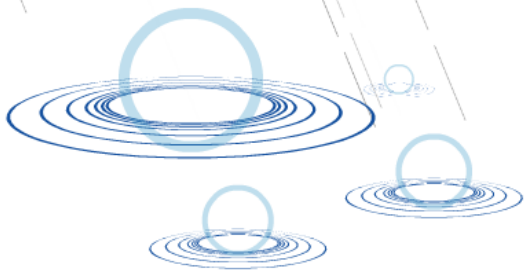
# Scoring Groundwater Infiltration & Sewage Exfiltration Risk in a Sanitary Sewage Collection System

Meredith S. Moore

CHARLOTTE WATER

PENNSTATE 1855



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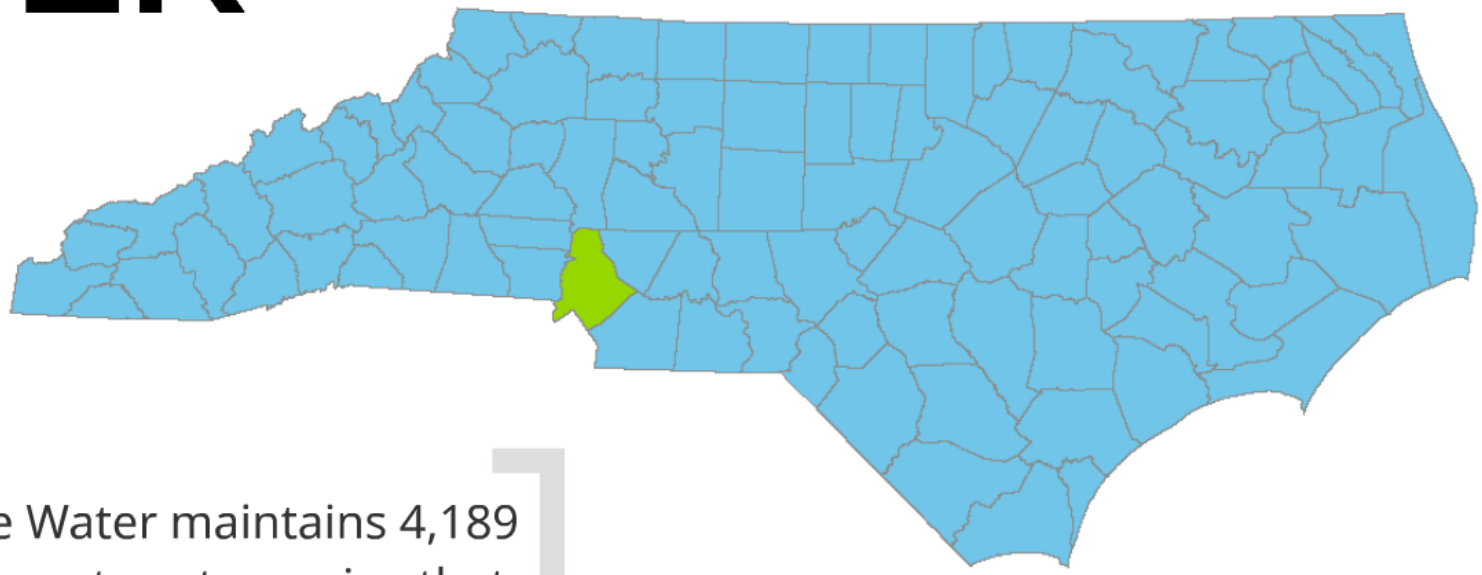
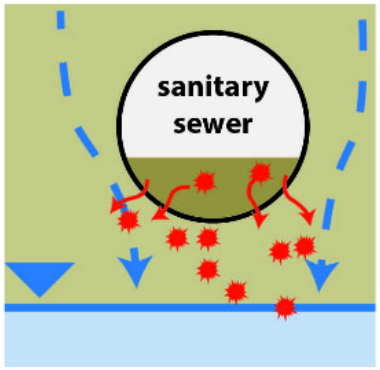


Charlotte Water maintains 4,189 miles of wastewater mains that carry 123 million gallons of sewage to be treated each day.

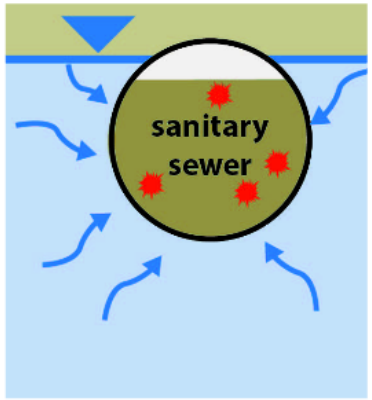
# *Sewage Exfiltration into Soils & Groundwater*




Derived from http://cfpub.epa.gov/ncer_abstracts/images/fckimages/index.cfm?imgid=6781

http://www.krwa.org/water-wastewater/

# Groundwater Infiltration into Sewer Lines

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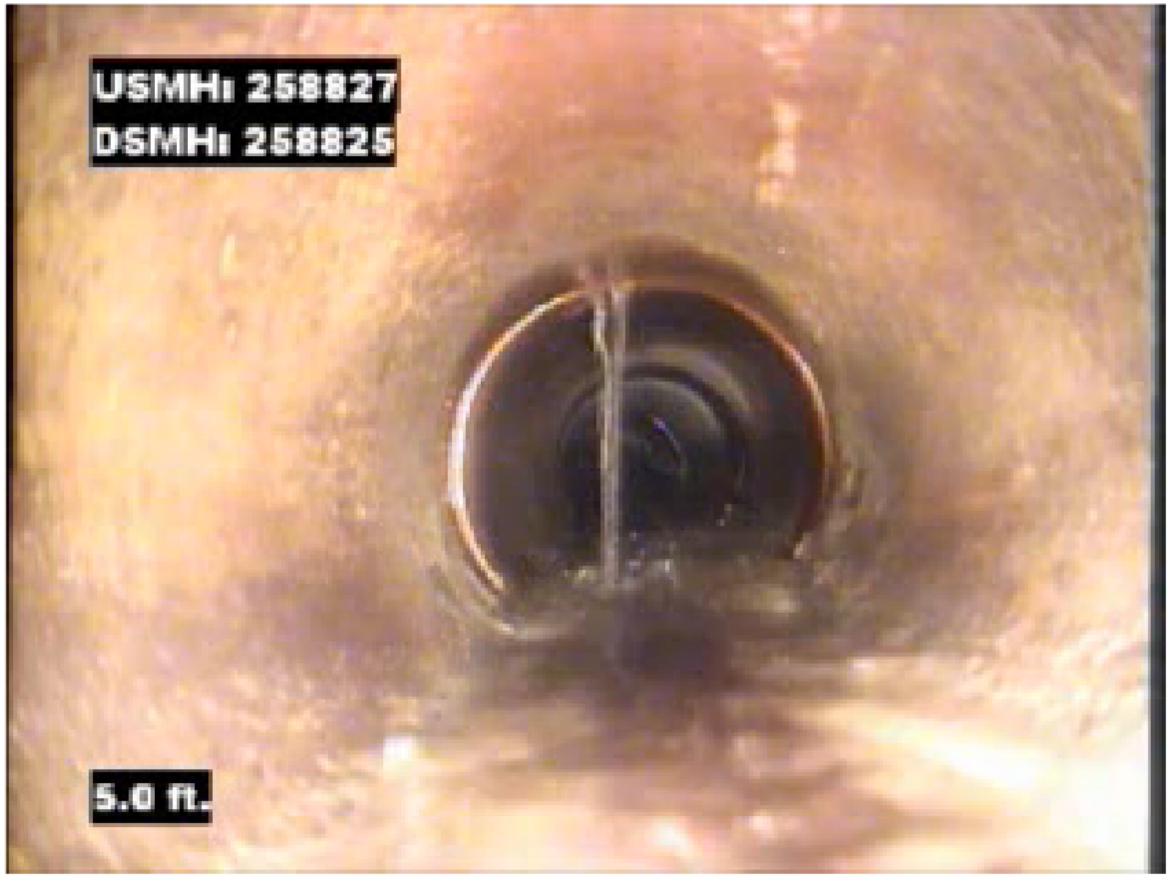

# The Plan

Locate or develop potential groundwater elevation (GWE) surfaces

Test surfaces against documented infiltration elevations

Spatial Analyst: Extract Values to Points

Select the best GWE surface

Extract survey-grade (SG) manholes from GIS data

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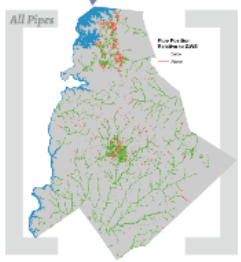
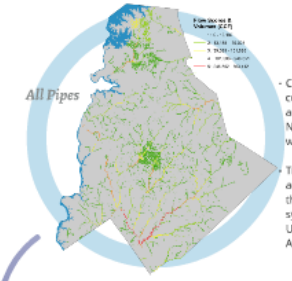
Assign GWE value to each SG manhole

Output Dataset: SG manholes with GWEs

Spatial Join: SG Manholes to Wastewater (WW) Mains

Append averaged manhole inverts & GWEs to each WW main; calculate position relative to GWE.




- Customer consumption amounts from November 2014 water meter data
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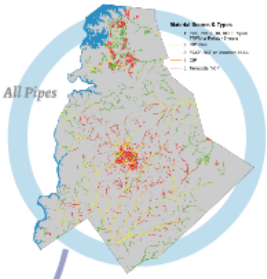



## Scoring

Assign Flow Volume Score (1 - 5)

Assign Pipe Material Score (1 - 5)

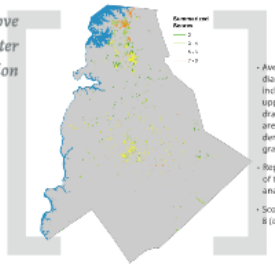
Output Dataset: WW mains w/scores, pipe elevations, GWEs, and position relative to GWE

Summarize Scores

Split datasets by position above or below GWE

WW mains **ABOVE** GWE scored by risk of sewage exfiltration

*Pipes Above Groundwater Elevation*



- Average pipe diameter of 8.5 inches: pipes in the upper portions of drainage basins in areas with a high density of survey grade data
- Represents 18.5% of the pipes in the analysis
- Scores only range to 8 (of a possible 10)

WW mains **BELOW** GWE scored by risk of groundwater infiltration

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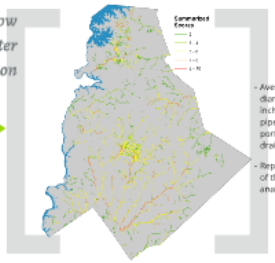

- Average pipe diameter of 14.4 inches: larger pipes in the lower portions of drainage basins
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# The Plan

