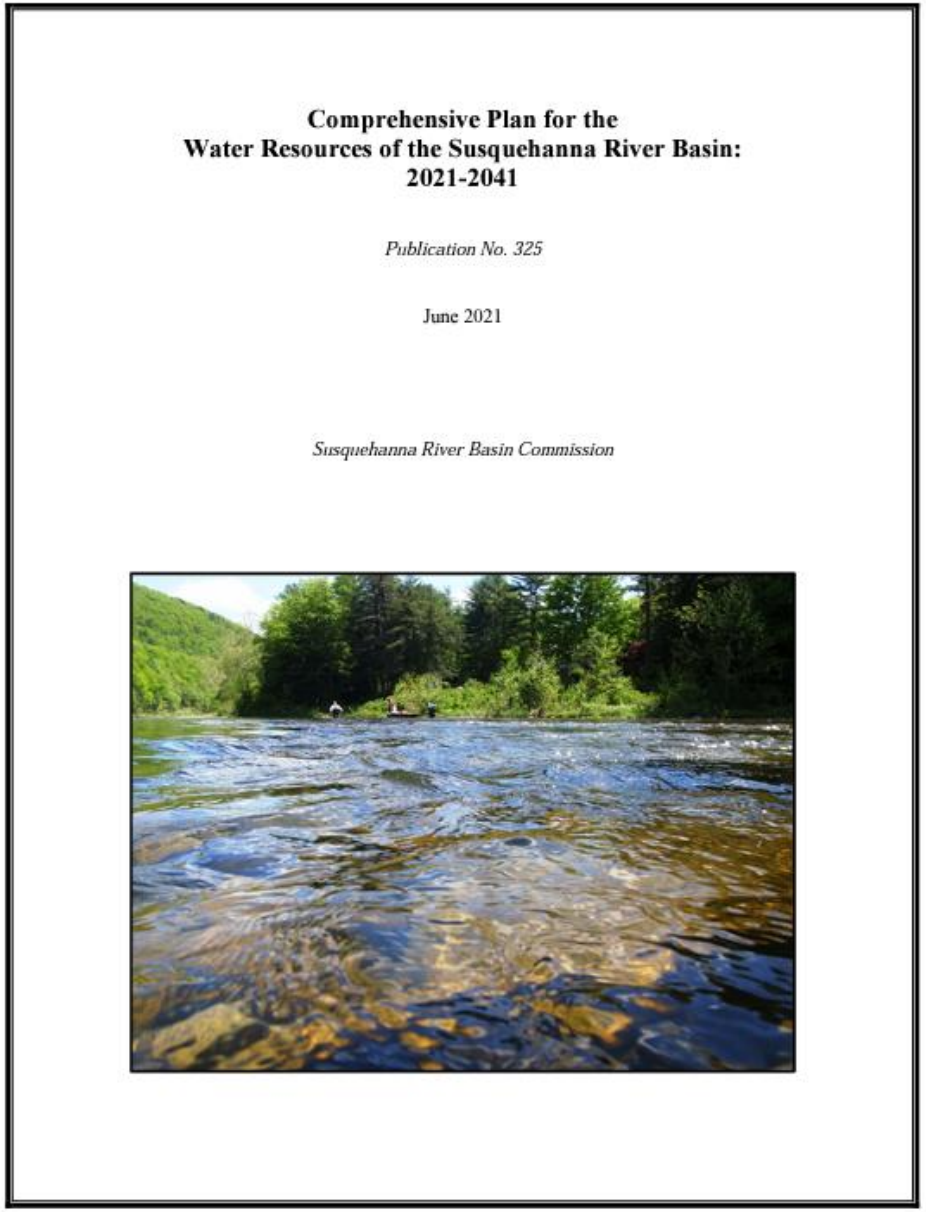
# Identifying Optimal Groundwater Recharge Locations and Critical Aquifer Recharge Areas Within the Susquehanna River Basin


