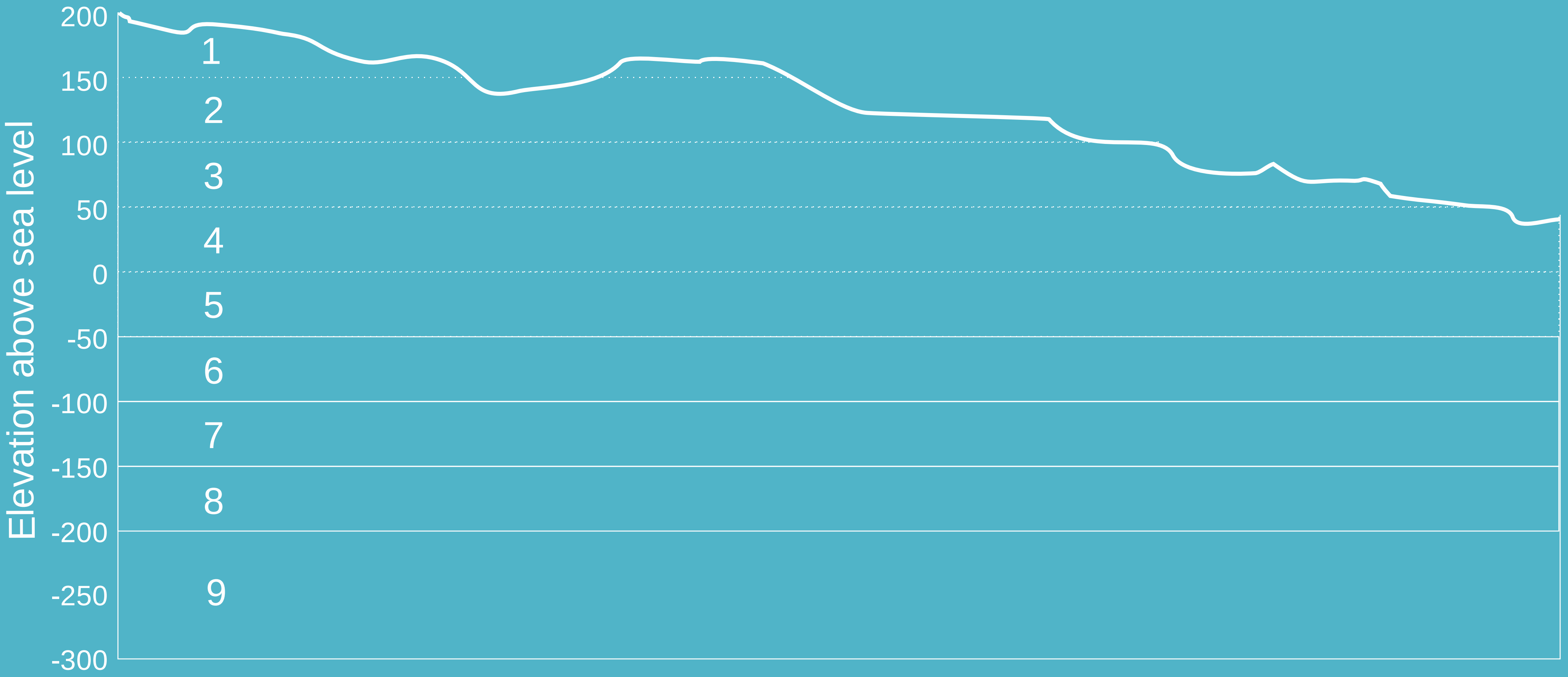
# Location of model boundaries



# Numerical Model

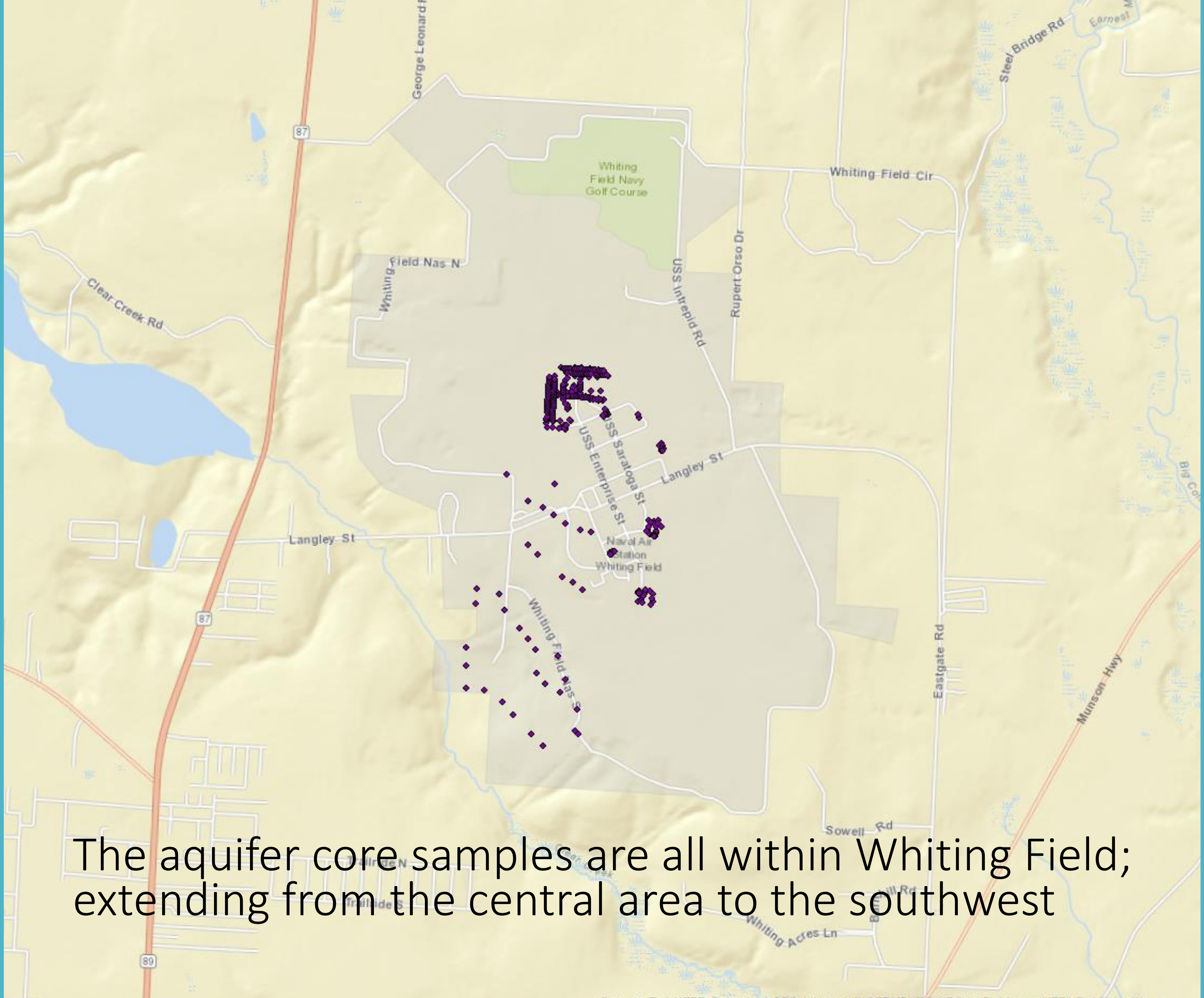
- MODFLOW three-dimensional groundwater flow model
- 100 foot horizontal grid spacing with 533 rows, 424 columns, 5 layers refined to 9 layers
- Surface water represented by drains at control elevations
- Steady-state model calibrated with parameter estimation technique to known water levels
- Modified for better vertical layer resolution and transient simulations