Locate or develop potential groundwater elevation (GWE) surfaces

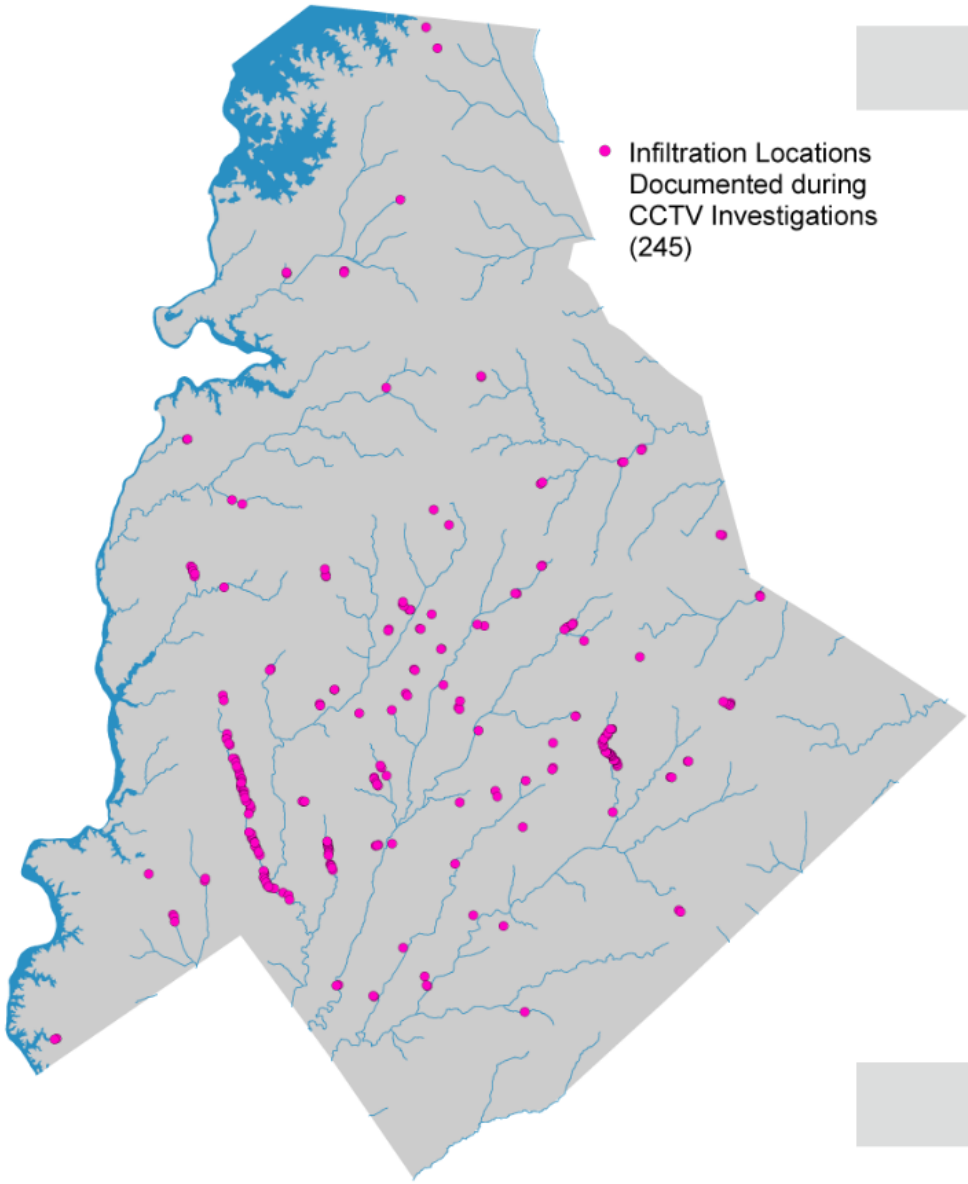
Test surfaces against documented infiltration elevations

**Spatial Analyst: Extract Values to Points**

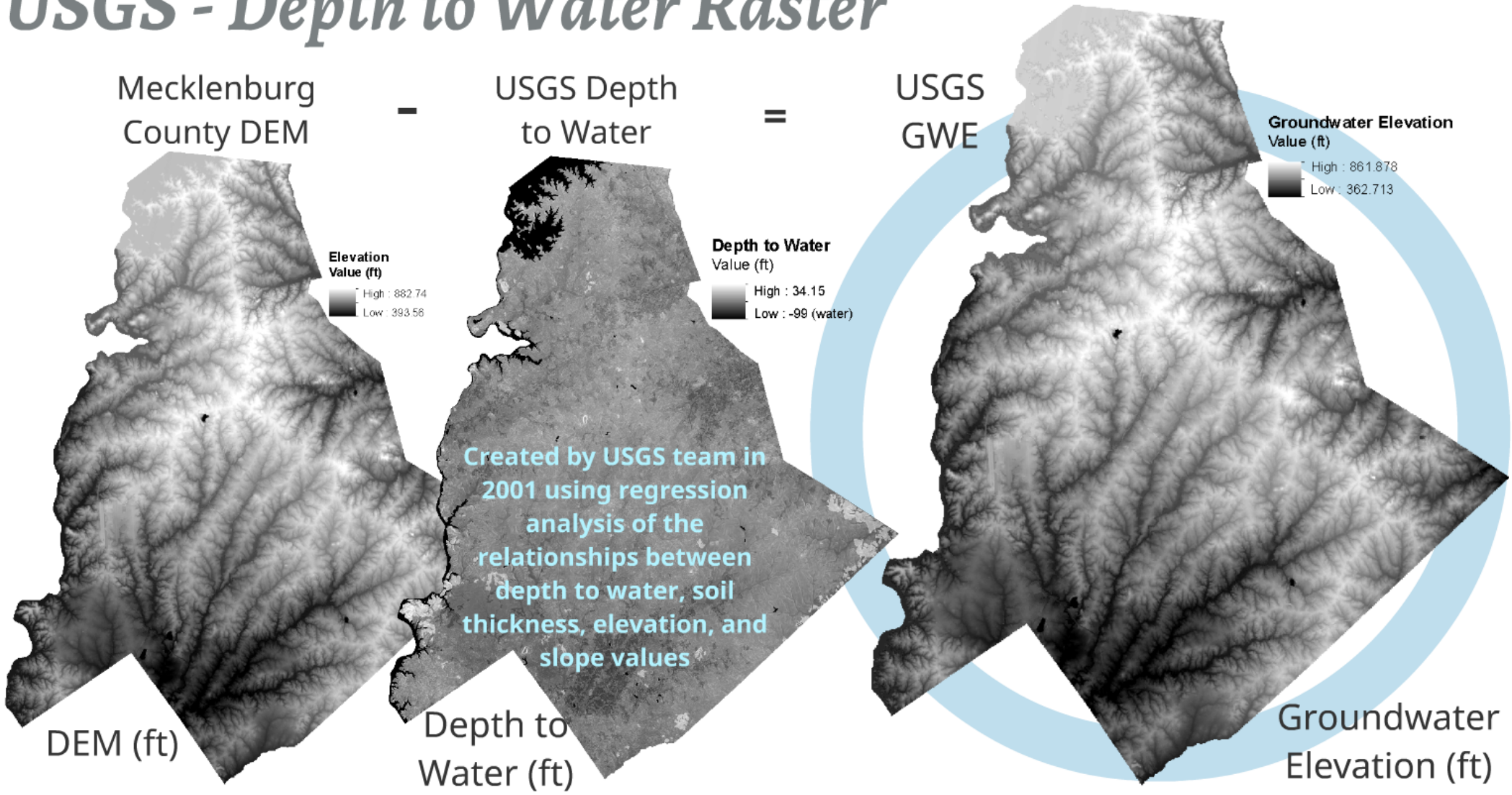
Select the best GWE surface

**Spatial A**
**Extract**
**to Po**

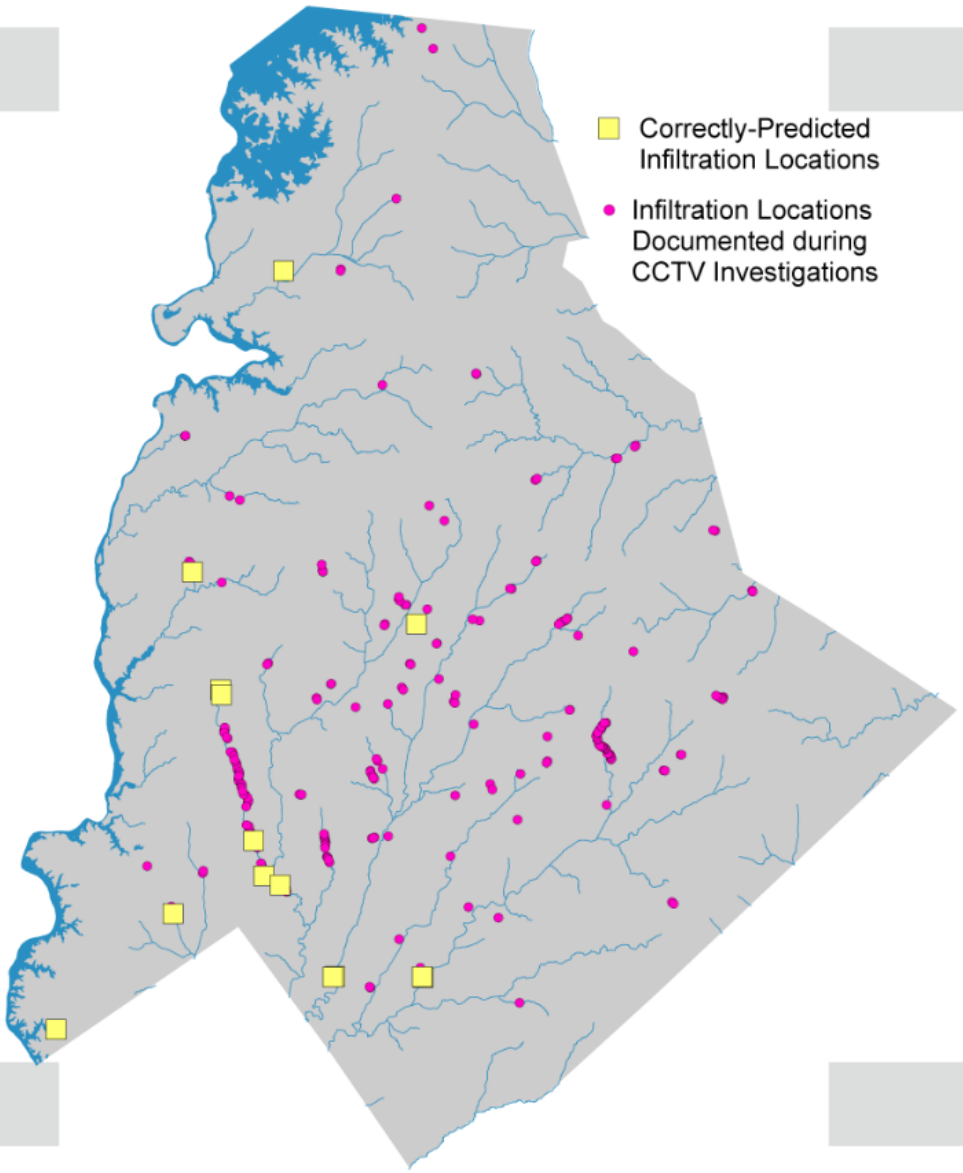
# CCTV-Documented Infiltration Locations



