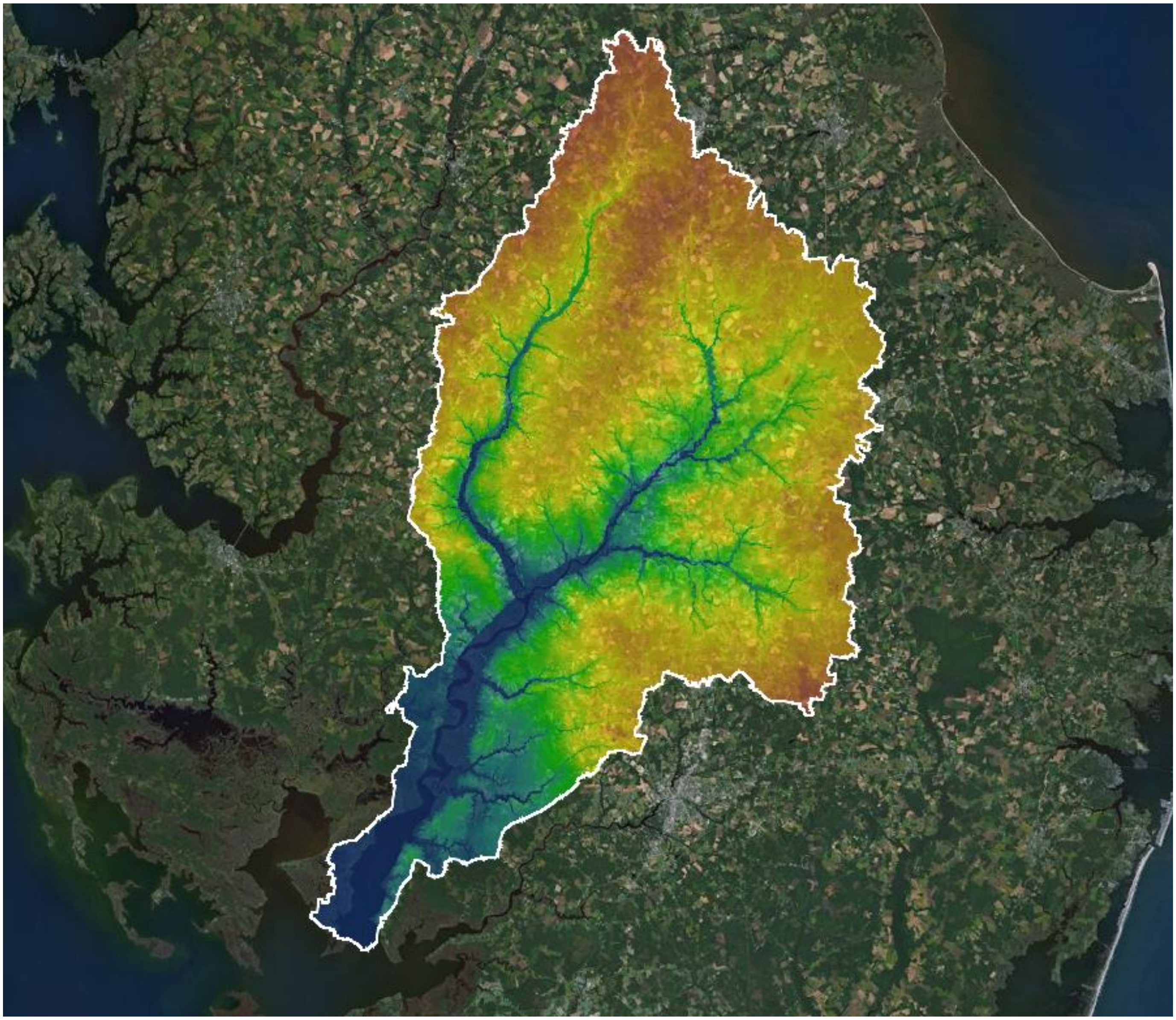

Nanticoke Watershed
Targeting Innovations and BMP Tracking

Burke
ENVIRONMENTAL
ASSOCIATES

Nanticoke Watershed
Targeting Innovations and BMP Tracking

Financial assistance for this project was provided by:

Keith Campbell Foundation for the Environment

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Executive Summary

In 2012 Burke Environmental Associates received funding from the Keith Campbell Foundation for the Environment to work in collaboration with Nanticoke Watershed Alliance to conduct a watershed targeting innovations and BMP tracking study in the Nanticoke River watershed. The study establishes an innovative, low-cost data collection, recording and analysis framework that can be used in various ways by the Nanticoke Watershed Alliance (NWA) and/or other organizations to track and plan water quality management activities through Arc Desktop and its cloud based extension ArcGIS Online.

A combination of desktop GIS analyses, field observations and image interpretation are used to identify potential Best Management Practices (BMPs); and conservation and restoration opportunities. A principal focus of the study is to examine agriculturally dominated watersheds that generate high incremental nitrogen and phosphorus loads from fertilizer and manure and to prioritize where these BMPs and conservation measures could most effectively be implemented to reduce non-point source pollution risks. In addition to considering where high N and P loads are projected to occur based on USGS data, the analytical process takes into account the potential for off-farm transport of sediment and nutrients to nearby waterways. This requires the use of selected USDA soils data, generalized at a subwatershed level, which ranks the potential for surface runoff, subsurface drainage, and leaching. An additional protocol for ranking surface runoff potential uses digital elevation data and the average stream and flow path network densities found in high loading N and P subwatersheds.

A review and summary of Chesapeake Bay Program and other innovative BMPs is also included in the study to highlight various practices and their associated pollution reduction efficiencies. A total of 98 federal Hydrologic Unit Code 14 (HUC 14) watersheds are evaluated. These areas, referred to as “ag enhancement priorities”, represent the top 25% of all 392 Nanticoke basin watersheds that are considered most worthy of attention based on the targeting protocols. Approximately, 10,654 linear meters of potential demonstration practices are identified for further investigation and implementation. The linear practices include forested buffers, bioswales, two-stage ditches and linear wetlands to treat runoff. The study team examined nearly half (47%) of the priority watersheds to determine how widely cover crops and conservation tillage practices were in place during 2012. The team found that out of all fields assessed (14,742 acres), approximately 34% appeared to be using cover crops and 76% appeared to be using conservation tillage practices. In the highest ranked priority watersheds (i.e. those of greatest concern) only 32% of the assessed fields used cover crops.

The study identifies nearly 1,000 acres of wetlands that function at “high” ranked levels for nutrient transformation and sediment retention. About 1,024 acres of riparian buffers are identified as priority conservation targets. Only three wetland restoration opportunities are identified, primarily because most areas that might technically support restoration are inconveniently located with respect to agricultural operations and irrigation infrastructure investments. All 492 poultry houses in priority watersheds are assessed for the presence and/or adequacy of heavy use protection area pads and on average 62% appear to be adequate.

Most of the locations selected for specific BMPs such as bioswales, 2-stage ditches or wetland restoration are clearly not “shovel-ready” for implementation. Outreach to appropriate landowners and organizations will be necessary to validate the desktop analysis and arms reach field assessments, which only offered the opportunity for quick visual inspections from public right-of-ways. Potentially, there are a number of funders who may be willing to support innovative implementation projects. At the same time, these types of projects offer great learning opportunities for NWA and landowners while curbing nutrient and sediment loads in critical places.

Watershed Targeting Innovations and BMP Tracking

Background

In the spring of 2012 Burke Environmental Associates was funded by the Keith Campbell Foundation for the Environment to conduct a watershed targeting innovations and BMP tracking study in the Nanticoke River watershed in collaboration with the Nanticoke Watershed Alliance. The goals and objectives of the study included the following key elements:

- Identify priority locations to enhance and/maintain nutrient and sediment reduction practices and natural landscape features in the watershed
- Recommend the deployment of cost efficient, environmentally effective non-point source pollutant reduction practices in the Nanticoke Watershed—examples include:
    - ➢ protection of wetlands with nutrient/sediment reduction capacity & opportunity to intercept pollutants

    - ➢ forested/grass buffer conservation/restoration
    - ➢ select agricultural BMPs

- ➢ stream/waterway restoration to increase potential for in-stream nutrient processing
- Use a combination of coarse and fine scale analysis methods to target small subwatershed and farm level opportunities for intervention
- Expand the level of information available to verify and track significant on-farm BMPs (e.g. cover crops, buffers, conservation tillage, etc.)

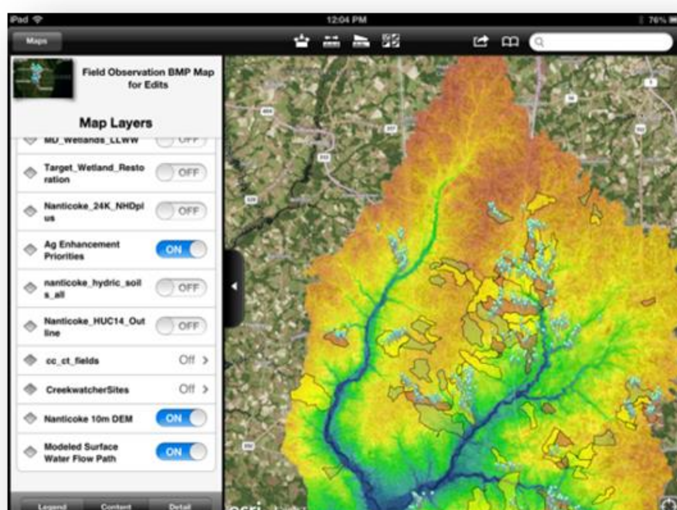
Use of Digital Technologies and ArcGIS Online

An over-arching goal of the study was to incorporate the use of internet, mobile devices and software technologies to facilitate the collection, analysis and display of Nanticoke watershed geo-spatial data. All of the maps and data produced through this study can be seen and manipulated on-line through Chesapeake Common's ArcGIS Online instance or it can be downloaded in a variety of formats by the Nanticoke Watershed Alliance (NWA) or others. A map and application gallery with easy access to the study maps along with a brief narrative description of the study process is housed in a special workgroup space created for the NWA. Based on consultations with NWA staff, many or all of the elements of the study will be released to the general public on Chesapeake Commons.

Chesapeake Commons is a small development and design shop based in Washington DC specializing in web cartography and data story telling that brings clarity to Bay restoration issues. Online publishing of map and data products is the wave of the future for environmental assessment work—providing an excellent alternative to lengthy static paper reports and maps that have far less value to watershed managers and others.

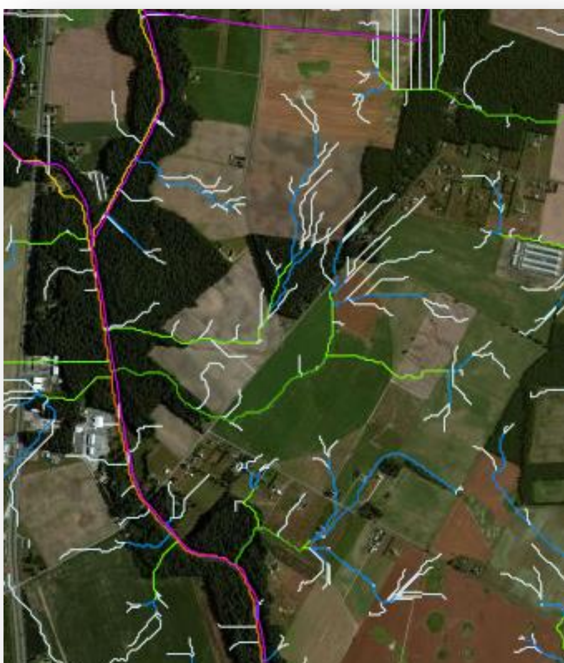
The following technologies were used in connection with this study:

1. 4th Generation iPad. The latest Apple iPad version was used with high resolution retina display. The iPad was used in the field to display a series of online ArcGIS map overlays (e.g. modeled water flow paths, wetland locations, hydric soils, sub-watersheds with high N&P loads, etc.) that helped the study team evaluate, on-the-fly, whether or not a potential location may be a candidate restoration



site. The iPad camera was used to take high resolution photos and record the GIS coordinates where an image was taken to reference field locations. A free ArcGIS "app" was downloaded, configured for specific data collection map layers and installed on the iPad as well as on the iPhone to record and transfer field-observed data to a cloud hosted map service.