The top layer of the original 5-layer model was refined to make a total of 9 layers

| segment | x_coord | y_coord | surf_elev | start_elev | end_elev | elev_unit | material_na | remark_1 | remark_2 | moisture |
|---|---|---|---|---|---|---|---|---|---|---|
| WHF-03-SO01-0 | 1175808 | 632366.1 | 172.7 | 172.7 | 170.7 | FT | SM | fine to medium silty SAND, 30% s | | |
| WHF-03-SO01-2 | 1175808 | 632366.1 | 172.7 | 170.7 | 168.7 | FT | SC | fine to medium clayey SAND, 30% | | |
| WHF-03-SO01-4 | 1175808 | 632366.1 | 172.7 | 168.7 | 166.7 | FT | SC | fine to medium clayey SAND, 30% | | |
| WHF-03-SO01-6 | 1175808 | 632366.1 | 172.7 | 166.7 | 164.7 | FT | SC | fine to medium clayey SAND, 30% | | |
| WHF-03-SO01-8 | 1175808 | 632366.1 | 172.7 | 164.7 | 162.7 | FT | SC | fine to medium clayey SAND, 40% | | |
| WHF-03-SO01-10 | 1175808 | 632366.1 | 172.7 | 162.7 | 161.7 | FT | SC | fine to medium clayey SAND, 40% | | |
| WHF-03-SO01-11 | 1175808 | 632366.1 | 172.7 | 161.7 | 160.7 | FT | ML | fine to medium SILT, 15% sand, ( | | |
| WHF-03-SO01-12 | 1175808 | 632366.1 | 172.7 | 160.7 | 158.7 | FT | ML | fine to medium SILT, 15% sand, ( | | |
| WHF-03-SO01-14 | 1175808 | 632366.1 | 172.7 | 158.7 | 156.7 | FT | ML | fine to medium SILT, 15% sand, ( | | |
| WHF-03-SO01-16 | 1175808 | 632366.1 | 172.7 | 156.7 | 154.7 | FT | ML | fine to medium SILT, 15% sand, ( | | |
| WHF-03-SO01-18 | 1175808 | 632366.1 | 172.7 | 154.7 | 152.7 | FT | ML | fine to medium SILT, 15% sand, ( | | |
| WHF-03-SO01-20 | 1175808 | 632366.1 | 172.7 | 152.7 | 150.7 | FT | SP | fine to medium SAND, (9/7.5YR_/ | | |
| WHF-03-SO01-22 | 1175808 | 632366.1 | 172.7 | 150.7 | 148.7 | FT | SP | fine to medium SAND, (9/7.5YR_/ | | |
| WHF-03-SO01-24 | 1175808 | 632366.1 | 172.7 | 148.7 | 146.7 | FT | SP | fine to medium SAND, (9/7.5YR_/ | | |
| WHF-03-SO01-26 | 1175808 | 632366.1 | 172.7 | 146.7 | 145.7 | FT | SP | fine to medium SAND, (9/7.5YR_/ | | |
| WHF-03-SO01-27 | 1175808 | 632366.1 | 172.7 | 145.7 | 144.7 | FT | SP | fine to medium SAND, (7.5R 8/3) | | |
| WHF-03-SO01-28 | 1175808 | 632366.1 | 172.7 | 144.7 | 142.7 | FT | SP | fine to medium SAND, (7.5R 8/3) | | |
| WHF-03-SO01-30 | 1175808 | 632366.1 | 172.7 | 142.7 | 140.7 | FT | SP | fine to medium SAND, (10R 8/2) p | | |
| WHF-03-SO01-32 | 1175808 | 632366.1 | 172.7 | 140.7 | 138.7 | FT | SP | fine to medium SAND, (10R 8/2) p | | |
| WHF-03-SO01-34 | 1175808 | 632366.1 | 172.7 | 138.7 | 136.7 | FT | SP | fine to medium SAND, (9.5/N) wh | | |
| WHF-03-SO01-36 | 1175808 | 632366.1 | 172.7 | 136.7 | 134.7 | FT | SP | fine to medium SAND, (9.5/N) wh | | |
| WHF-03-SO01-38 | 1175808 | 632366.1 | 172.7 | 134.7 | 132.7 | FT | SP | fine to medium SAND, (9.5/N) wh | | |
| WHF-03-SO01-40 | 1175808 | 632366.1 | 172.7 | 132.7 | 130.7 | FT | SP | fine to medium SAND, (9.5/N) wh | | |
| WHF-03-SO01-42 | 1175808 | 632366.1 | 172.7 | 130.7 | 128.7 | FT | SP | fine to medium SAND, (9.5/N) wh | | |
| WHF-03-SO01-44 | 1175808 | 632366.1 | 172.7 | 128.7 | 127.7 | FT | SP | fine to medium SAND, (9.5/N) wh | | |
| WHF-03-SO02-0 | 1175710 | 632391.7 | 172.9 | 172.9 | 170.9 | FT | SM | fine to medium silty SAND, 30% s | | |
| WHF-03-SO02-2 | 1175710 | 632391.7 | 172.9 | 170.9 | 168.9 | FT | SM | fine to medium silty SAND, 30% s | | |
| WHF-03-SO02-4 | 1175710 | 632391.7 | 172.9 | 168.9 | 166.9 | FT | SC | fine to medium clayey SAND, 30% | | |
| WHF-03-SO02-6 | 1175710 | 632391.7 | 172.9 | 166.9 | 165.9 | FT | SC | fine to medium clayey SAND, 40% | | |

