Nanticoke River Watershed Water Quality Study

Presented by
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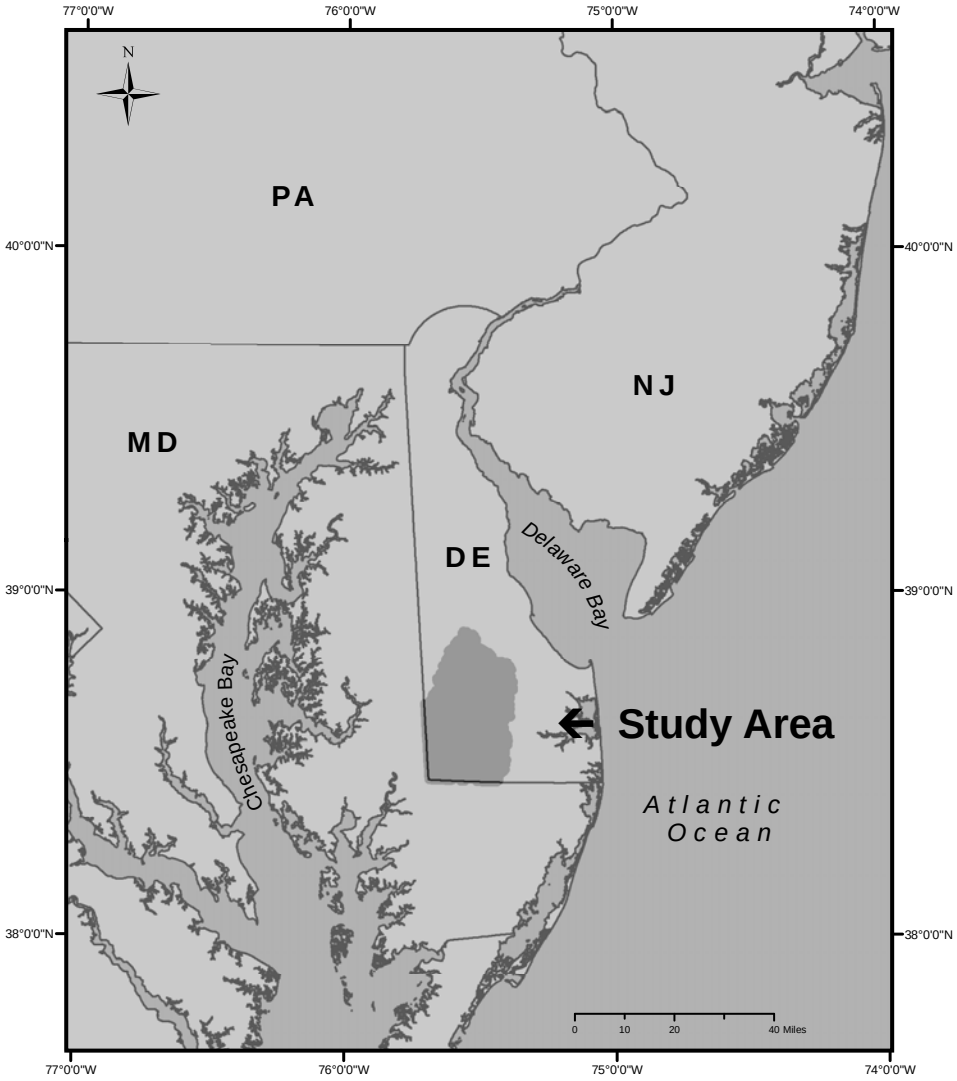
Department of Natural Resources and Environmental Control
Division of Water

CTAC Meeting May 1, 2013

Study Area


77°0'0"W
76°0'0"W
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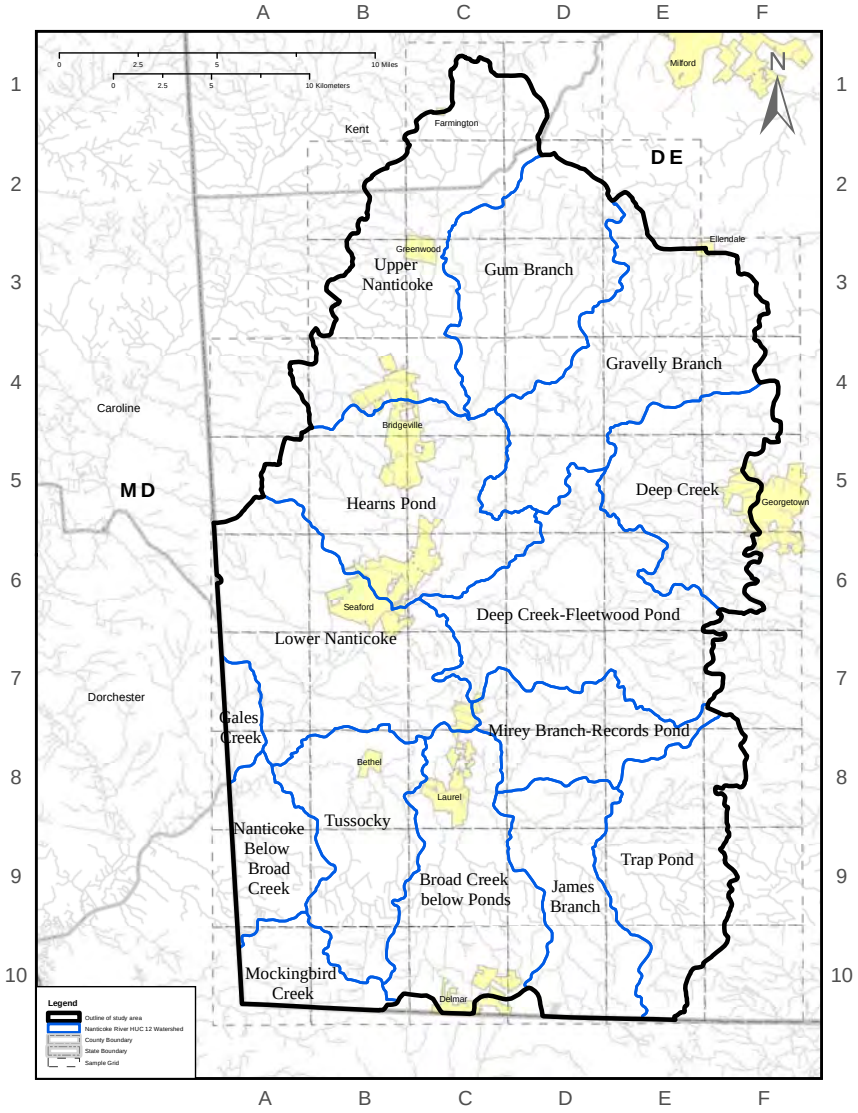
N
PA
NJ
MD
DE
Delaware Bay
Chesapeake Bay
Study Area
Atlantic Ocean
0 10 20 40 Miles


A B C D E F
1 2 3 4 5 6 7 8 9 10
N
DE
MD
Kent
Farmington
Milford
Ellendale
Greenwood
Caroline
Bridgeville
Georgetown
Seaford
Dorchester
Bethel
Laurel
Delmar
Upper Nanticoke
Gum Branch
Gravelly Branch
Hearns Pond
Deep Creek
Deep Creek-Fleetwood Pond
Lower Nanticoke
Gales Creek
Mirey Branch-Records Pond
Tussocky
Nanticoke Below Broad Creek
Broad Creek below Ponds
James Branch
Trap Pond
Mockingbird Creek
Legend
Outline of study area
Nanticoke River HUC 12 Watershed
County Boundary
State Boundary
Sample Grid

Purpose of the Study

- Executive Order 13508, issued in 2009
- Total Maximum Daily Load for Nanticoke requires Nitrogen reduction by 30%, Phosphorus reduction by 50% (WIP)
- Lack of regional water quality studies in the area
- Primary source of drinking water within the watershed
- Groundwater comprises 75% to 80% water in streams (Andres, 1994; Johnston, 1974)

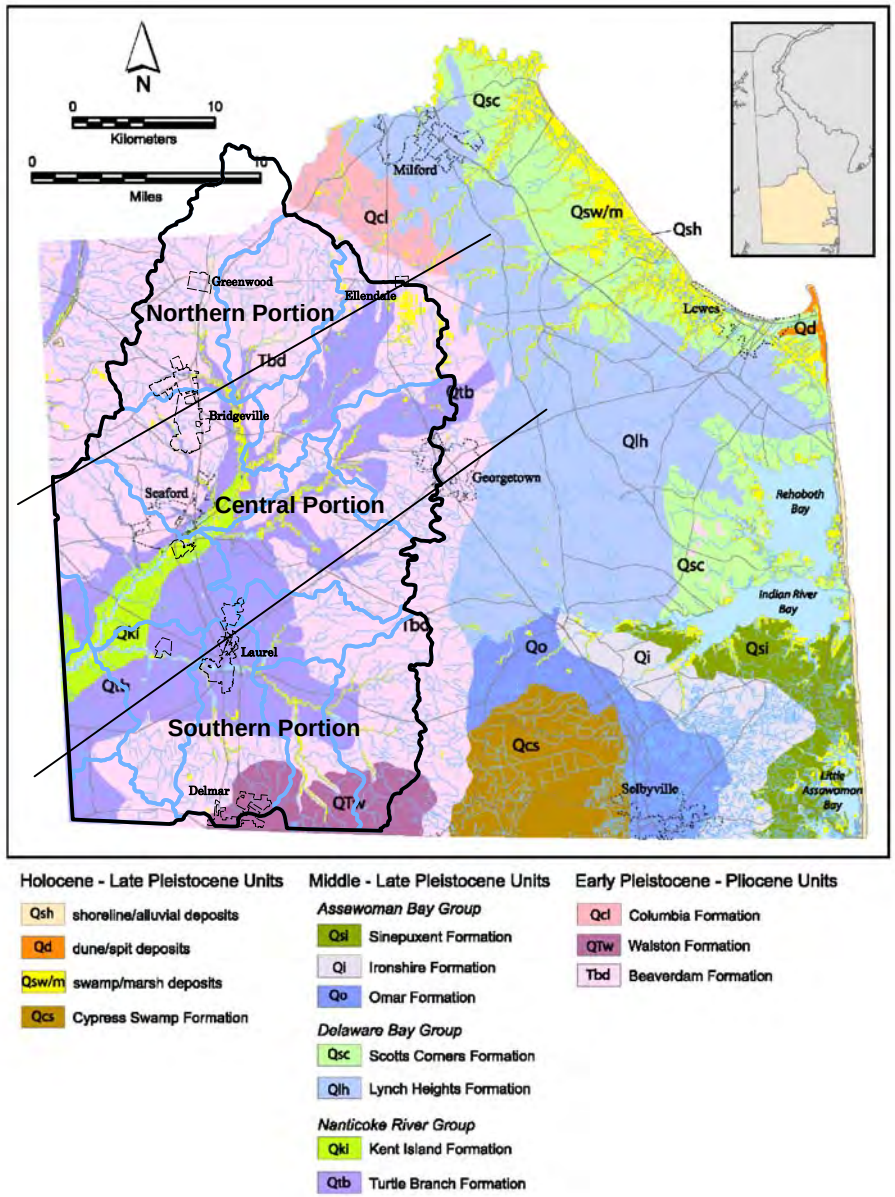
Geology

The Nanticoke Watershed Occurs within the Atlantic Coastal Plain Physiographic Province

