Utilization of Geospatial Analysis Tools to Identify and Evaluate Septic System Pollution Risk to Aquatic Resources

Southeast Stormwater Association Conference

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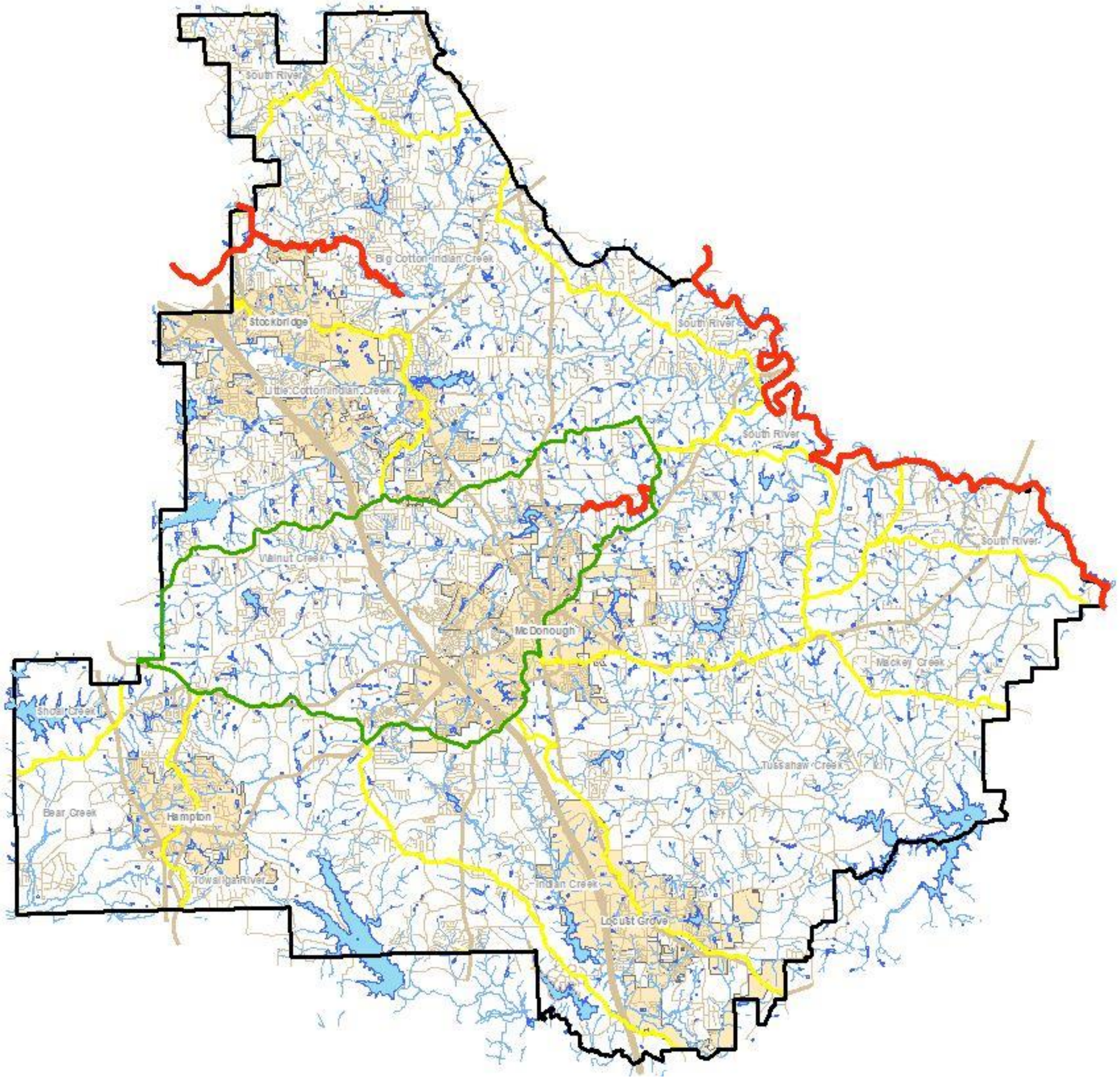
Project Goal

Utilize GIS to create a method to analyze and score individual septic systems based on their risk of pollution to aquatic resources.

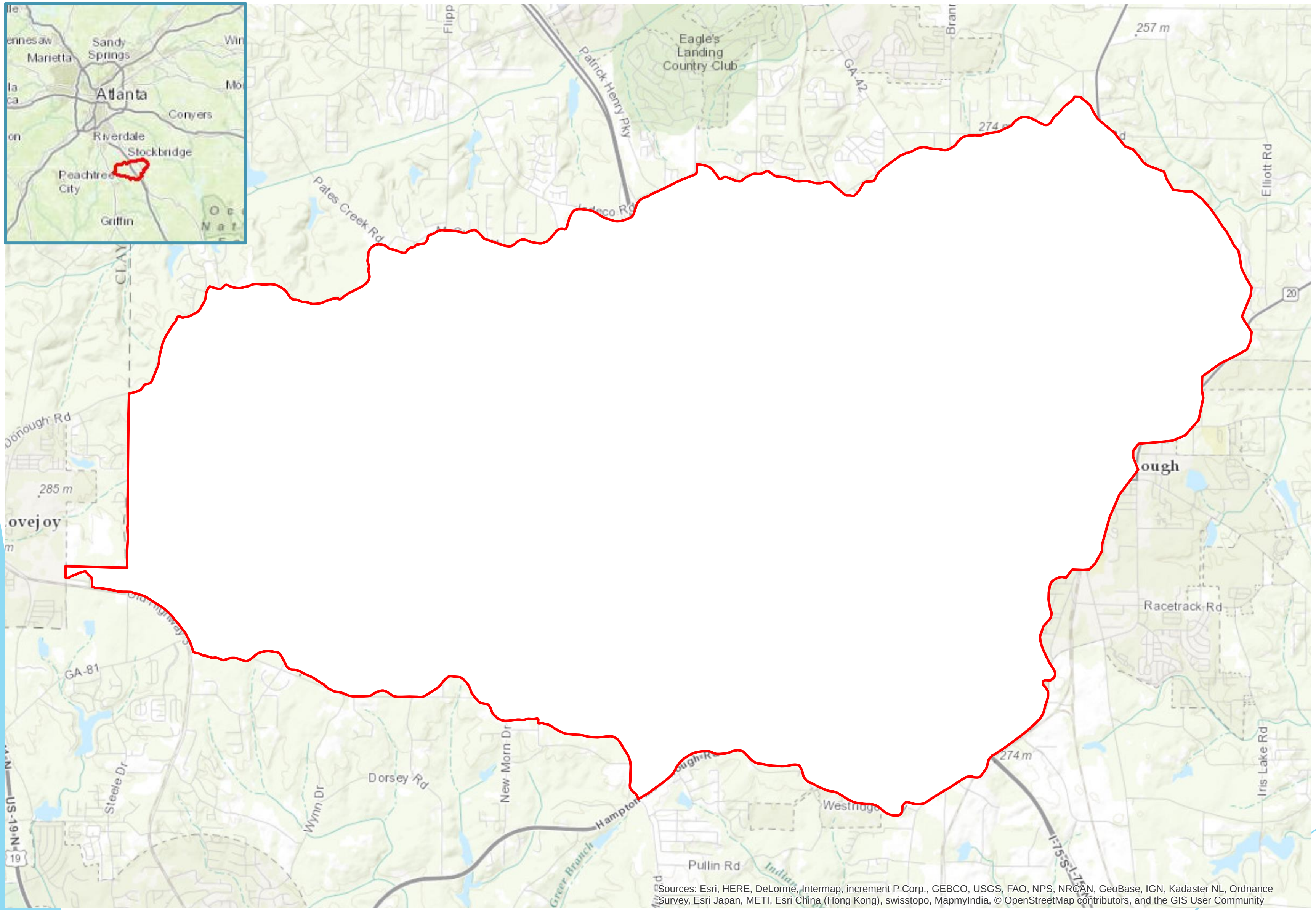
Project Methodology

- Step 1: Define project Area of Interest (AOI)
- Step 2: Map the septic systems
- Step 3: Add localized GIS attribution to each septic system
- Step 4: Create the rating system
- Step 5: Analyze results



- 11 GAEPD 303(d) polluted stream segments in Henry County
- 6 of the polluted stream segments are impaired due to Fecal Coliform contamination
- The 6 impaired segments are located in 4 separate streams, with the South River and Big Cotton Indian Creek containing two impaired segments apiece (along with Panther and Walnut Creeks)
- Of the 4 impaired streams, three are listed as impaired prior to flowing into the County, unlike Walnut Creek, in which nearly its entire watershed is contained within Henry County
- The Walnut Creek watershed contains a high density of septic systems in which we have available data/information