# USGS - Depth to Water Raster



## *USGS Groundwater Elevation Raster*




Correct Predictions: 14 out of 245 locations, 5.7%

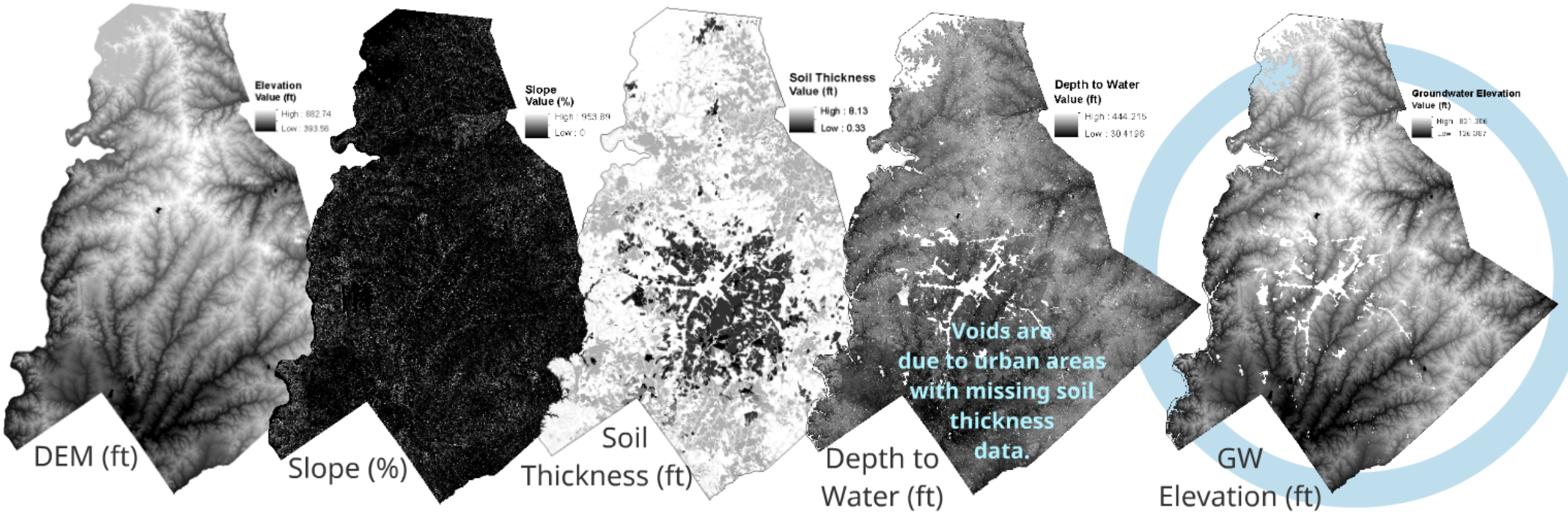
*"Keep in mind this was created in 2001!  The elevation and slopes aren't based on the new elevation data derived from lidar, so it may be worth alternate ways of getting to the estimate of depth to water."*

*-Silvia Terziotti*
*USGS*

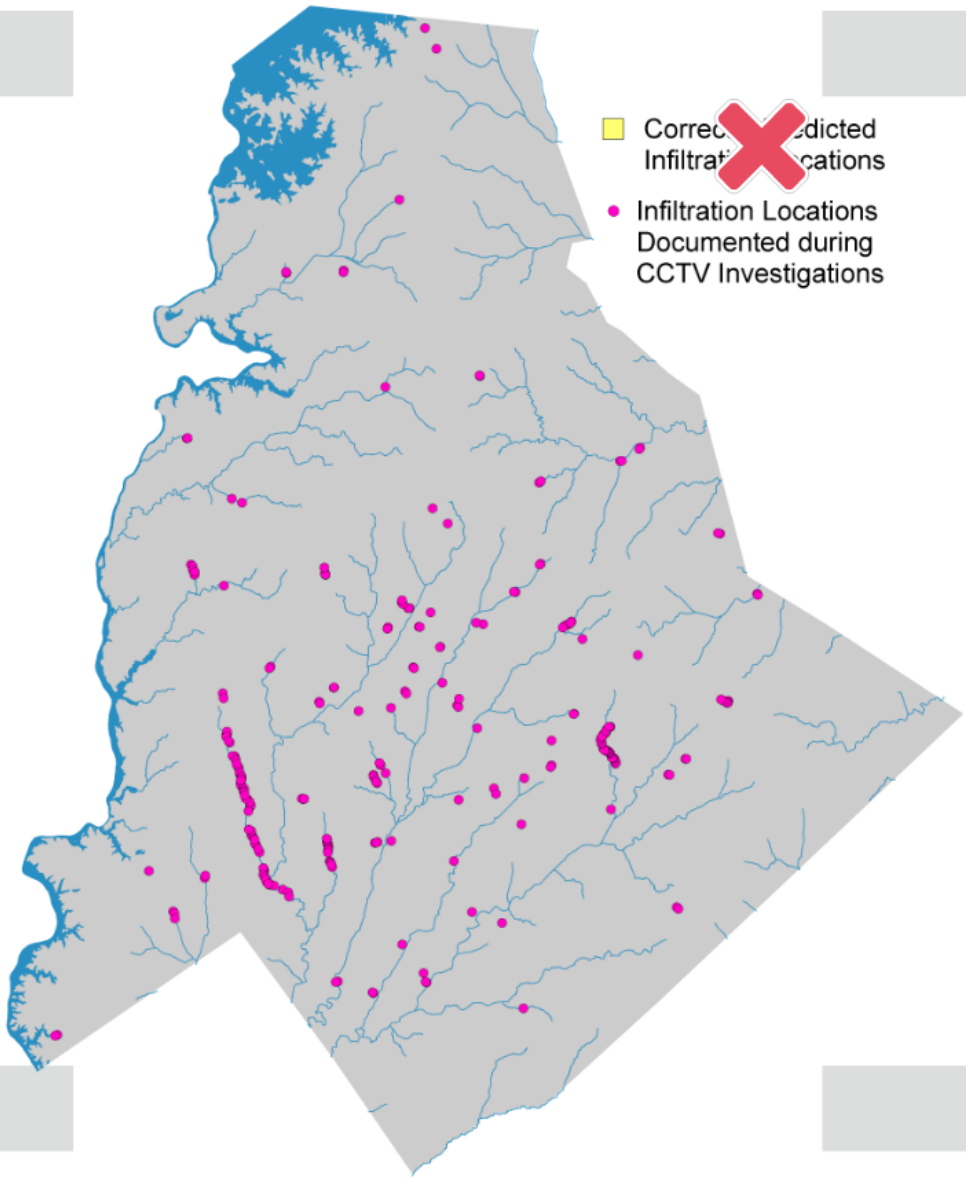
# *USGS Regression Equation with New Input Data*

-5.3870 +

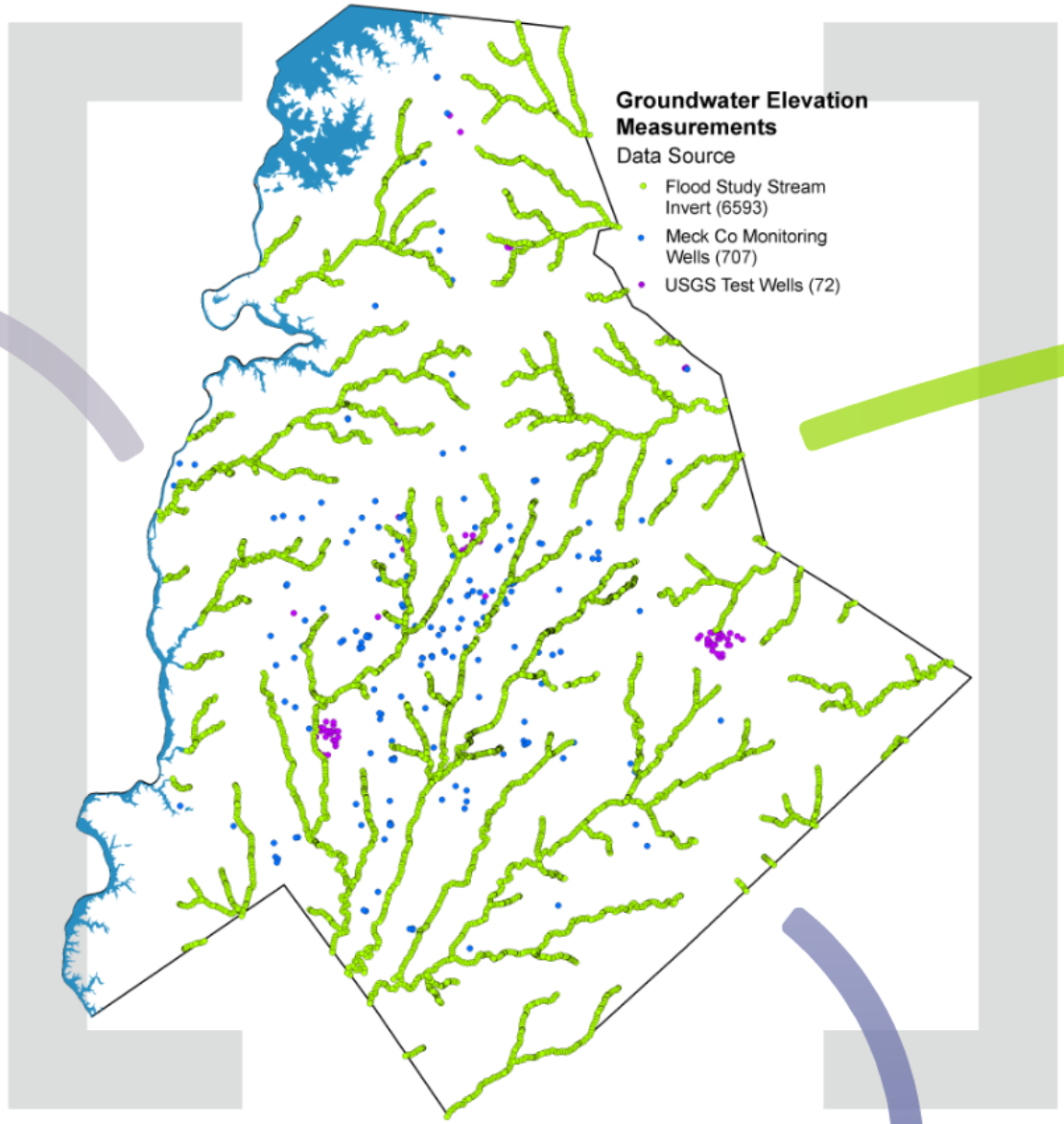
(0.0622* elevation) + (0.2959* slope) + (1.7001* thickness) = Depth to Water → Subtract Depth to Water from DEM to create groundwater elevation raster




# *USGS Regression Equation with New Inputs*



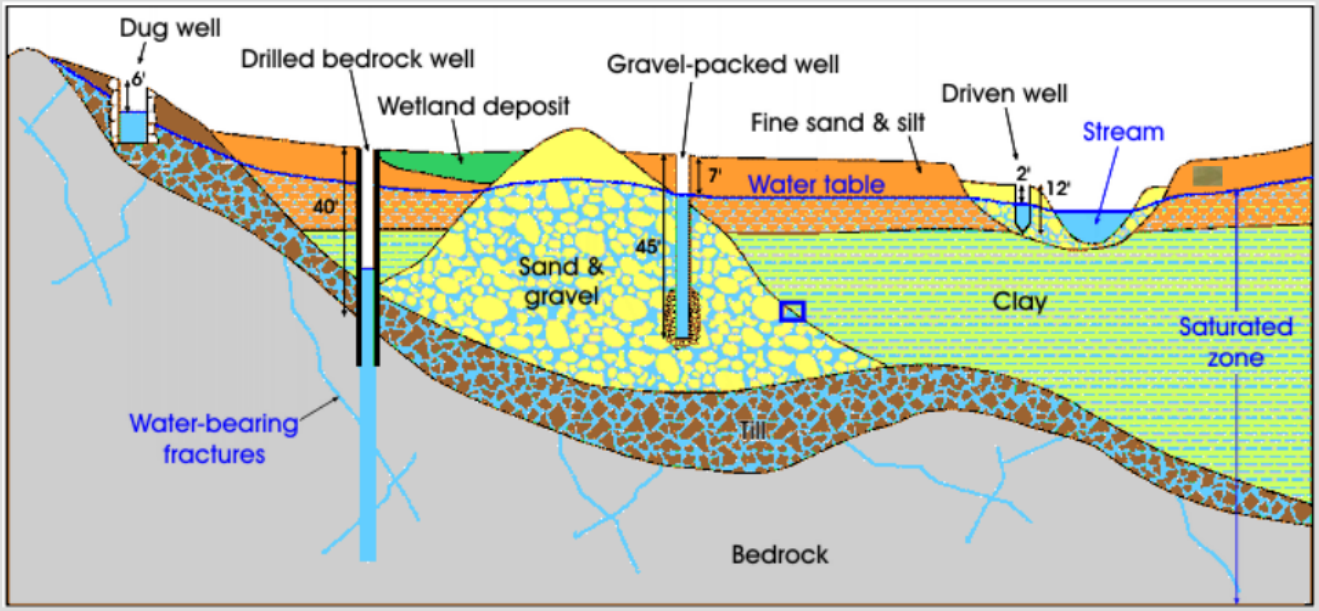

Correct Predictions: 0 out of 245 locations, **NONE**




## Flood Study Points:

- 1,046 survey grade cross sections/stream inverts collected for Meck Co flood study
- 5,547 remaining stream inverts were modeled with HEC-RAS