Coastal Plain sediments attain a thickness greater than 5000’ in the study area

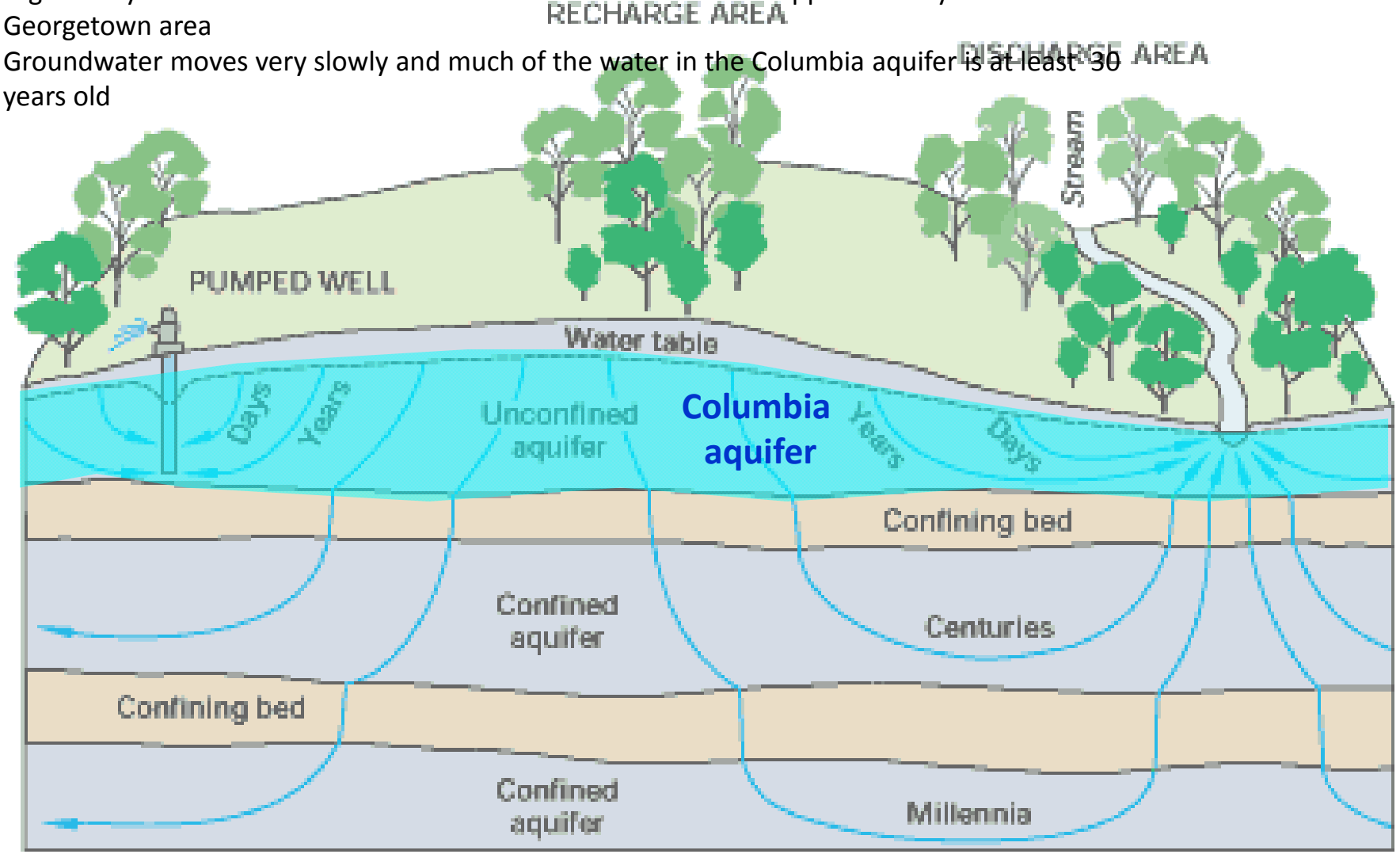
Only the upper surficial units within about 200’ of the ground surface are important in the frame work and composition for the Columbia aquifer

- Major Formations (Fm.) comprising the sandy portions of the Columbia aquifer
  - Beaverdam Fm.
  - Cat Hill Fm. (Unit B)
- Major Fms. comprising the basal confinning layers of the Columbia aq.
  - Bethany Fm.
  - Cat Hill Fm. (Unit A)
  - St Marys Fm.
- Local Confining Units
  - Nanticoke Group deposits
  - Walston (Silt) Fm.
  - Local silt and clay beds in the Beaverdam Fm.



General Hydrogeology

- Groundwater in the Columbia aquifer supplies most of the water found in non-tidal streams and is the primary source of drinking water for residents in the watershed
- The Columbia aquifer is generally unconfined but is locally confined in many locations.
- Is highly susceptible to contaminants introduced at the ground surface.
- Is generally thicker than 75’ and attains a maximum thickness of approximately 150’ in the Georgetown area
- Groundwater moves very slowly and much of the water in the Columbia aquifer is at least 30 years old