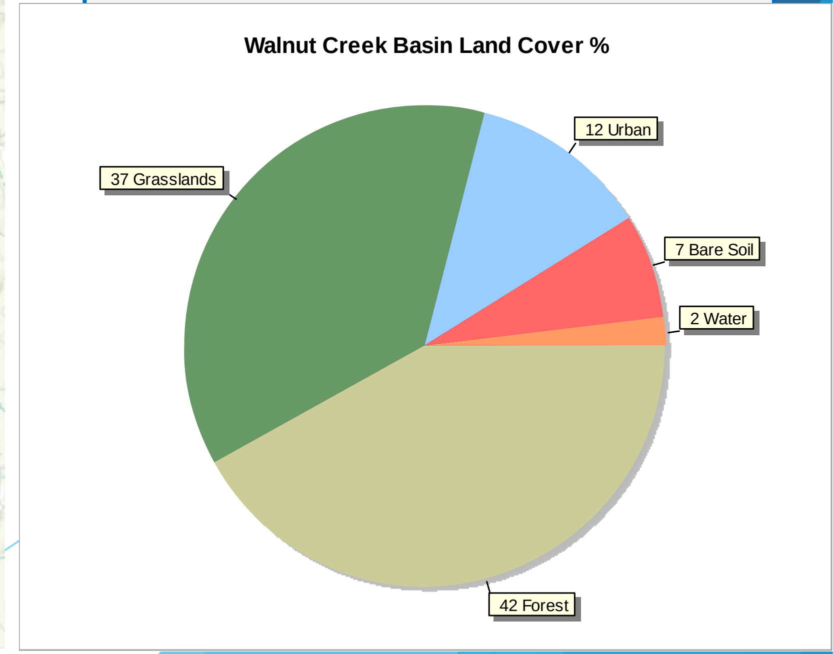
AOI: Walnut Creek Basin



41.4 Square Miles

4,458 Septic Systems

Avg. 107 Septic Systems Per Square Mile Area

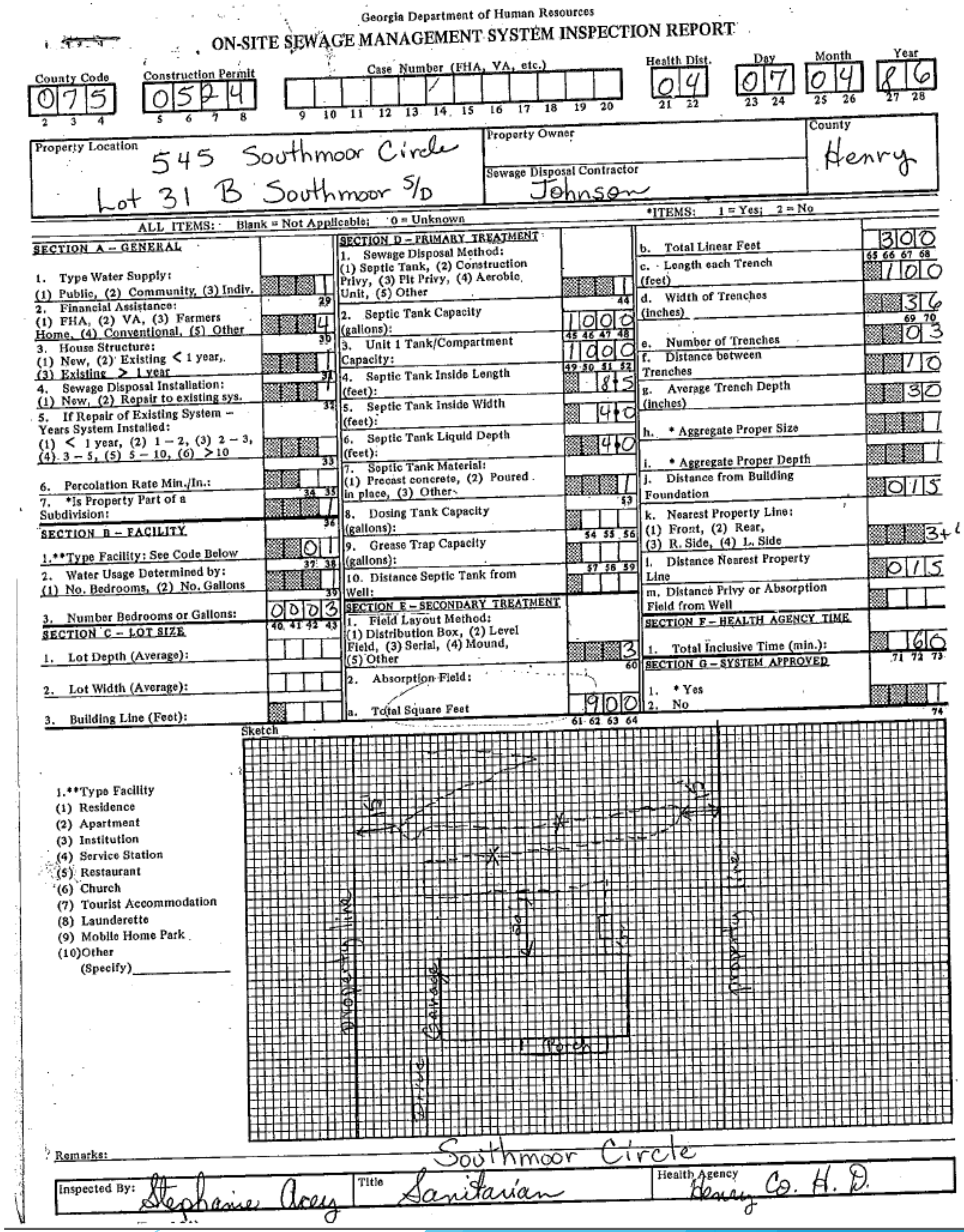


Map the Septic Systems

What we started with

The first hurdle to overcome was to determine where the septic systems were.

- No digital septic records, only paper copies.
- There is a state-wide septic mapping effort titled “WelSTROM,” but it is mostly incomplete for Henry County.



Georgia Department of Human Resources

ON-SITE SEWAGE MANAGEMENT SYSTEM INSPECTION REPORT

County Code: 075 | Construction Permit: 0524 | Case Number (FHA, VA, etc.) | Health Dist.: 04 | Day: 07 | Month: 04 | Year: 86

Property Location: 545 Southmoor Circle, Lot 31 B Southmoor S/D

Property Owner:

Sewage Disposal Contractor: Johnson

County: Henry

ALL ITEMS: Blank = Not Applicable; 0 = Unknown. *ITEMS: 1 = Yes; 2 = No

SECTION A – GENERAL
1. Type Water Supply: (1) Public, (2) Community, (3) Indiv.
2. Financial Assistance: (1) FHA, (2) VA, (3) Farmers Home, (4) Conventional, (5) Other — 4
3. House Structure: (1) New, (2) Existing < 1 year, (3) Existing > 1 year — 1
4. Sewage Disposal Installation: (1) New, (2) Repair to existing sys. — 1
5. If Repair of Existing System – Years System Installed: (1) < 1 year, (2) 1 – 2, (3) 2 – 3, (4) 3 – 5, (5) 5 – 10, (6) > 10
6. Percolation Rate Min./In.:
7. *Is Property Part of a Subdivision: 1

SECTION B – FACILITY
1. **Type Facility: See Code Below — 01
2. Water Usage Determined by: (1) No. Bedrooms, (2) No. Gallons — 1
3. Number Bedrooms or Gallons: 0003

SECTION C – LOT SIZE
1. Lot Depth (Average):
2. Lot Width (Average):
3. Building Line (Feet):

SECTION D – PRIMARY TREATMENT
1. Sewage Disposal Method: (1) Septic Tank, (2) Construction Privy, (3) Pit Privy, (4) Aerobic Unit, (5) Other — 1
2. Septic Tank Capacity (gallons): 1000
3. Unit 1 Tank/Compartment Capacity: 1000
4. Septic Tank Inside Length (feet): 8.5
5. Septic Tank Inside Width (feet): 4.0
6. Septic Tank Liquid Depth (feet): 4.0
7. Septic Tank Material: (1) Precast concrete, (2) Poured in place, (3) Other — 1
8. Dosing Tank Capacity (gallons):
9. Grease Trap Capacity (gallons):
10. Distance Septic Tank from Well:

SECTION E – SECONDARY TREATMENT
1. Field Layout Method: (1) Distribution Box, (2) Level Field, (3) Serial, (4) Mound, (5) Other — 3
2. Absorption Field:
a. Total Square Feet: 900
b. Total Linear Feet: 300
c. Length each Trench (feet): 100
d. Width of Trenches (inches): 36
e. Number of Trenches: 03
f. Distance between Trenches: 10
g. Average Trench Depth (inches): 30
h. * Aggregate Proper Size: 1
i. * Aggregate Proper Depth: 1
j. Distance from Building Foundation: 015
k. Nearest Property Line: (1) Front, (2) Rear, (3) R. Side, (4) L. Side — 3
l. Distance Nearest Property Line: 015
m. Distance Privy or Absorption Field from Well:

SECTION F – HEALTH AGENCY TIME
1. Total Inclusive Time (min.): 60

SECTION G – SYSTEM APPROVED
1. * Yes
2. No — 1

1.**Type Facility
(1) Residence
(2) Apartment
(3) Institution
(4) Service Station
(5) Restaurant
(6) Church
(7) Tourist Accommodation
(8) Launderette
(9) Mobile Home Park
(10) Other (Specify)

Sketch

Remarks:

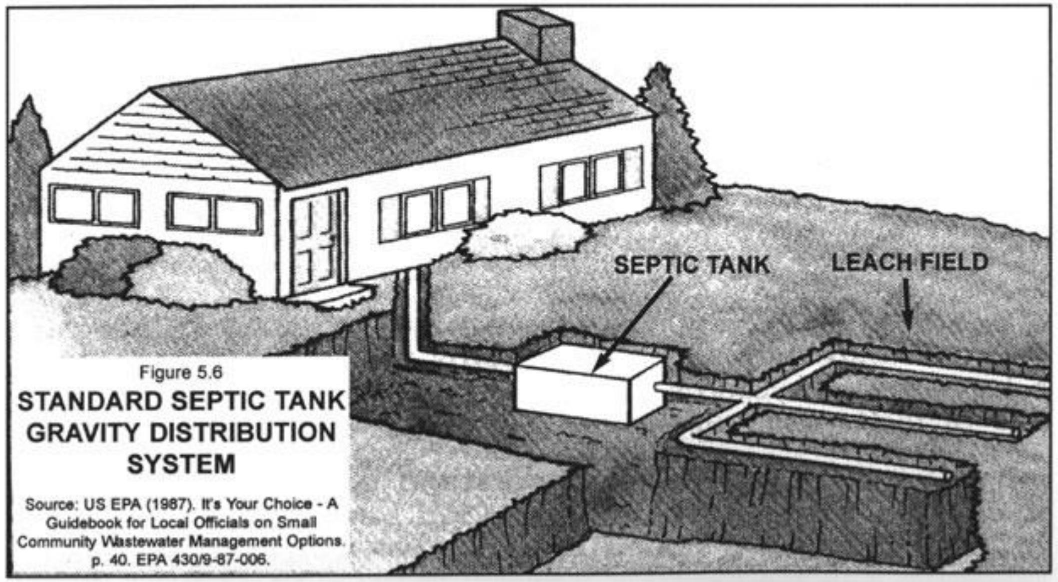
Inspected By: Stephanie Arey | Title: Sanitarian | Health Agency: Henry Co. H. D.

Map the Septic Systems

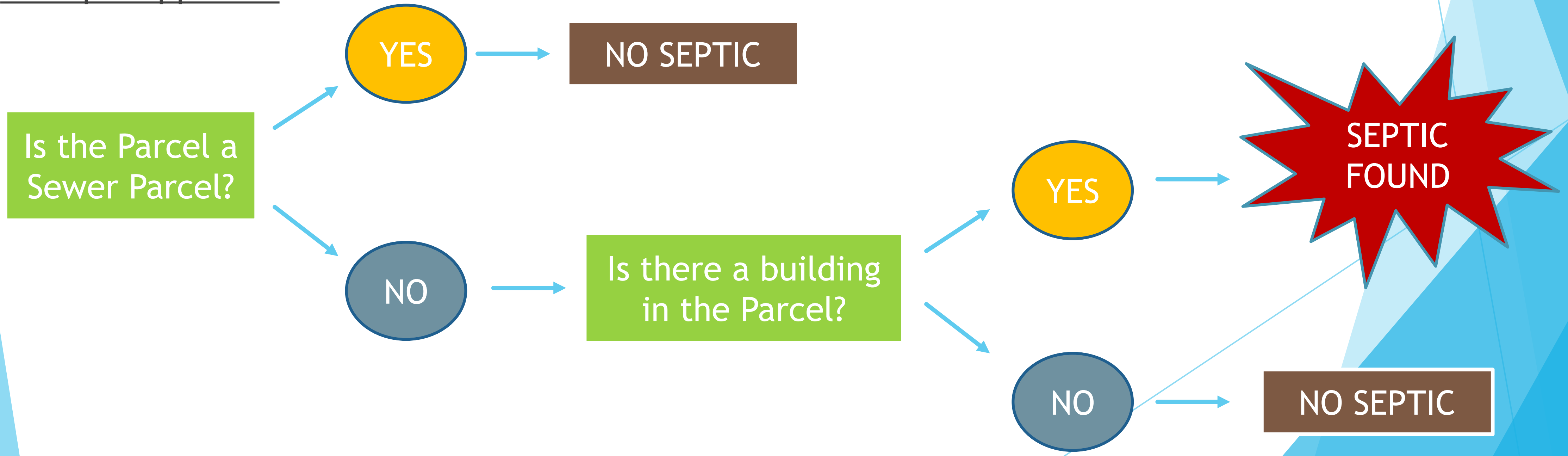
Identify Property Parcels on Septic

Work with the GIS layers that we already have:

- Property Parcels
- Sewer Parcels
- Buildings



A Simple Approach



Map the Septic Systems

Identify Individual Buildings on Septic

```
arcpy.MakeFeatureLayer_management(InParcels, "lyr_
Scursor = arcpy.SearchCursor("lyr_Septic_Parcels")
for l in Scursor:# for each septic parcel
    row_id = l.getValue("row_id")
    arcpy.MakeFeatureLayer_management("lyr_Septic_
    arcpy.MakeFeatureLayer_management(InBuildings,
    arcpy.SelectLayerByLocation_management("lyr_Bu
    Scursor2 = arcpy.SearchCursor("lyr_Buildings")
    UpdateCounter = 0
    BigArea = 0
    WinBldg_id = 0
    for m in Scursor2:
        UpdateCounter += 1

    if UpdateCounter != 0:
        Scursor2 = arcpy.SearchCursor("lyr_Buildin
        for m in Scursor2:
            CurrArea = m.getValue("area")
            if BigArea < CurrArea:
                bldg_id = m.getValue("bldg_id")
                BigArea = CurrArea
        arcpy.SelectLayerByAttribute_management("l
        arcpy.CalculateField_management("lyr_Build
    print "processing parcel.. " + str(row_id)
```

At this point we know which parcels have a septic system, but we want to narrow down the specific area(s) in which these systems are located.

- Option 1: ~~Use the centroid of the parcel~~ too general
- Option 2: Use the building location as a starting point.

We quickly discovered a problem - we can't simply assume every building within the septic parcels has a septic system. There are many accessory buildings such as sheds, garages, etc.

In general, there is most likely only one septic system per parcel; that system will most likely be associated with the largest building.

Using the Python programming language, we developed a script that looked at the buildings located in each septic parcel. If there was more than one building, it would review the size of the buildings and assign the largest building in that parcel as having the septic system.

Map the Septic Systems

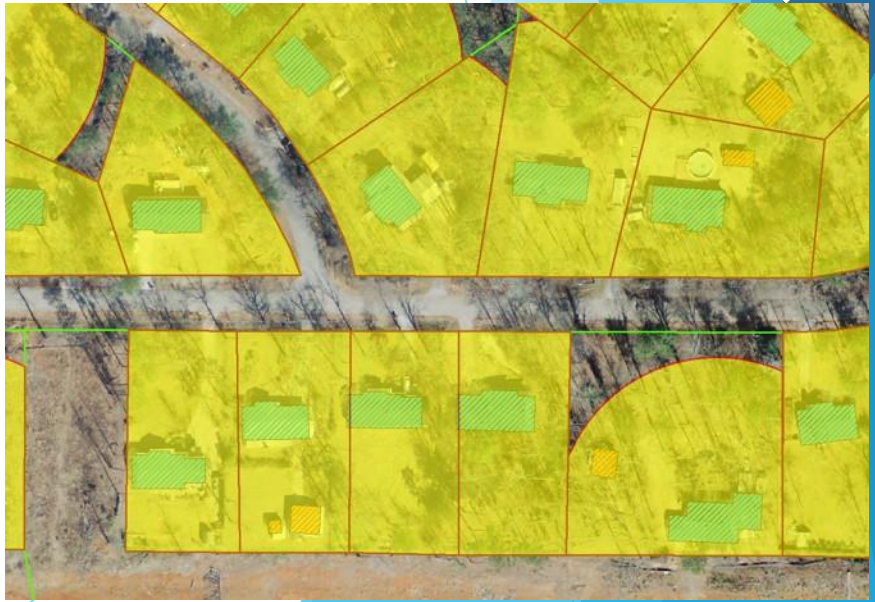
Identify Potential Septic Drain Field Areas

Part 1

Now we have a good starting point for each septic system area, which is the centroid of a building polygon that we've identified as having a septic system.