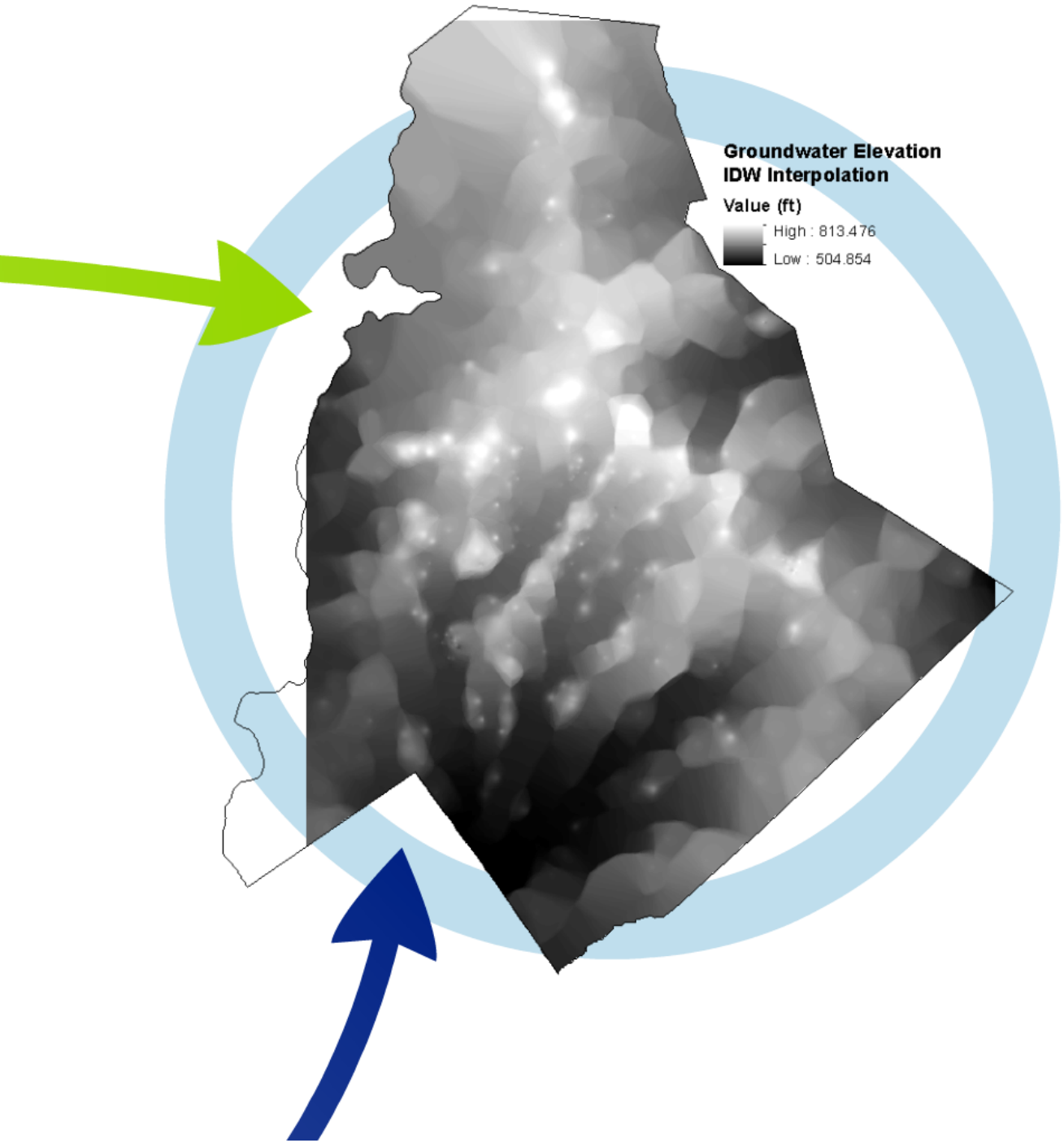
Piedmont stream beds and monitoring wells intersect the water table.




http://www.maine.gov/dacf/mgs/explore/water/facts/aq-01. gif

**Stream Invert Elevation = Groundwater Elevation**

**Monitoring Well Static Water Level = Groundwater Elevation**




# *Inverse Distance Weighted Interpolation Groundwater Elevation Raster*

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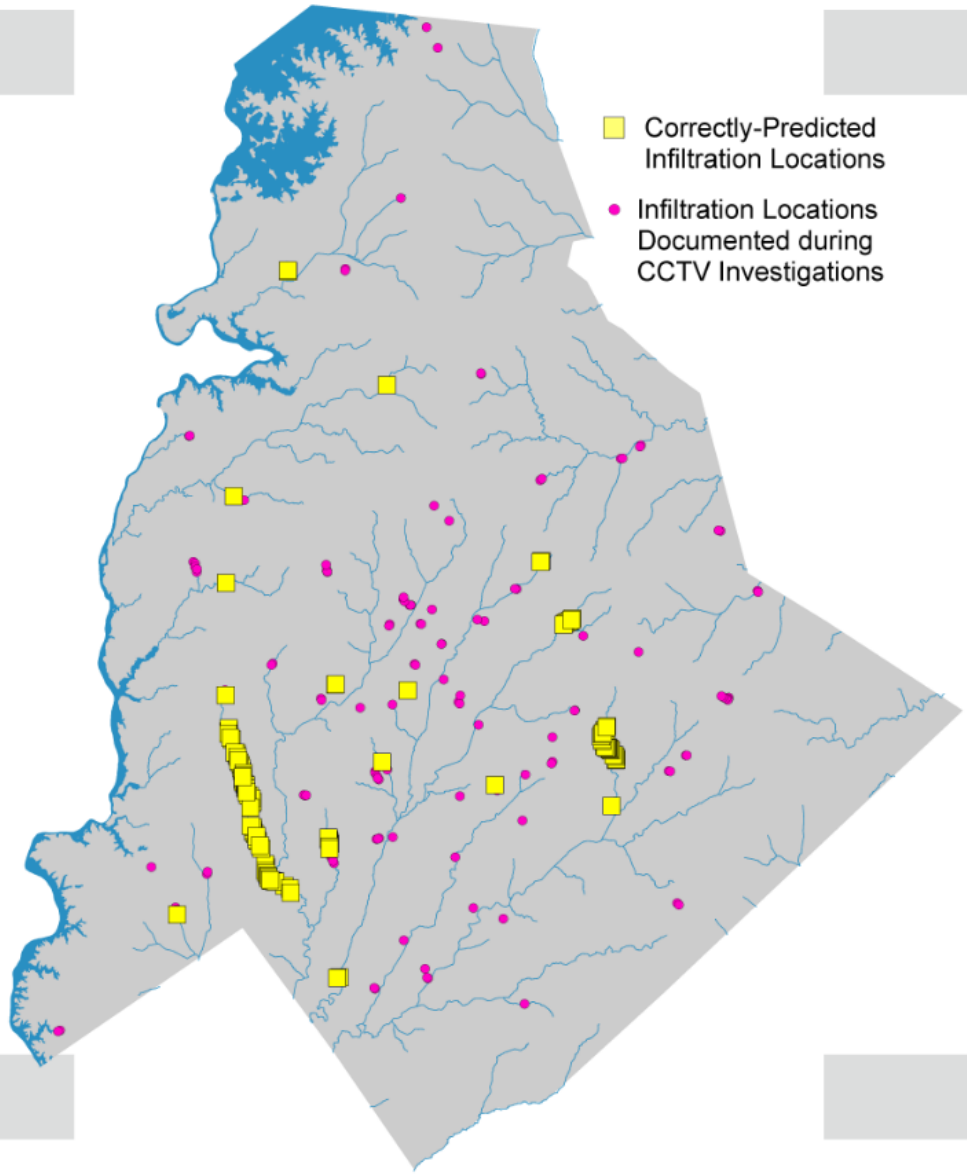
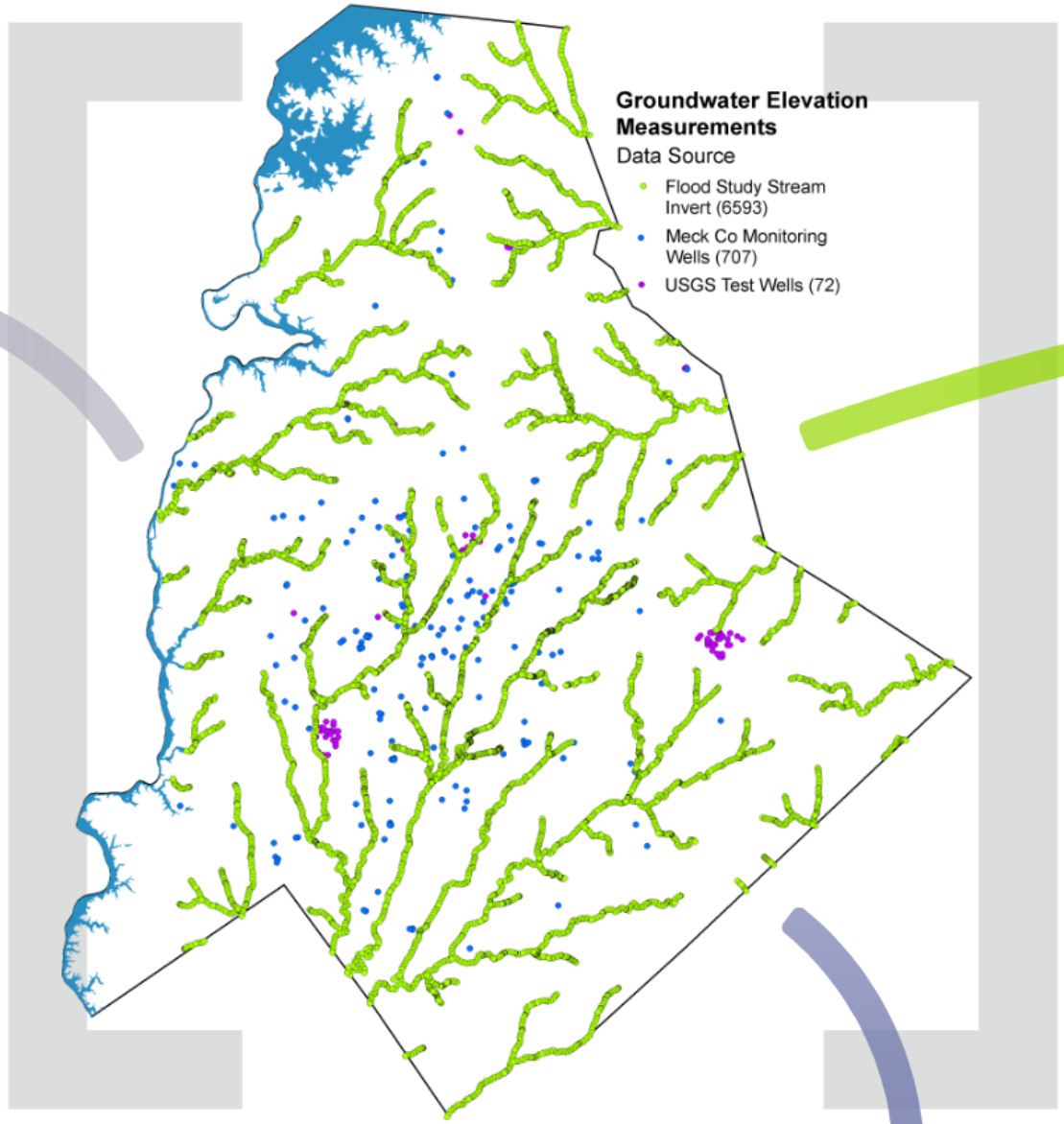