Core samples indicating location, depth, and material type can be used to guide vertical distribution of hydraulic conductivity in new refined layers




The aquifer core samples are all within Whiting Field; extending from the central area to the southwest

| SM | SC | ML | SP | SPSC | CL | SWSC | SWSM | SW | CH | SPSM | AS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68.8 | 68.8 | 68.8 | 68.8 | 31.6 | 68.8 | 15.8 | 51.4 | 51.4 | 68.8 | 68.8 | 13.1 | Maximum Hyc |
| 14.2 | 6.8 | 15.9 | 11.8 | 11.3 | 12.4 | 4.9 | 17.0 | 12.1 | 15.8 | 13.0 | 7.1 | Median Hyc |
| 2.1 | 2.1 | 2.2 | 2.3 | 2.7 | 2.2 | 3.2 | 3.6 | 5.5 | 2.8 | 2.2 | 6.6 | Minimum Hyc |
| silty sand | clayey sand | silt | poorly graded sand | poorly graded sand, clayey sand | clay of low plasticity | well-graded sand, clayey sand | well-graded sand, silty sand | well-graded sand | clay of high plasticity | poorly graded sand, silty sand | Surficial areas overlain with asphalt | |

Multiplication factors based on ratio of median Hyc to median Hyc of all

| SM | SC | ML | SP | SPSC | CL | SWSC | SWSM | SW | CH | SPSM | AS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.198 | 0.570 | 1.341 | 0.996 | 0.953 | 1.046 | 0.409 | 1.434 | 1.021 | 1.333 | 1.097 | 0.602 |

# Aquifer material types are correlated with the model calibrated hydraulic conductivity values and the new field data is used to define the vertical variation in the refined layers