Source Water Protection Partnership Presentation

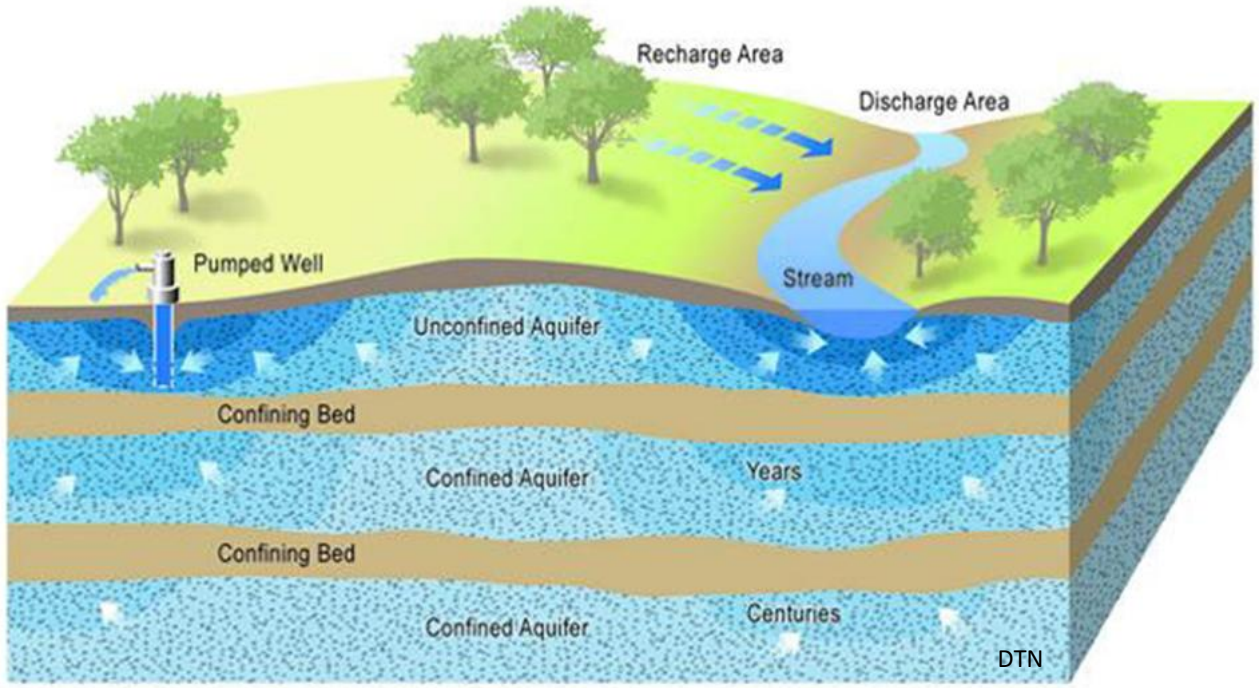
December 16, 2025

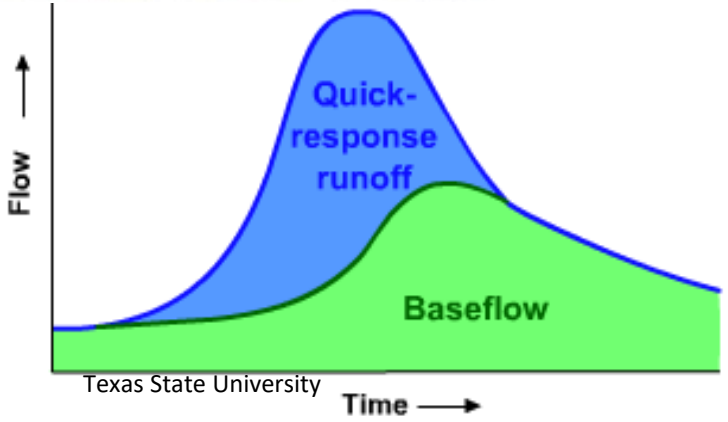
# Planning Context




- Comprehensive Plan Objective D-1
  - Protect critical aquifer recharge areas
    - Identify and promote open space and other land uses that provide for increased groundwater recharge to enhance the resiliency of water supply, stream baseflow, and water temperatures.

# Definitions




Texas State University

- <u>Recharge:</u> *the addition of water from the land surface to underground water-bearing zones*
  - Typically from precipitation but could also be artificial
- <u>Baseflow:</u> *non-runoff portion of streamflow sustained by groundwater*
  - Often used as an approximation of recharge
  - Can be measured / estimated using hydrograph separation techniques

# Why is Preserving Recharge/Baseflow Important?

- Water quality benefits
  - more infiltration/filtering and less runoff, erosion, sediment (phosphorus)
- Increased recharge = increased baseflow
  - cold-water contributions from groundwater/springs
  - Provides thermal refuge and sustained habitat (wetted area & depth) for cold-water species during hot/dry periods
- Increased drought resiliency
  - Ensures water is available in aquifers and streams for water supply

# Study Goal(s)

- Develop a Geographic Information Systems (GIS) framework to identify areas of greater and lesser recharge potential throughout the basin

- Use the framework to delineate **Critical Aquifer Recharge Areas**
  - I.E. land surface areas that are responsible for a large fraction of recharge

# Recharge Potential vs. Recharge (rates)

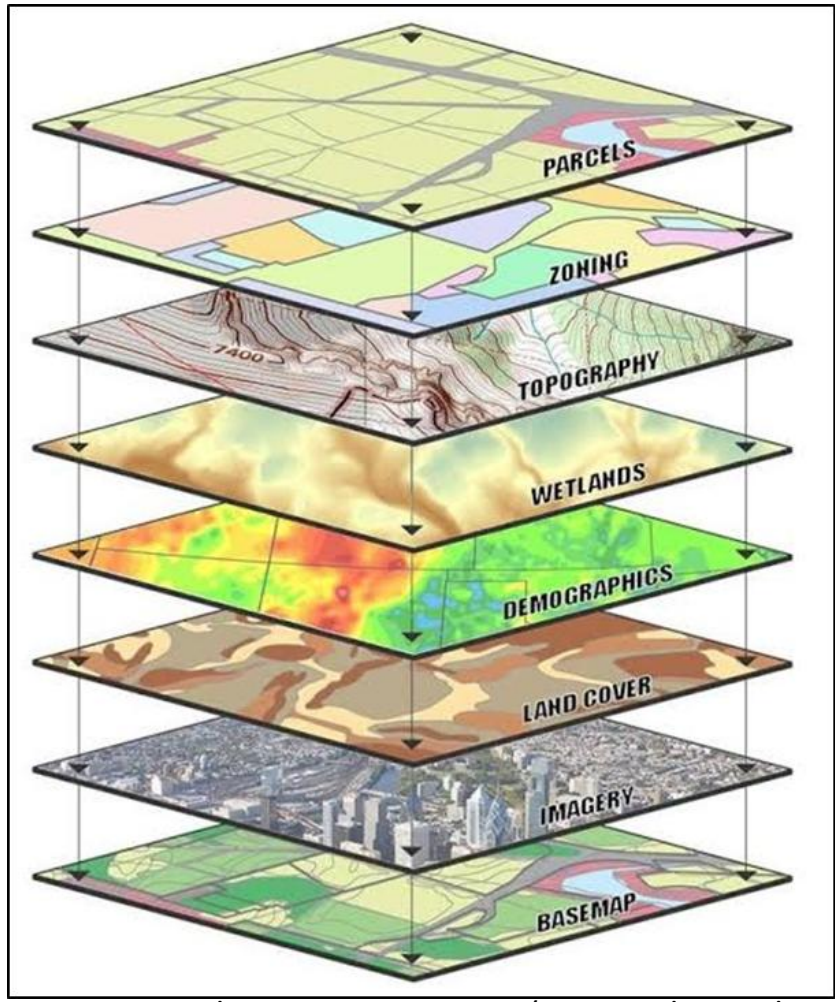
- Recharge Potential
  - The **likelihood** of any land surface area accepting or limiting infiltration, regardless of available precipitation
    - Assessed relative to surrounding areas within user-defined area
- Recharge (rates)
  - The **amount** of water reaching underground water-bearing zones over a period of time (i.e. inches per year)
  - Ranges from 25.6 to 2.5 in/yr, on average, Basin-wide
  - Largely dependent upon climatic factors (precipitation and evapotranspiration)

# What influences Groundwater Recharge?

- Excluding precipitation and evapotranspiration, recharge in the Susquehanna Basin is primarily governed by:
  - Land Cover / Impervious Area
  - Land Surface Slope/Topography
  - Sand and Clay Content in Soils
  - Depth to Bedrock (Soil Thickness)
  - Drainage Density
  - Karst Features
  - Faults / Fractures
- Criteria informed by physical basin characteristics used in regional regression equations to predict baseflow (recharge) in ungaged locations