Correct Predictions: 115 out of 245 locations, **47%**

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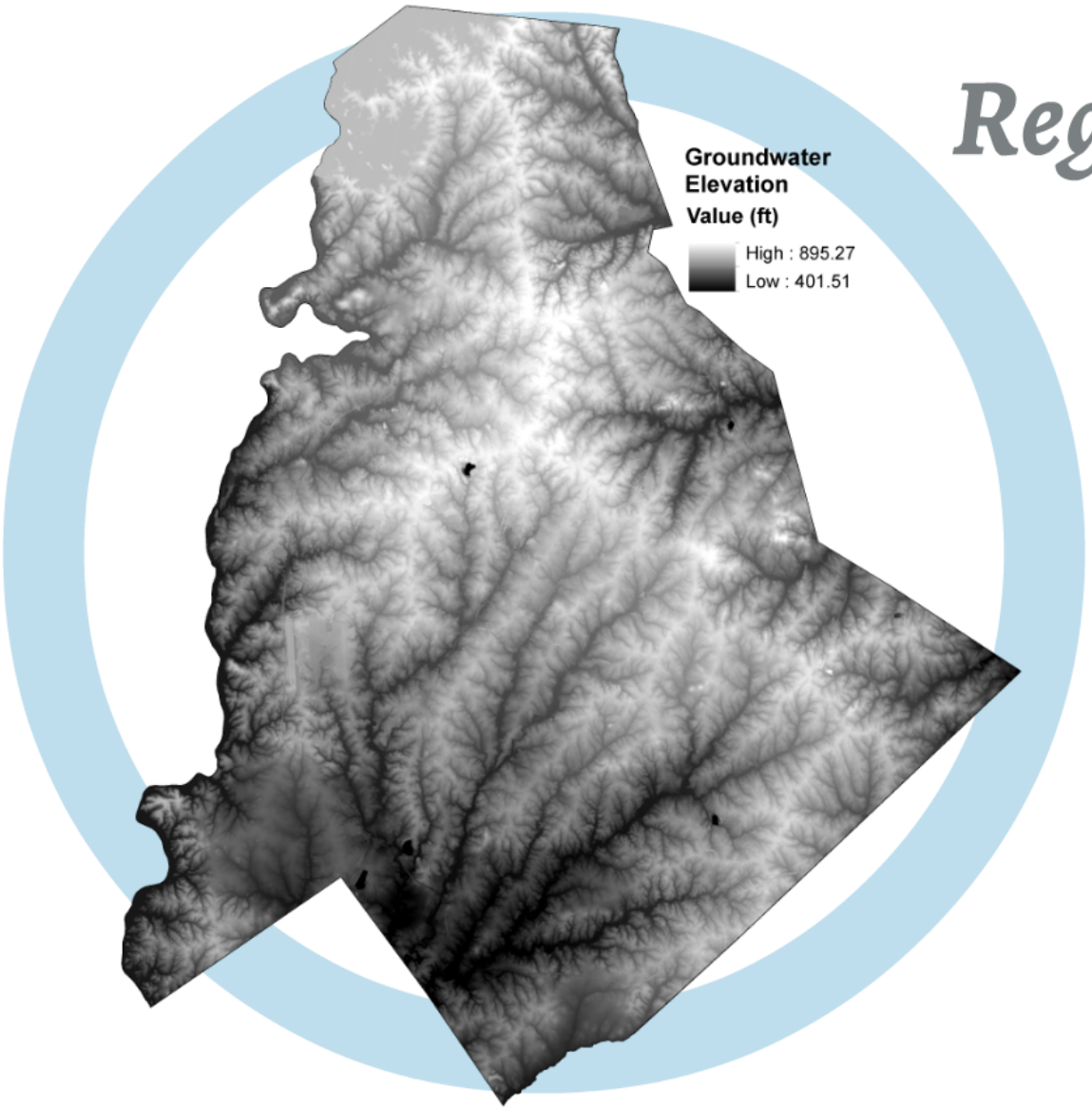


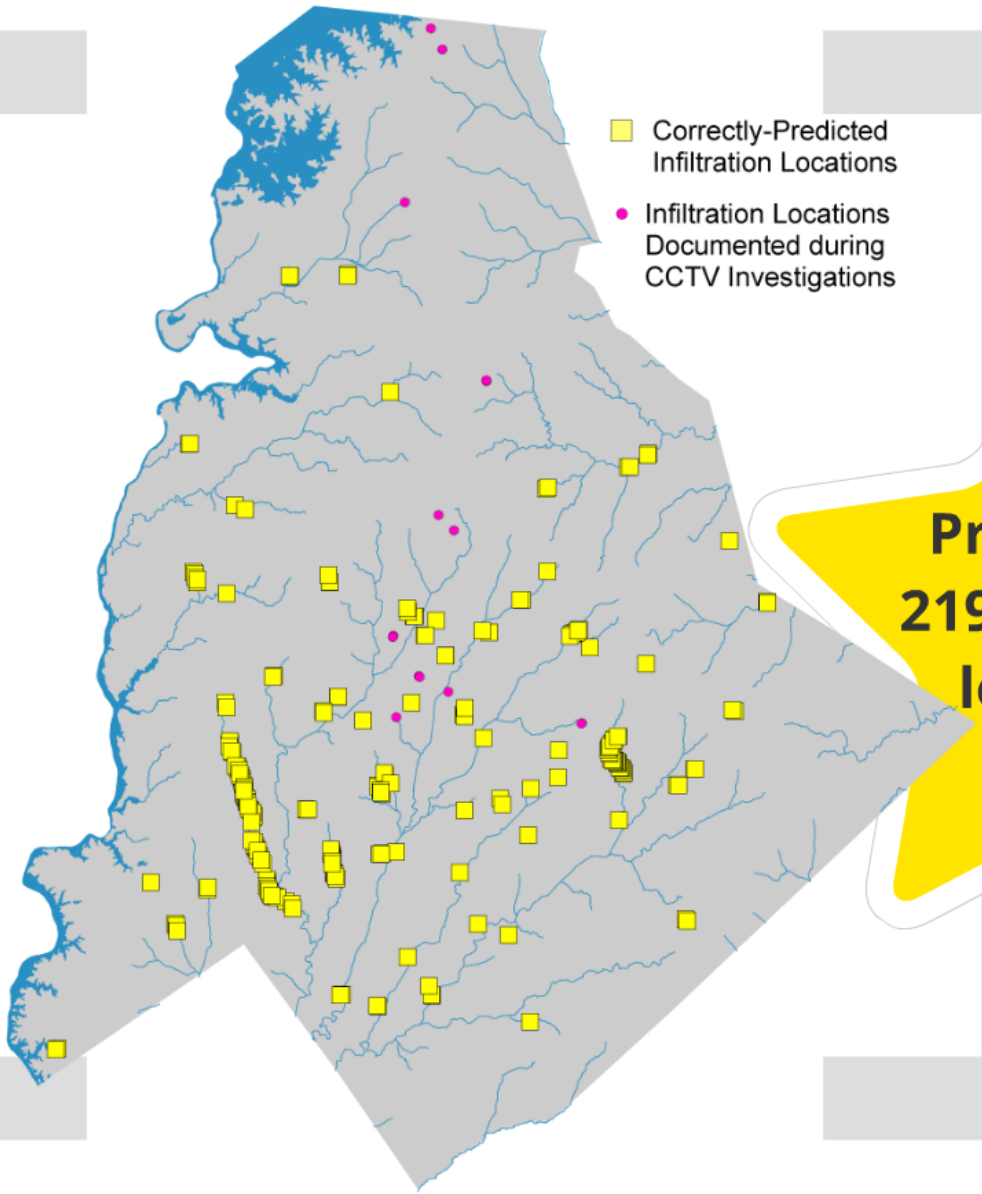

# *Regression Analysis*

- Performed regression analyses on multiple combinations of available datasets (specific to Mecklenburg County)

- On the advice of USGS staff, chose a regression equation that incorporated GWE, elevation, and slope values :

**GWE = 26.209**
**+ (0.954*Elevation)**
**+ (0.085*Slope)**

# *Mecklenburg County Regression Analysis Groundwater Elevation Raster*




**Correct Predictions: 219 out of 245 locations, 89%**

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Select the best GWE surface

Extract survey-grade (SG) manholes from GIS data

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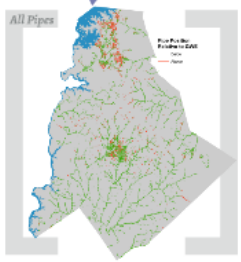
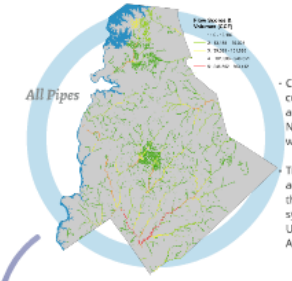
Assign GWE value to each SG manhole

Output Dataset: SG manholes with GWEs

Spatial Join: SG Manholes to Wastewater (WW) Mains

Append averaged manhole inverts & GWEs to each WW main; calculate position relative to GWE.