Source: Fig. 3 of USGS Circular 1139

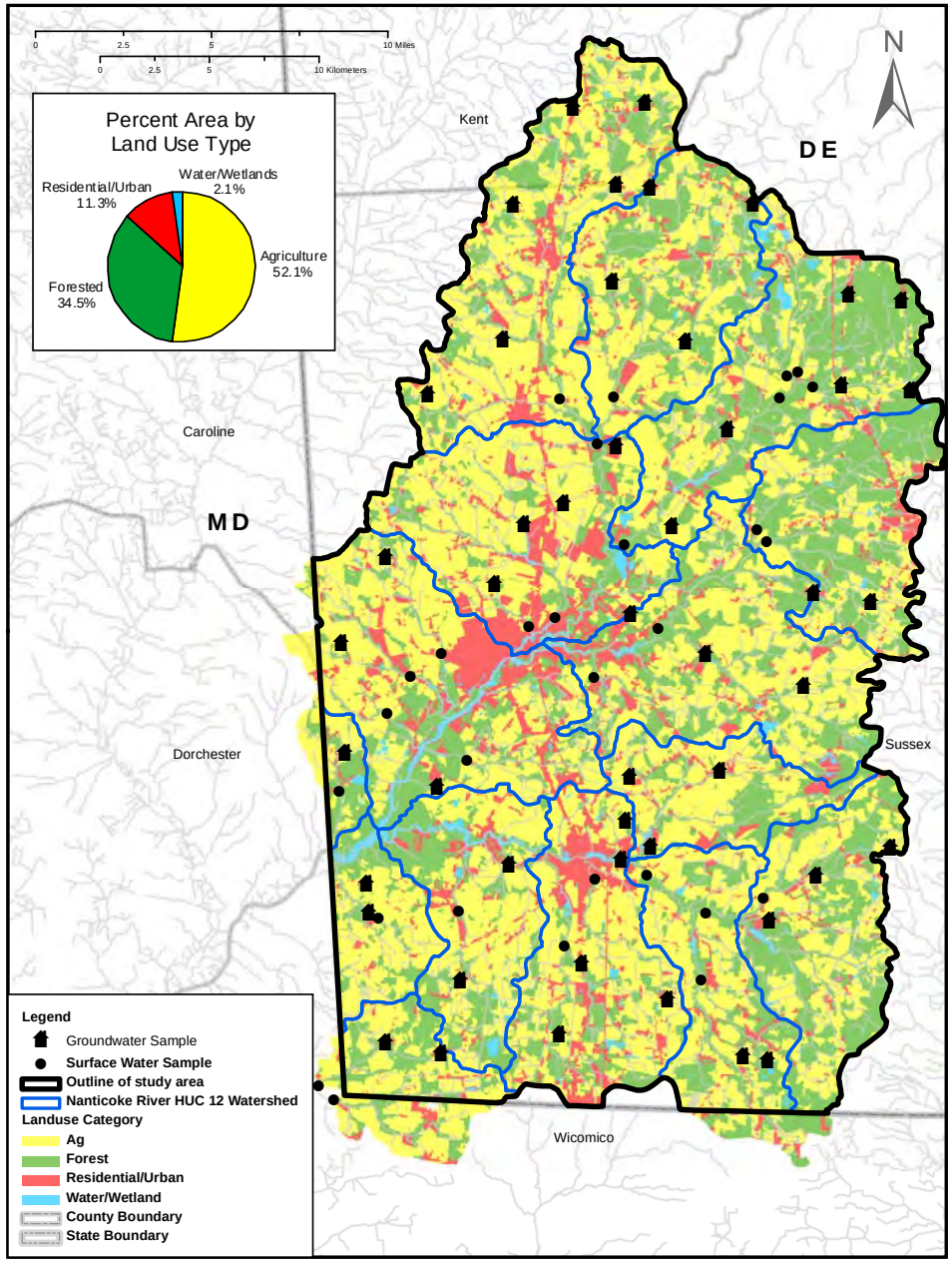
Land Use in the Watershed

Agriculture – 52%

Forested – 35%

Residential/ Urban – 11%

Water/Wetlands – 2%



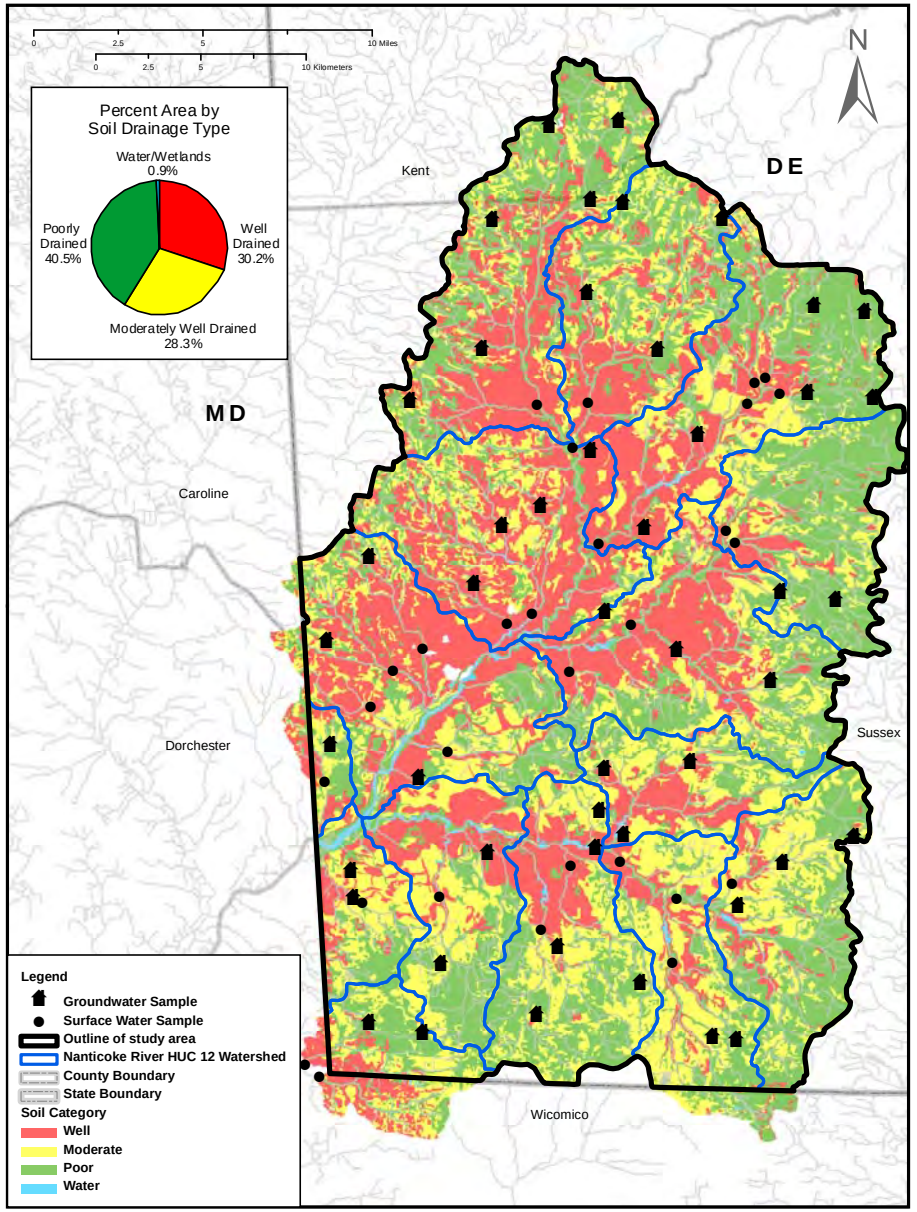
Soil Drainage Across the Watershed

Well Drained – redoximorphic (redox) features >40 inches – 30%

Moderatley Well Drained – redox features 20 to 40 inches – 28%

Poorly Drained – redox features <20 inches – 41%

Water – 1%



Sampling Methodology

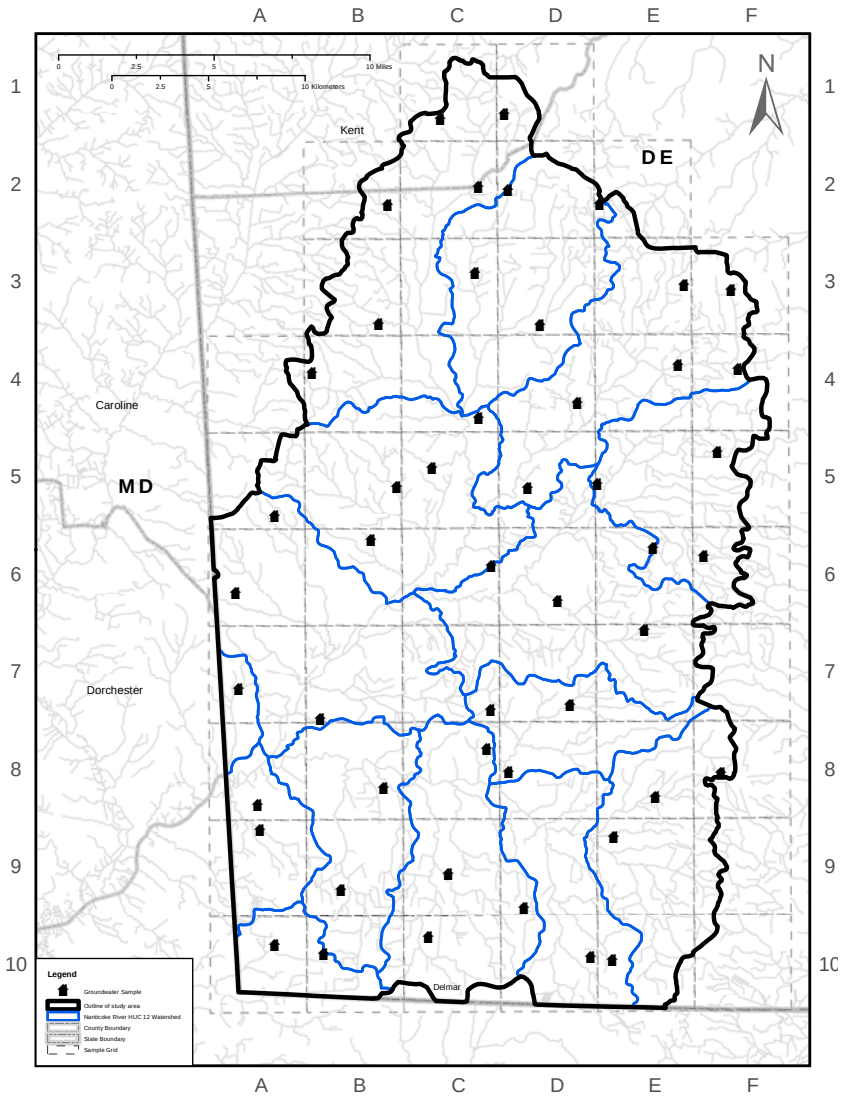
- Groundwater Sampling
  - Collected 50 groundwater samples
- Surface Water Sampling
  - Collected Stream samples at 30 sites
  - Sampling was completed during high baseflow conditions
  - 6 sites resampled during low baseflow conditions
- Special Study Areas
  - Poorly Drained Forested
  - Poorly Drained Agriculture
  - Well Drained Residential
  - Well Drained Agriculture

Sample Methodology

- Field Parameters
  - Temperature
  - pH
  - Specific Conductance
  - Dissolved Oxygen
  - Discharge (Surface Water only)
- Nutrients
  - Nitrate/Nitrite as N
  - Ammonia as N
  - Phosphorus
- Sampled for major ions and anions
  - Calcium
  - Iron
  - Magnesium
  - Potassium
  - Sodium
  - Chloride
  - Sulfate
  - Silica
  - Alkalinity

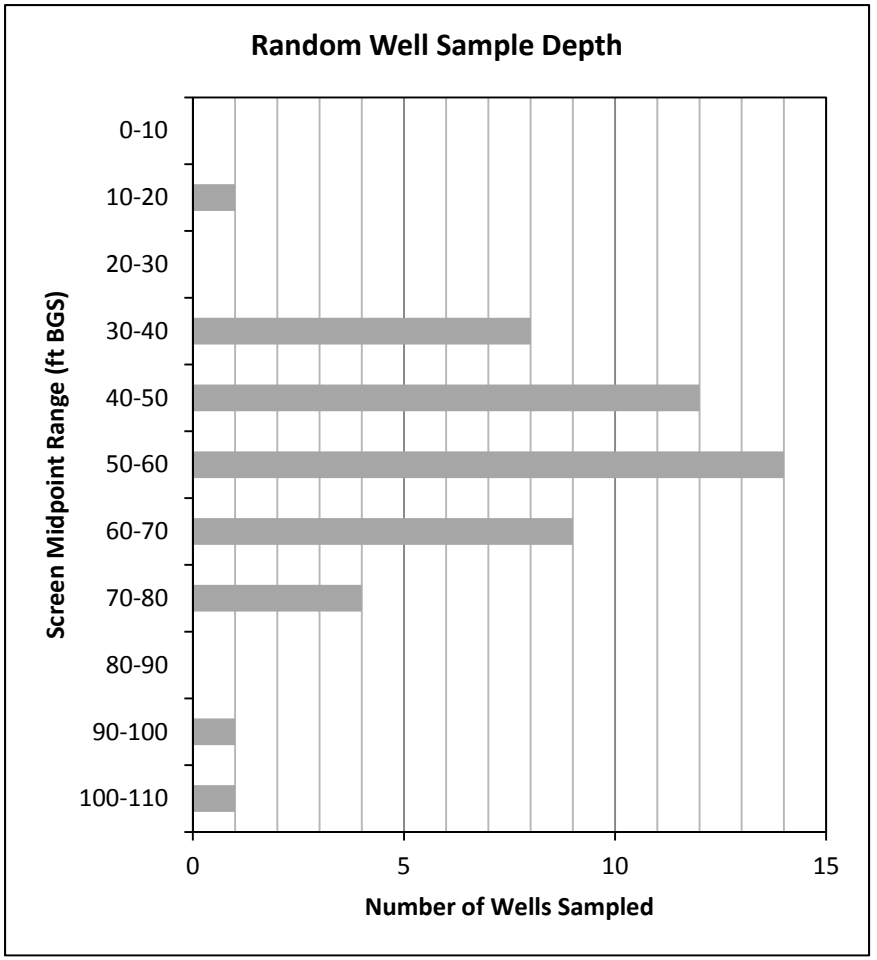
Groundwater Sampling

- Collected 50 random samples from across the watershed
- Complete paperwork at the Department
- Depth less than 100 ft in the Columbia aq.
- Water must be raw