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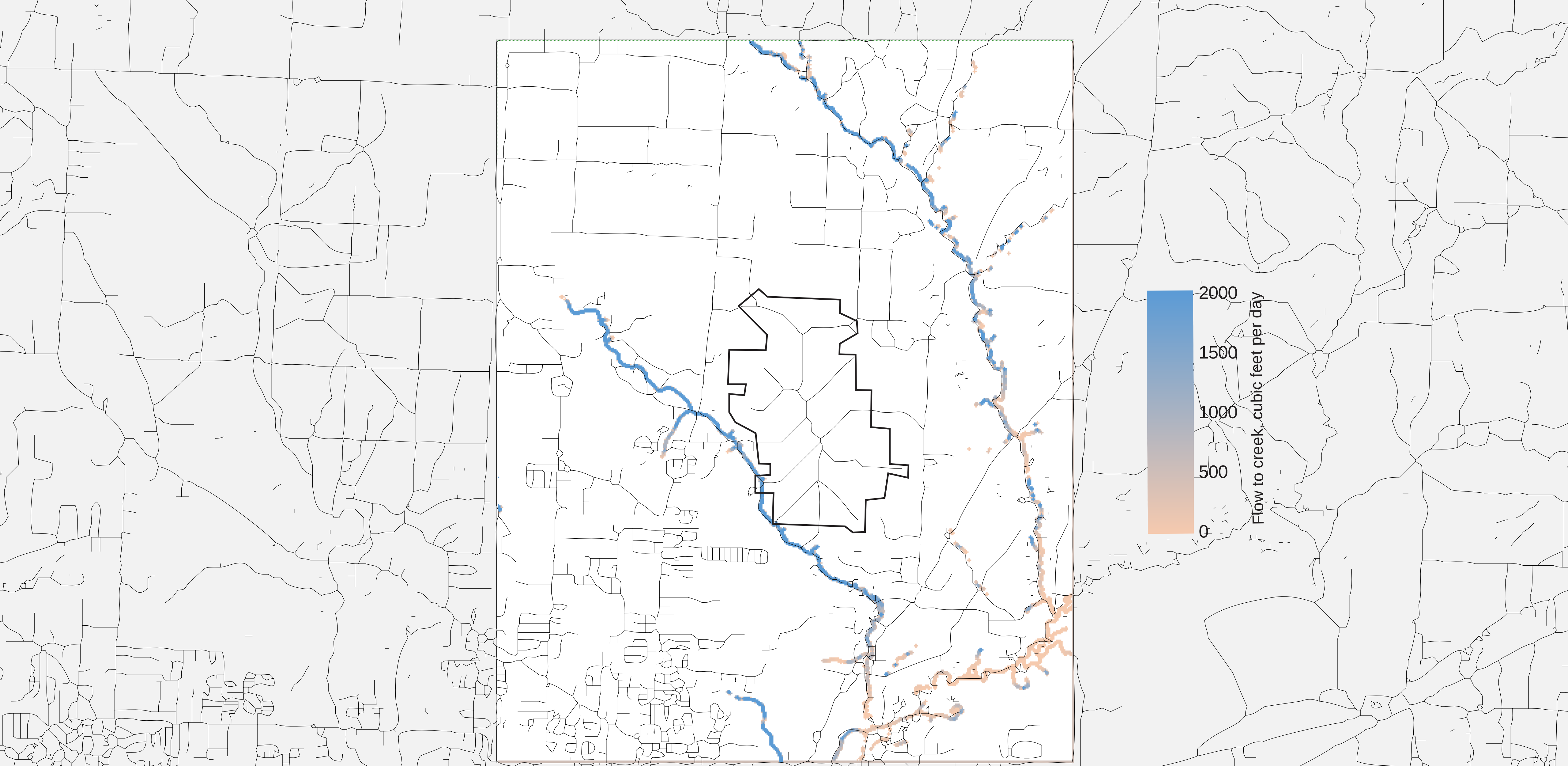