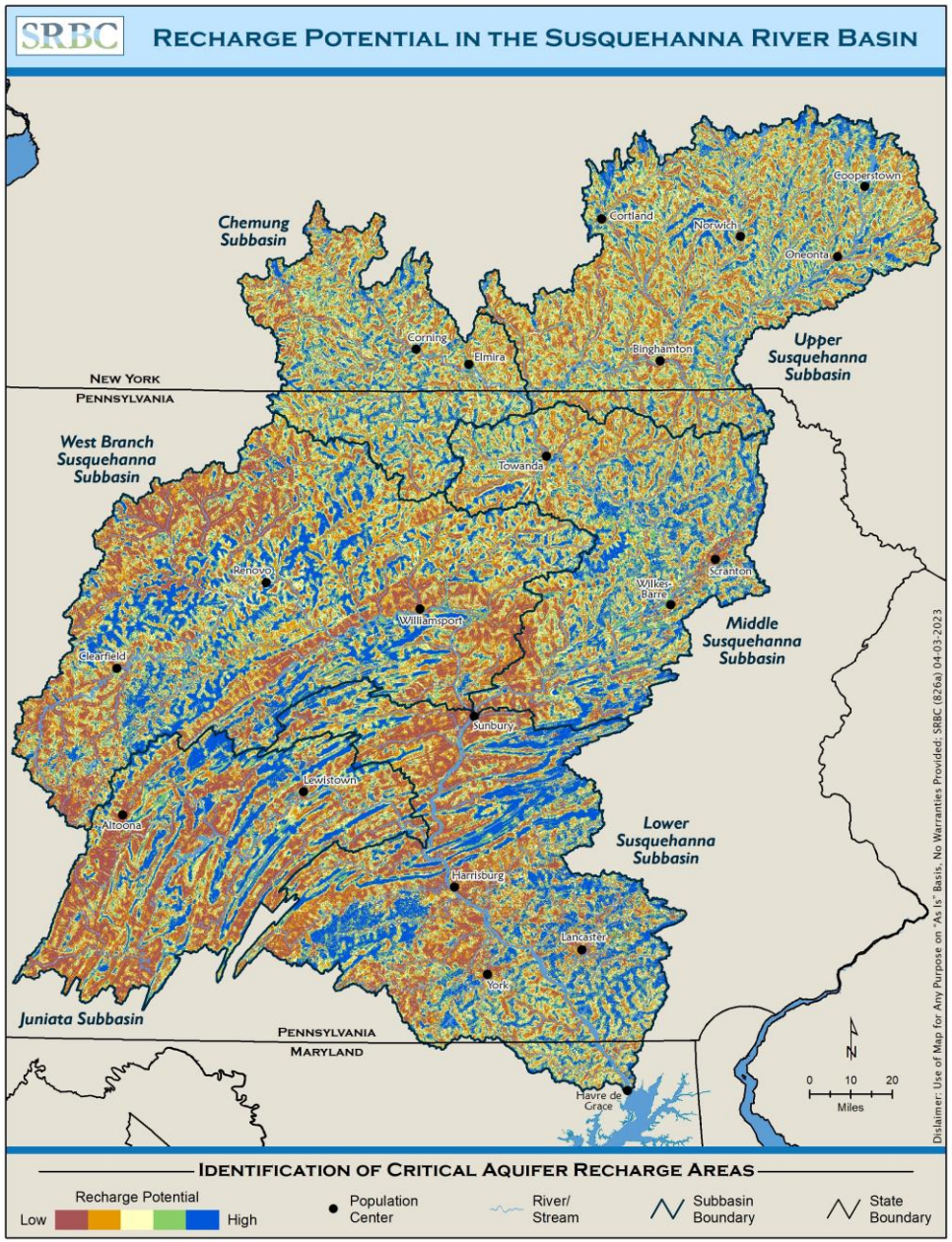
# GIS Framework: Multi-Criteria Decision Analysis

- Each data layer's (raster) cell/pixel (standardized) value is multiplied by the weight or "percent influence"
- Values are summed for each overlapping cell/pixel for a composite output/index
  - I.E. "recharge potential"




Multi-Criteria Decision Analysis Representation (Ryan and Nimick, 2019)

- Each pixel has a recharge potential index value ranging from 100 (low) to 500 (high)