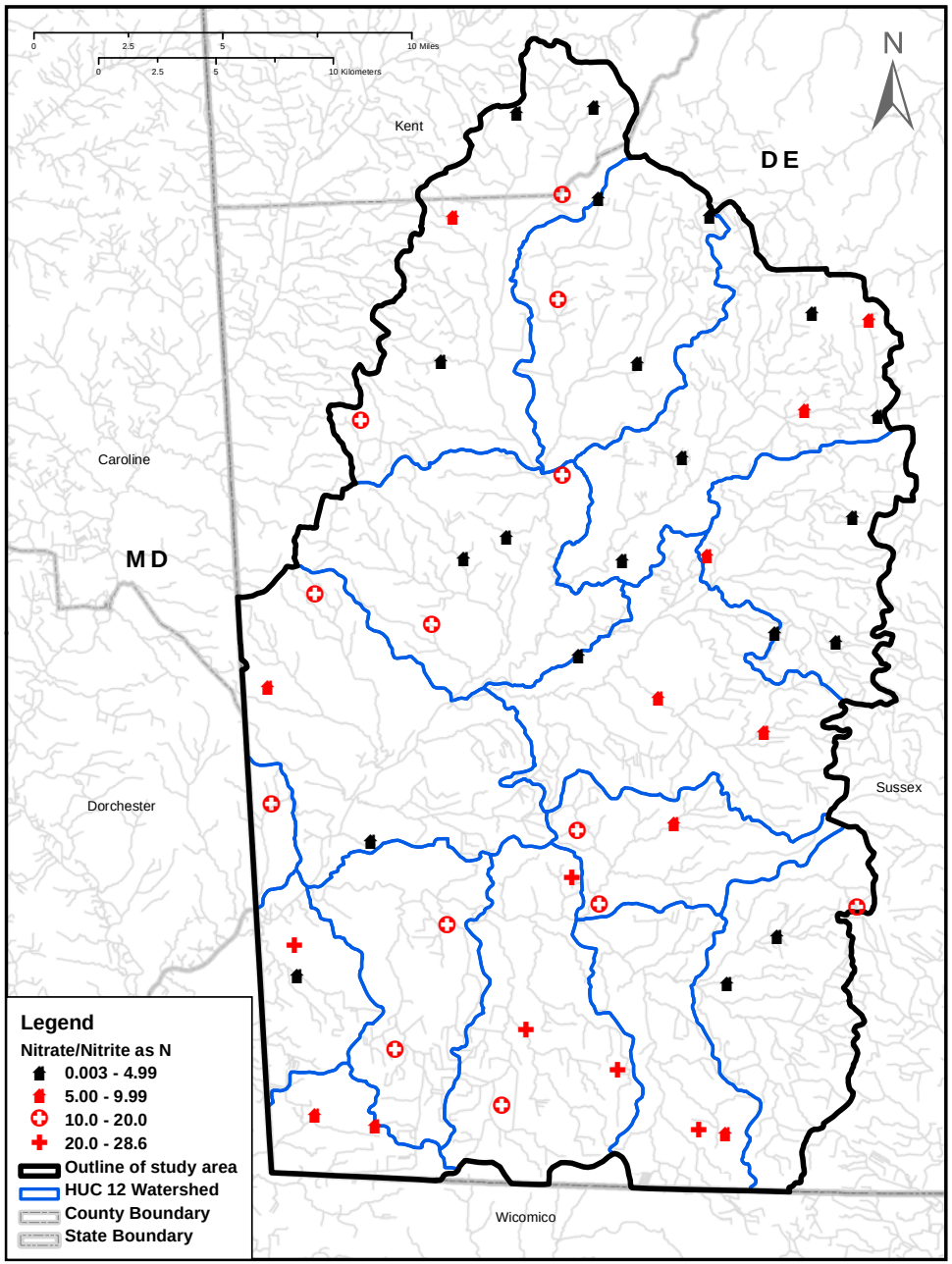
Groundwater Sampling

- Samples collected from domestic, monitoring and agriculture wells
- Screen settings ranged from 10 to 105 ft
- Median sampling depth 55 ft
- 50% of the wells had mid-point screen intervals from 40 to 60 feet.



Nitrate Concentrations – Groundwater Samples

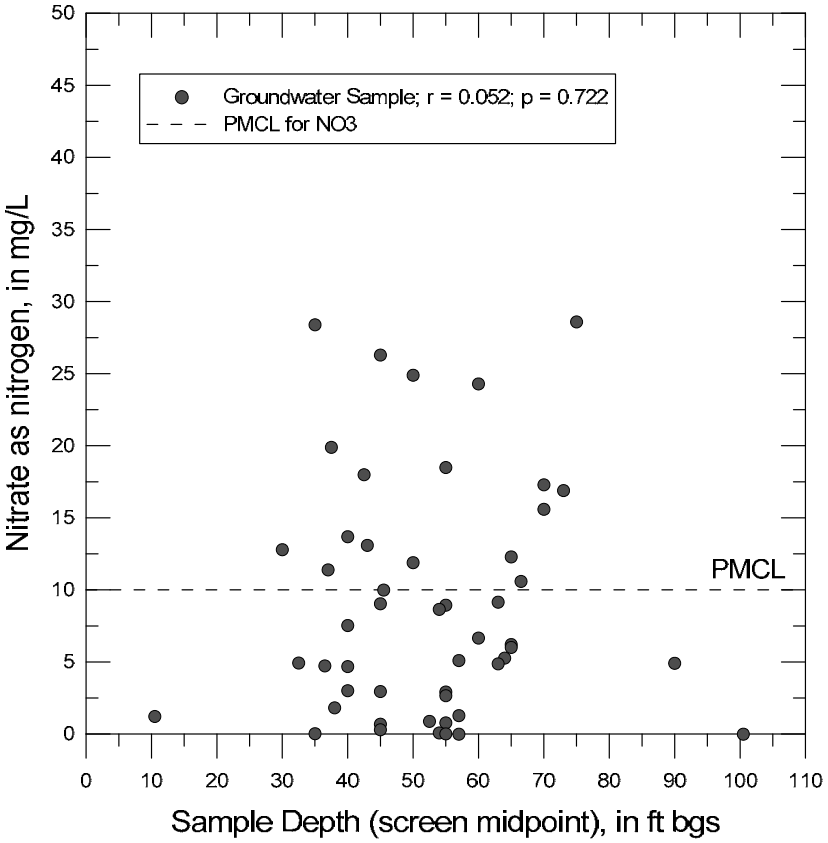
- Concentrations ranged from Non-Detect to 28.6 mg/L
- Highest concentration occurred at sample depth of 75’ BGS
- 28.6 mg/L occurred in well where Agriculture is 78% of landuse and MWD soils comprise 62% of area within a 500 meter radius of well
- Median nitrate concentration – 6.45 mg/L
- IRGWMN study by Kasper and Strohmeier had median nitrate concentration of 6.4 mg/L
- DGS Coastal Sussex GW Quality Survey by Andres (1991) resulted in a median nitrate value of 5.6 mg/L
- This Study 39% exceed drinking water standard of 10 mg/L
- Andres 1991 study 23% exceed standard



Nitrate Concentrations – Groundwater Sampling

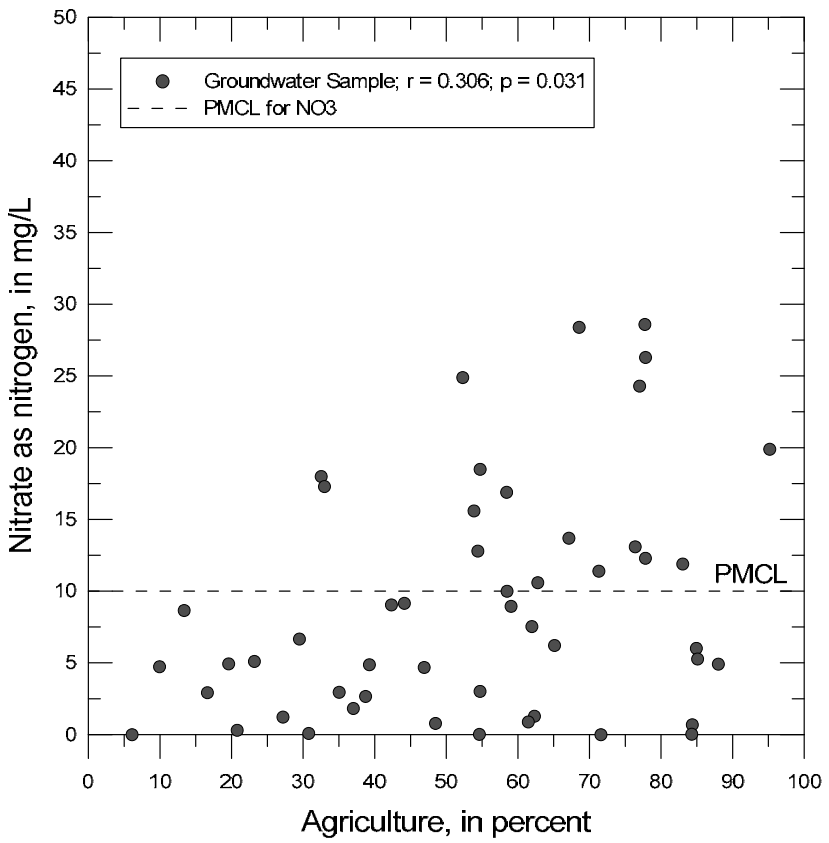
Scatter Plots and Statistical Analyses: Spearman Rho Correlation Analysis