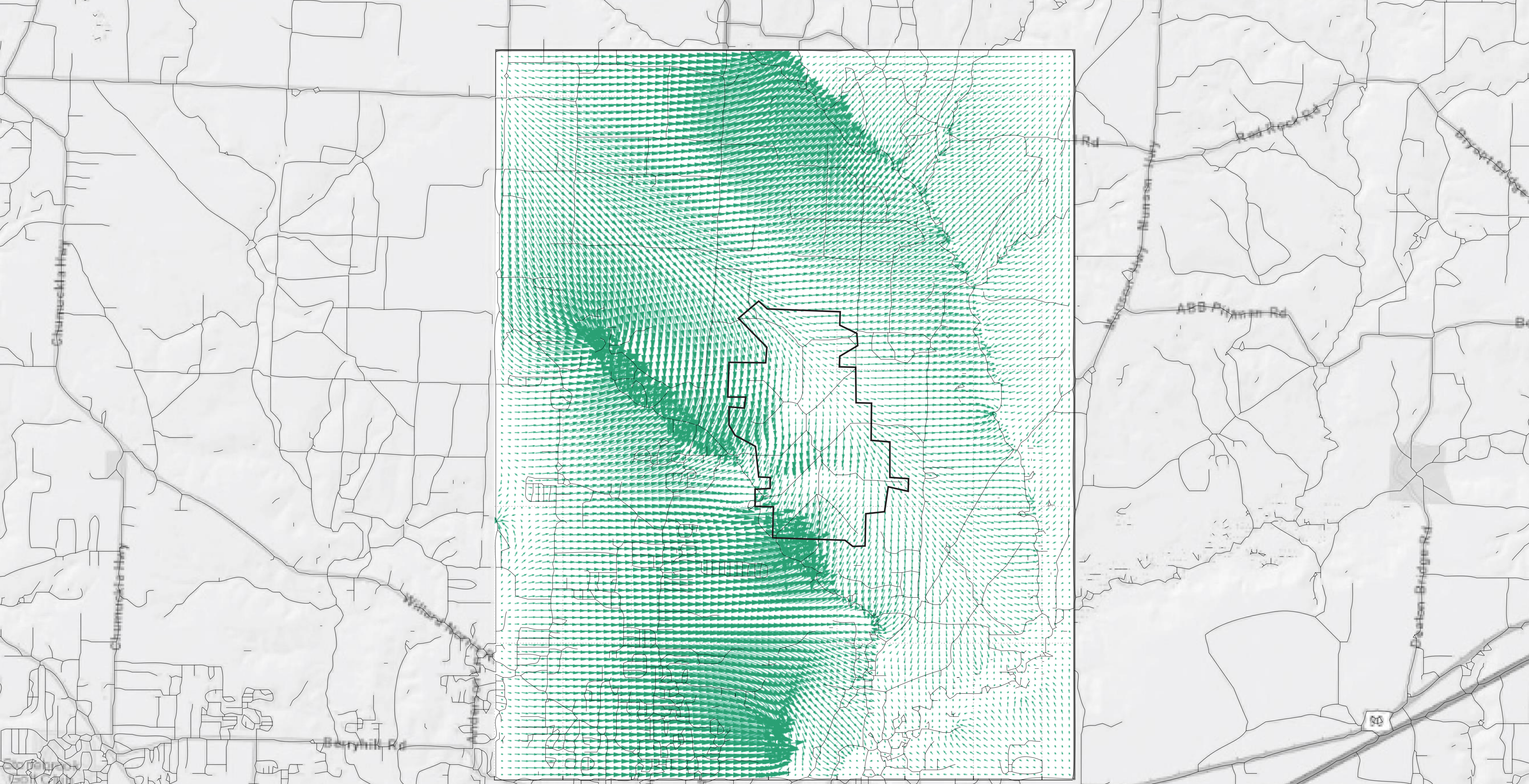
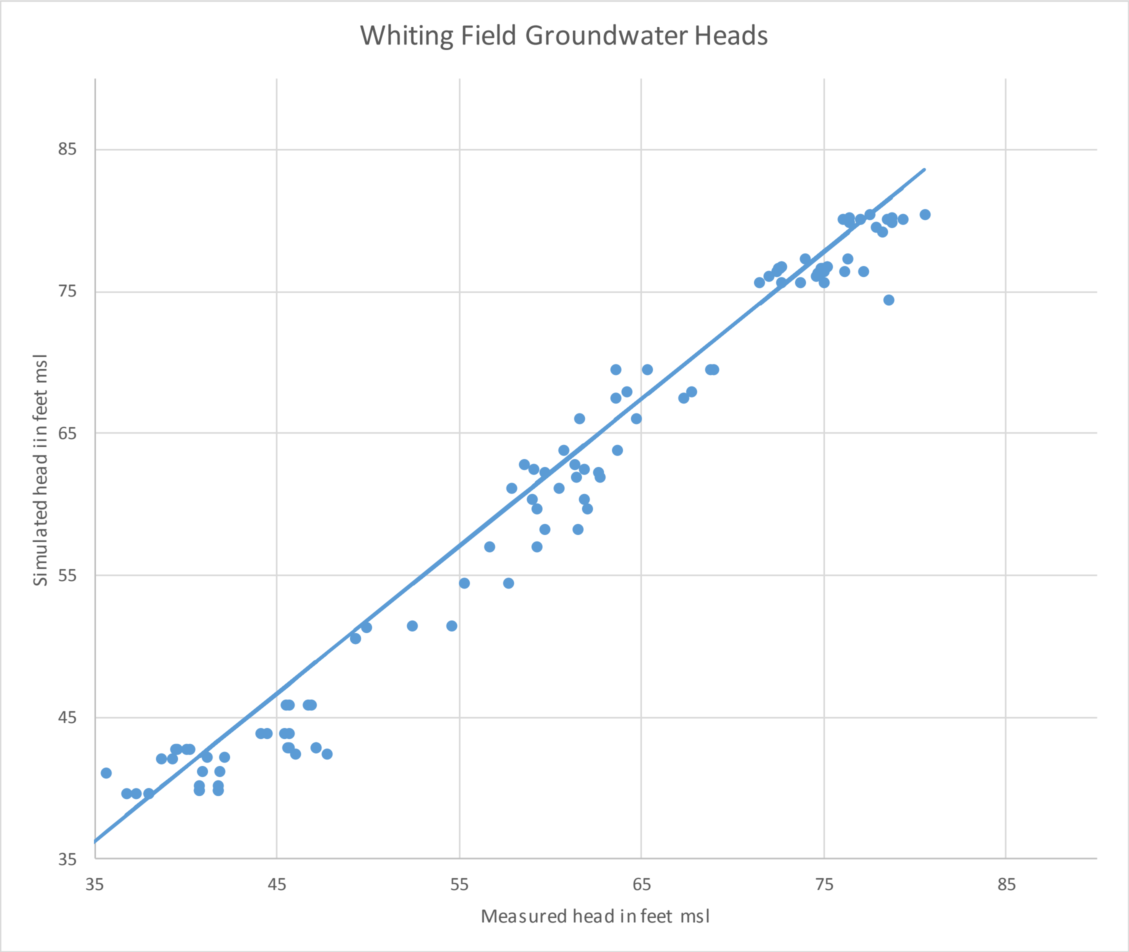