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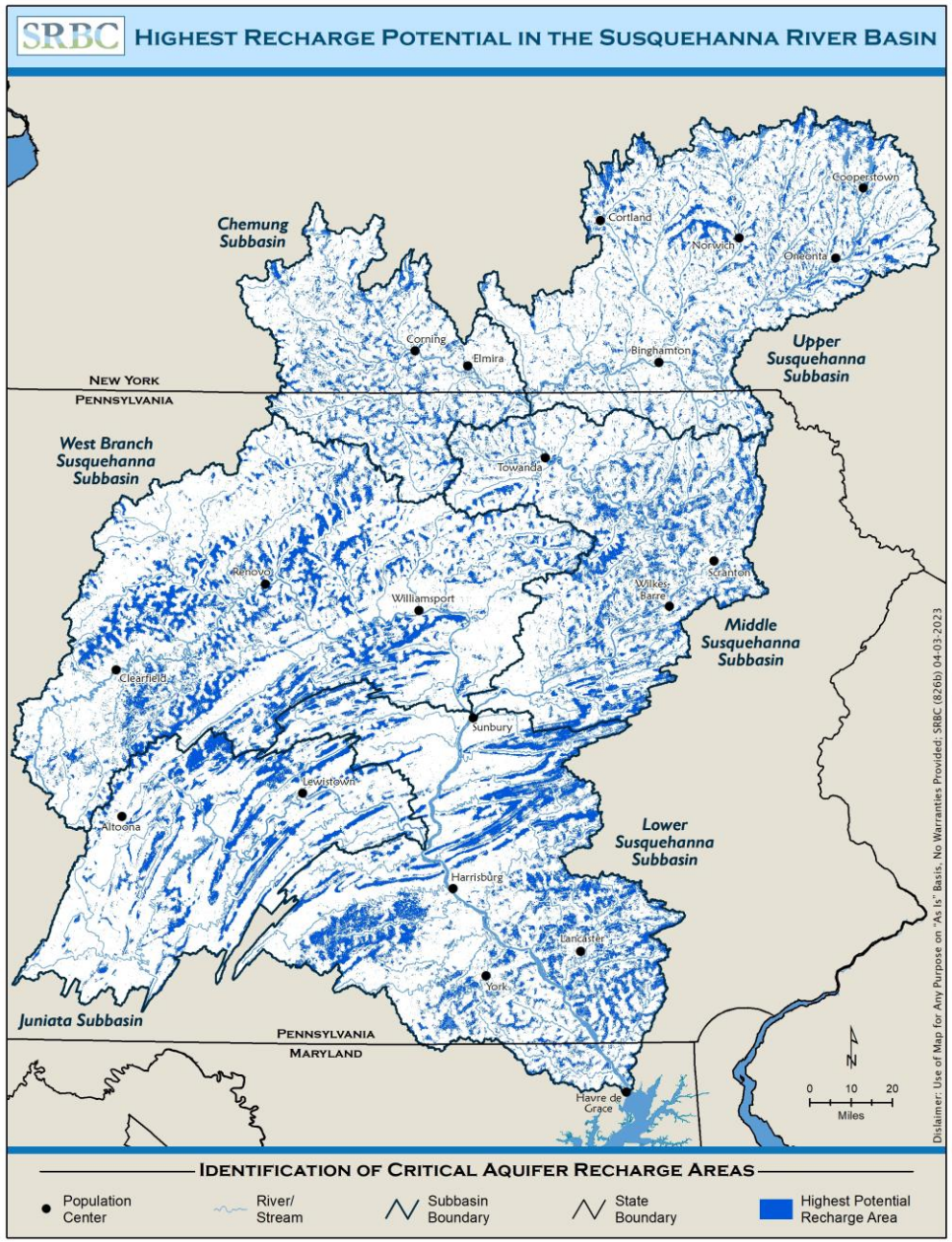
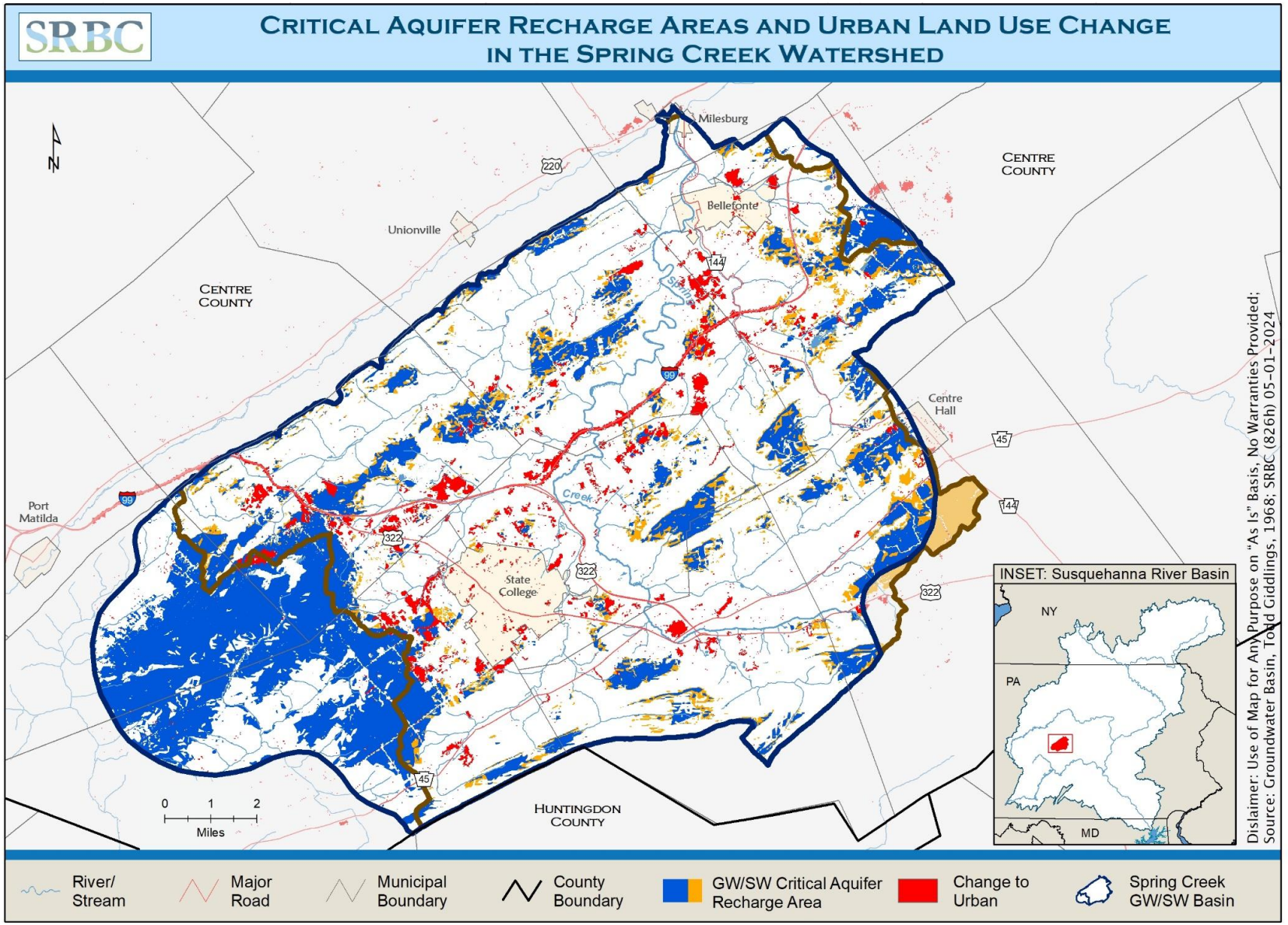
- Highest recharge potential described by upper 20% of pixel values.