Nitrate Concentration vs. Sample Depth



No Correlation

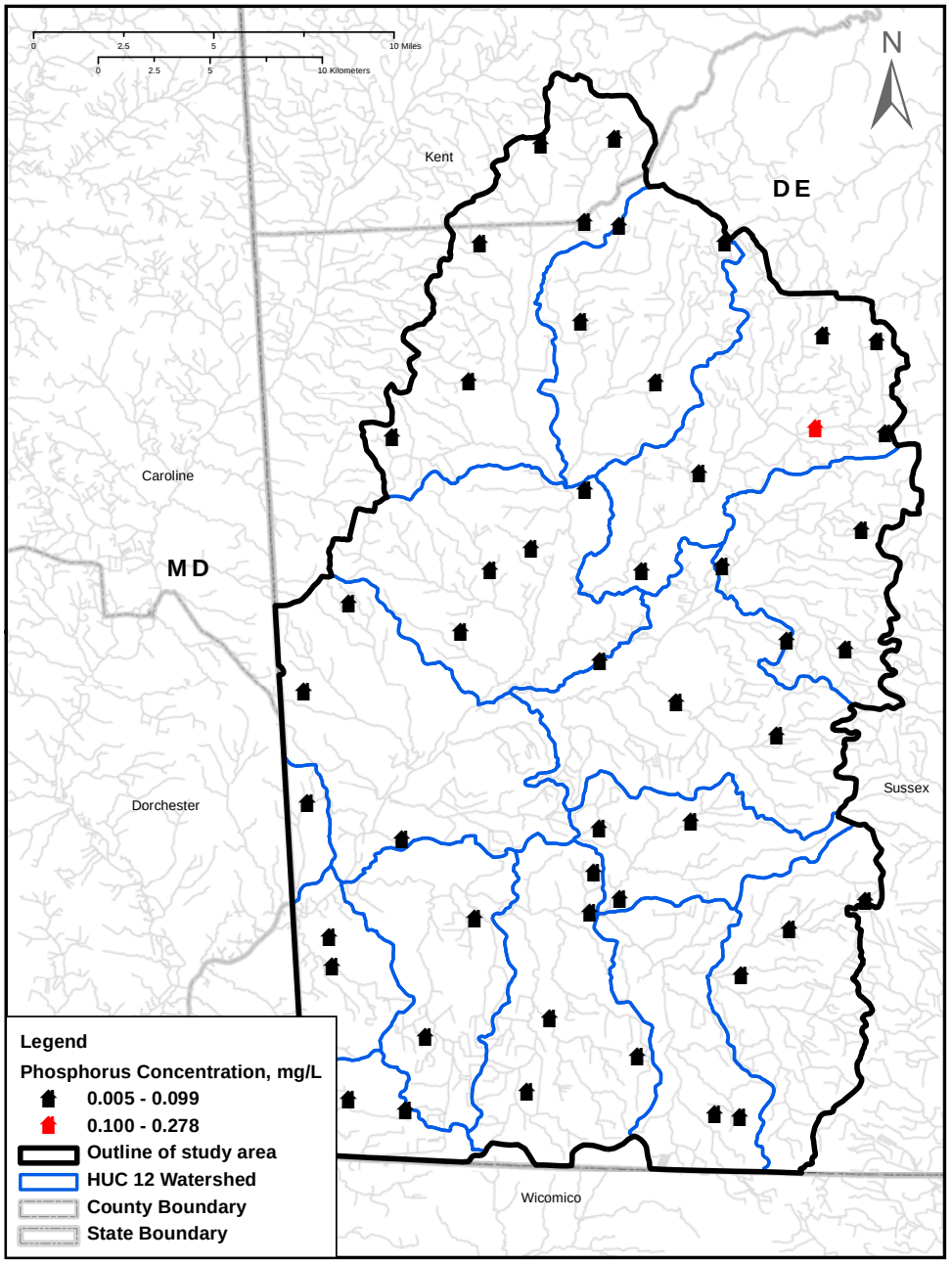
Nitrate concentration vs. Percent Ag



Significant Positive Correlation

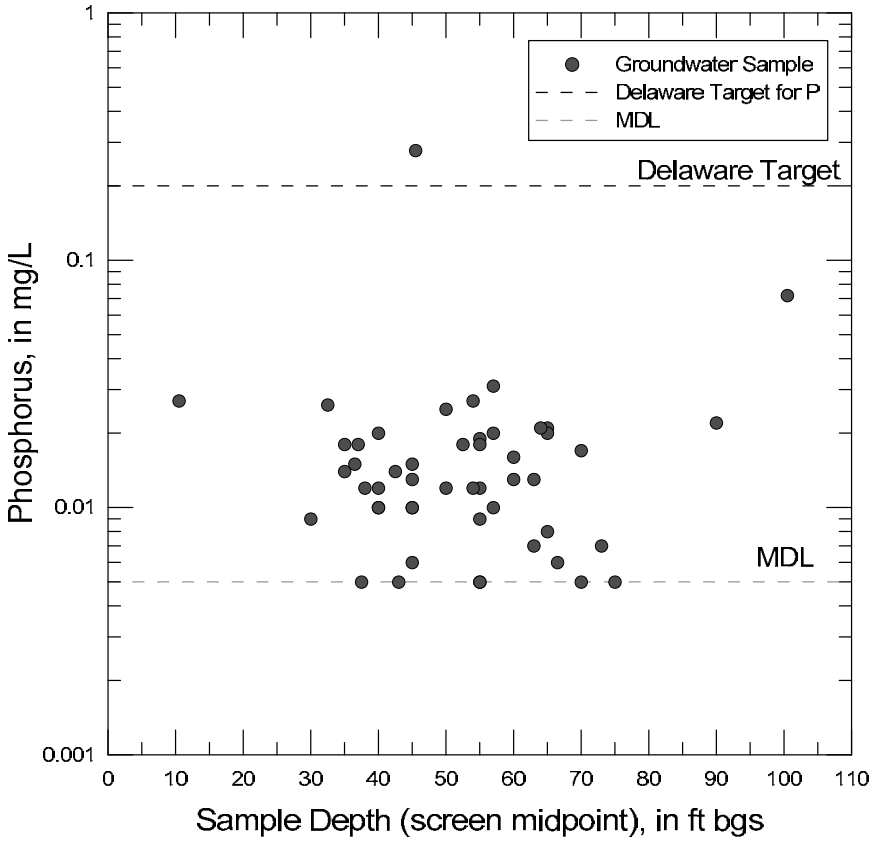
Phosphorus Concentrations – Groundwater Samples

- Concentrations ranged from Non-Detect to 0.278 mg/L
- Highest concentration occurred in the Gravelly Branch Subwatershed at sample depth of 45.5’ BGS
- 0.278 mg/L occurred in well where Agriculture is 58% of landuse and PD soils comprise 76% of area within a 500 meter radius of well
- Median Concentration – 0.013 mg/L
- IRGWMN study by Kasper and Strohmeier had median phos. concentration of 0.014 mg/L
- 1 sample exceeded the State’s target value of 0.2 mg/L for surface water. Concentrations in excess of this generally result in detrimental eutrophication



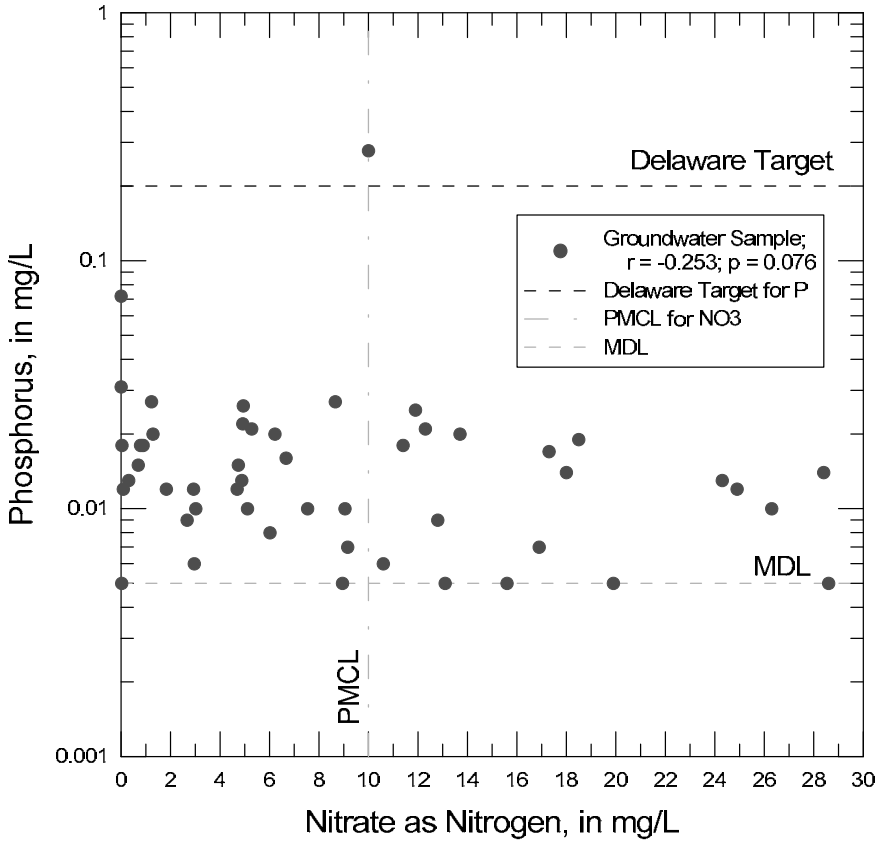
Phosphorus Concentrations – Groundwater Sampling