2. IPhone with Wi-Fi hot-spot. An iPhone 4S was used in conjunction with a tethering plan. The tether allowed for a "hot-spot" Wi-Fi connection that was used to provide internet access to the iPad without purchasing more expensive "built-in" Wi-Fi access. This connection allowed instant, internet uploading of images and field recorded notes to base maps housed in ArcGIS Online. This step avoids the need to assemble and organize field notes and then translate them into geo-referenced map features.
3. RiverTools software. This software was purchased for the assessment because it allowed the study team to process high resolution digital elevation data to show headwater stream channels and "synthetic" or theoretical water flow paths and how they move across the landscape and farm fields. This information helped the study team quickly locate areas where potential BMPs could be installed to intercept and reduce nitrogen, phosphorus and sediment pollution. More recently, we discovered that a very similar software program developed by the Utah State University called TauDEM is available for free. TauDEM (Terrain Analysis Using Digital Elevation Models) is a suite of Digital Elevation Model (DEM) tools for the extraction and analysis of hydrologic information from topography as represented by a DEM. It also works better with standard ArcGIS software and will be used by the team in the future instead of RiverTools.

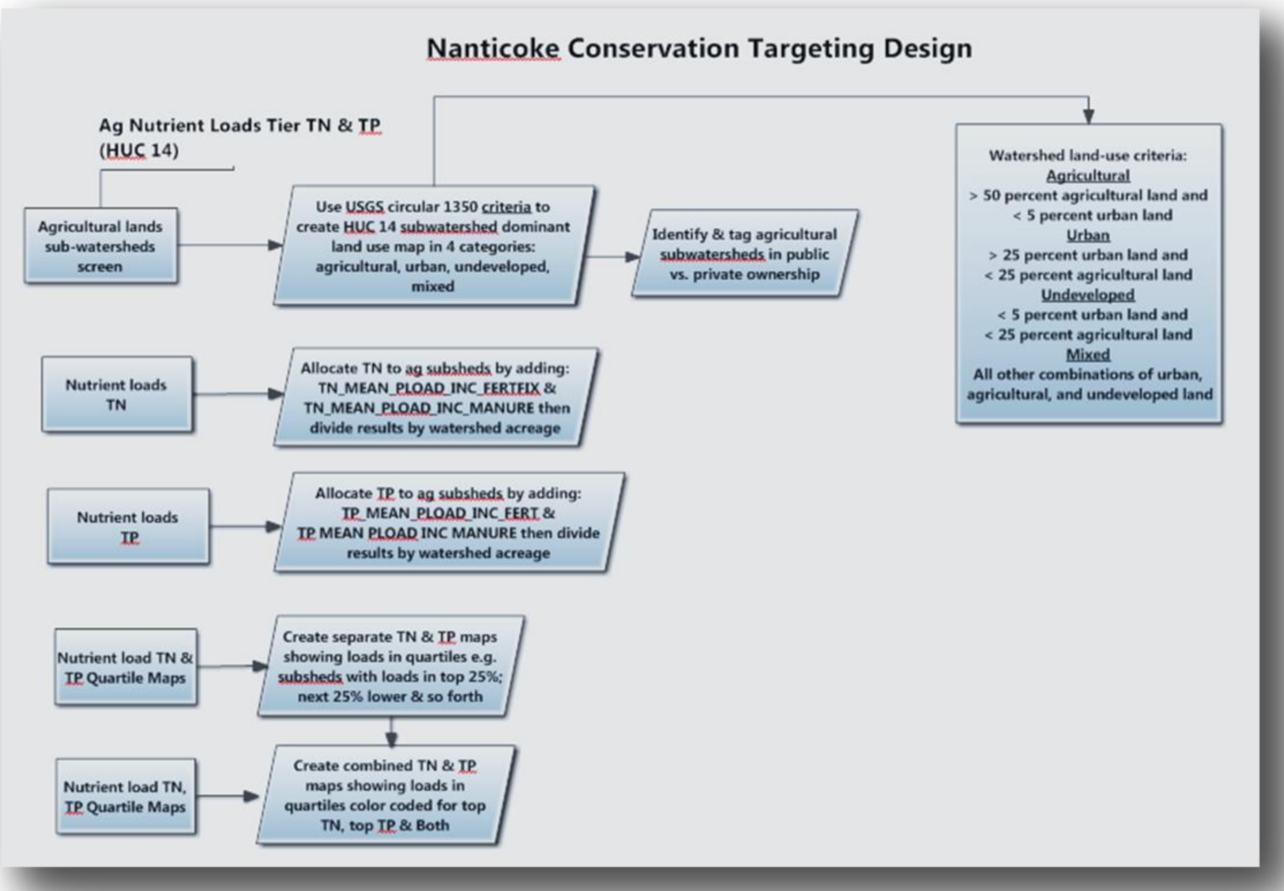


4. ArcGIS online platform. For single users, ArcGIS online is a cloud based extension of ArcDesktop. It is used primarily to host and edit geo spatial data over a server as well as use data services to create web maps and applications. Users can create and join groups, that ensures data is shared with the proper audience. ArcGIS Online is not a replacement for ArcDesktop and is

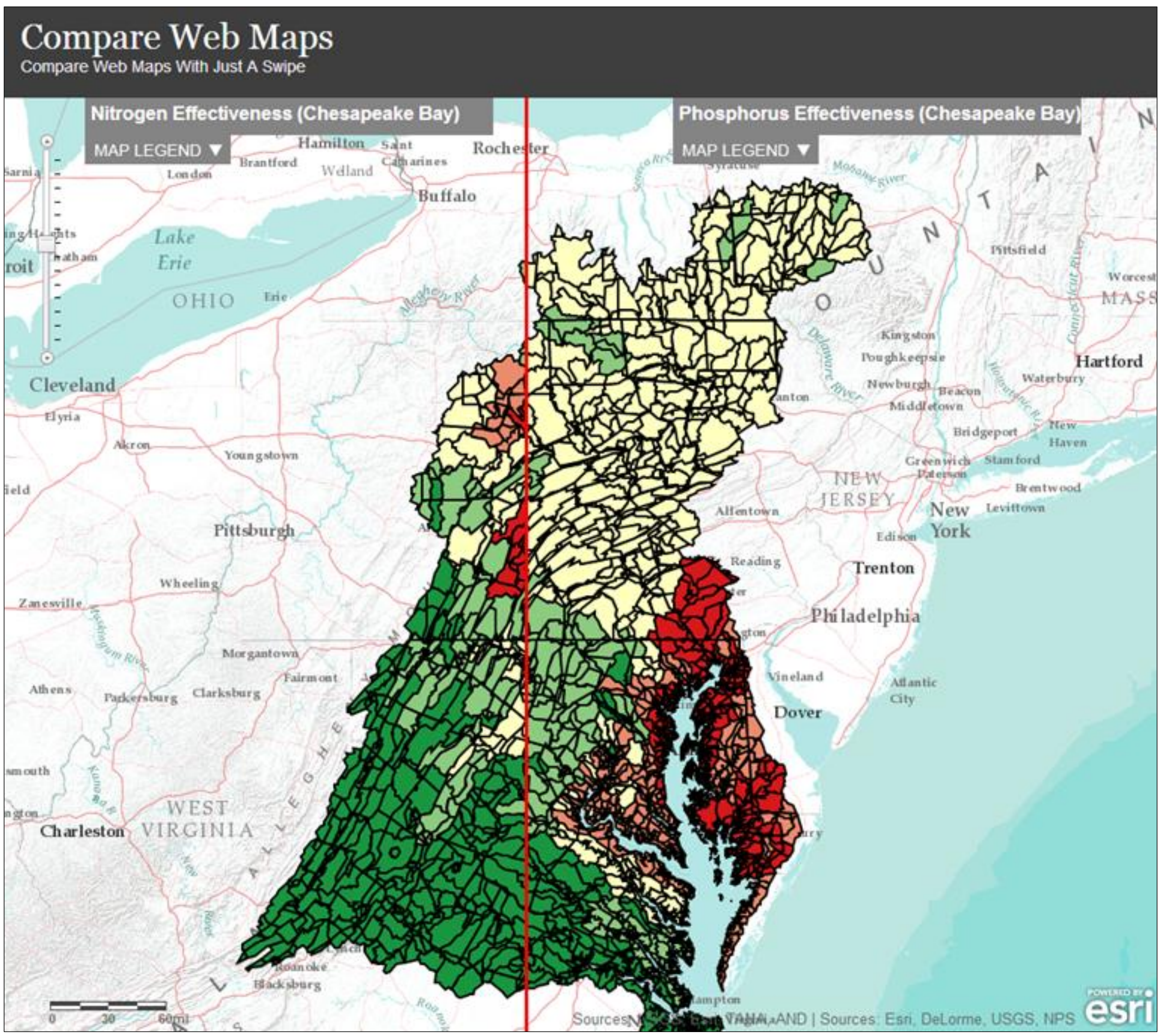
built to allow for the easy sharing of published web mapping applications and marking up geo spatial data over a server.

Study Design Process and Summary Maps

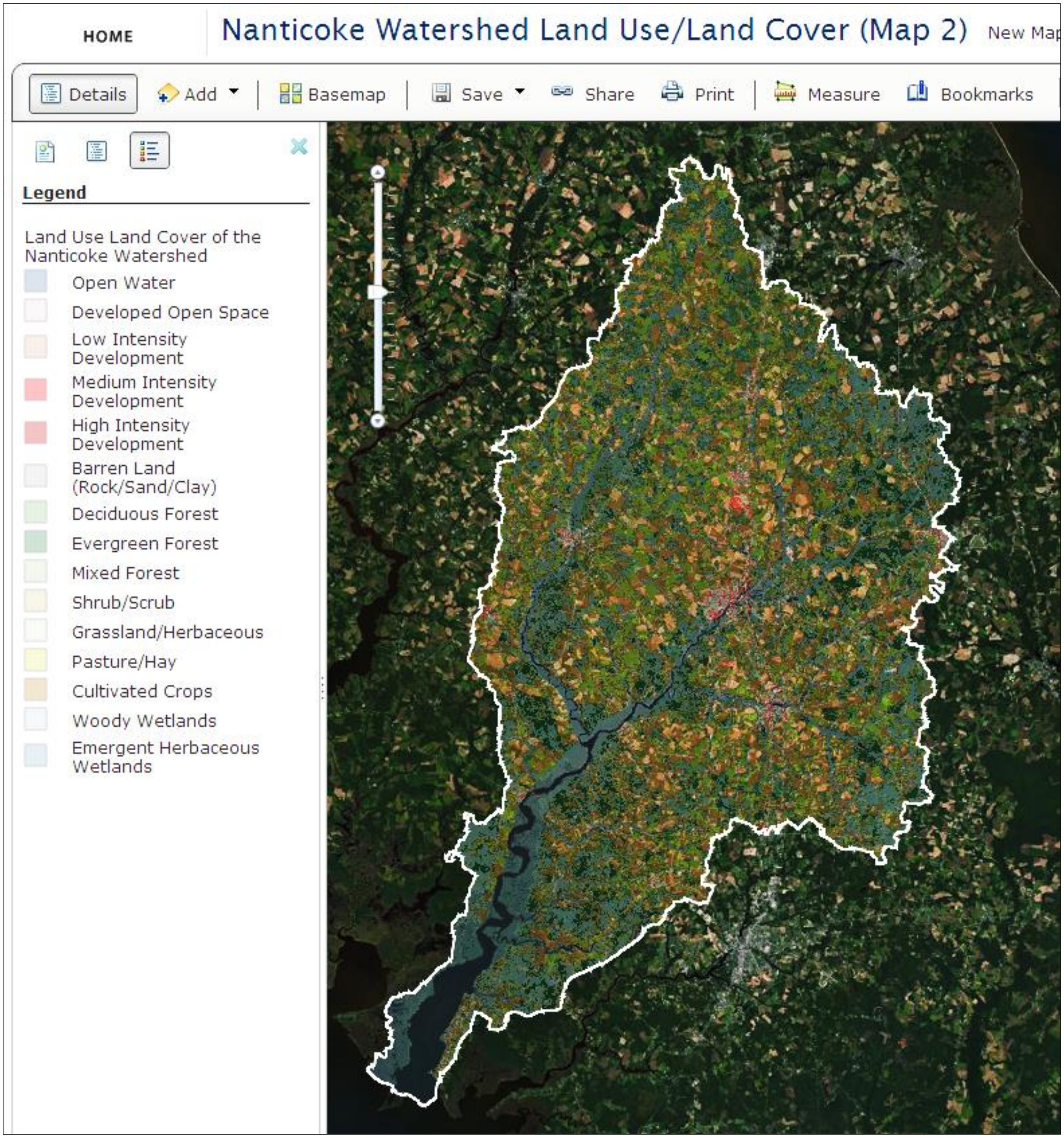
Given the complexity of geo-spatial analysis components involved with the study process, the project manager developed initial flow charts briefly describing the sequence of steps needed to produce a series of maps that help summarize what factors are used to create conservation and restoration priorities for the watershed. The graphic illustrates one of the flow charts created during the study design process. It should be noted that as the study progressed, several of prescribed steps deviated from what was actually done. This was due to changes in the types of data we were able to obtain as well as the methods needed to perform particular assessments. The summary maps produced for this project are described below (note, full size maps can be accessed via the web):