# Local Applications: Critical Aquifer Recharge Area (CARA) Delineation

- Resampling in smaller user-defined areas where water supply has become more-limited amid development and increasing impervious cover
- Results are relative to all areas/characteristics within boundary
- Identify highest recharge potential in areas with otherwise limited, or increased recharge potential

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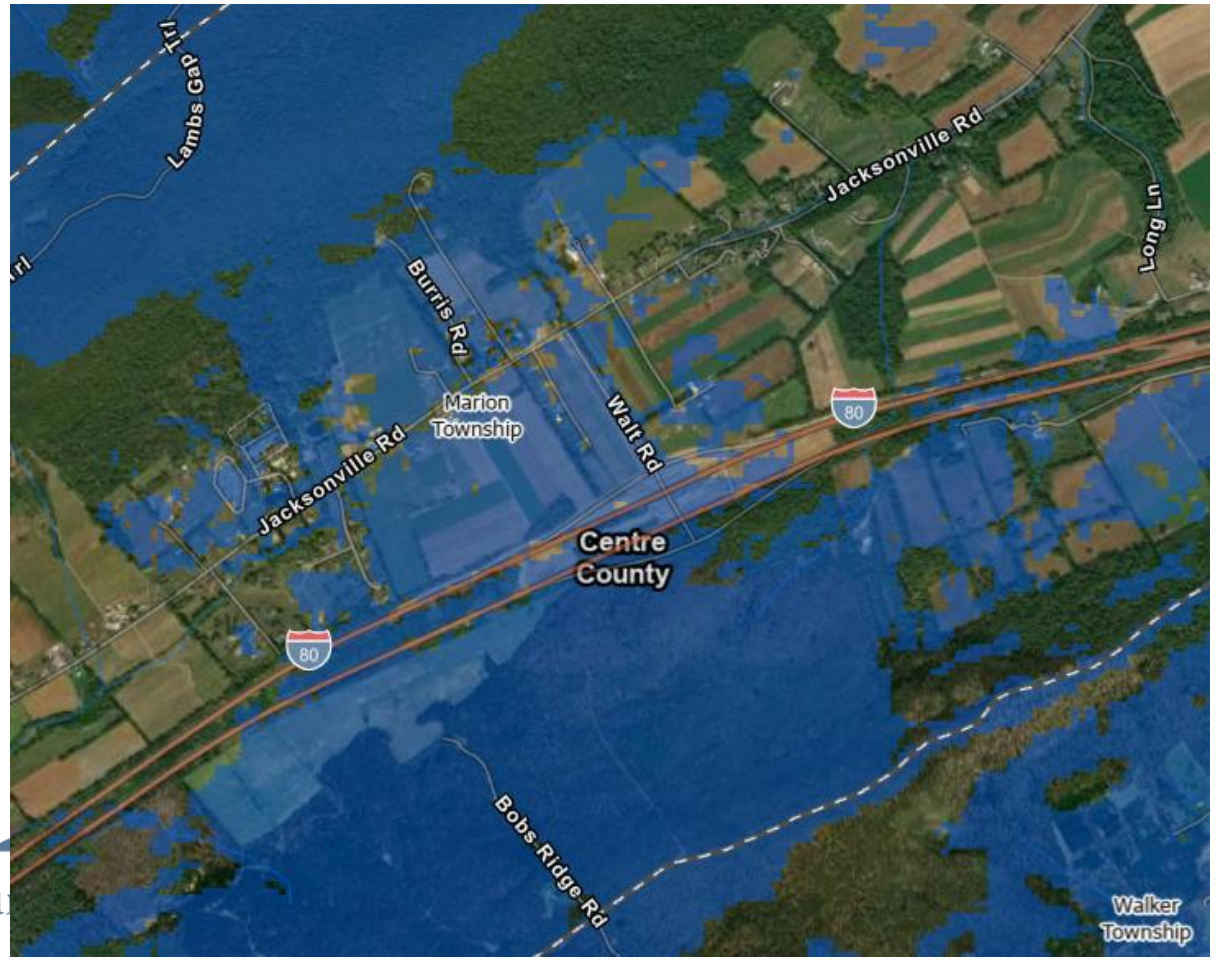
# Use Cases: Centre County

- Centre Region Planning Agency – CARA Integration into (updated) Future Land Use Map
  - Used to inform "growth"


- Centre County Planning – informing local zoning/land-use decisions
  - Proposed re-zoning from agriculture to commercial for local access (I-80) interchange