Phosphorus Concentration vs. Sample Depth



No Correlation

Nitrate vs. Phosphorus Concentration



No Correlation

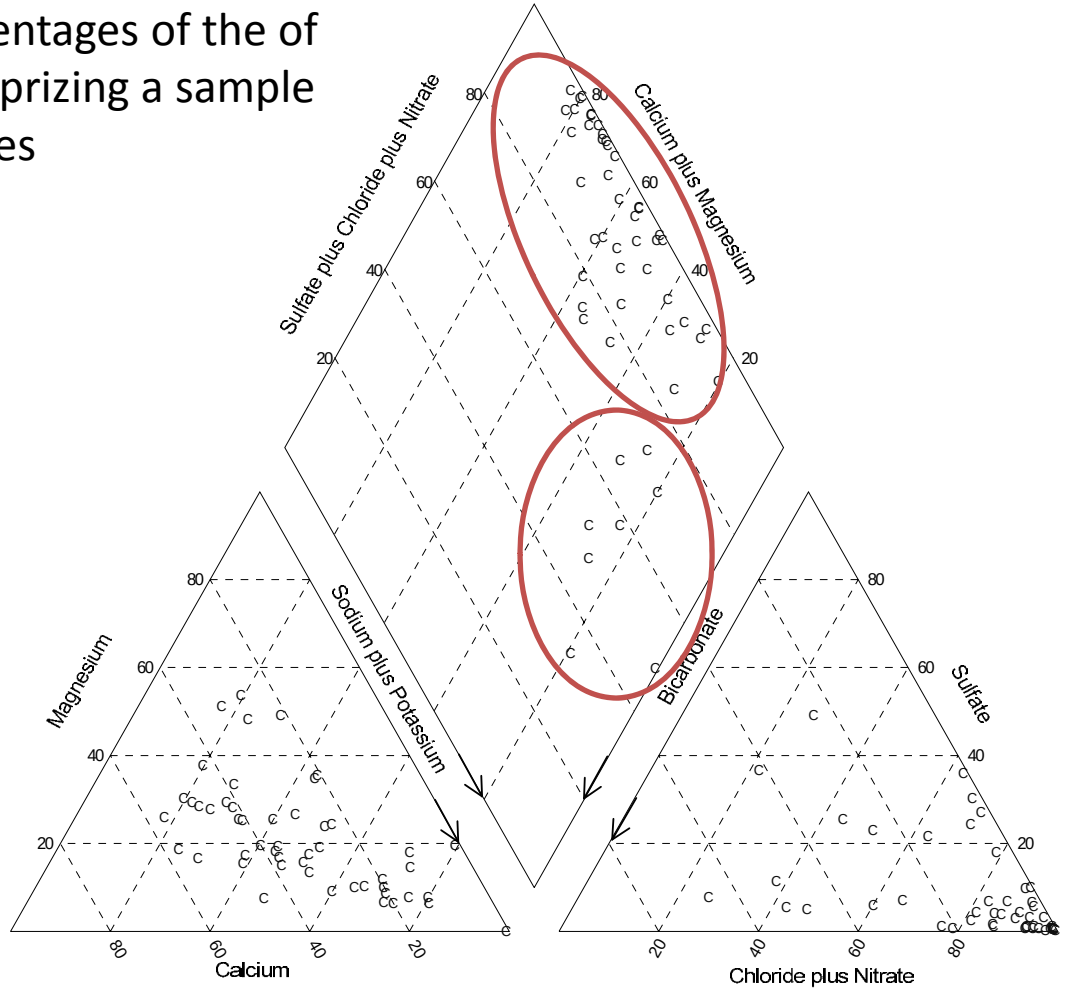
Groundwater Water Types

Piper Diagrams AKA Trilinear Plots are used to help type water quality

Piper Plots show normalized percentages of the of the major cations and anions comprizing a sample based on the charge of the analytes

- Sodium-Bicarbonate Water Type
  - Natural to nearly Natural water
  - Occurs in 14% (7) of the wells sampled
  - Areas dominated by Forests, Poorly Drained Soils, and/or locally confined
  - Generally low concentrations of Calcium, Magnesium, Potassium, Chloride, and Dissolved Oxygen
  - Generally elevated concentrations of Iron and Bicarbonate

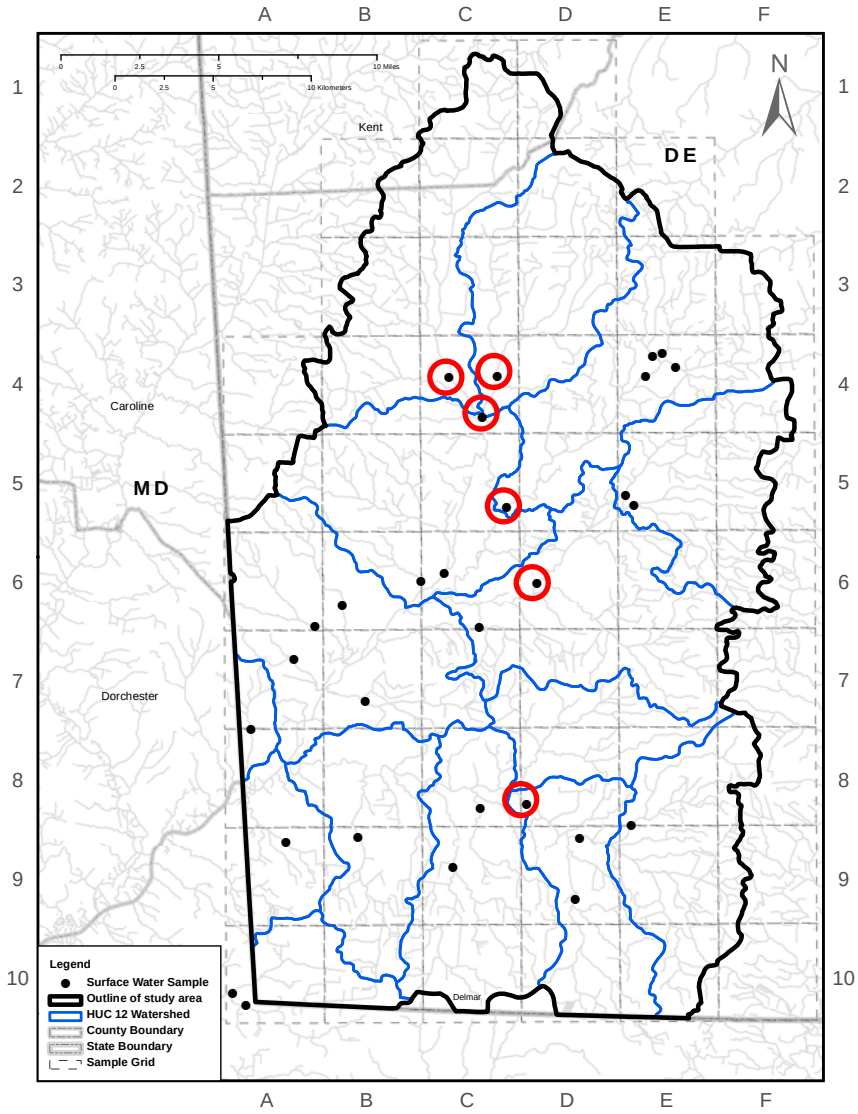
- Calcium plus Magnesium-Chloride plus Nitrate type
  - Impacted by humans
  - Common water type in areas impacted by agricultural practices
  - Occurs in 86% wells (43) sampled
  - Generally elevated concentrations of Calcium, Magnesium, Potassium, Sodium, Chloride, Nitrate, and Dissolved Oxygen
  - Generally low concentrations of Iron and Bicarbonate



Surface Water Sampling

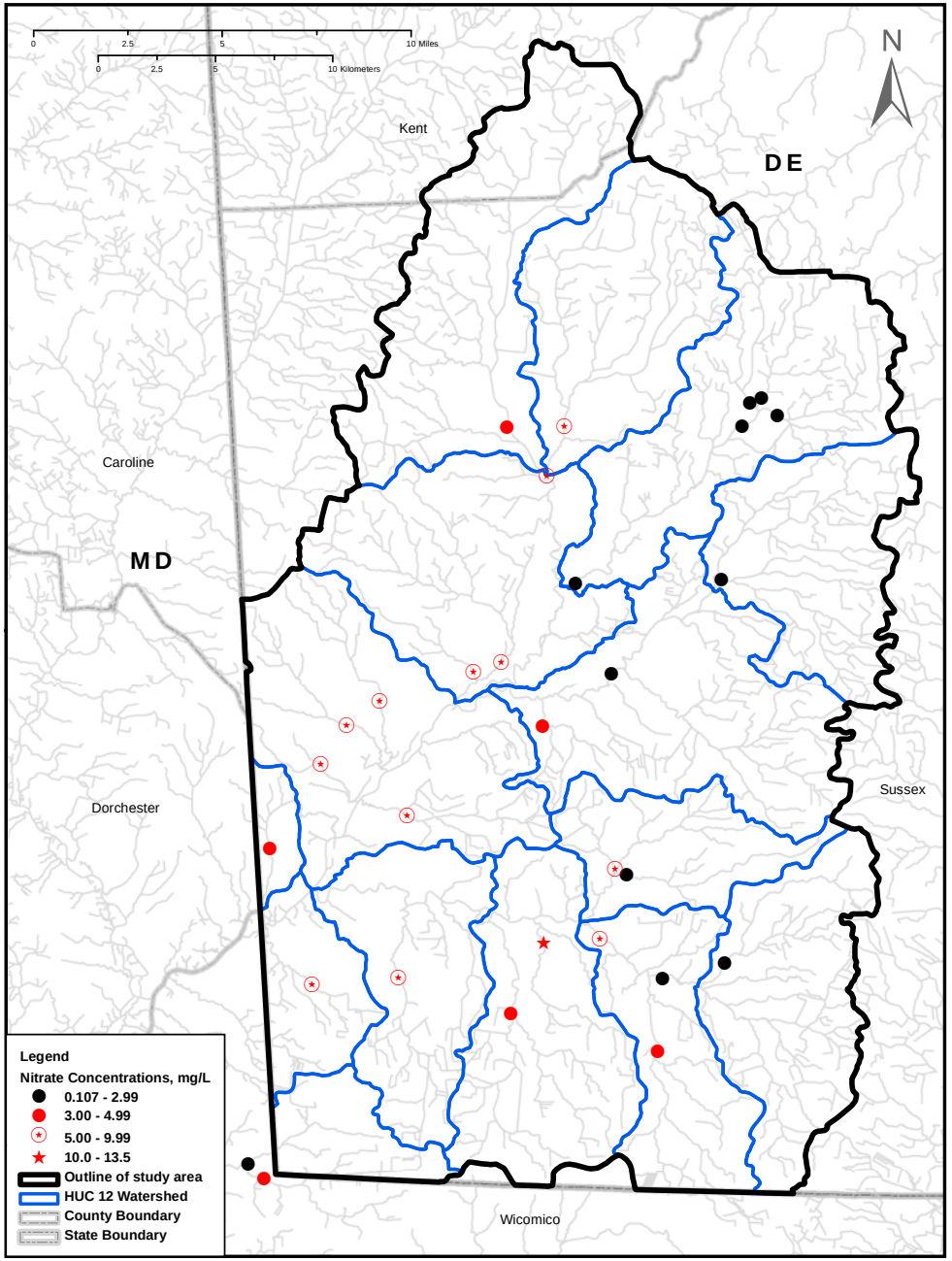
Criteria for Sampling

- Non tidal portions of streams
- Stream under baseflow (groundwater) flow conditions
- Sampling occurred in March and April, 2011 (High baseflow conditions)
- 6 stations were resampled in August, 2011 (Low baseflow conditions)