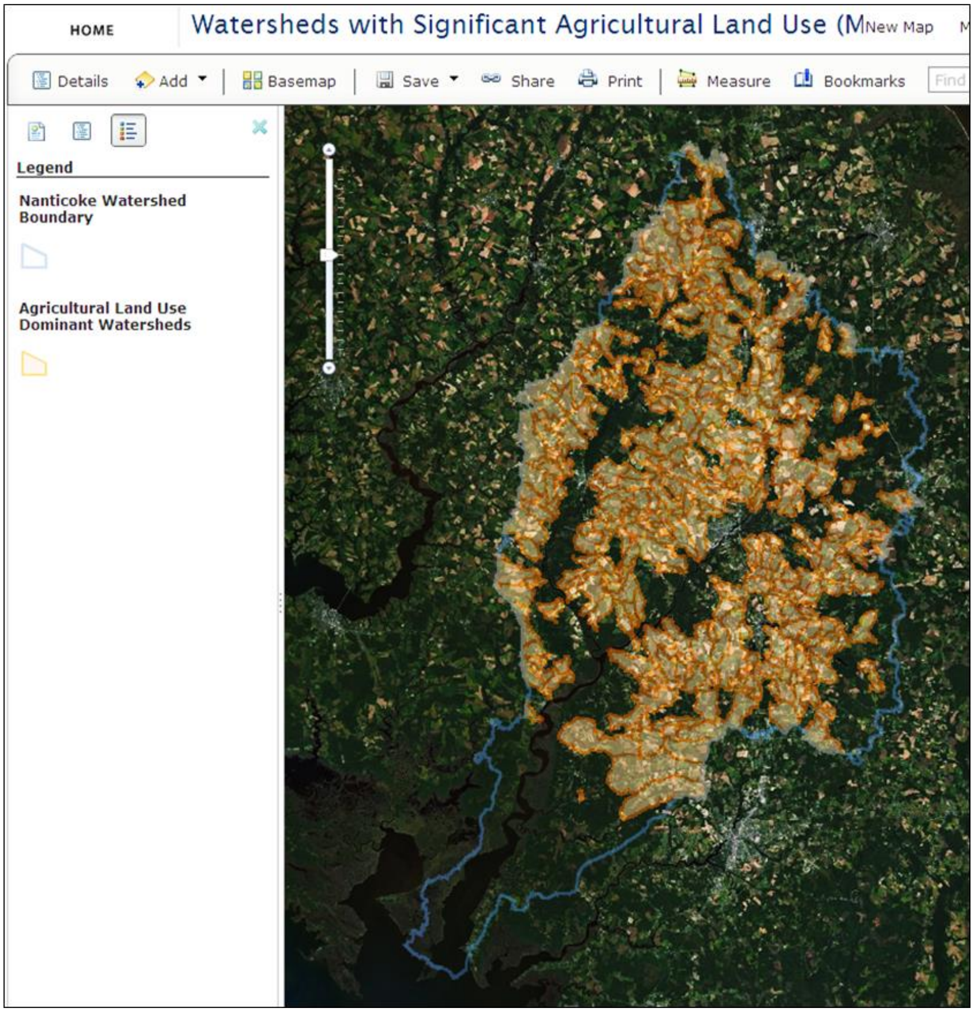


Map 1: In December 2011 Burke Environmental Associates conducted a comparative indicator study identifying several Chesapeake Bay Local Government jurisdictions that ranked high for water quality related environmental stressors such as: high effective nitrogen and phosphorus, excessive soil phosphorus concentrations, high percentages of impaired stream miles and impervious cover.



Map 2: Following the comparative indicator work, a subsequent study was launched in partnership with the Nanticoke Watershed Alliance to assess the Nanticoke Watershed for potential opportunities to deploy nutrient and sediment reduction practices to complement the Alliance's watershed restoration work.

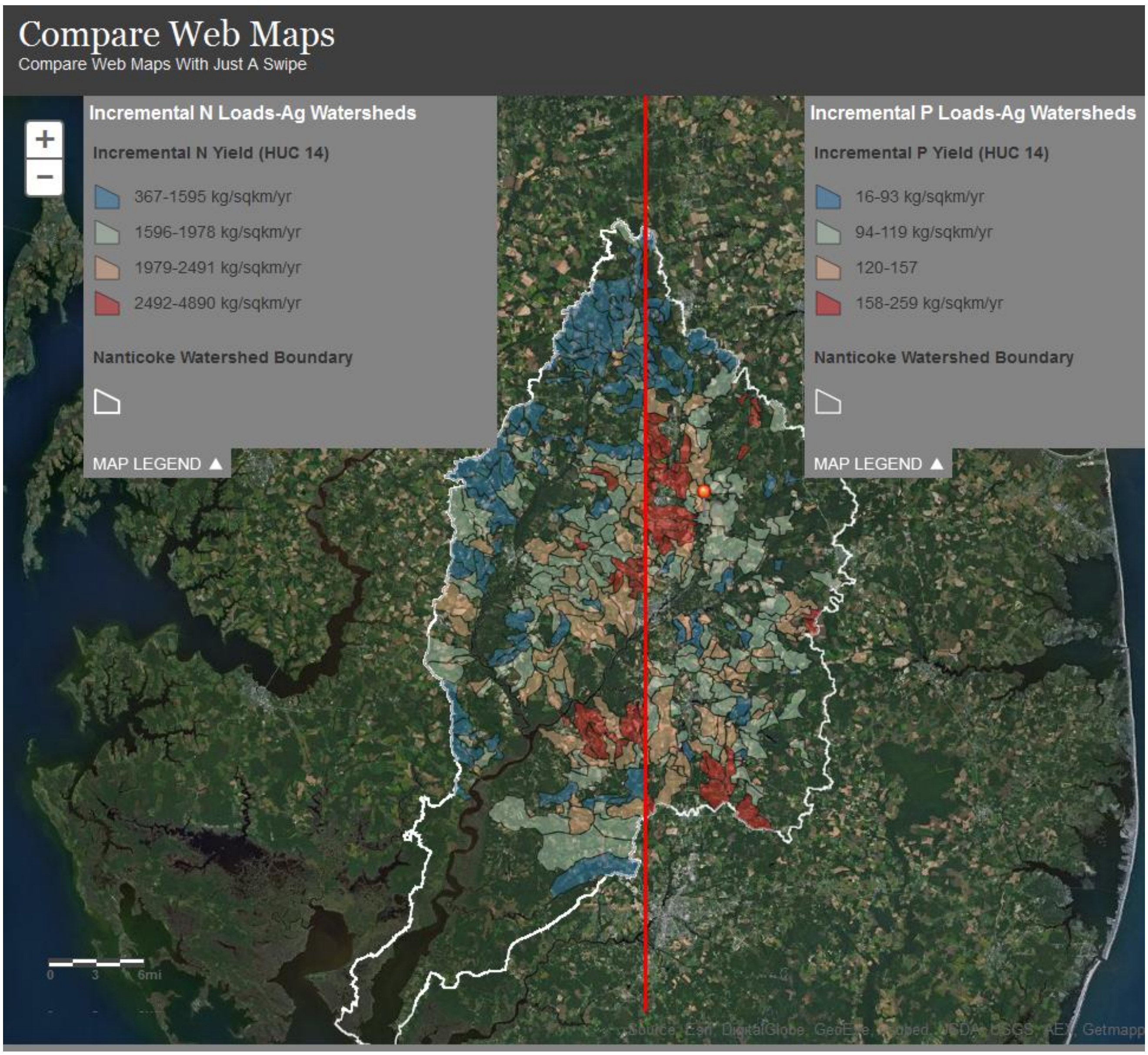




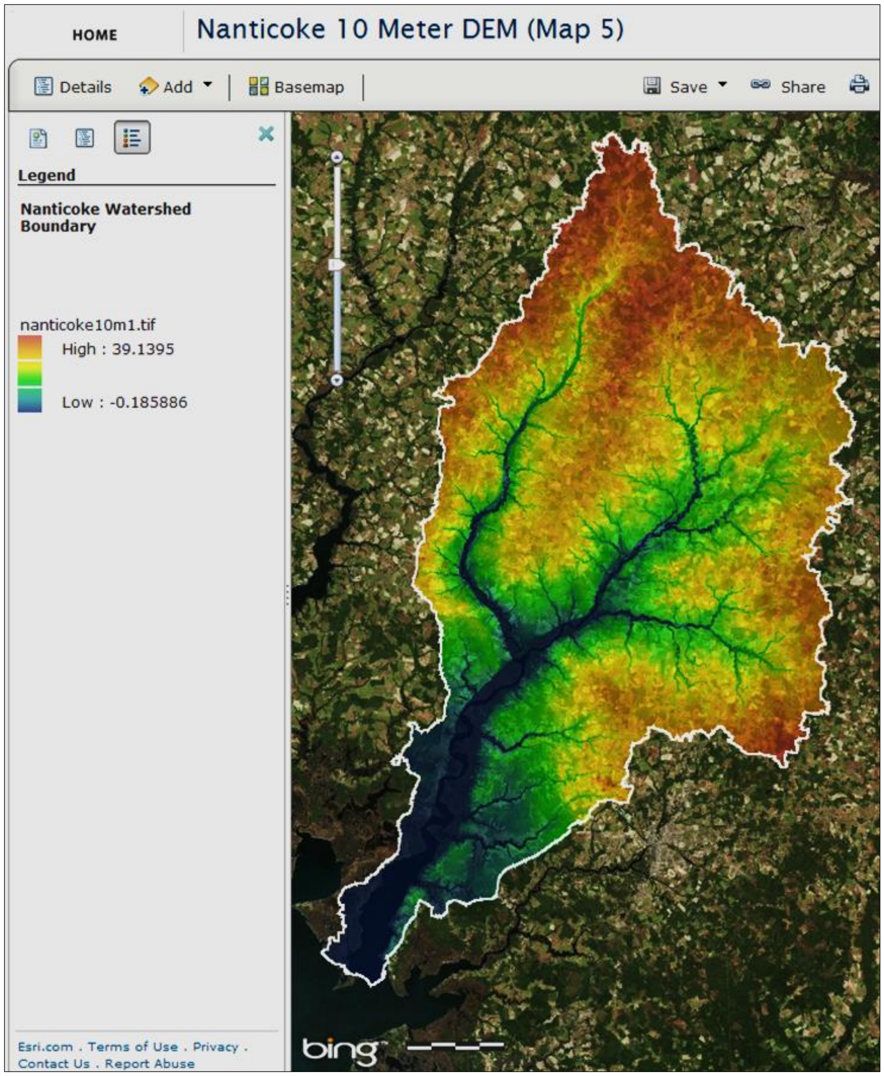
Map 3: The decision was made to focus the study on subwatersheds with significant agricultural land use (greater than 50%). A combination of analytical methods using desktop, GIS-based and field-scale data were used to target small subwatershed and farm level opportunities for potential intervention. An important goal of the study is to identify cost efficient, environmentally effective pollutant reduction practices within non-point source "hot spots" in the Nanticoke Watershed. Potential practices include:

- protection of wetlands with nutrient/sediment reduction capacity & opportunity to intercept pollutants
- forested/grass buffer installation
- select agricultural BMPs
- stream restoration to increase potential for in-stream nutrient processing

Map 4 (Nanticoke Basin Incremental N/P Yields in Agricultural Land Use)**:** The incremental nitrogen (N) and phosphorus (P) maps were derived from USGS's SPARROW (spatially referenced regressions on watershed attributes) model runs released in October of 2011. The yields depicted in these maps show incremental yields in kilograms per square kilometer per year for N and P (from agricultural sources of fertilizer and manure). The N and P maps viewed online allow the user to compare N and P yields between watersheds with a special "swipe" bar (shown in red). The yield ranges are broken into quartiles (i.e. top to bottom 25th percentiles). Incremental yield (vs. delivered yield) is the load generated by the area that drains directly to the reach without loads from upstream. Incremental yields provide an indication of the relative importance of local drainage areas to N and P loading, but do not account for instream losses that occur as pollutants are transported to the Chesapeake Bay. The Nanticoke Basin is one area that drains directly to a large stream (Nanticoke River) that is close to the Bay. Areas like this have high incremental loading for N and P. Further upon entering the Bay estuary they have greater impact due to short attenuation time and the counter clockwise circulation of Bay currents. These subwatersheds represent good candidates for prioritizing agricultural BMPs, stream and wetland restoration, and riparian forest buffer plantings based on load and effectiveness.