The next step was to create a polygon representing the area in which the septic drain field is most likely located for each individual parcel. This polygon will be used later in the project to extract localized statistics for each septic system from a couple of different raster data sources.

(A) 150ft Buffer Polygon



(B) Remove Buffer not in subject parcel

Using our Land Cover Layer, we discounted any part of the polygon that was 'Urban' or 'Water'

(C) 'Urban' and 'Water' removed

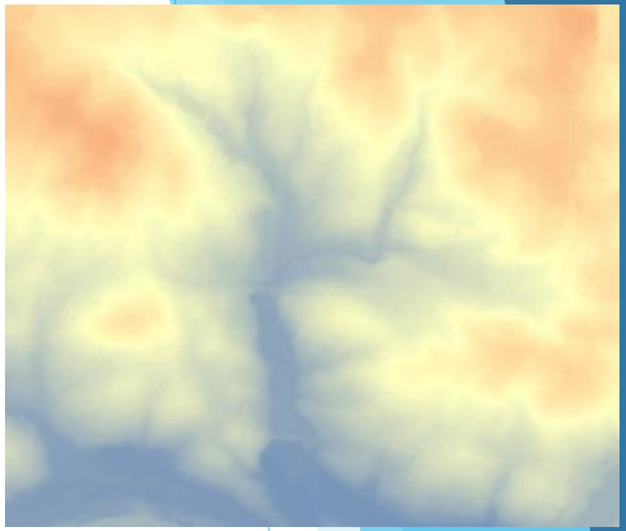
Map the Septic Systems

Identify Potential Septic Drain Field Areas

Part 2

We could stop right there in regards to identifying the septic drain field area, but we decided to go a step further and isolate the area even more based on elevation in relation to the elevation of the house.

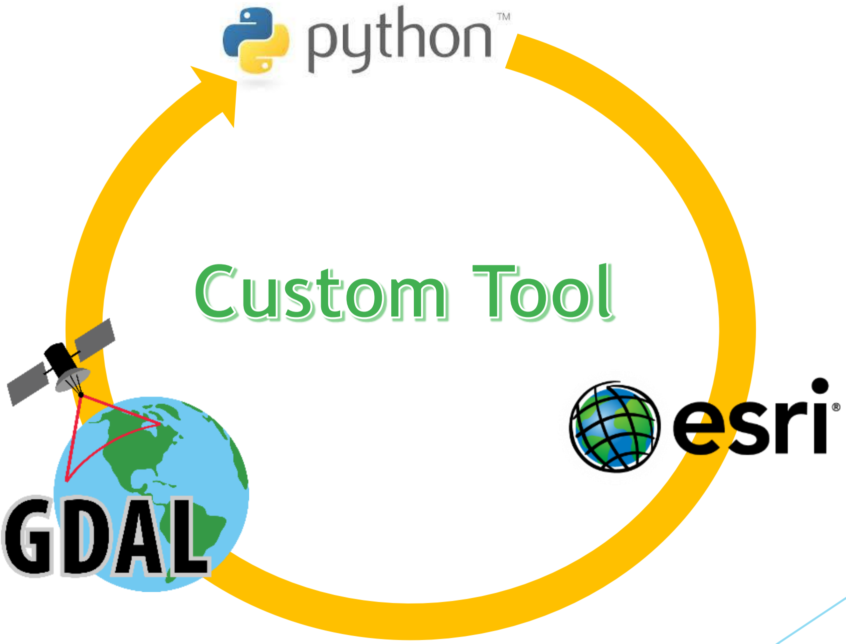
In general, unless a pump is involved, the septic drain field is at around the same elevation as the base of the house or less so it can be gravity feed. That being the case, we wanted to take the base elevation of the house and split our septic drain field area polygons up based on either being above or below the base elevation of the house.



(1) From LiDAR DEM, add Z of each septic building centroid to it's septic drain field area polygon

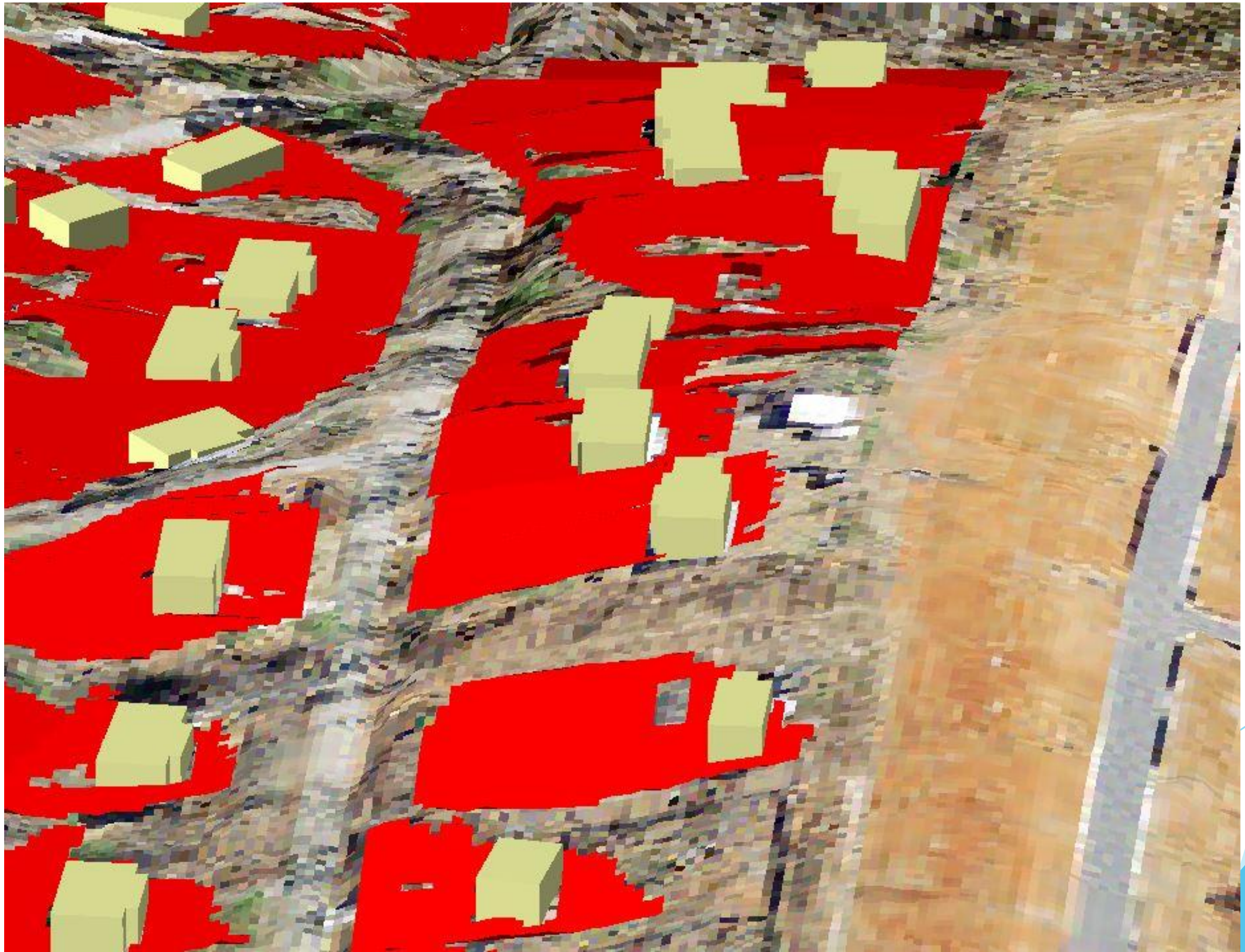
(2) We developed a custom Python tool that looks at each septic drain field area polygon and assigns all the area within that polygon at the house base elevation and lower as the primary septic area. Any area higher than house base elevation is assigned as a secondary septic area. The minimum area requirement for primary or secondary septic areas are 2500 square feet. The tool used a combination of ESRI and GDAL geoprocessing tools resulting in about a 100 lines of code.

The elevation source used was a 5ft resolution Digital Elevation Model (DEM) derived from LiDAR collected in 2007.