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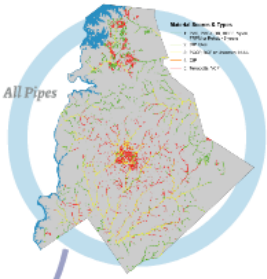


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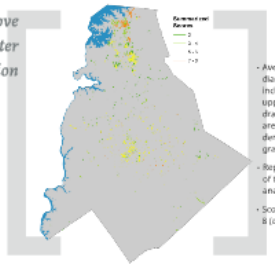

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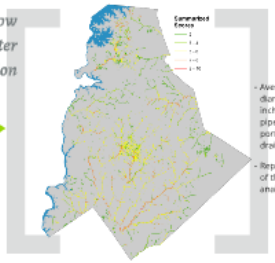

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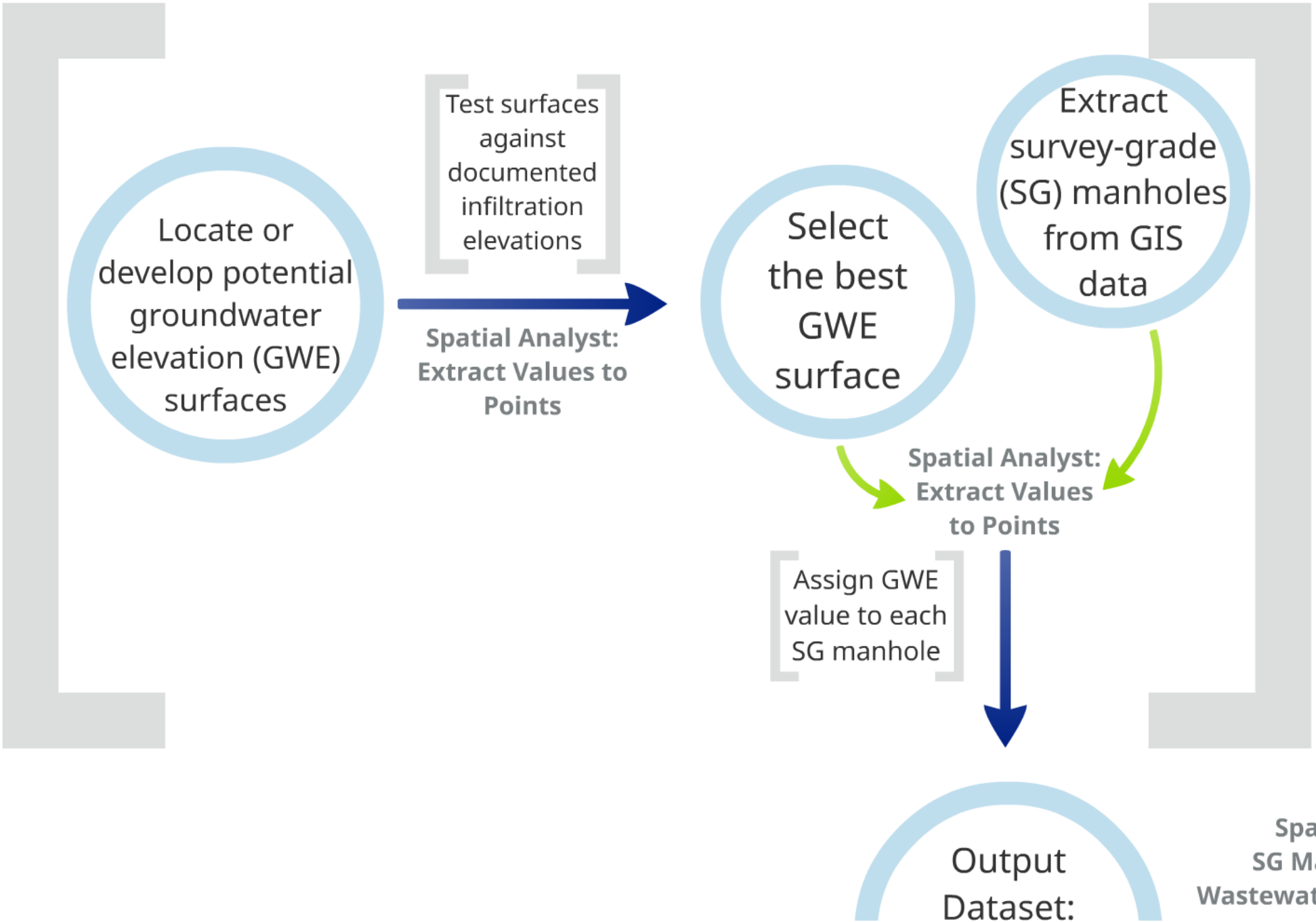
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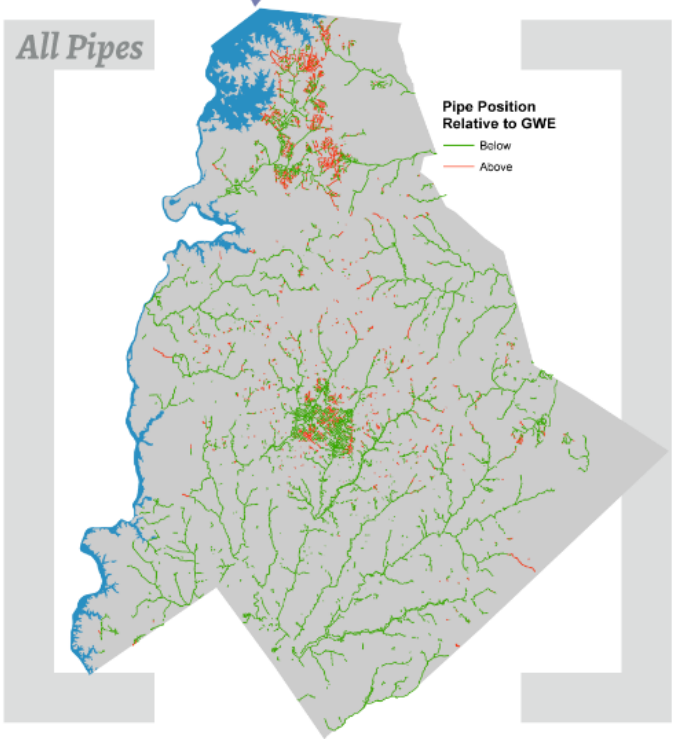

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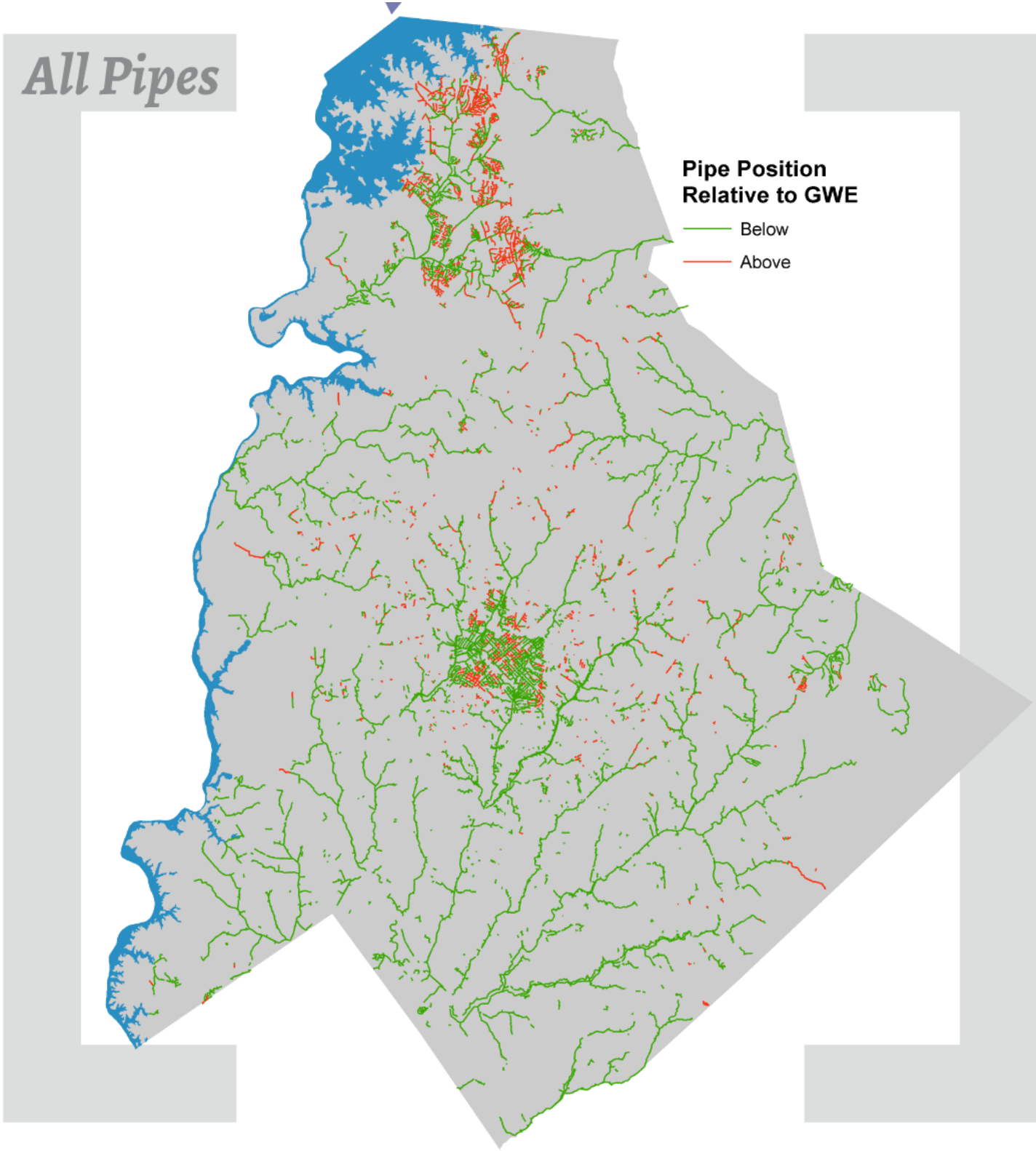

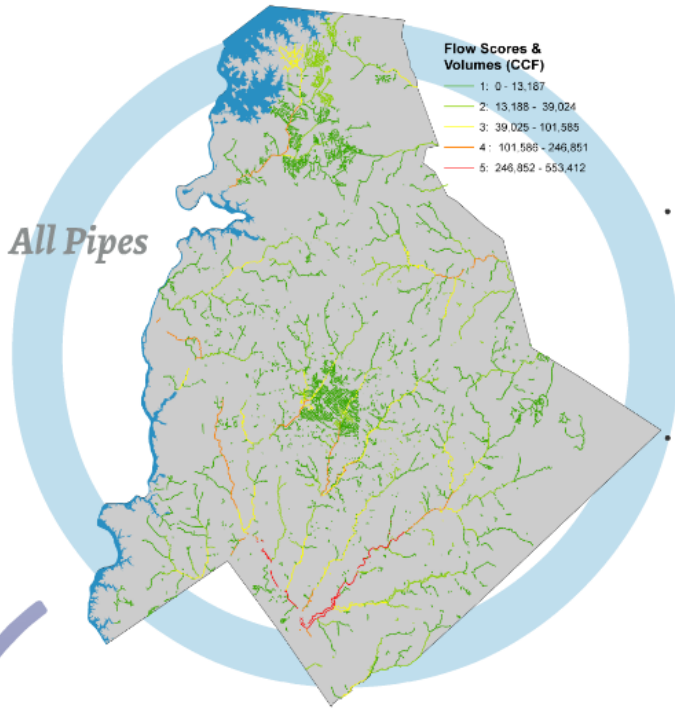


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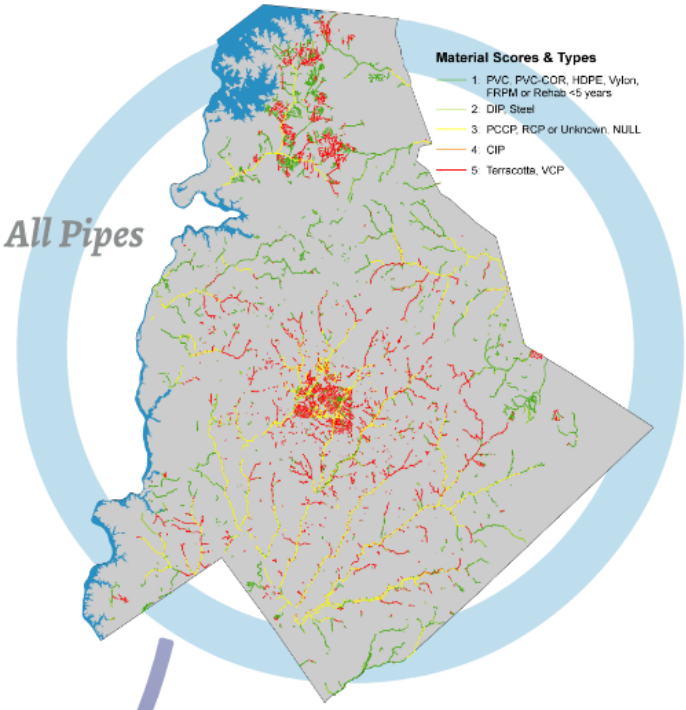