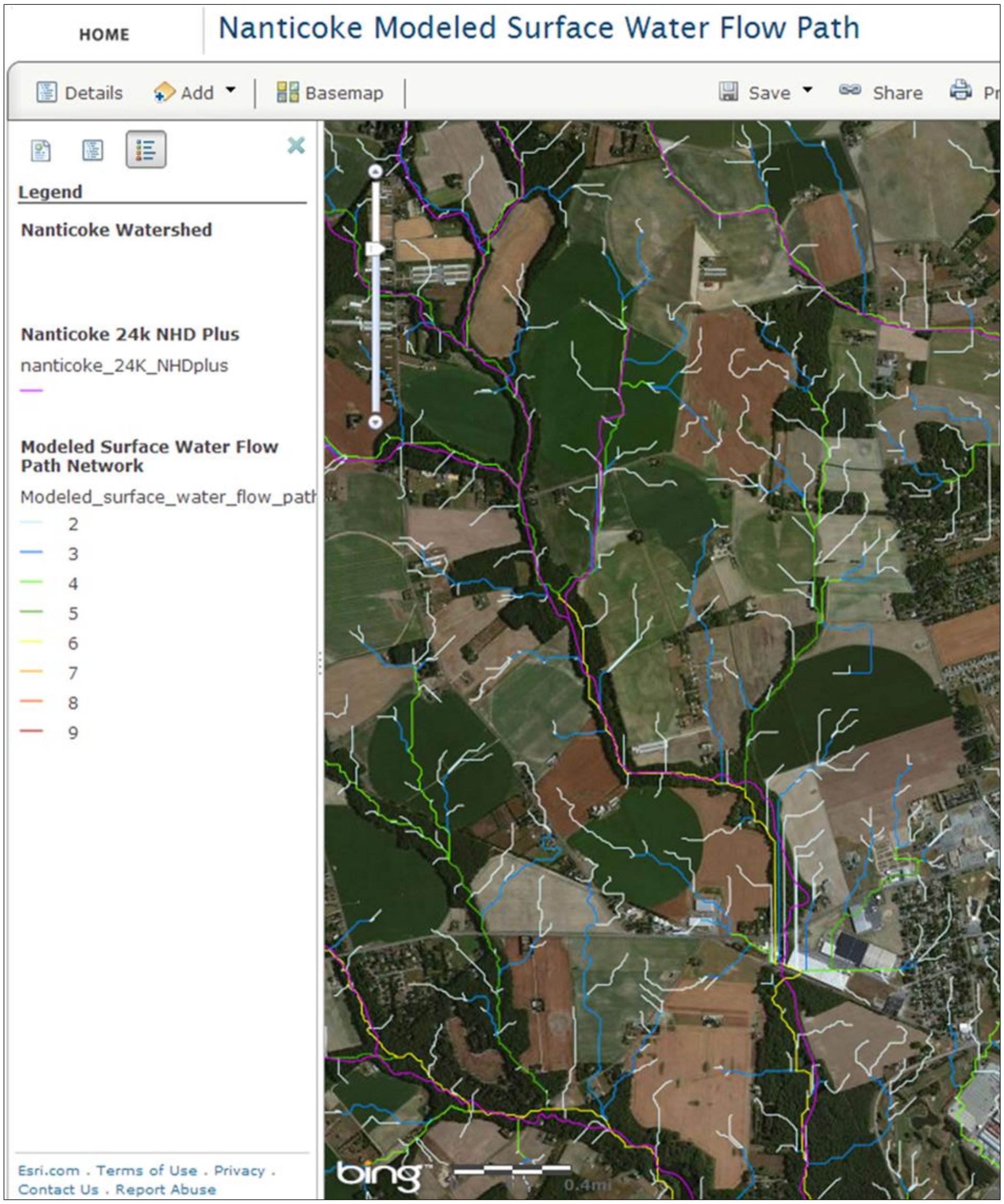


Map 5: This elevation map is based on the National Elevation Dataset (NED) produced by USGS. All elevation values are in meters and are referenced to the North American Vertical Datum of 1988 (NAVD 88). The elevation data is shown over 2012 ESRI aerial imagery to give the observer a clear picture of how the drainage patterns and stream systems related to the topography and land use of the Nanticoke Basin. The NED layer was composited from many individual maps using RiverTools software. Unfortunately, there are differences in the density and quality of data points that are apparent between information gathered in Delaware versus Maryland,



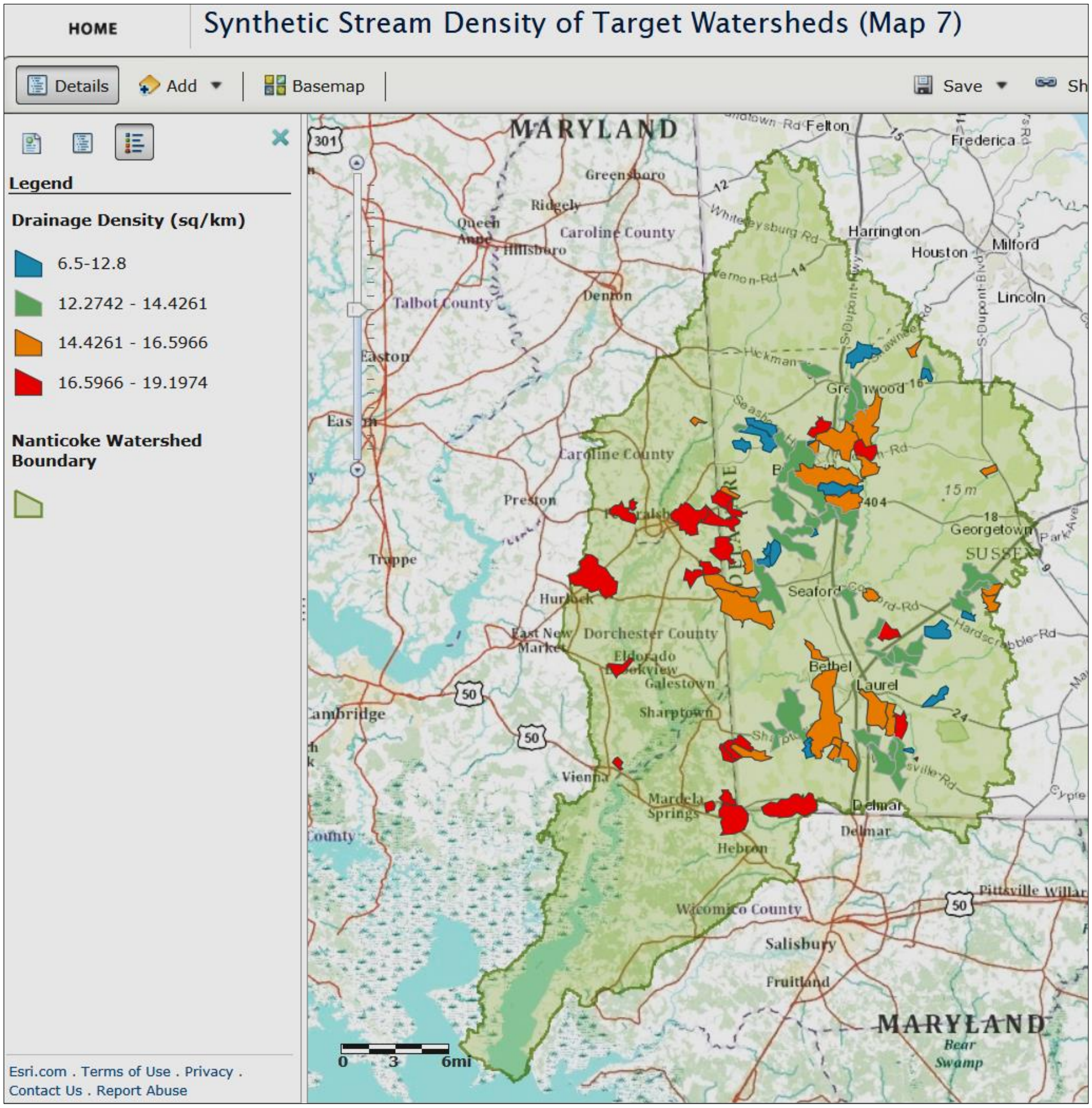
however, the data gaps are not significant overall. This layer was used to derive a synthetic water flow network to help the planning team perform additional targeting analyses related to nutrient and sediment transport. Using NED allows the visualization of accurate flow paths, making it easy to site buffers and other practices in a highly precise manner, which can both reduce BMP costs and increase their effectiveness.

Map 6: Two datasets are available for comparison – one is based on a proprietary modification of the National Hydrography Dataset (Functional River Network) and the second represents the stream and flow path network produced using RiverTools software and other editorial modifications. The flow path network is a calculated representation of water flow paths produced by averaging elevation points contained in the National Elevation Dataset shown in Map 5. This synthetic network provides a more complete picture of the hydrologic connectivity of drainage networks and water bodies to pollutant sources. The spatial arrangement and position in the watershed of pollutant sources relative to key landscape features such as crop type, soils, management BMPs, forest buffers, wetlands, slopes, depth to groundwater etc., can



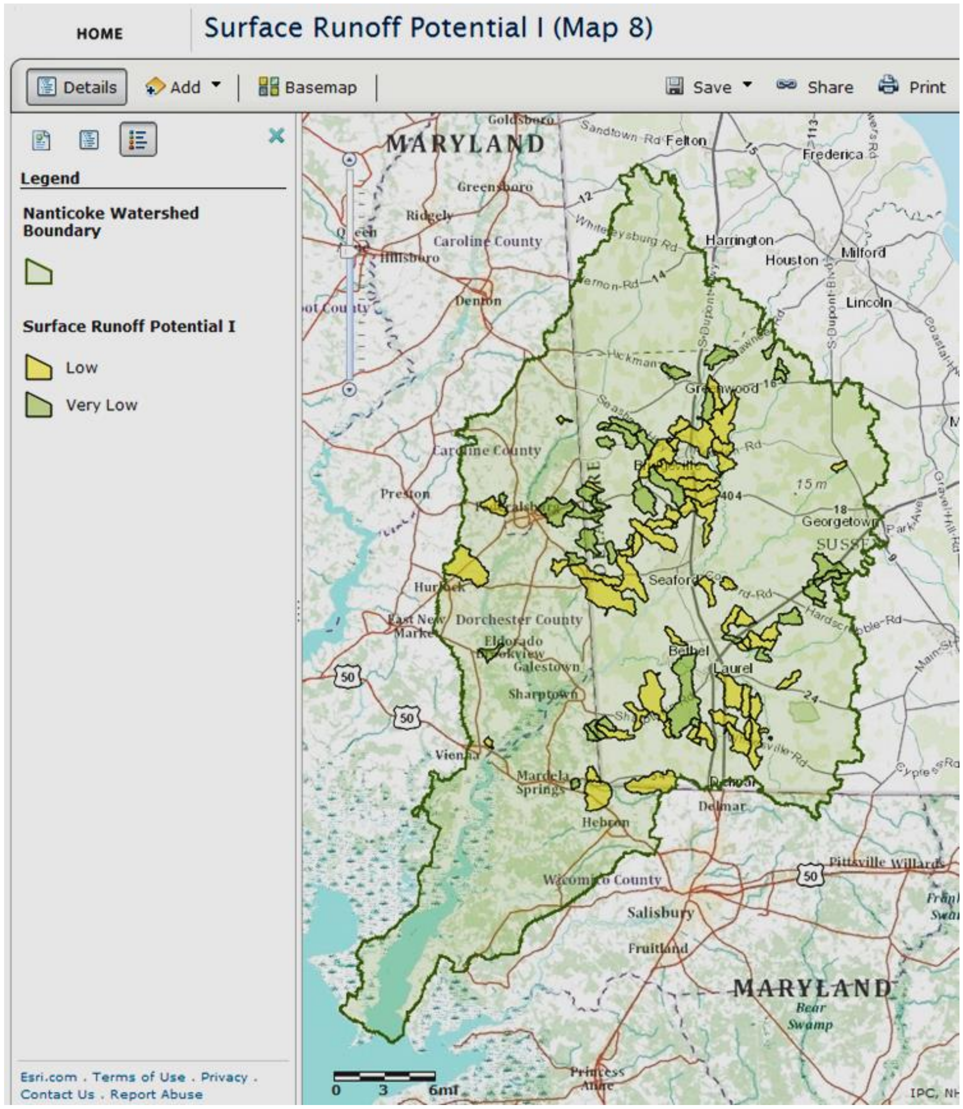
be used to build predictive models about how fluxes of sediments and nutrients may affect nearby receiving waters. First order streams and drainage paths can be significant sources of sediment and nutrients and can exhibit different nutrient processing and sediment transport characteristics that can be closely examined to determine ways of slowing down or “enhancing” transient water storage to prevent water quality degradation.