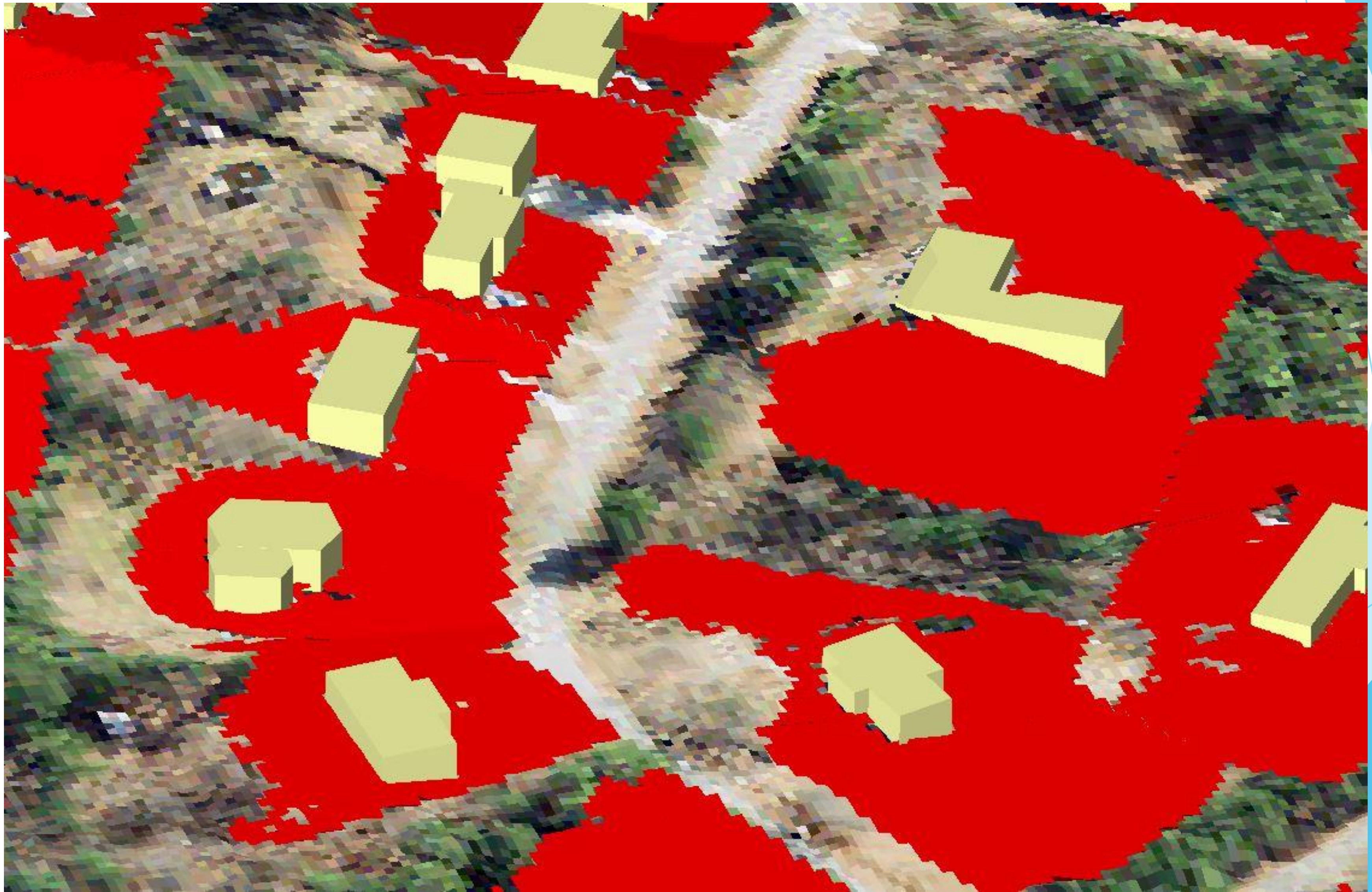
Map the Septic Systems

Primary Septic Areas – 3D View



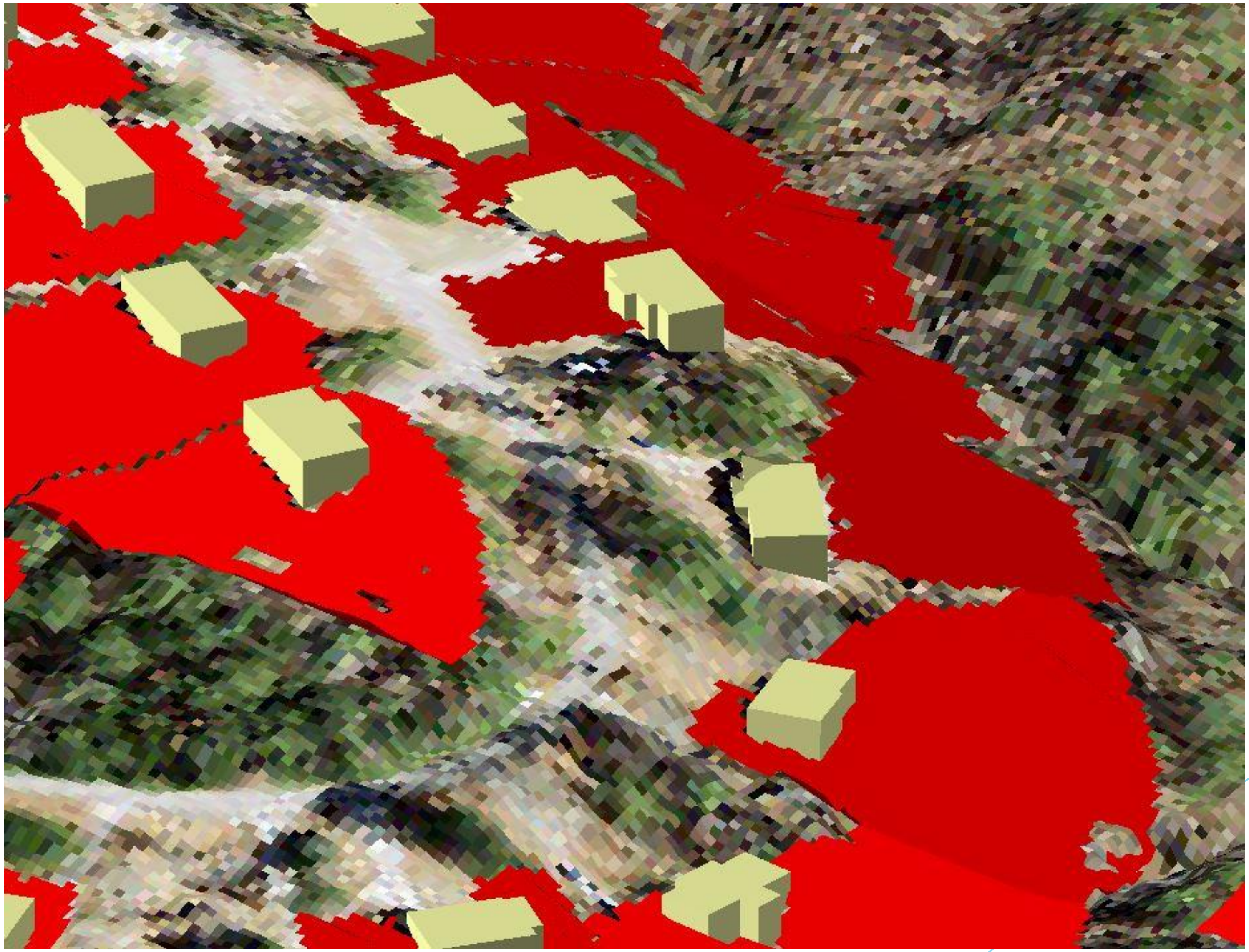
Map the Septic Systems

Primary Septic Areas – 3D View



Map the Septic Systems

Primary Septic Areas – 3D View



Add localized GIS attribution

Adding Septic Age and Water Usage

Now that our septic systems were mapped, we could start adding localized attributes to each individual septic system.

From our county parcel data, we have the year the building was built, which should also be the year the septic system was installed in most cases.

Using water usage data from 2014, we calculated an average monthly usage and added that to each septic system. We only had water usage data for about 75% of our 4458 septic systems.