# Scoring

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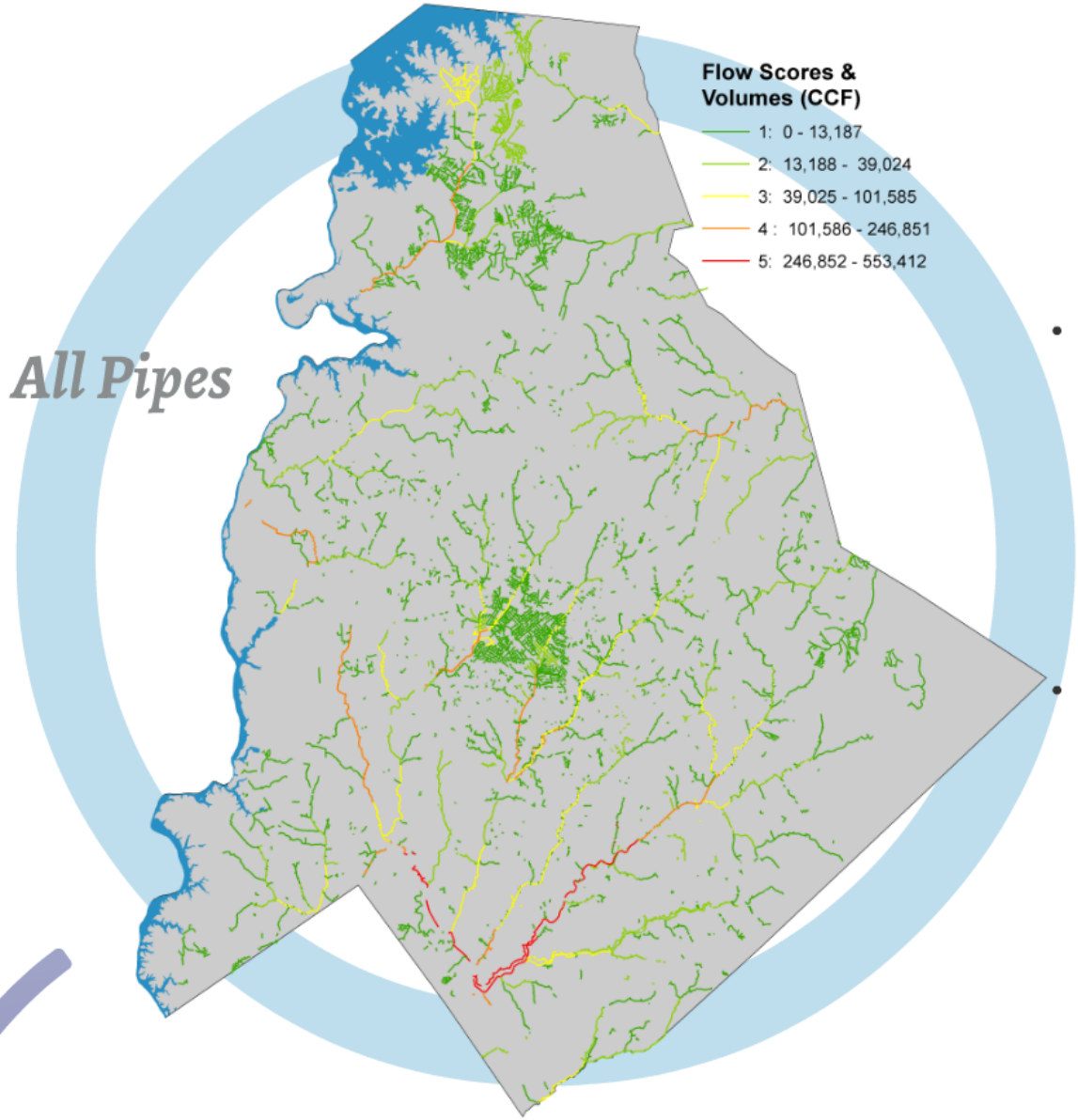
**Spatial Join:**
**SG Manholes to**

Output Dataset:

Summarize Scores

WW n
**ABOV**
scored
of se
exfiltr

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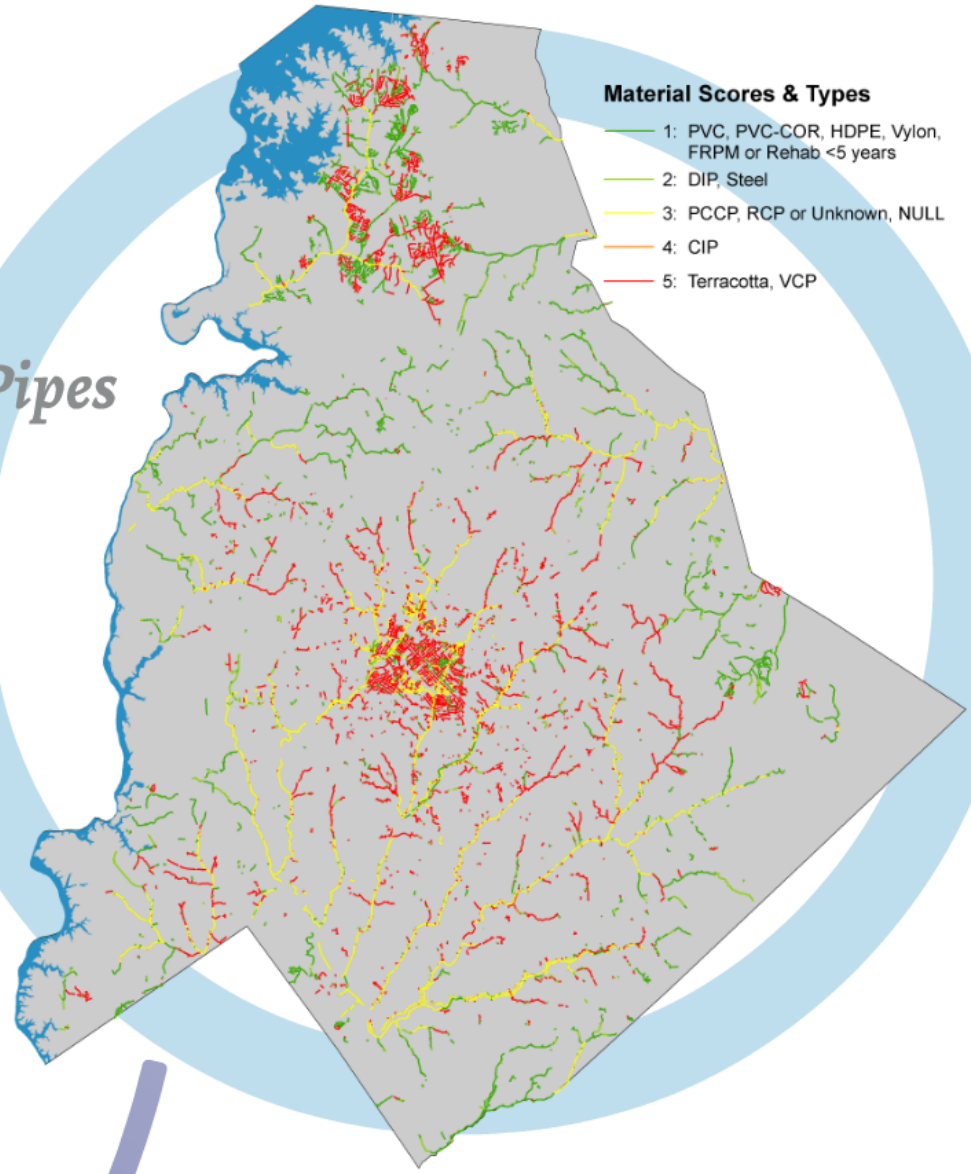
Material Scores & Types
1: PVC, PVC-COR, HDPE, Vylon, FRPM or Rehab <5 years
2: DIP, Steel
3: PCCP, RCP or Unknown, NULL
4: CIP
5: Terracotta, VCP

November 2014 water meter data

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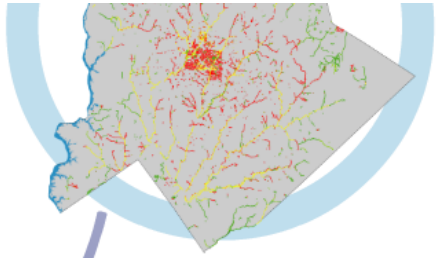

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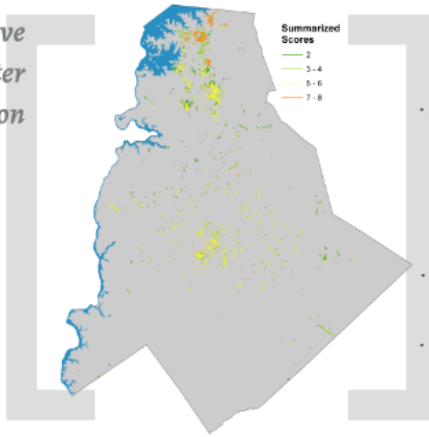


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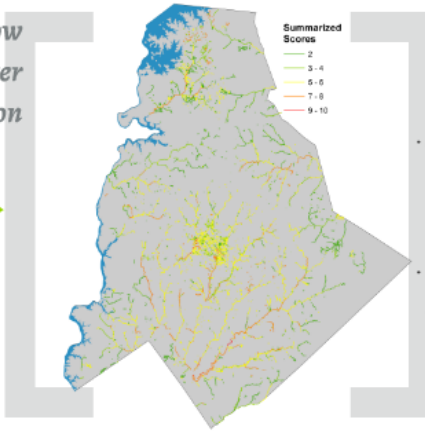