Map 7: This map shows the relative stream and flow path drainage network density per square kilometer of each agriculturally dominated subwatershed with high N and P yields. The drainage network shown here is somewhat different than the functional network of streams as it consists of a system of actual interconnected stream channels and synthetic drainage ways and flow paths (see discussion on Map 6). Generally, surface water runoff and peak flows

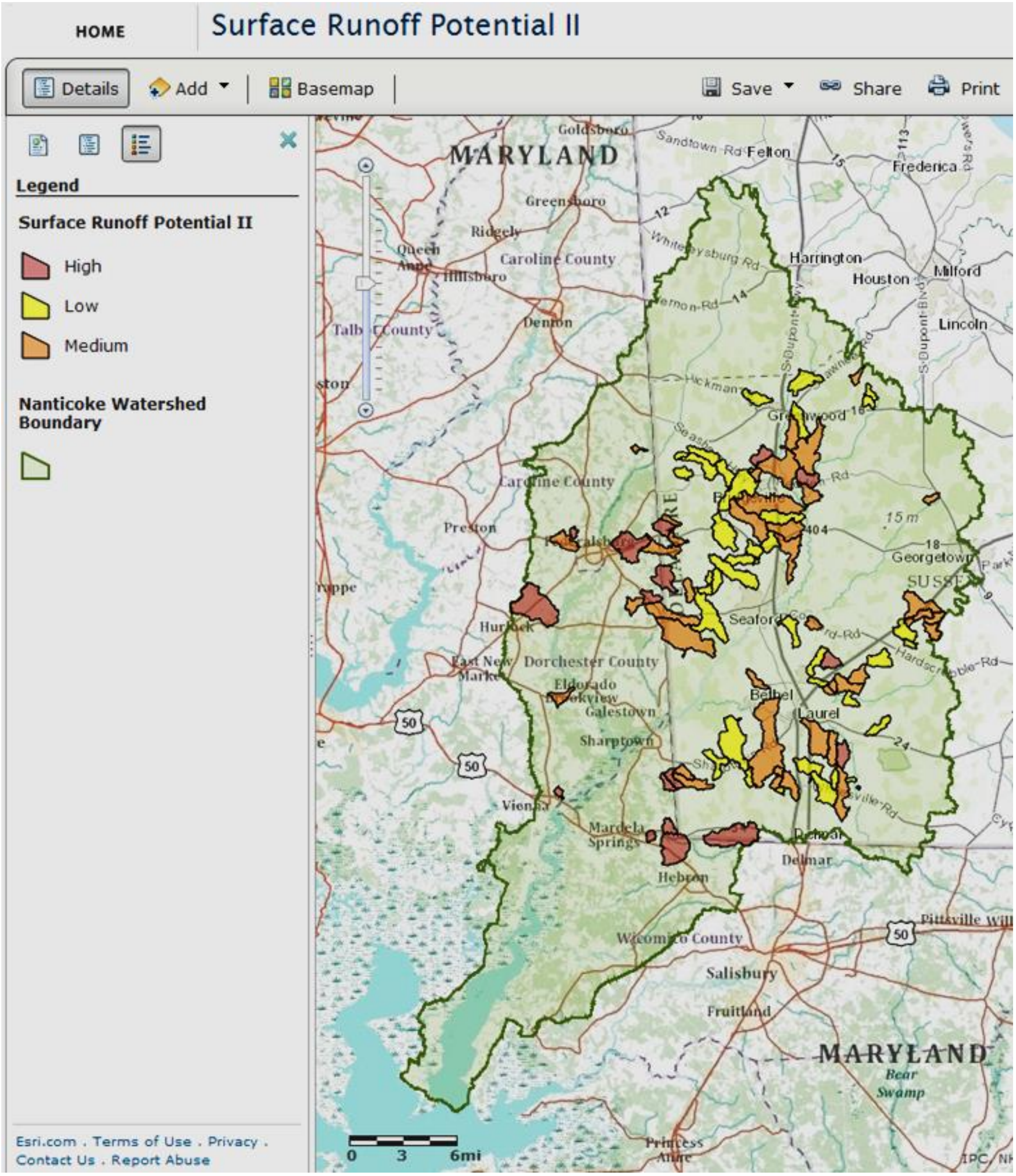


increase as drainage density increases. Factors that influence drainage density include climate, topography, soil infiltration capacity, vegetation, and geology. Drainage density in this study is being used to help identify where potential nutrient and sediment transport and the loss of topsoil may be more likely to occur in the absence of other mitigating factors such as soil management BMPs, in-place nutrient management strategies, distance to nearest waterways/groundwater and vegetative buffering around the fields, etc. By itself, this index cannot be used to identify priorities for pollutant reduction, but it is a useful measure when other mitigating factors are taken into account.

Map 8: The Surface Runoff Potential I map is based on an evaluation of averaged soil permeability and slope parameters of the predominant soil types in each agriculturally dominated subwatershed. The study team was guided by and adapted several of the soils based technical criteria and parameter values used in the Maryland Phosphorus Index (Part A) discussed in Soil Fertility Management (SFM-7), March 2008, University of Maryland Extension. The soil data was obtained from the USDA, NRCS online Soil Data Mart.

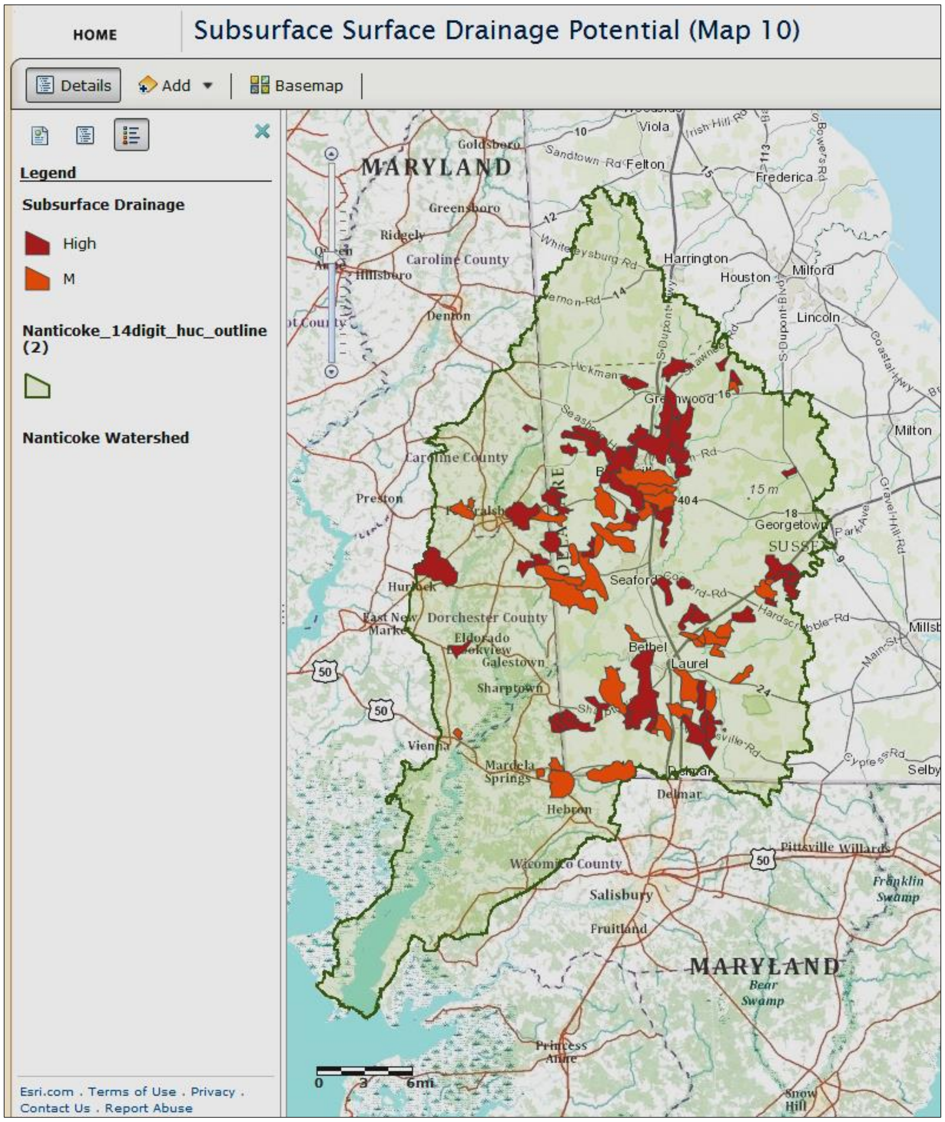


Map 9: The Surface Runoff Potential II map is based on the functional stream and flow path drainage network density data shown in Map 7. A Chesapeake Bay Watershed wide analysis of average stream density ranges in all HUC 8 watershed basins was used, in part, to help calibrate the parameter values of the functional stream and flow path density averages found in the agriculturally dominated subwatersheds.