Average Septic Age = 27 years old

Average Water Usage = 5200 gal/month

Table 1: US EPA Typical Hydraulic Use vs. Georgia Design Flows

User Unit	EPA Typical Water Use gpd	GA Design Flow gpd
Residential – per Bedroom	120*	150
Restaurant – per Seat	10	50
Office/factory – per Person	13	25
Hotel (resort) – per Guest	50	75
Theater – per Seat	3	5
Hospital – per Bed	165	300

* Two persons per bedroom at a median flow of 60 gallons/day/person

Septic System Design Flows

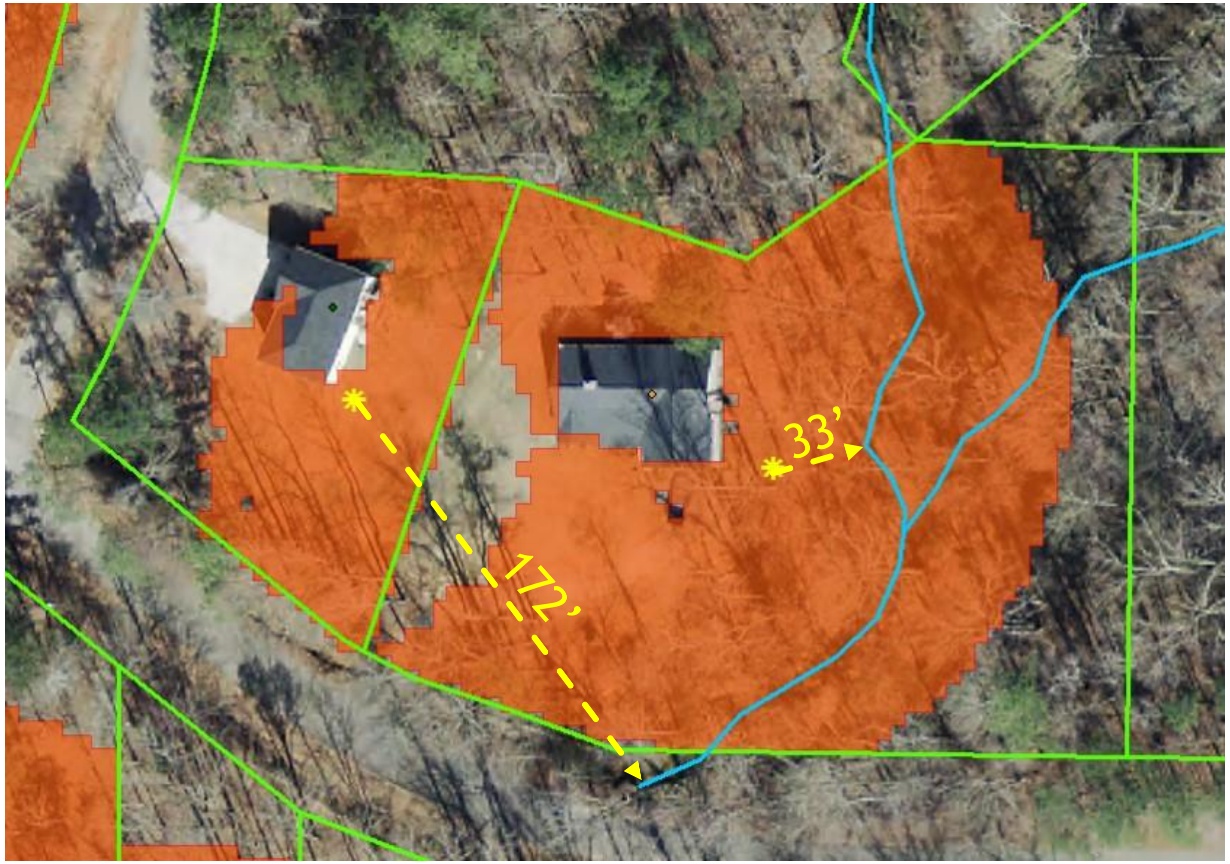
Based on this table, septic systems in Georgia should be designed to handle around 13,500 gallons a month for a typical 3 bedroom home.

Source: Georgia Department of Public Health

Add localized GIS attribution

Add Distance to Surface Water

The proximity a septic system is located to surface water plays a big factor in it's risk level to water resources.

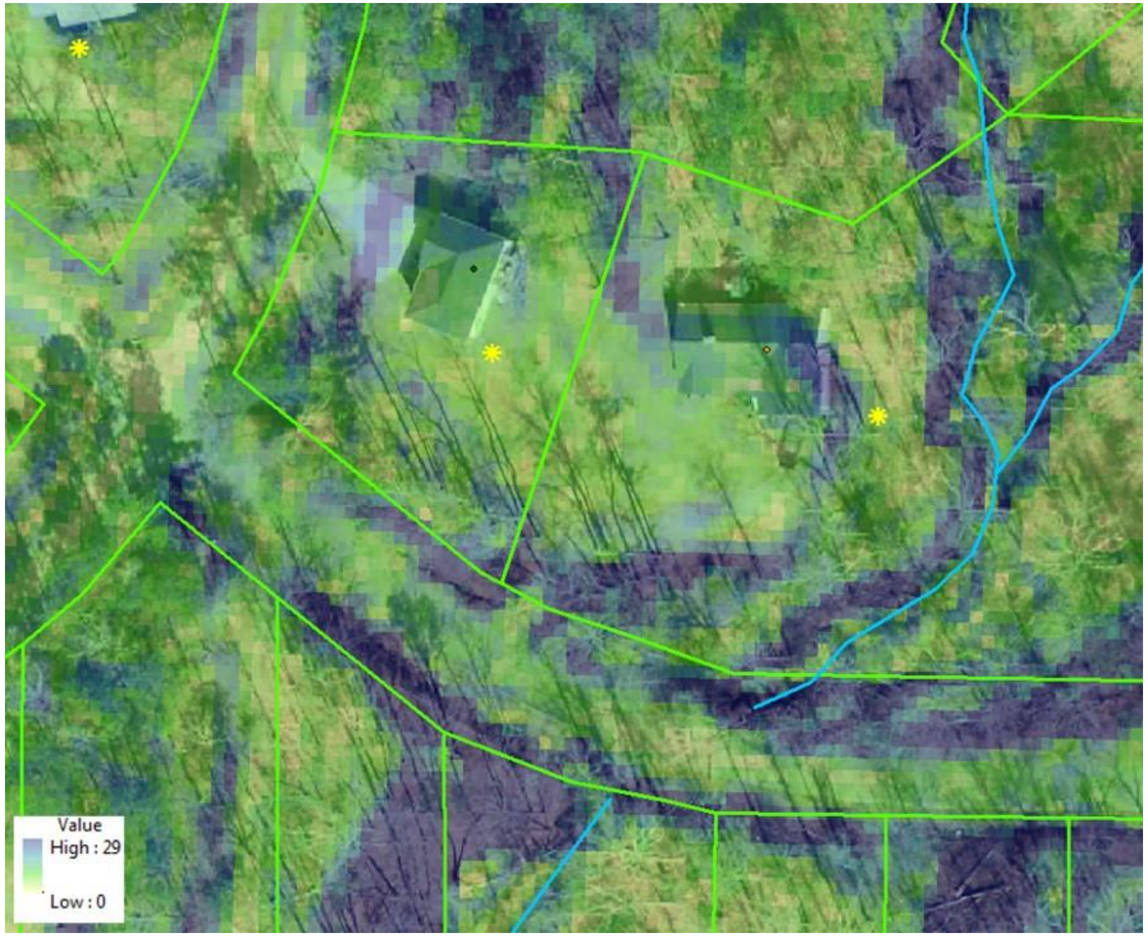


Using the ArcGIS 'NEAR' tool, we calculated the distance from the primary septic area centroid to the nearest surface water feature (stream,pond,lake) for each septic system.

Add localized GIS attribution

Add Slope

The mean slope of each primary septic area is calculated and added to the attributes for every septic system.



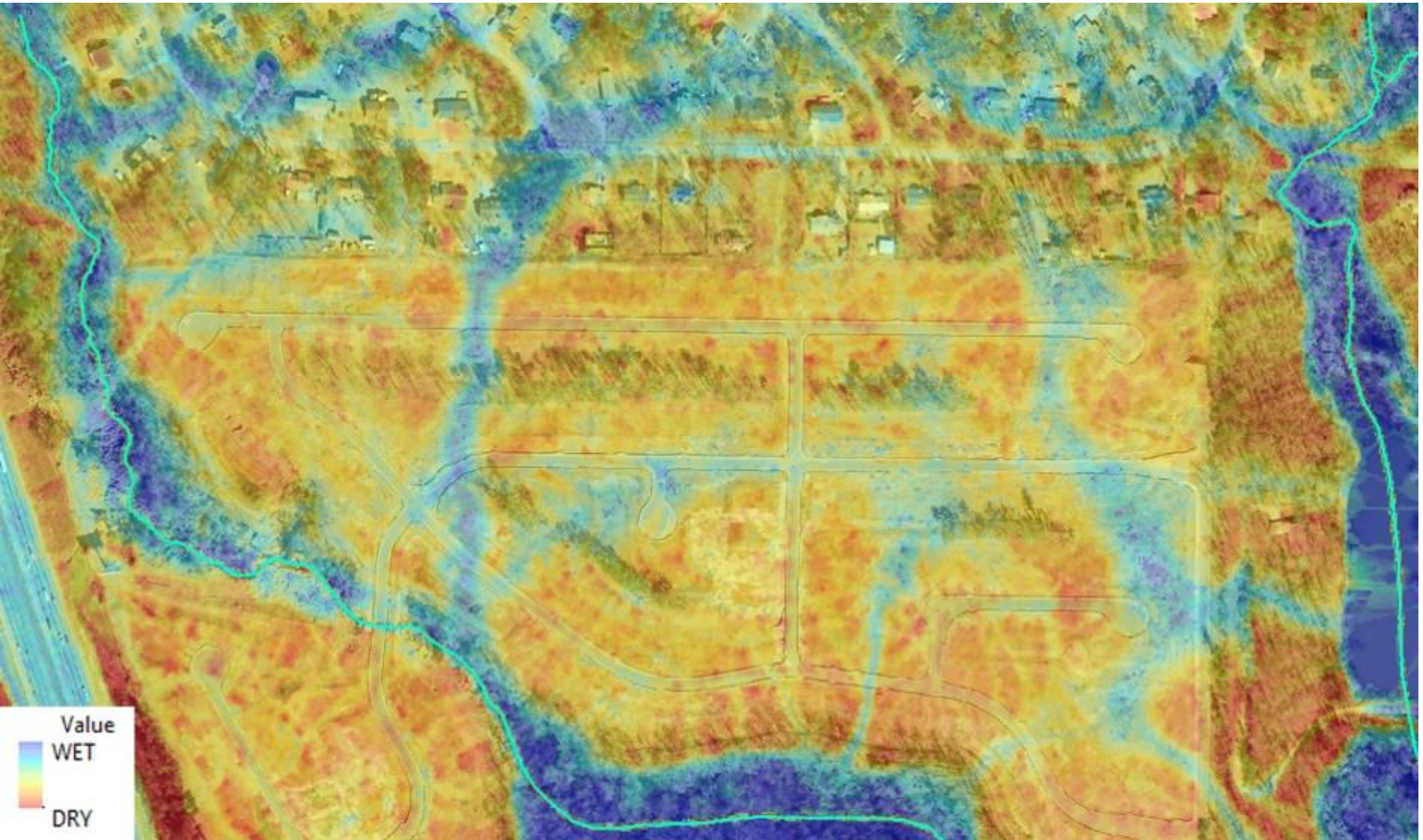
Step 1: Create the Slope Raster layer from our DEM in QGIS.