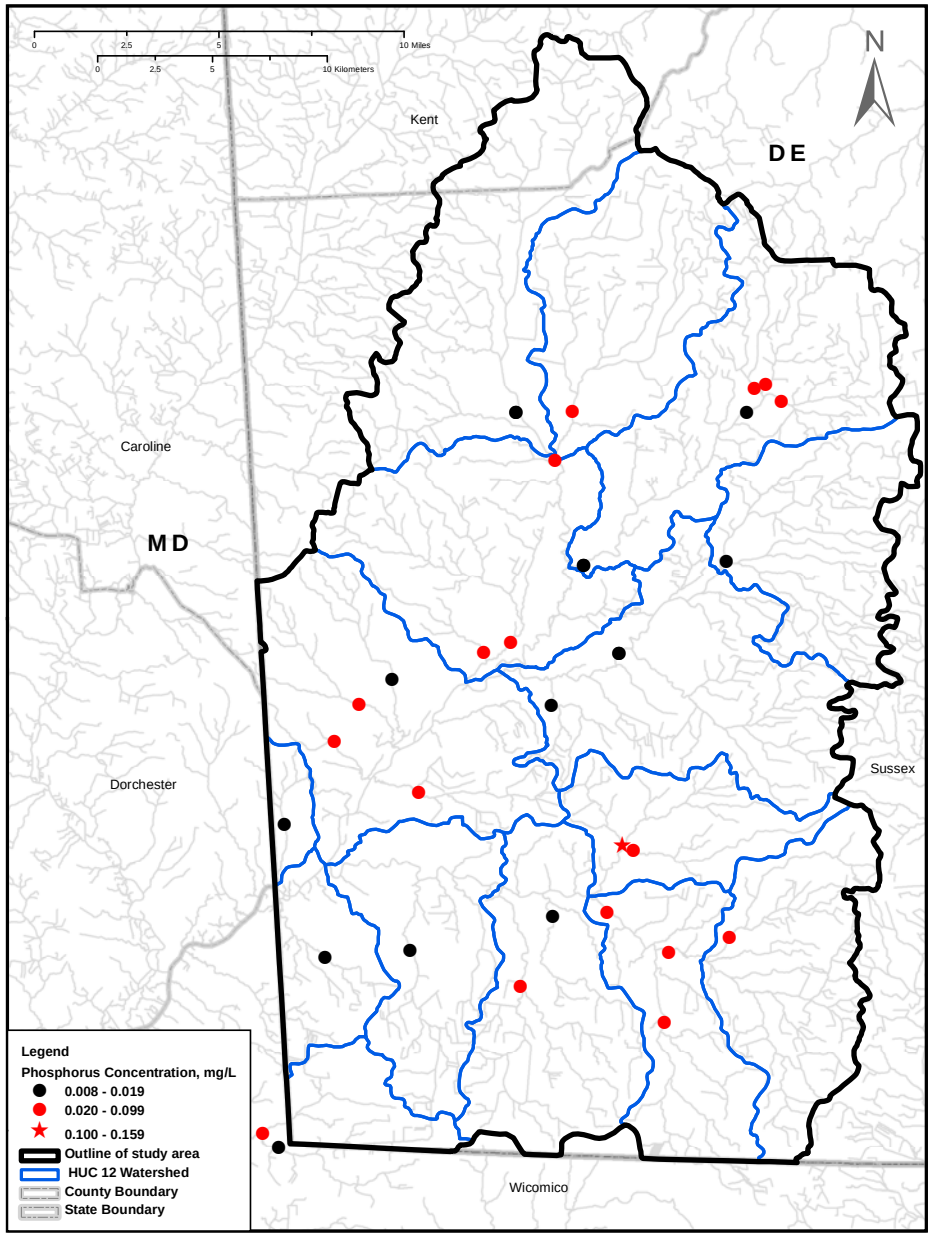
Nitrate Concentrations – Surface Water Samples

- Concentrations ranged from 0.107mg/L to 13.5 mg/L
- 13.5 mg/L occurred in HUC 12 WS where agriculture is 63% of areas landuse.
- .107 mg/L occurred in HUC 12 WS (GB) where poorly drained soils cover 46% of the WS's land area.
- Median Concentration – 4.18 mg/L
- 17 stations (57%) exceeded 3.0 mg/L (Watershed Stewardship's target value)
- 34 samples (94%) exceed the USGS estimated limit of 0.59 mg/L for natural streams



Phosphorus Concentration: Surface Water Samples

- Concentrations ranged from 0.008 mg/L to 0.159 mg/L
- 0.159 mg/L occurred in HUC 12 WS (MBRP) where agriculture is 57% of area's landuse
- Median Value – 0.02 mg/L
- 17 samples (47%) exceeded USGS criteria for natural streams with phosphorus concentration greater than 0.02 mg/L (estimated median concentration for natural streams in U.S.)
- No sample exceed the State's target for phosphorus of 0.2 mg/L



Surface Water Water Types

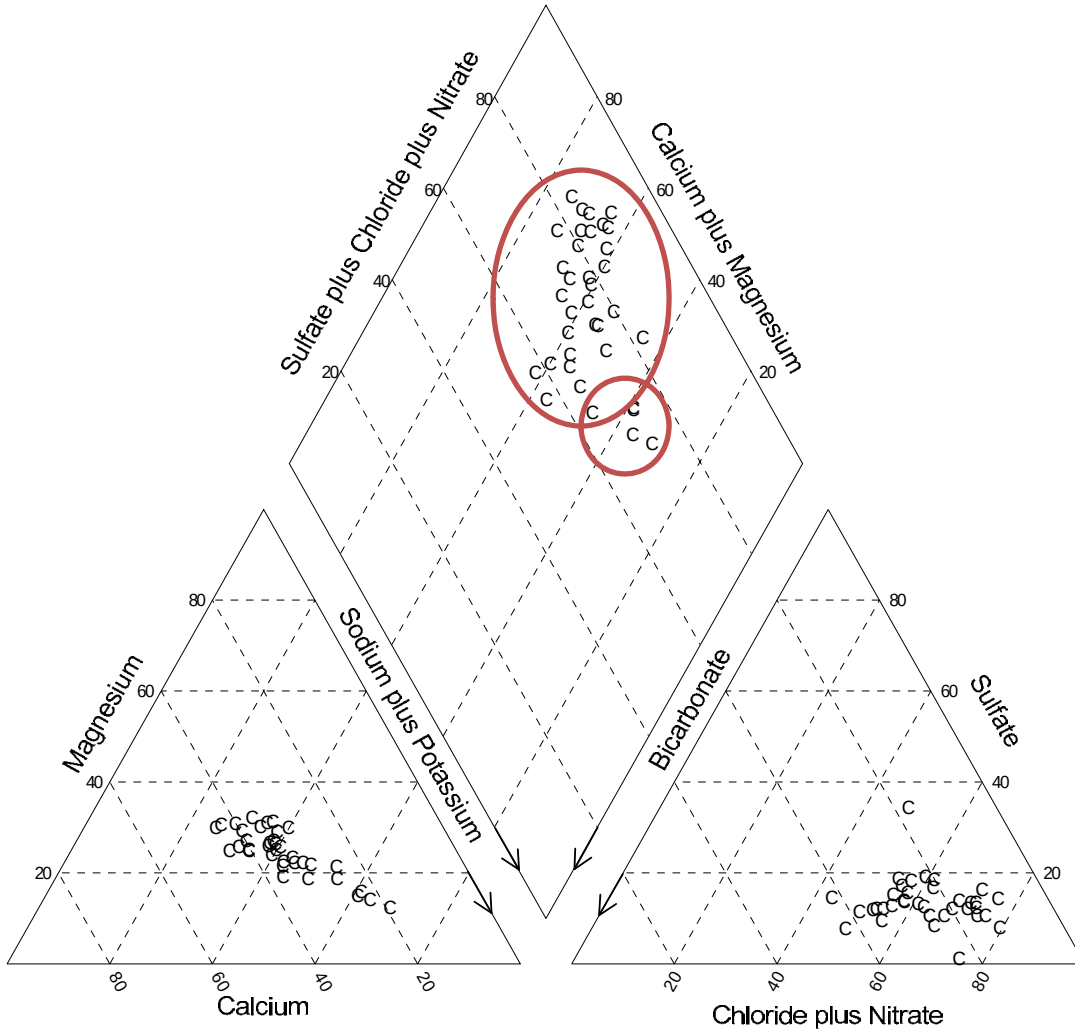
- At least two cluster of points, i.e. water types, indicated on plot

- Calcium plus Magnesium-Chloride plus Nitrate Type
  - Represents Impacts by humans
  - The water type for 32 samples (89%)

  - Elevated levels of Potassium, sodium, calcium, magnesium, chloride and nitrate

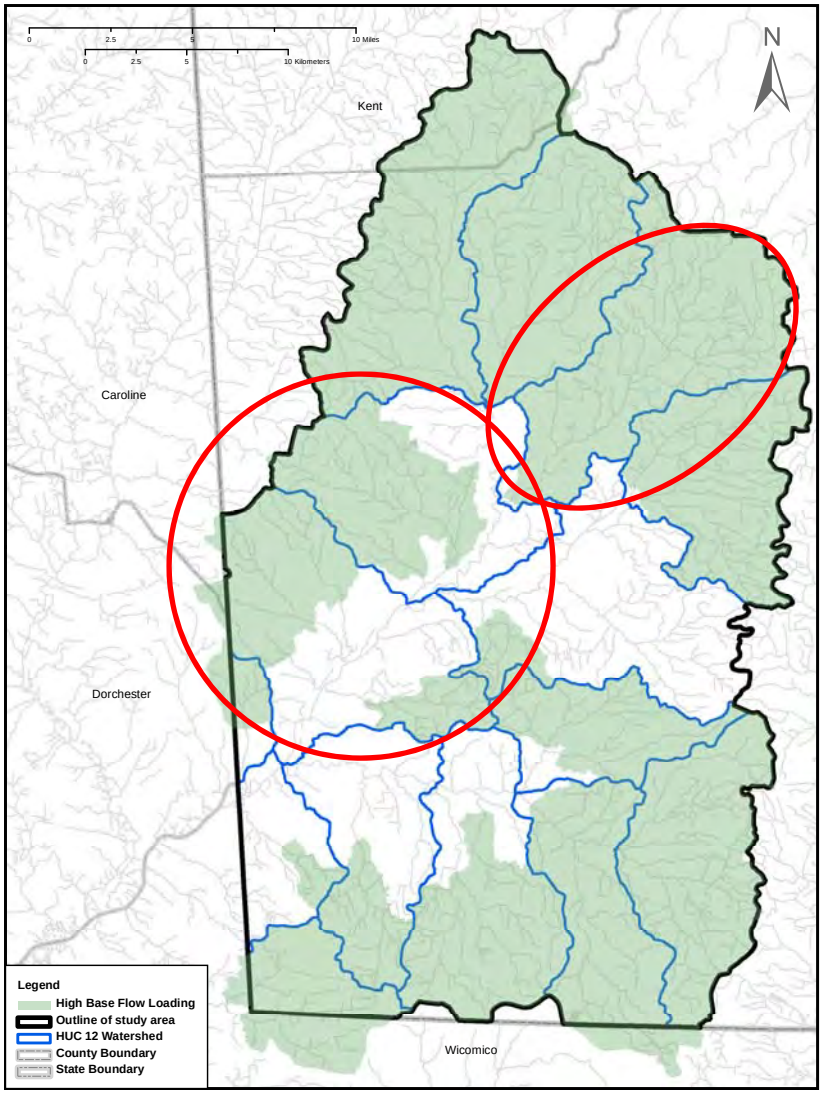
  - Dominant type in areas where agriculture and well drained soils are wide spread