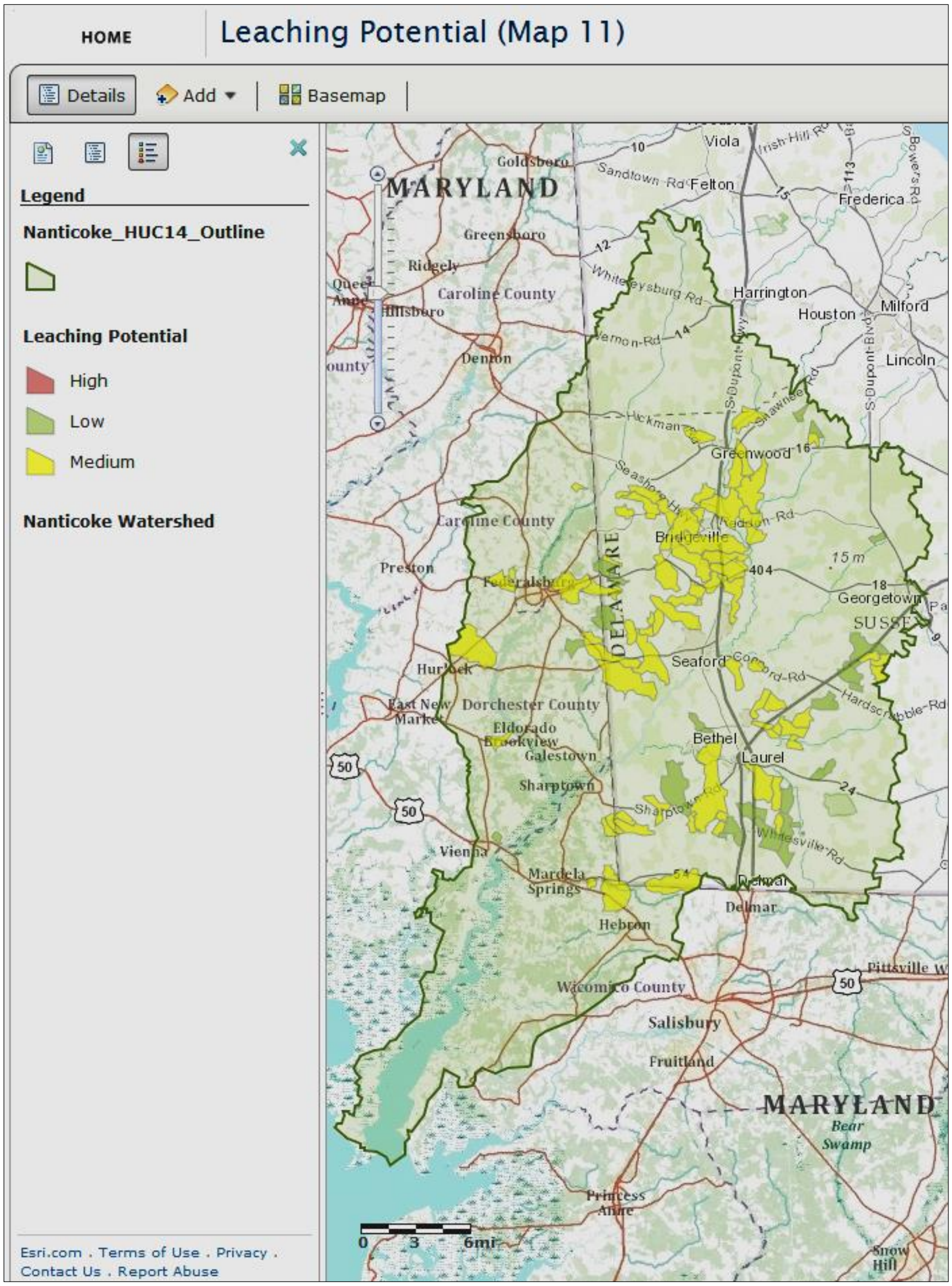
Map 10: The Subsurface Drainage Potential map is based on an evaluation of averaged soil drainage class and the High Water Table depth parameters of the predominant soil types in each agriculturally dominated subwatershed. The study team was guided by and adapted several of the soils based technical criteria and parameter values used in the Maryland Phosphorus Index (Part A) discussed in Soil Fertility Management (SFM-7), March 2008,

University of Maryland Extension. The soil data was obtained from the USDA, NRCS online Soil Data Mart. Data was unavailable for specific agricultural fields that may have artificial subsurface drainage (tile drains, mole drains, etc.) in the study area. However, this situation is not expected to materially affect the targeting exercise.

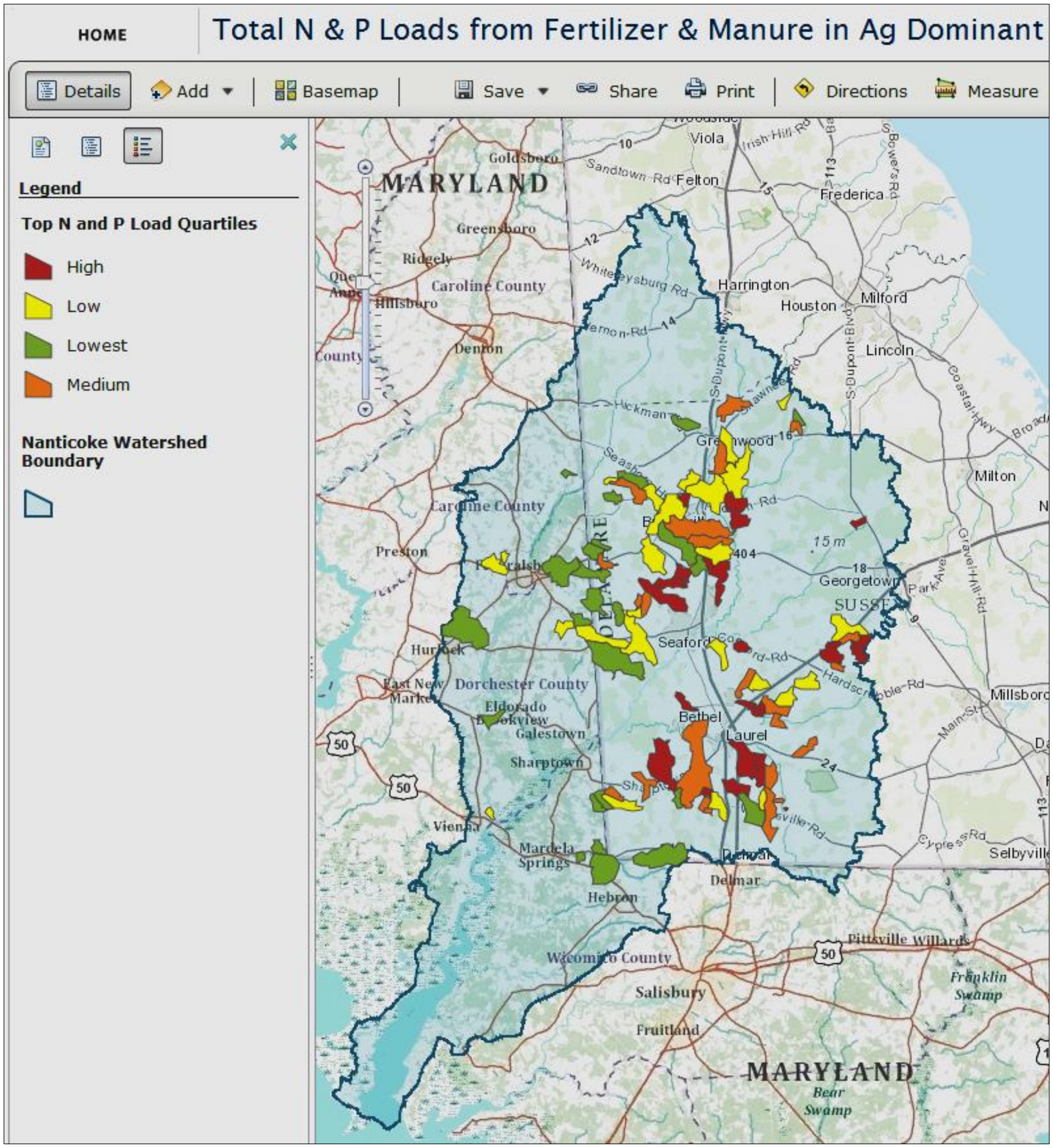


Map 11: The Leaching Potential map is based on an evaluation of averaged High Water Table depth and NRCS Leaching Value parameters of the predominant soil types in each agriculturally dominated subwatershed. The study team was guided by and adapted several of the soils based technical criteria and parameter values used in the Maryland Phosphorus Index (Part A) discussed in Soil Fertility Management (SFM-7), March 2008, University of Maryland Extension.

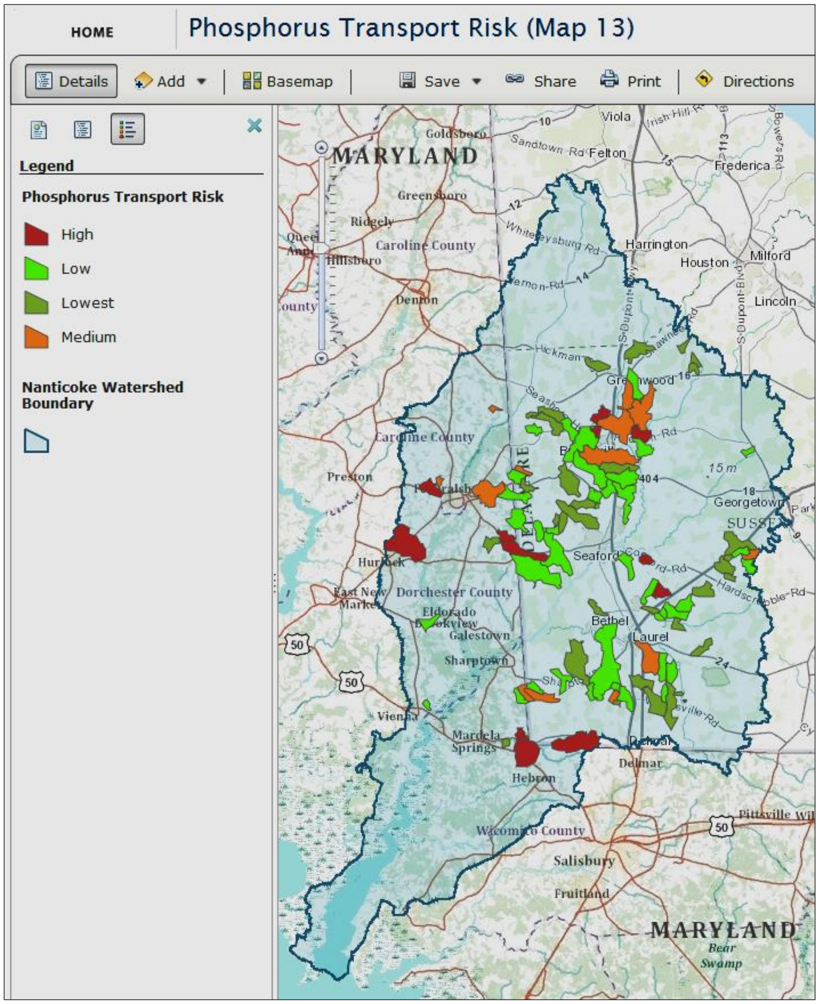
The soil data was obtained from the USDA, NRCS online Soil Data Mart. Some leaching values were not available for certain soil types, but were inferred from soil types with similar characteristics. However, this situation is not expected to materially affect the targeting exercise.



Map 12: The Incremental Nitrogen plus Phosphorus Yields from Fertilizer and Manure in Ag Dominant Watersheds map is based on the SPARROW data from Map 4. Incremental yields were summed and placed in quartiles (i.e. top to bottom 25th percentiles).

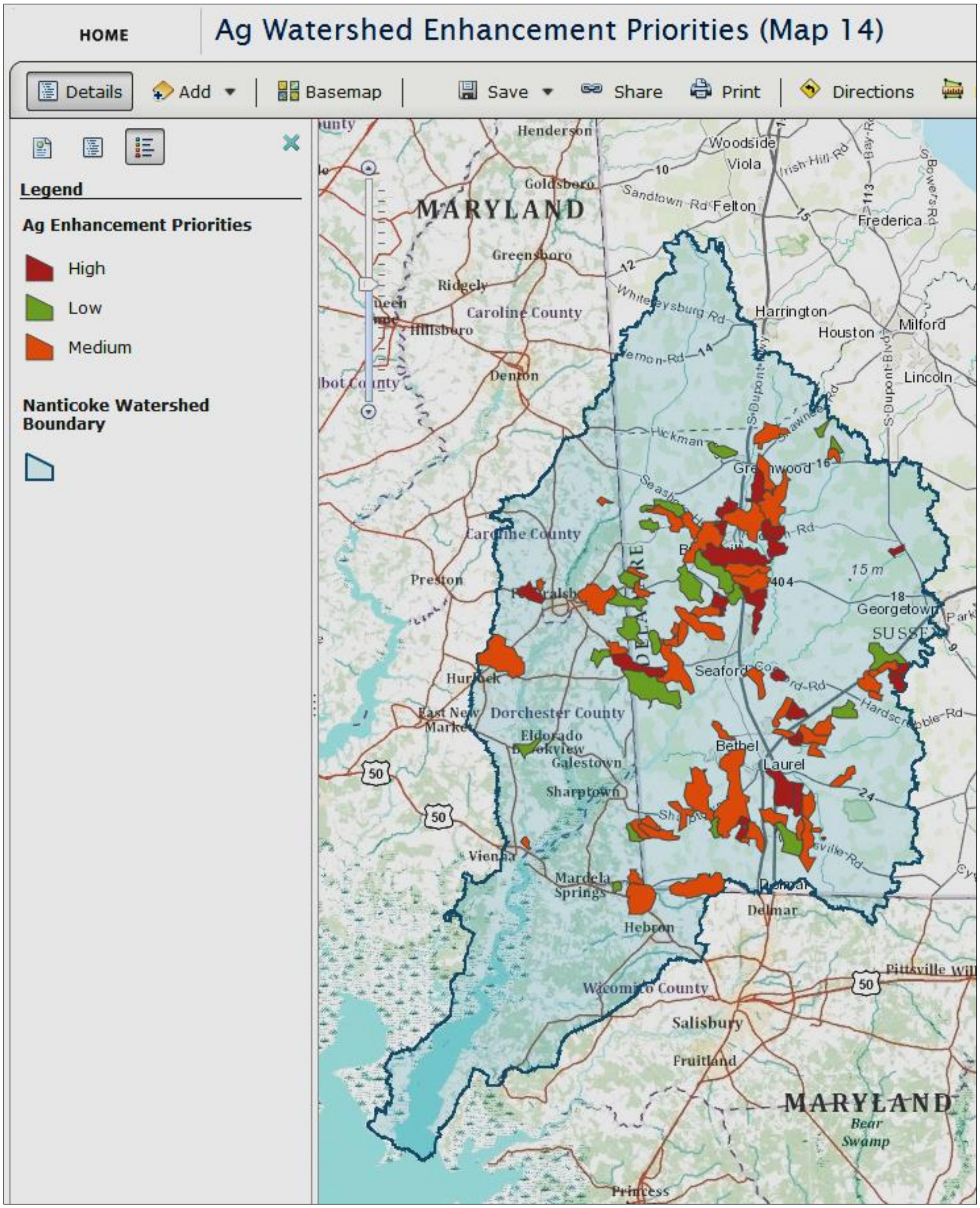


Map 13: The Phosphorus Transport Risk map aggregates values developed from maps 8-11 into a single composite indicator of the potential for phosphorus to be transported off agricultural areas via: 1) surface water runoff; 2) leaching of phosphorus, fertilizers, pesticides or other water soluble substances out of the soil and into receiving surface or groundwater; or 3) drainage water removed artificially by surface ditches or subsurface conduits. Total risk values were summed and placed in quartiles (i.e. top to bottom 25th percentiles).