Step 2: Using the zonal statistics plugin in QGIS, we calculated the mean slope for each primary septic polygon.

Add localized GIS attribution

Add Soil Wetness Index

An important aspect of septic system functionality is the type of soil they are installed in. The NRCS soil survey data, in our opinion, is not accurate enough to use at the scale we are working in. For that reason, we decided to derive our own soil wetness index raster. Our soil wetness index does appear to give good general insight on the hydrologic conditions of the soil primarily based on landscapes alone, but it does not account for soil permeability.



Step 1: Burn Streams into the DEM

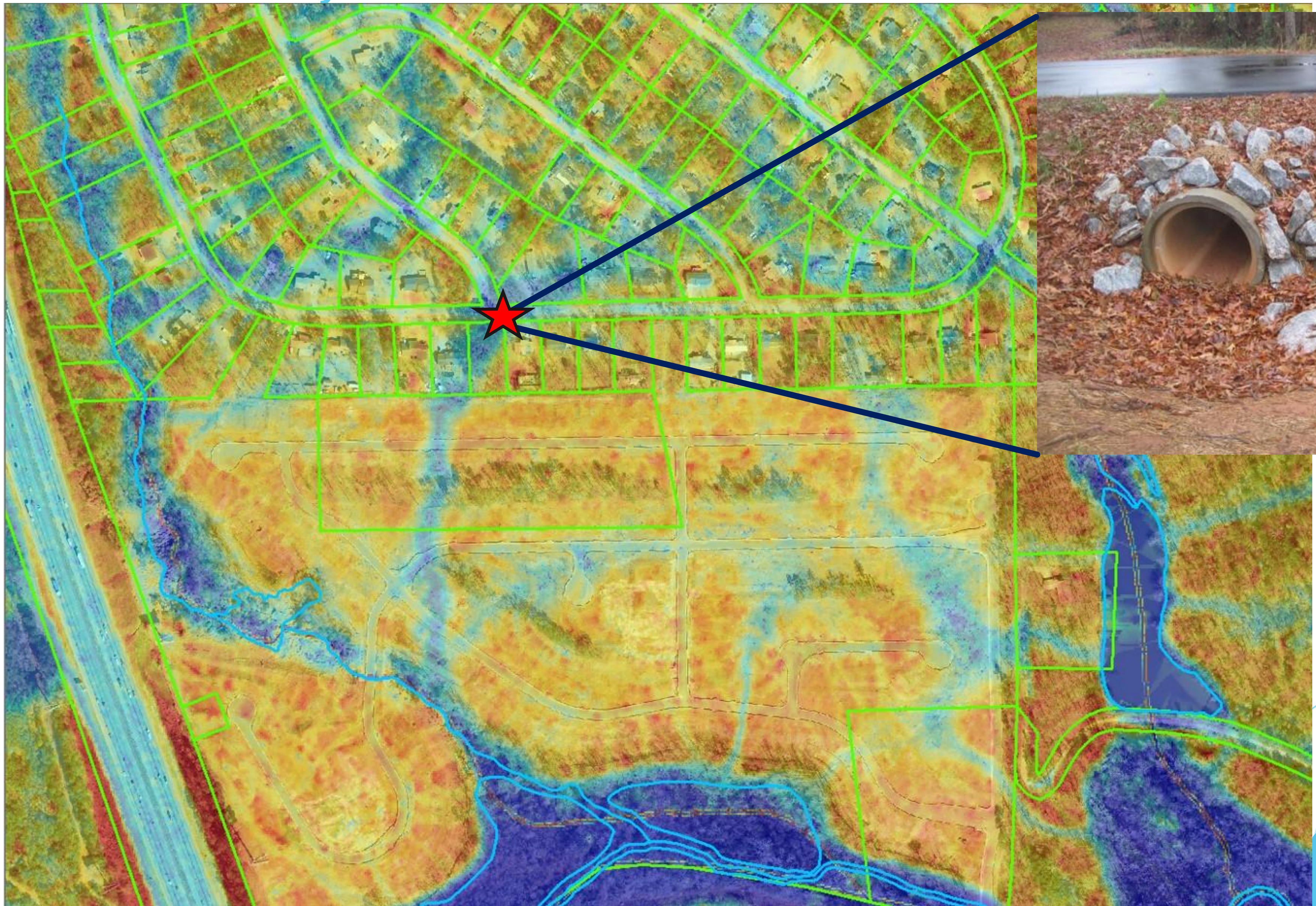
Step 2: Fill Sinks (depressions)

Step 3: Run SAGA Wetness Index

Step 4: The Wetness Index is raster data so just as we did previously for slope, we brought the Wetness Index Raster and Primary Septic polygons into QGIS. In QGIS, we ran zonal statistics which added the mean Wetness Index value for each primary septic area.

Add localized GIS attribution

NRCS Soil Survey Data VS Soil Wetness Index



Create the Rating System

SEPTIC PROJECT - WATER QUALITY RISK RATINGS	8/18/2015	
Type	**Range**	**Rating Value**
Wetness	0	0
	>0 and < 2.5	1
	>=2.5 and < 5	2
	>=5 and < 6	3
	>=6 and < 10	5
Slope	0	2
	>0 and <4	2, 4*
	>=4 and <12	2, 3*
	>=12 and <25	2, 5*
	>=25 and <120	4, 6*
		**if within 100ft of water*
Septic Age	Unknown	2
	1800 < 2000	3
	>=2000	2
Distance(ft) to Water	>=0 and <50	5
	>=50 and <100	4
	>=100 and <150	3
	>=150 and <250	2
	>250	1
Avg Monthly Water Usage (gallons)	Unknown	2
	0	1
	>0 and < 4000	2
	>=4000 and < 8000	3
	>=8000 and <14000	4
	>=14000	5
		Rating Possible Range: 6 - 24

Bldg_Year	TWI	Slope	Near	Rating	AVG_WATER
1998	4.039483	4.234708	374.8586	10	-9999
1987	2.310912	18.52184	90.55213	16	5000
2003	4.421326	9.619222	547.3007	11	8500
1993	3.15114	8.875294	260.2237	11	6916.666504
1935	4.313309	6.566809	1247.481	10	-9999
1987	4.732197	4.999356	1013.56	10	2750
1988	3.631996	8.015595	707.941	10	2083.333252
1988	3.668529	11.06487	85.8074	14	2750
1992	4.387762	5.276773	1666.912	11	6083.333496
1988	5.600504	4.748052	379.575	12	4166.666504
1985	4.145959	4.414519	864.9125	10	-9999
1943	3.216543	7.48634	349.522	10	83.333336
1993	3.887444	4.429316	417.875	11	4666.666504
1988	4.610886	3.858141	723.718	12	9000
1989	2.691376	13.16252	123.7526	12	3833.333252
1992	5.400431	3.500363	941.84	11	2916.666748
1988	3.286445	15.82384	322.7869	10	-9999