- Sodium-Bicarbonate-Chloride plus Sulfate Type
  - Natural to mixed water type
  - Occurs in 4 samples
  - Occurred in a watershed draining mostly Forests and Poorly Drained Soils



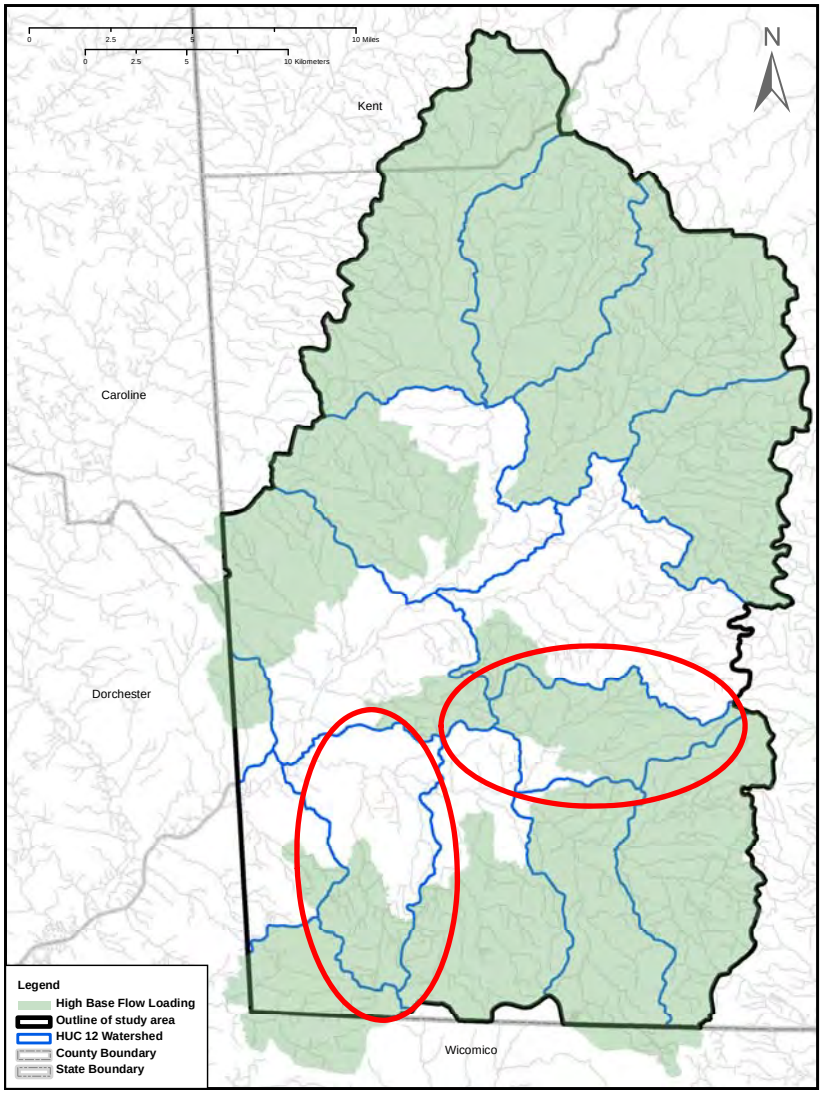
Surface Water Loading

- Average Nitrate Loading Rate 3.29E-02 lb/acre/day
- Calculate Load for 73% of Watershed - 6500 lb/day
- Highest Loading Rate (lb/acre/day) – 5.5E-02
  - Hearns Pond
  - Lower Nanticoke
- Lowest Loading Rate (lb/acre/day) – 0.75E-02
  - Deep Creek



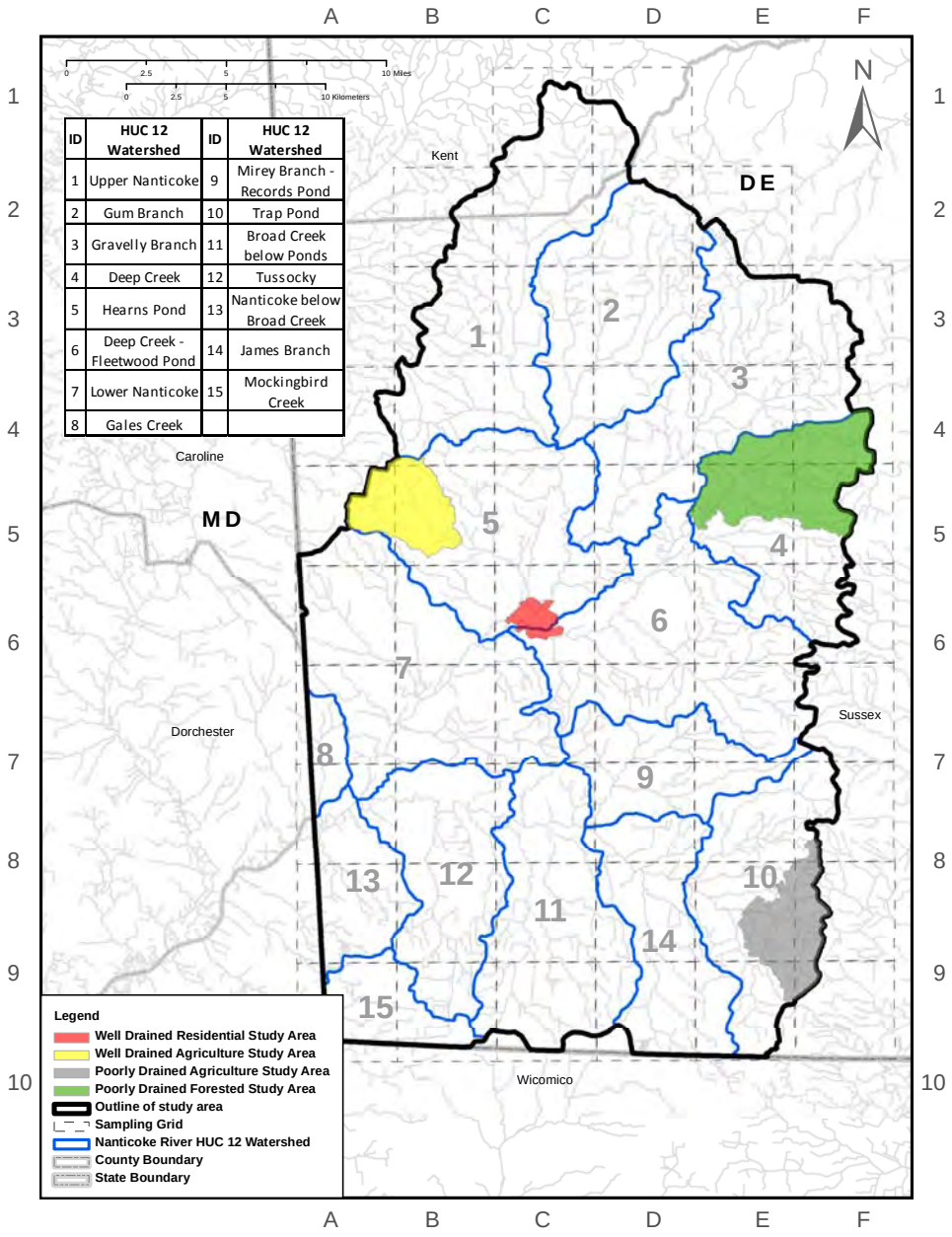
Surface Water Loading

- Average Phosphorus Loading Rate 19.4E-05 lb/acre/day
- Calculate Load for 73% of Watershed - 50 lb/day
- Highest Loading Rate (lb/acre/day) – 57.6E-05
  - Mirey Branch-Records Pond
- Lowest Loading Rate (lb/acre/day) – 3.4E-05
  - Tussocky



Special Study Areas

- Study areas looked at Land Use and Soil Drainage Type
  - **Poorly Drained Forest**
  - **Poorly Drained Agriculture**
  - **Well Drained Residential**
  - **Well Drained Agriculture** (partnered with USGS for additional work)
- Groundwater Samples
  - At least 10 samples
- Surface Water Samples
  - Sampled at high base flow, low base flow and after Hurricane Irene



ID	HUC 12 Watershed	ID	HUC 12 Watershed
1	Upper Nanticoke	9	Mirey Branch - Records Pond
2	Gum Branch	10	Trap Pond
3	Gravelly Branch	11	Broad Creek below Ponds
4	Deep Creek	12	Tussocky
5	Hearns Pond	13	Nanticoke below Broad Creek
6	Deep Creek - Fleetwood Pond	14	James Branch
7	Lower Nanticoke	15	Mockingbird Creek
8	Gales Creek		

Study Findings

- Most of the watershed has degraded groundwater quality due to anthropogenic activities
- Groundwater quality is negatively impacting Surface Water quality
- Geology, Soils and Land Use dictate the degree of these impacts and in some areas are capable of mitigating water quality.

Contact Information

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