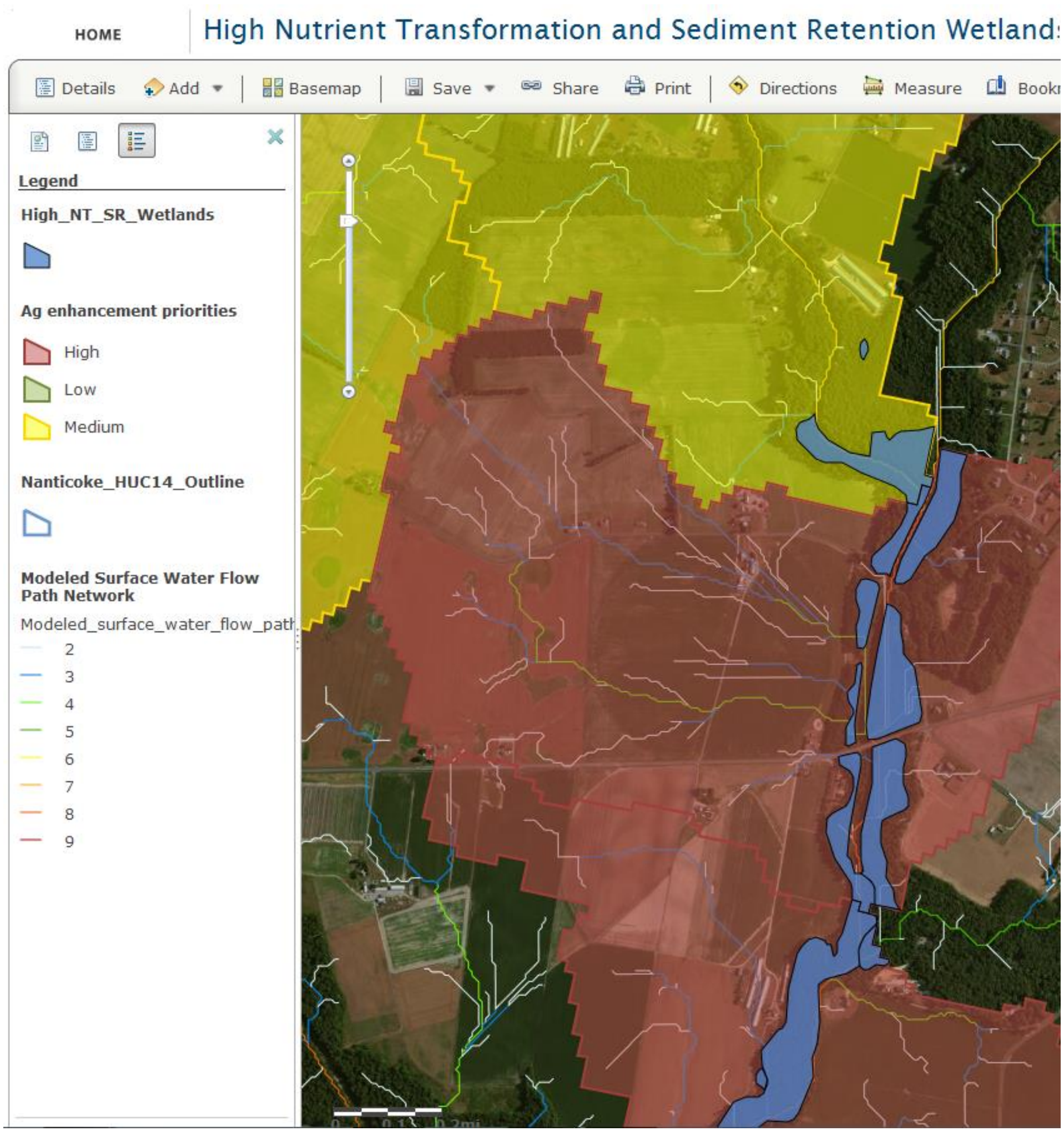


Technical Note: Map 13 also takes into account Nitrogen transport risk from surface runoff and shallow subsurface flow. N from agricultural sources is transported to waterways first, through surface runoff and shallow subsurface flow; and second, through ground water (about 50% on average, from these two sources). Phosphorus is not highly soluble, binding tightly to soil particles. Under normal agronomic conditions most P enters waterways by traveling with soil particles in runoff. However, a small portion of P can move down through the soil profile: to tile drains through large cracks and earthworm channels; along perched water tables on underlying impermeable horizons or shallow bedrock; and through other bypass anomalies related to soil properties; and then eventually enter waterways. Also, soils highly saturated with P can release P when in contact with water. Most annual crops uptake of fertilizer or manure nutrients is less than 50% of the applied amount, thus that portion not taken up by the crop is subject to movement off-farm. Poultry litter contains N and P not in balance with crop requirements, therefore the steady buildup of excess P in soils over time on farms that routinely use this source of fertilizer..

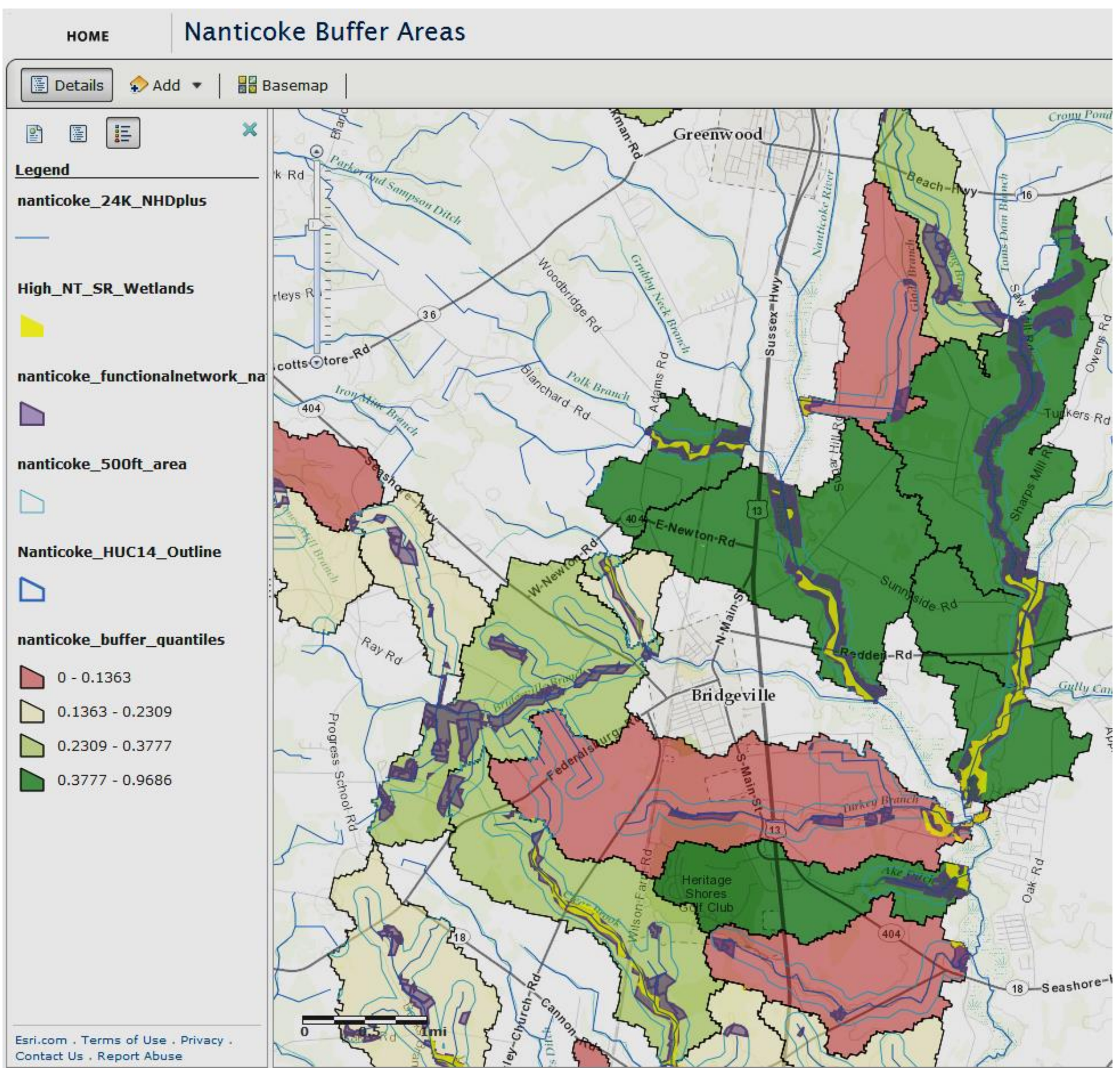
Map 14: The Agricultural Watershed Enhancement Priorities map represents a composite and summary ranking of each subwatershed's score from the Incremental Nitrogen plus Phosphorus Yields from Fertilizer & Manure in Ag Dominant Watersheds (Map 12) and the Phosphorus Transport Risk (Map 13). Based on the scoring method, the agriculturally dominated watersheds fell into three categories of low, medium and high priority reflecting locations where enhancement opportunities will be evaluated through the next sequence of maps.