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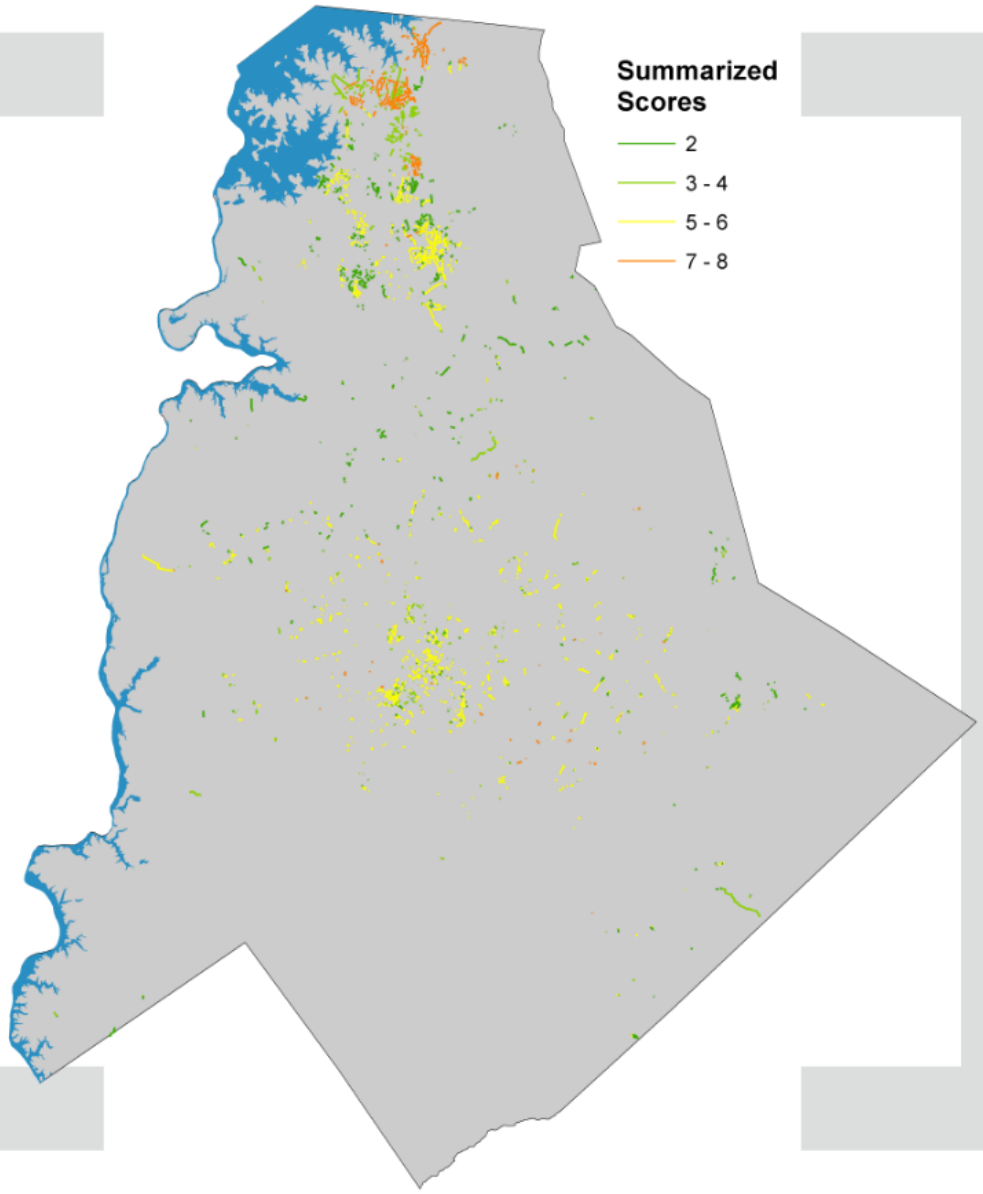
# *Pipes Above Groundwater Elevation*

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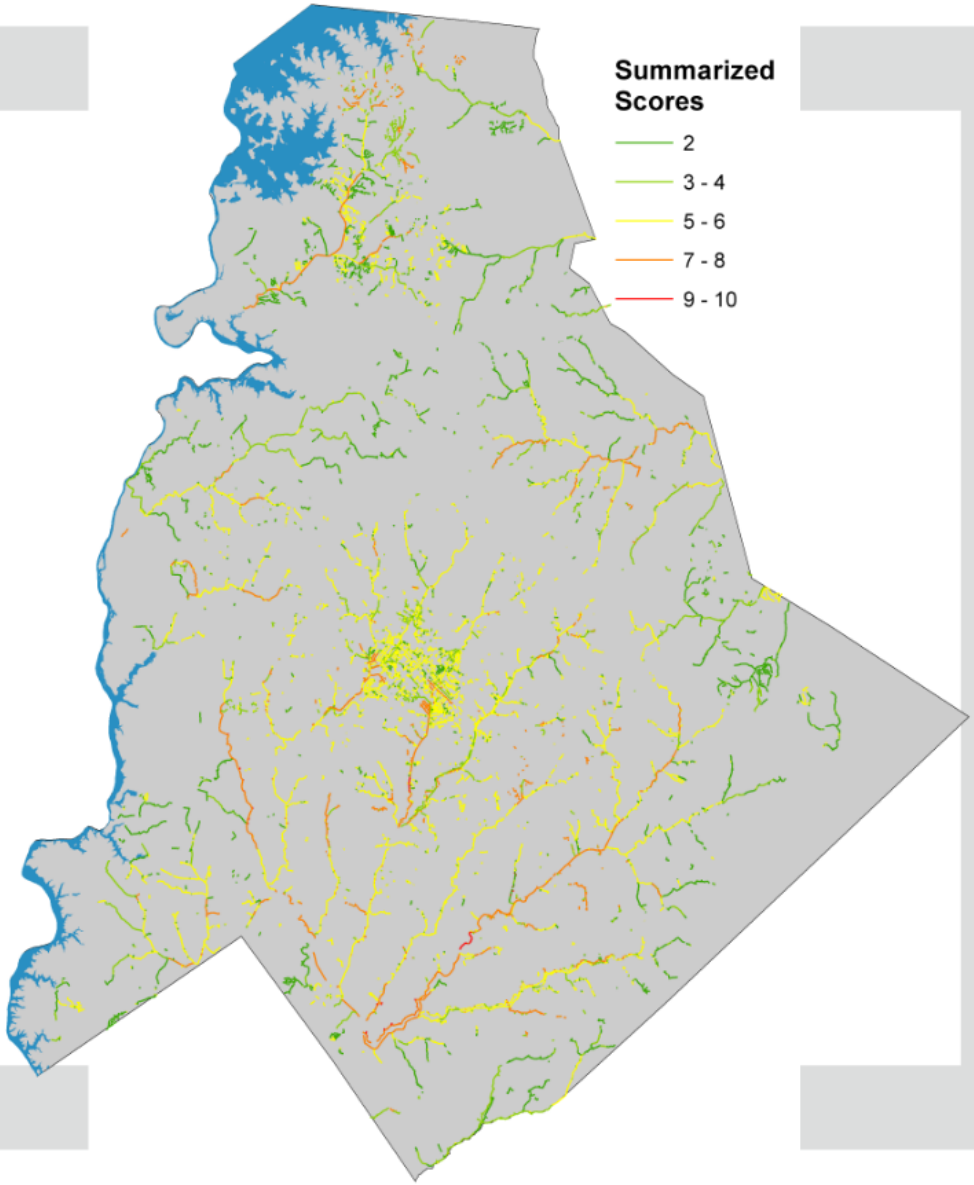


- Average pipe diameter of 14.4 inches: larger pipes in the lower portions of drainage basins
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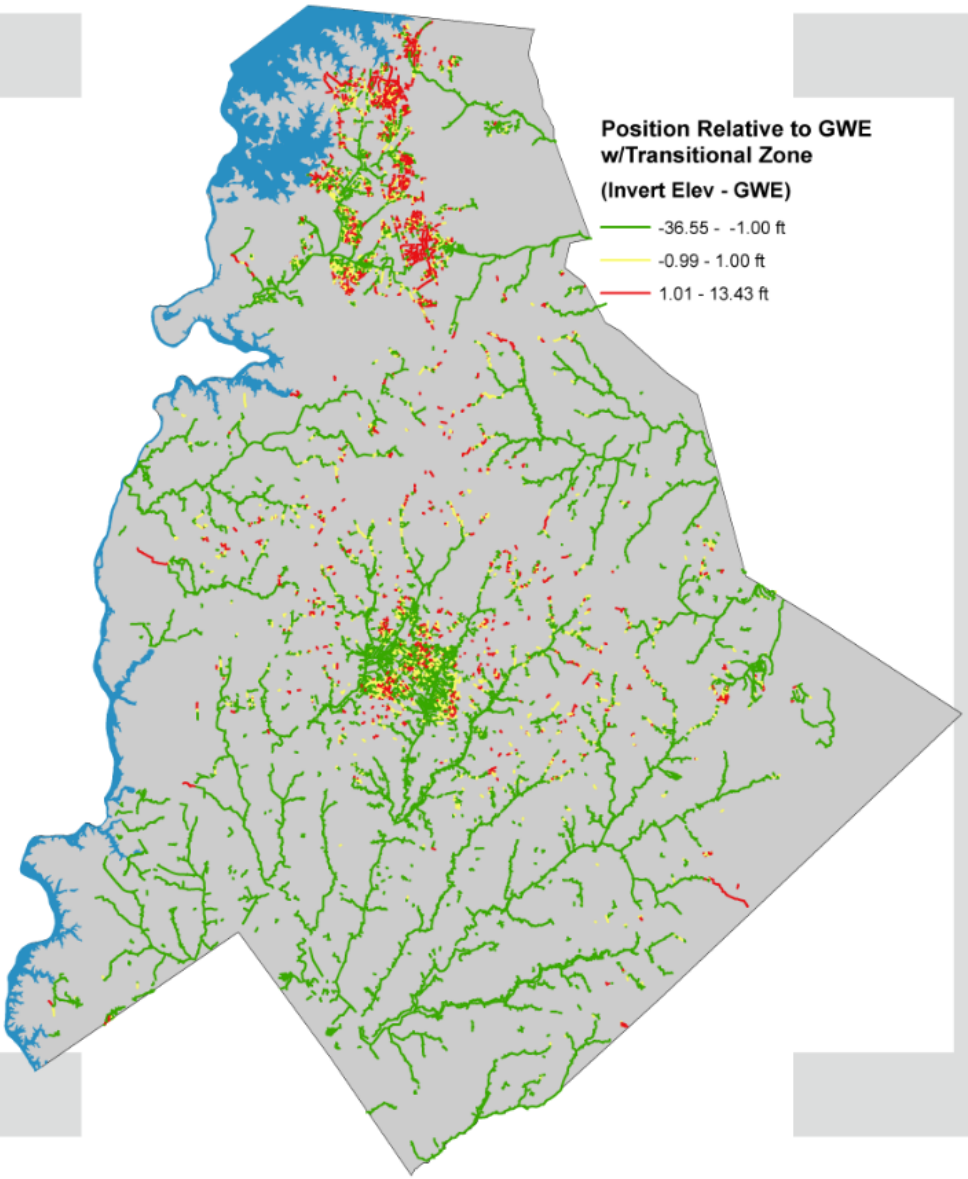
# *Pipe Position in Relation to Groundwater Elevation*

## Transitional Zone




- Average pipe diameter of 9 inches
- Represents 13% of the pipes in the analysis

# Future Plans & Uses for the Datasets

- Scored pipe datasets can be extracted by varying elevation criteria, but the flow and material scoring will be consistent no matter what the pipe position relative to the groundwater elevation.
- This is a flexible dataset. As we gather more survey grade data for our infrastructure, more pipes can be scored and evaluated.
- The flow data will change over time and will need to be reevaluated as population grows, shrinks, or shifts around the county.
- This data can be used as criteria in prioritizing sewer line rehabilitation and repair plans.
- The datasets and groundwater elevation raster will be provided to CMSWS for potential use in planning targeted water quality monitoring.

# Acknowledgments


Dr. Barry Evans
Penn State

PENNSTATE
1855

Rob Bailey
Charlotte Water

CHARLOTTE WATER

James Scanlon
CMSWS

Charlotte-Mecklenburg STORM WATER Services

Silvia Terziotti
USGS

USGS
science for a changing world

# References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