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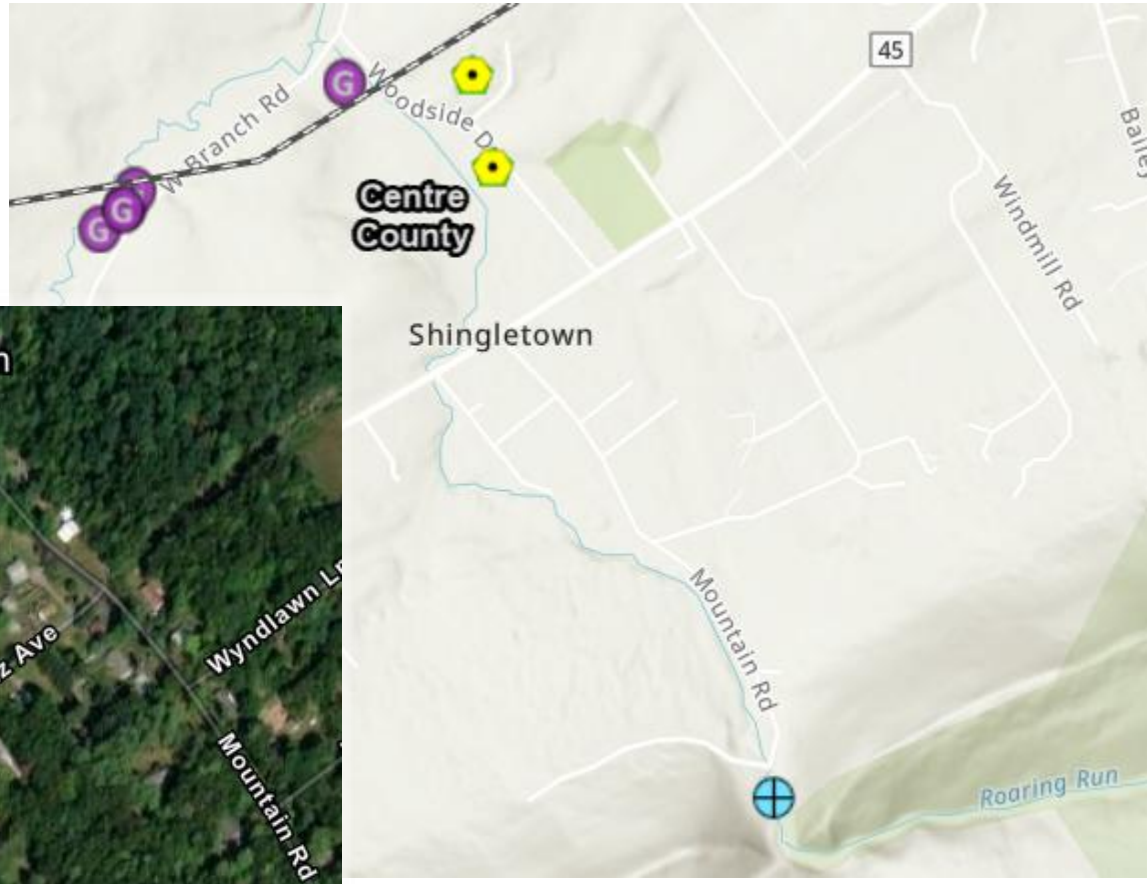
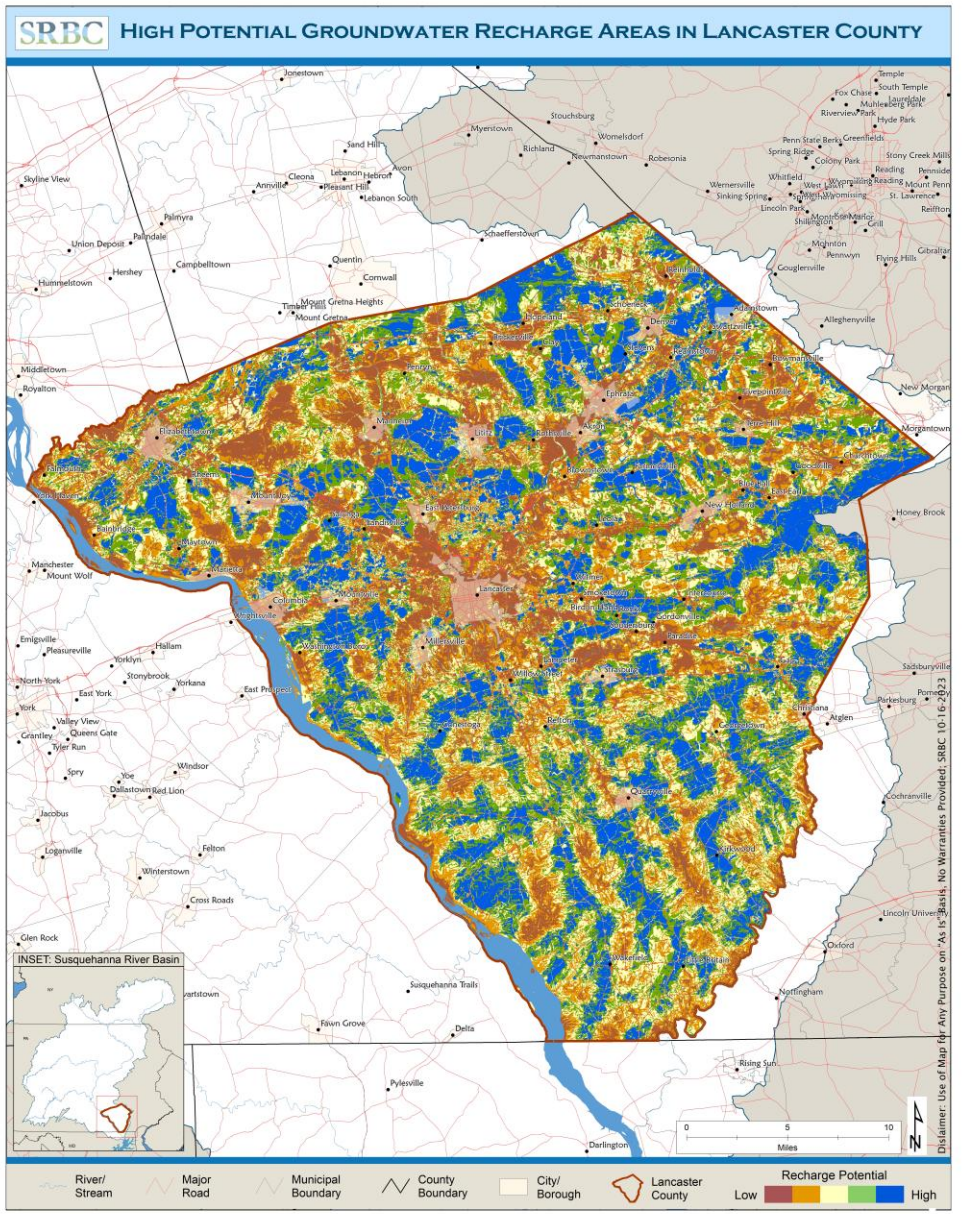
# Use Cases: Hess Farm, Spring Creek Watershed