# Steady-State Drain Flows




# Flux map shows interaction at rivers




Comparisons with known groundwater level measurements indicated slight improvement with a reduction of sum of squared differences from 0.043 to 0.039 $ft^2$

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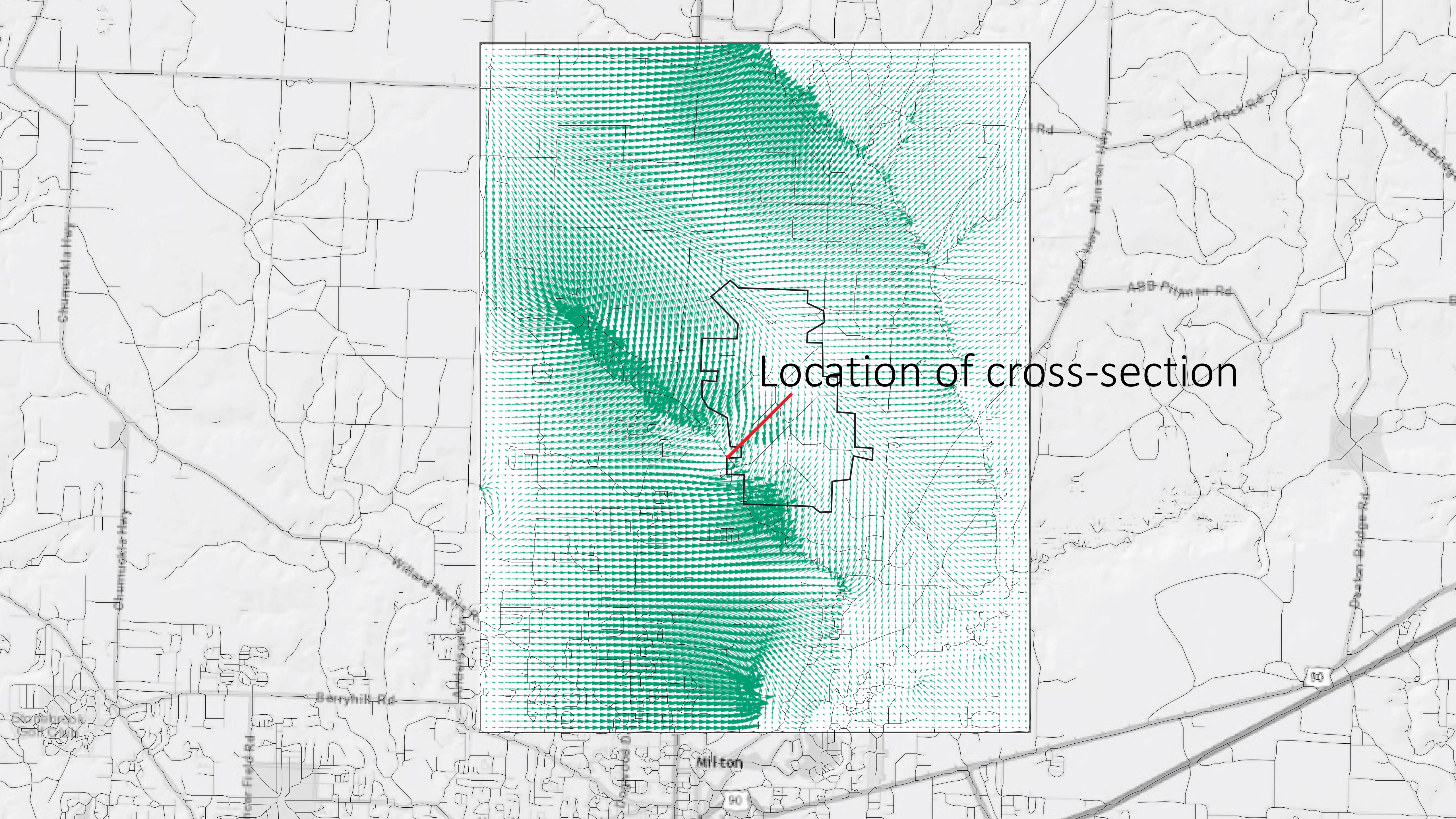
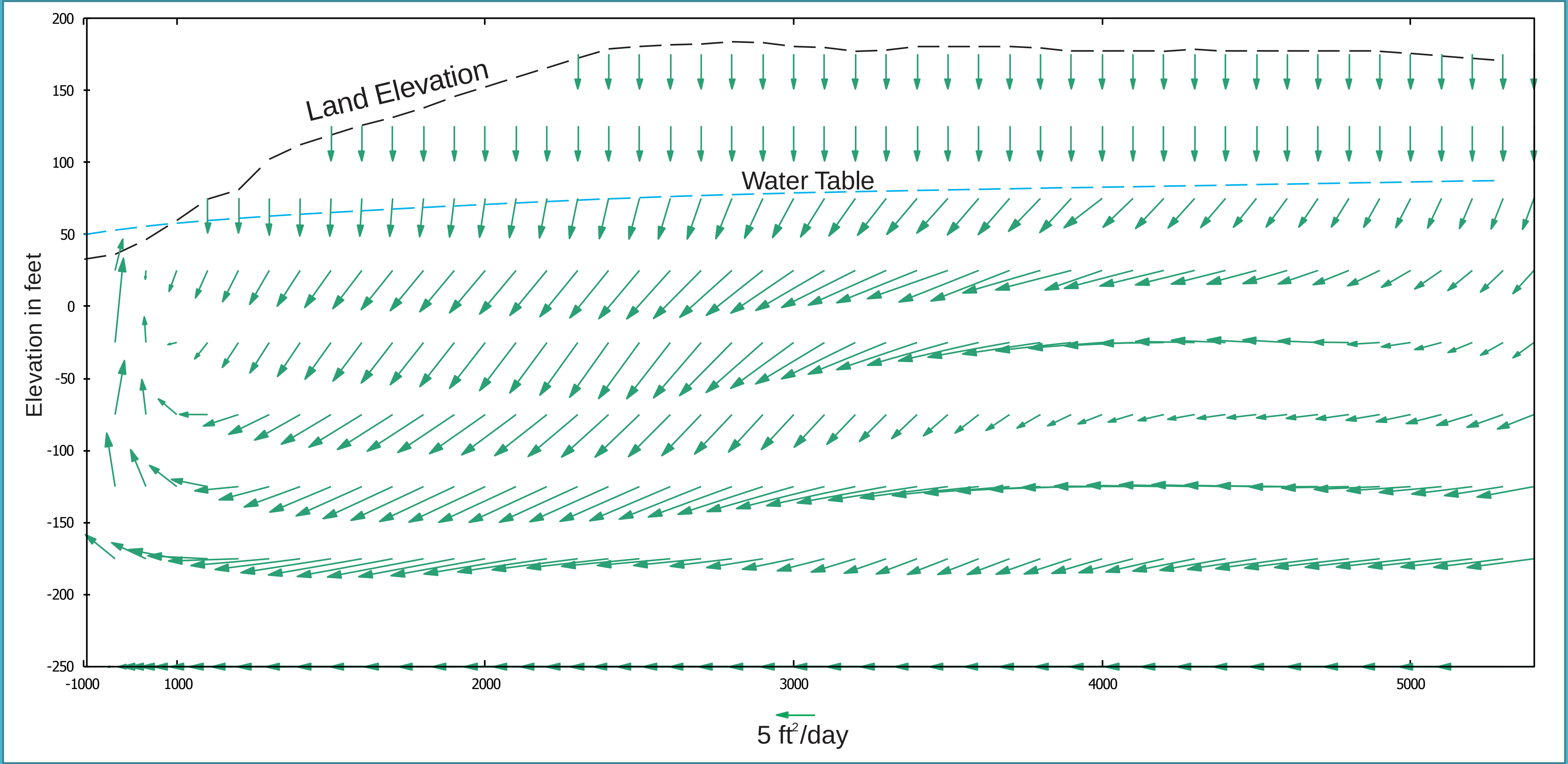