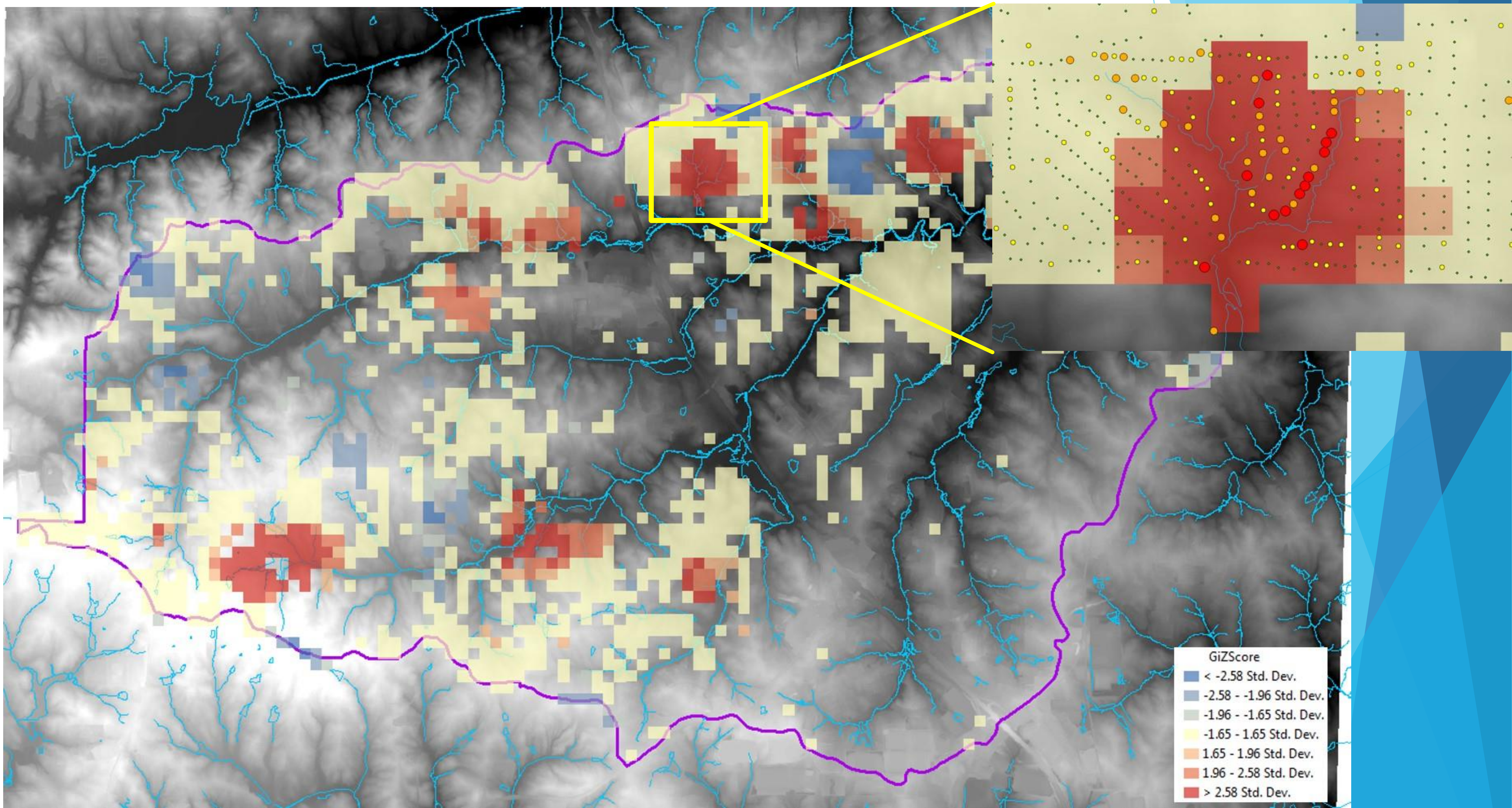
Attribute table showing sample rating data

Rating	Group	Description
6-11	1	**Low Risk**
12-13	2	**Medium Risk**
14-16	3	**High Risk**
17-24	4	**Extremely High Risk**

Group Ratings

Analyze the Results

Visual Inspection



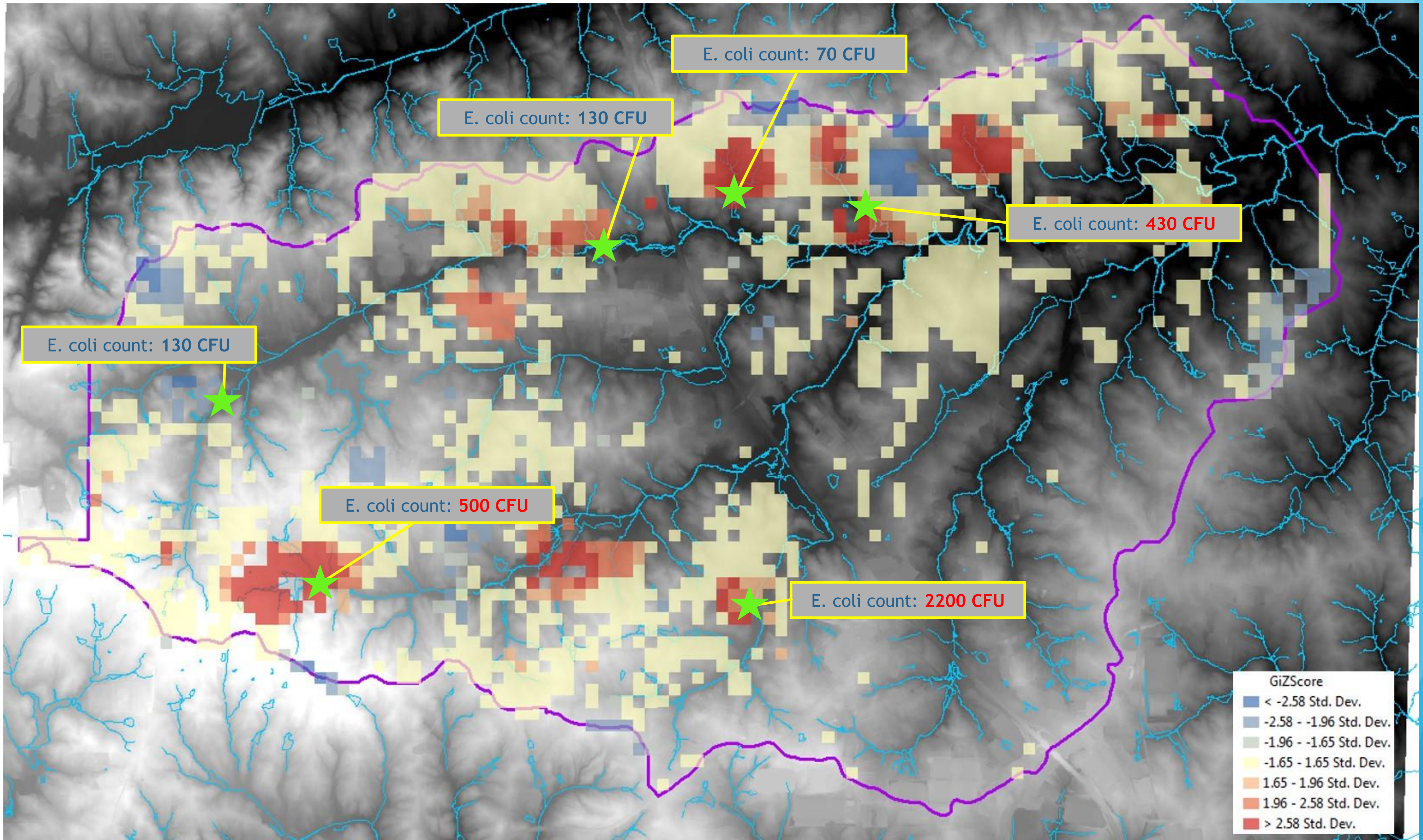
Analyze the Results

Visual Inspection

bldg_id	11131
Septic	yes
FLOOD_PLAI	NO
LAND_USE_1	S F RESIDENTIAL
MUNICIPAL	Henry County
In_City	
Bldg_Year	1996
SQ_Footage	1790.619315
TWI	2.703199
Slope	25.02524 ★
Near	24.98272 ★
Rating	20
AVG_WATER	11166.666992 ★

Analyze the Results

E. coli Contamination Analysis



Potential Use / Future Development

<u>Potential Uses</u>

- Identifying potential septic pollution sources
- Avocation of State, Federal, and other agency grant monies and assistance programs
- Prioritizing water quality monitoring and improvement initiatives

<u>Future Development</u>

- Perform same septic analysis for the remainder of the County
- Share septic information with non-GIS users by web maps for ease of access
- Identify areas of concern ahead of future development

A Special Thanks for Their Involvement and Support

Kim Tucker – HCSMD

Tiffany Hunter – HCSMD

Wade Stroud – HCSMD

Henry County Water Authority

Henry County Department of Environmental Health

QUESTIONS?

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