- Prioritizing purchasing/acquisition of conservation easements

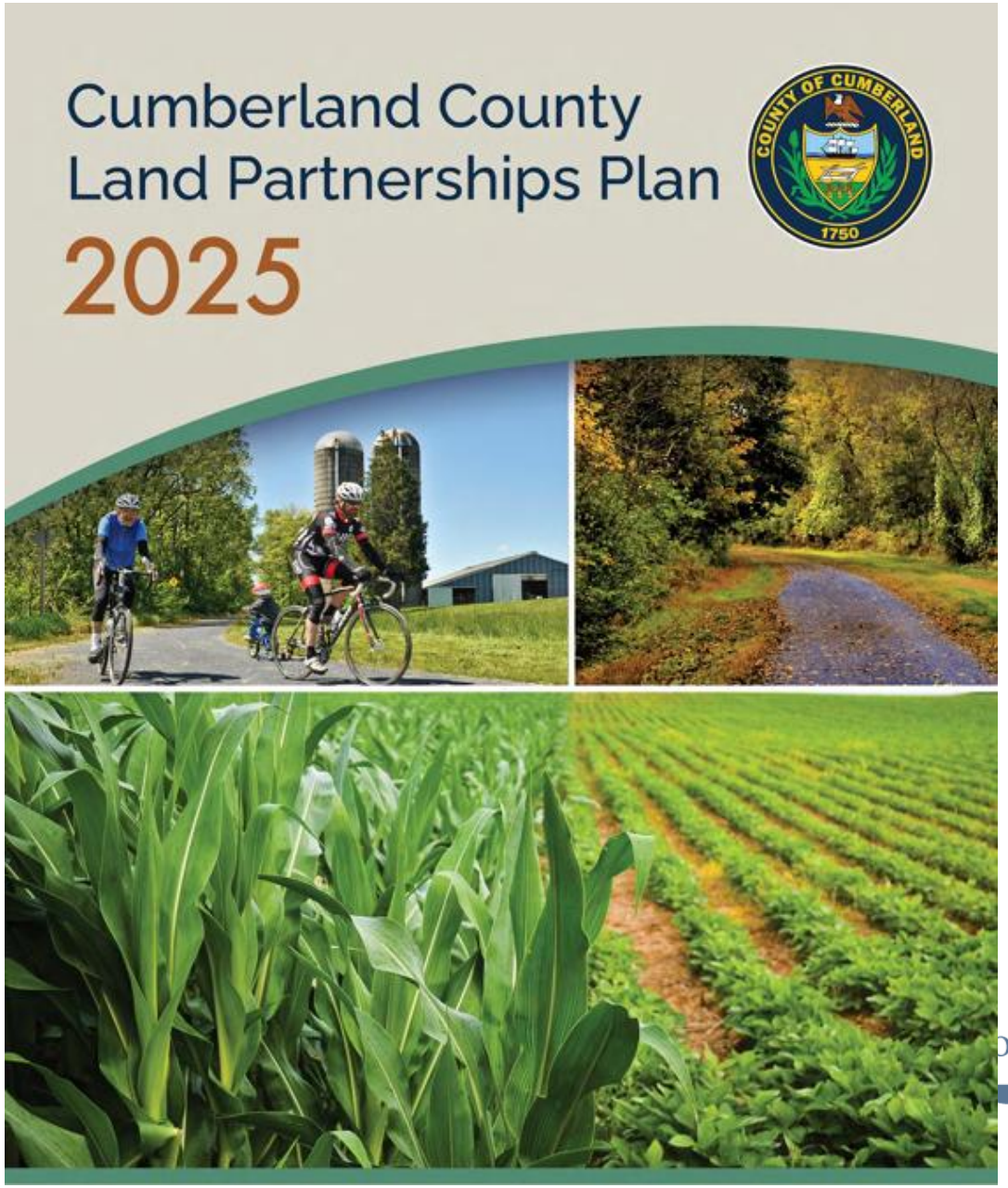



# Use Cases: Lancaster County

- Lancaster County Agricultural Preserve Board
  - Prioritization of easements
- Little Conestoga Integrated Water Resource Management Study
  - Identification of:
    - Large Parcels for CARA conservation
    - Aquifer/stormwater recharge enhancement projects



# Use Cases: Cumberland County




- **Strategy 4: Preserve the County's Critical Aquifer Recharge Areas**
  - Identify priority recharge areas with SRBC and pursue preservation funding
  - Develop model ordinances to guide land use
  - Integrate CARA into Agriculture Conservation Easement Purchase Program
  - Educate municipalities and residents on recharge area protection

# Product Availability

- Datasets available for download at the Pennsylvania Spatial Data Access (PASDA) geospatial data portal
  - Groundwater Recharge Potential
  - Highest Groundwater Recharge Potential Areas
- Additional information available on the Commission's website
  - Preview layers on the Susquehanna Atlas
- If a local assessment of recharge potential in any region, county, watershed, or other scale is desired, a request can be made through the Commission's website

# Identifying Optimal Groundwater Recharge Locations and Critical Aquifer Recharge Areas Within the Susquehanna River Basin

# Questions


Graham Markowitz, PG
Hydrologist
4423 North Front Street
Harrisburg, PA 17110
gmarkowitz@srbc.gov
717.238.0423 ext. 1218

Pierre MaCoy, PG
Hydrogeologist
4423 North Front Street
Harrisburg, PA 17110
pmacoy@srbc.gov
717.238.0423 ext. 1230

# Variables Used in Assessing Recharge Potential

Informed by physical basin characteristics used in regional regression equations to predict baseflow (recharge) in ungaged watersheds

Requirements:

- Geospatial coverage for the entire basin
- Data accessible without site visit, or proprietary information
- Consistent spatial scale (30x30 m) fine enough to identify discrete areas

| First-Level Factors | Weight | Second-Level Factors | Weight | Data Source |
|---|---|---|---|---|
| Land Cover / Terrain | 40 | Impervious Area | 25 | USGS (2019) National Land Cover Dataset |
| | | Land Surface Slope | 15 | USDA NRCS SSURGO Database |
| Shallow-Subsurface Geology | 20 | Percent Sand | 15 | USDA NRCS SSURGO Database |
| | | Percent Clay | 2.5 | USDA NRCS SSURGO Database |
| | | Depth to Bedrock | 2.5 | USDA NRCS SSURGO Database |
| Structural / Bedrock Geology | 40 | Drainage Density | 25 | SRBC calculated from USGS (2019) National Hydrology Dataset (NHD) |
| | | Karst Density | 10 | DCNR-PGS (2003) Density of Mapped Karst Features |
| | | Fault Density | 5 | Isachsen and McKendree (1977); Berg and others (1980) |