Location of cross-section
Red Rock Rd
ABB Pittman Rd
Berryhill Rd
Milton

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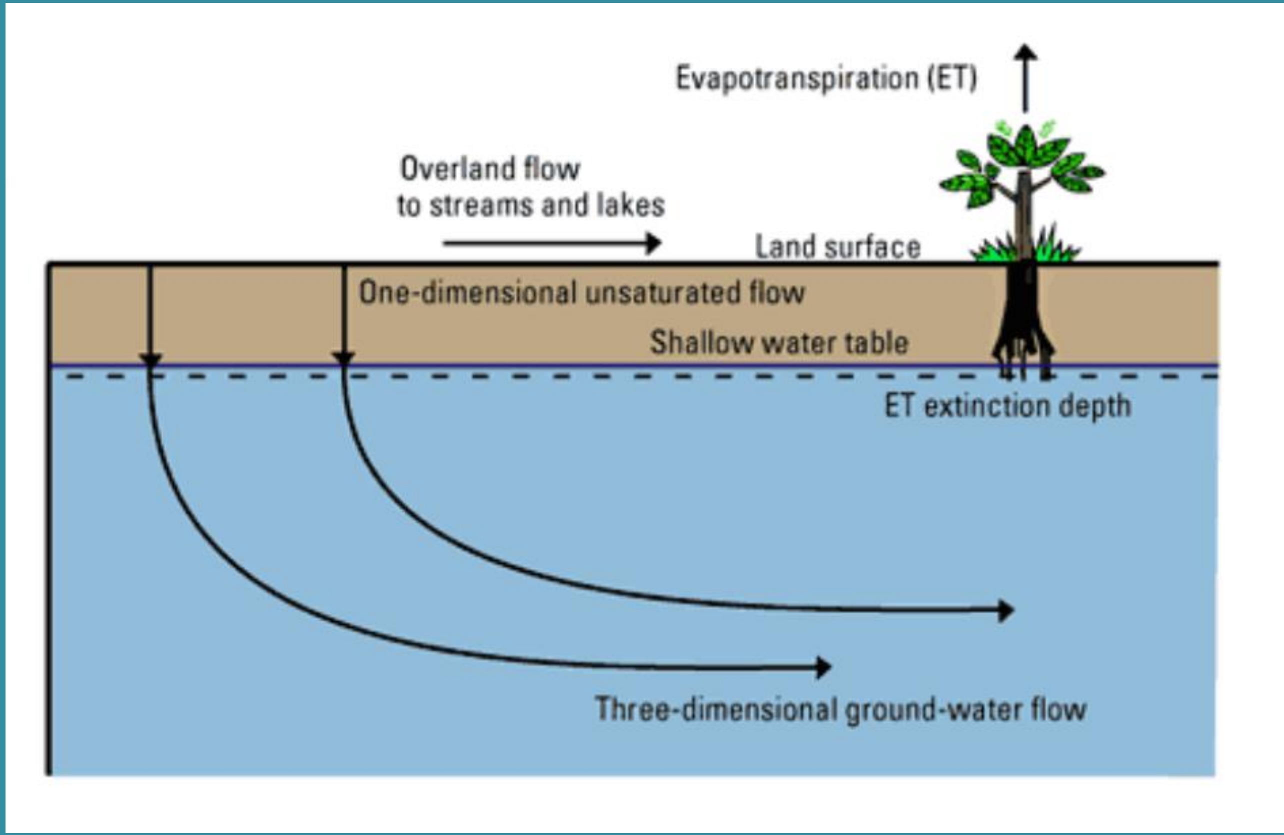
Cross-section shows flows to Clear Creek.

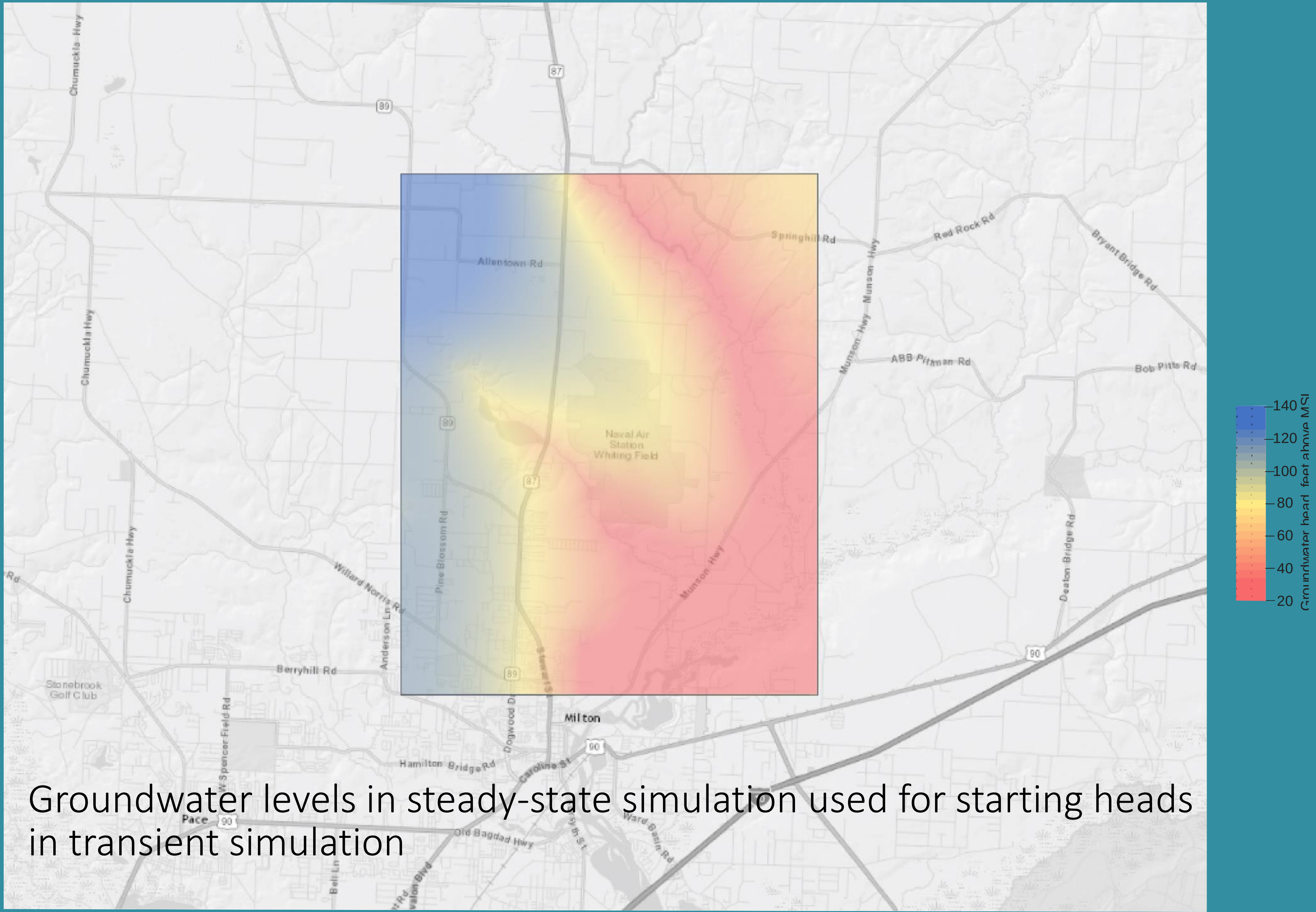
Water-table location shows upper two layers in unsaturated zone.

# Incorporating Unsaturated Zone Representation

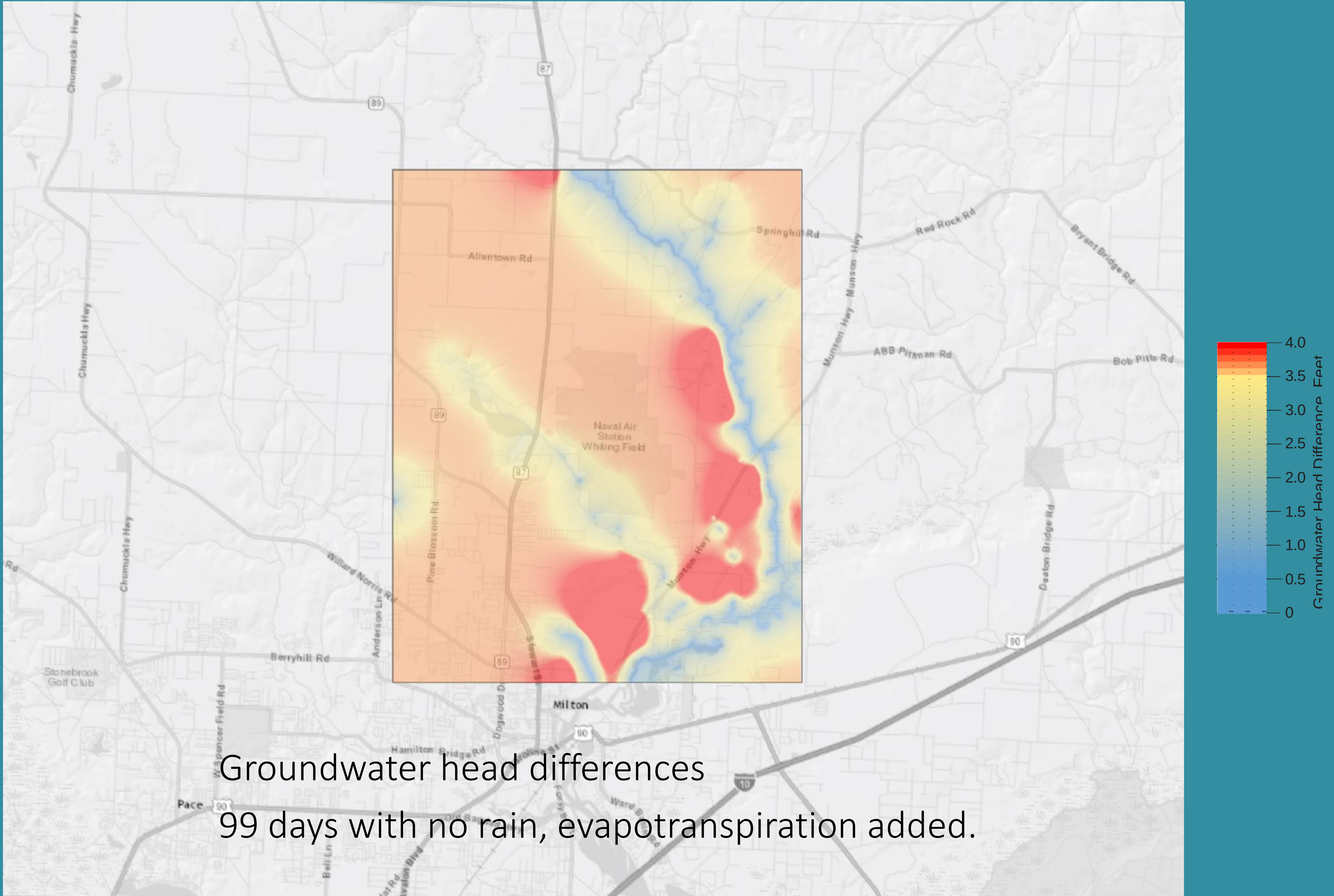



Saturated vertical flow in upper layers is not accurate.

The Unsaturated Zone  (UZF1) Package is a substitution for the Recharge and Evapotranspiration Packages which uses the kinematic-wave approximation to considers the effects of flow, ET, and storage in the unsaturated zone




Groundwater levels in steady-state simulation used for starting heads in transient simulation




Groundwater head differences

99 days with no rain, evapotranspiration added.

# Future Development

- Incorporate unsaturated zone representation
- Develop representative lateral boundaries
- Develop transient simulations
- Incorporate constituent transport
- Test alternate representations of surface water