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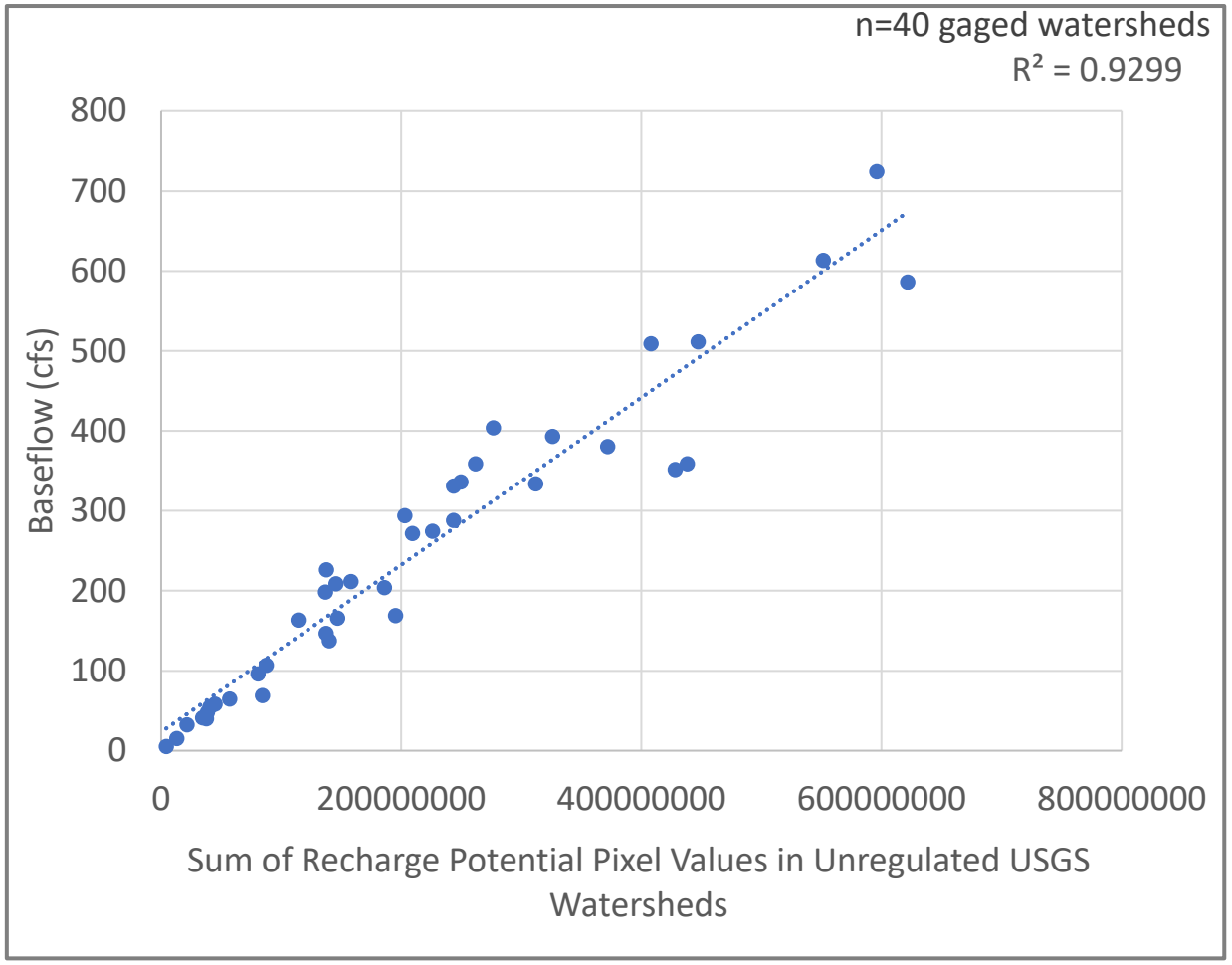
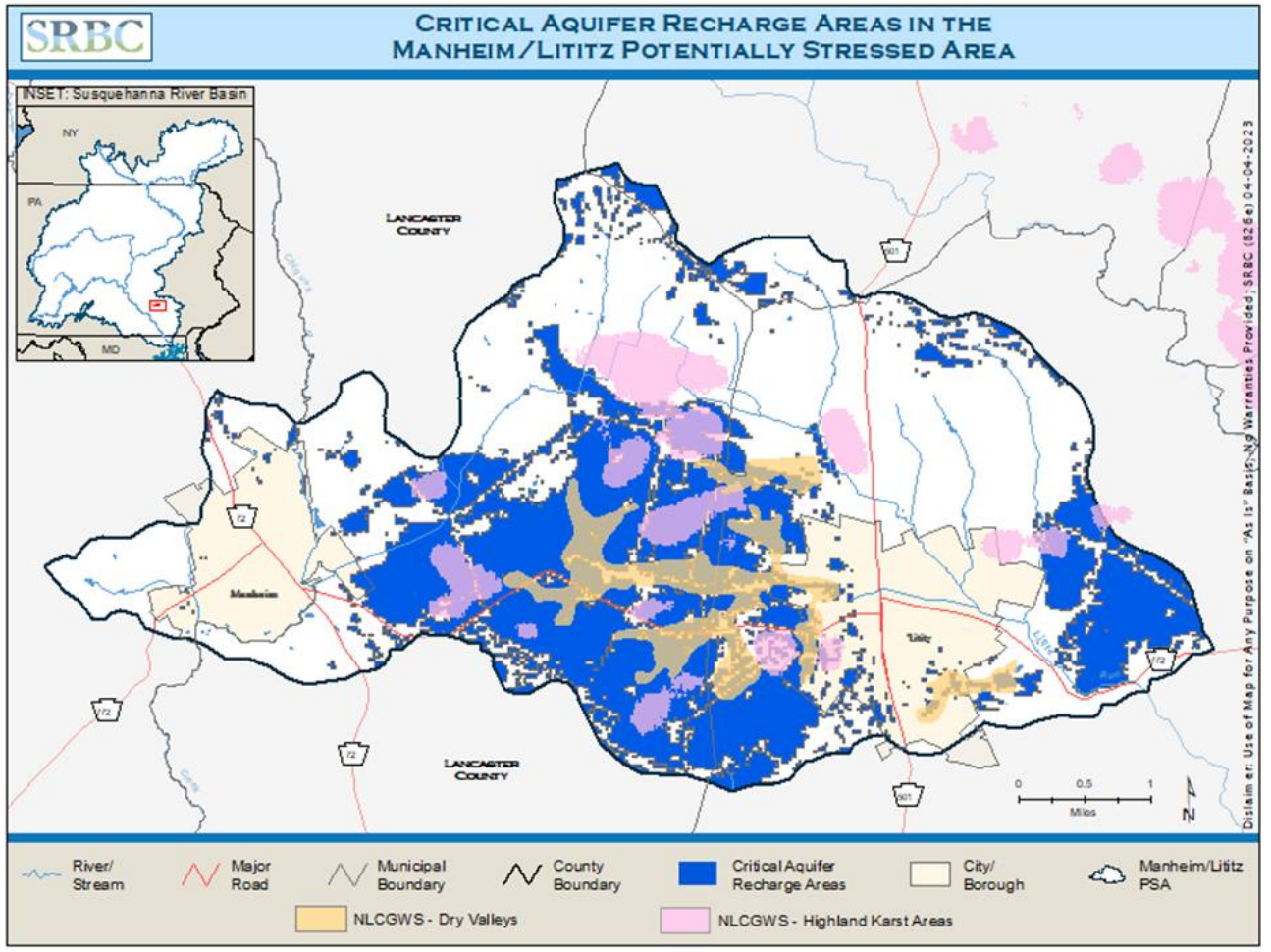
# Desktop Verification

- The sum of all "recharge potential" pixels within a watershed can predict average annual baseflow (recharge) within 19.7% (average standard error)
- Comparison of High Recharge Potential Areas and Critical Aquifer Recharge Areas Identified in Northern Lancaster Groundwater Study (Edwards and Pody, 2005)



# Use Cases: Rock Lititz, Lancaster County

- Leveraging/enhancing dry stream valleys for stormwater infiltration
  - Alternative BMP for NPDES permitting - Stormwater Discharges Associated with Construction