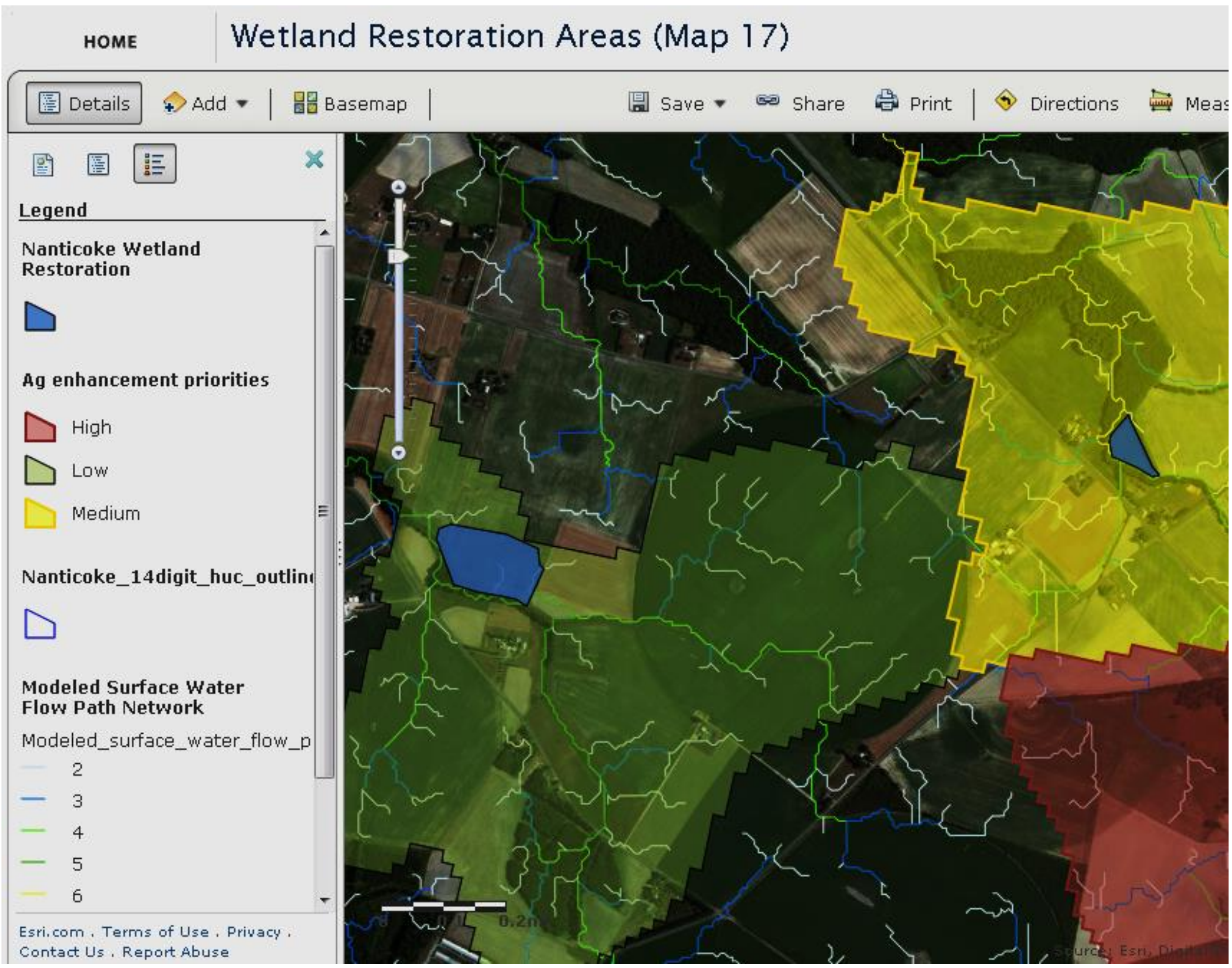
Map 15: The High Nutrient Transformation and Sediment Retention Wetland map shows an example of our watershed-wide mapping of Palustrine System non-tidal, vegetated wetlands that have a high potential to recycle nutrients at high levels of performance and/or to trap and retain sediments and particulates at significant levels. The wetlands included in the maps represent a smaller set of non-tidal wetlands identified by the authors based on a study by U.S. Fish and Wildlife Service (Tiner, Bergquist, Swords and McClain, 2001. *Watershed-based Wetland Characterization for Delaware's Nanticoke River Watershed: A preliminary Assessment Report*). Also shown is the flow path network where surface runoff enters these wetlands. These wetlands are excellent candidates for extra protection measures that help retain their ecological integrity and hydrological regimes. Protective measures include potential resource conservation and restoration management activities, limiting disturbances, buffer zones, and conservation easements.



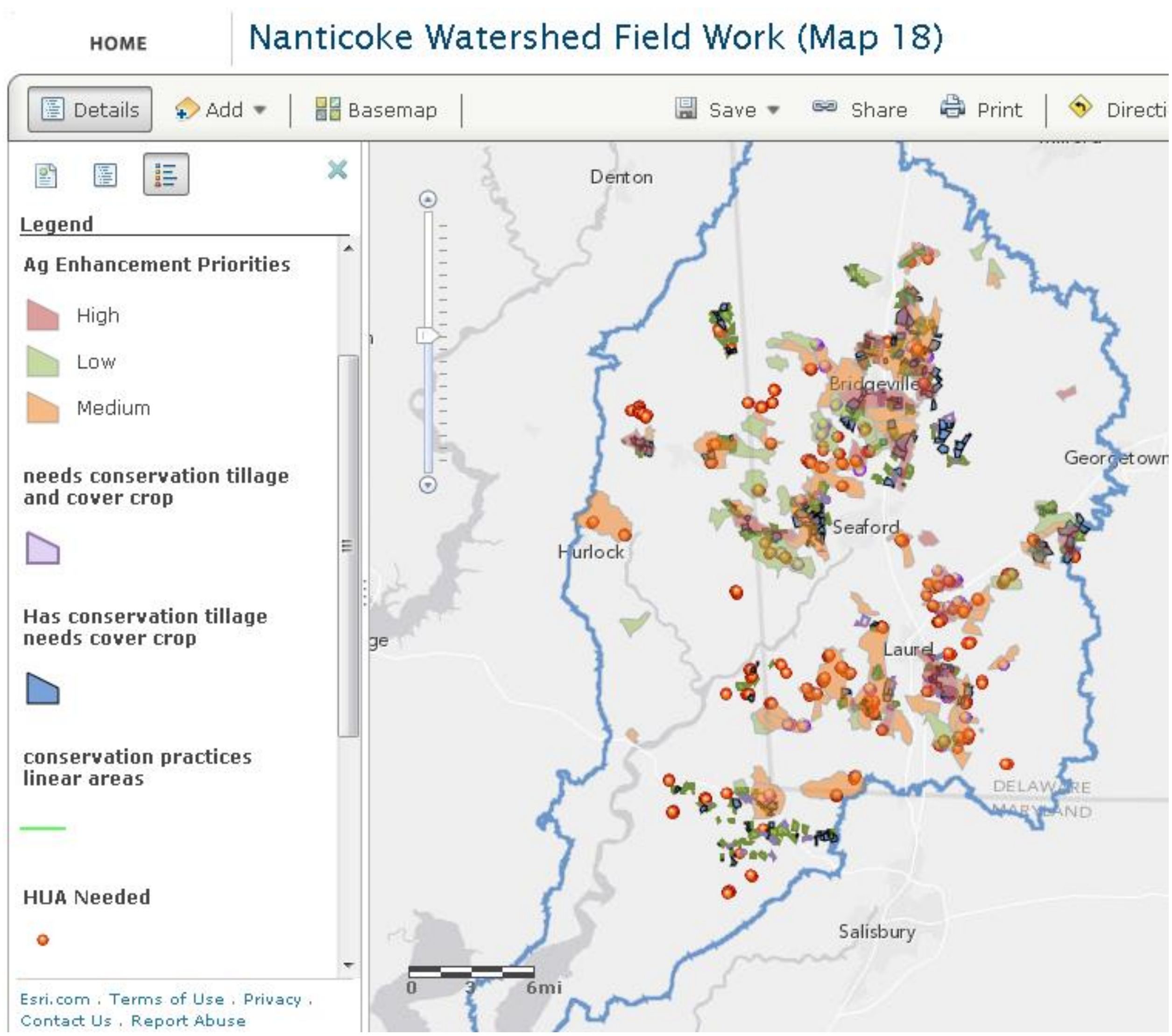
Map 16: The Nanticoke Buffer Areas map displays several natural vegetated buffer (i.e. forest and/or wetlands) characteristics that can play a role in determining conservation and restoration priorities. First, HUC 14 watersheds are organized by quartile classifications that quickly place subwatersheds in a hierarchy of riparian buffer coverage percentages—from high to low. For example, the green quartile shows that 38%-97% of a fixed buffer corridor of 500 ft. on either side of the streams in a particular subwatershed is buffered with forest or wetland vegetation. This allows the user to quickly see what subwatersheds are contributing the greatest relative buffer coverage. At the same time this information can show where vegetative restoration is appropriate (i.e. in non-vegetated buffer “gaps”)—particularly in watersheds with high pollutant loads (Map 14—Ag Watershed Enhancement Priorities Map). Second, at a finer scale the user can see how balanced the buffer coverage is on either side of the stream by observing the functional stream network natural buffer coverage layer (purple) within the 500ft. buffer zone (light blue line). The map also reveals (yellow layer-High_NT_SR_Wetlands) where wetlands are performing high nutrient transformation and/or sediment retention functions, thereby effectively reducing pollutants.



Map 17: The wetland restoration areas map shows two of three potential areas where wetlands could be restored within an Ag enhancement priority watershed. The three selected restoration sites range from 2 to over 9 acres in size and will require additional field work to verify their potential for restoration. The selected sites do not appear to interfere with irrigation infrastructure—something the study team felt would be a "non-starter" with most landowners. The overwhelming majority of potential wetland restoration sites were situated poorly with respect to irrigation infrastructure and farming operations. The selected sites are located on farmed, non-wetland hydric soils, are not on a mapped wetland, and receive "theoretical" surface water runoff from a 4th order or higher synthetic flow path.



Map 18: The online version of the Nanticoke Watershed Field Work map shows the apparent locations of existing management practices and potential BMPs and conservation practices (not covered in Maps 15-17) in relation to the Ag enhancement priority watersheds. The observations were made from a combination of publicly available data sources including GIS data, aerial imagery interpretation and field observed site conditions. The judgments made reflect those of the authors who are not trained agronomists or image interpretation experts and are, therefore subject to a range of potential errors. Verification of observed BMPs is greatly facilitated through an examination of current soil and water conservation and nutrient management plans and site specific field records —all of these sources are, unfortunately, not publicly available. The data on this map does provide a general indication of where additional BMPs and conservation practices may be appropriate at a watershed level. Direct consultation with affected landowners and local soil conservation district office personnel is the best way to verify this information.



Field and Aerial Imagery Reconnaissance

The Agricultural Watershed Enhancement Priorities map (14) was used by the study team as the starting point to perform additional field work and desk top computer analyses to help locate potential areas where a variety of watershed conservation, restoration and BMP actions could be undertaken to improve water quality conditions over current background levels. Other subwatersheds that were not identified as an Ag enhancement priority watershed were also assessed to varying degrees. The additional assessment work was performed during our field reconnaissance surveys and during initial GIS targeting work that was discontinued after further evaluations revealed these watersheds were actually lower on the priority rankings.

Validating whether certain BMPs were in place on agricultural lands within priority watersheds was necessarily limited to the identification of a select number of practices. This is due to Section 1619 Farm Bill provisions that prevent the disclosure, by the USDA, of information that has been provided to the agency by an agricultural producer or owner of agricultural land concerning the operation, practices or the land itself. Geospatial information is aggregated to land river segments and large watersheds by the EPA Bay Program for the purpose of generally describing these practices, but at a resolution that always prevents the determination of field specific practices. This research could be done much more affordably and accurately if the team was able to access nutrient management plans and soil conservation and water quality plans for specific watersheds.

Best Management Practice Review

Prior to selecting which BMPs would be field inventoried or identified using publicly available aerial imagery sources, a review of EPA's Chesapeake Assessment and Scenario Tool General Features and User's Guide (November, 2011) was undertaken. There are over one hundred BMPs in CAST that are divided into 7 categories that generally follow source sectors:

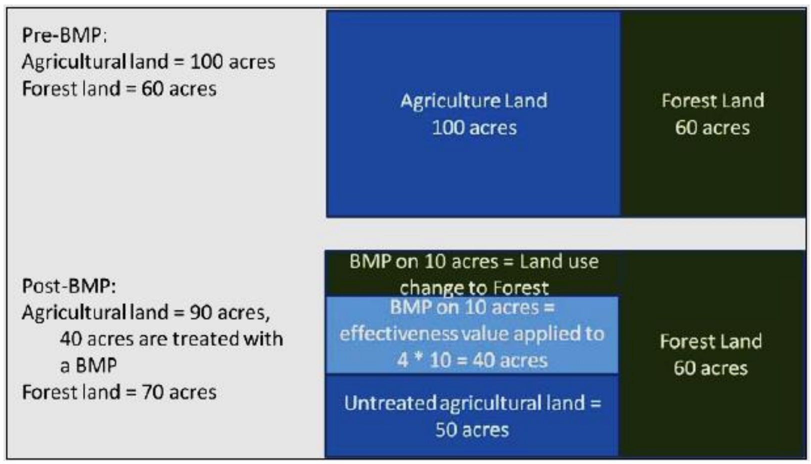
1. Agriculture BMPs
2. Urban BMPs
3. Forest BMP
4. Animal BMPs
5. Manure transport
6. Septic BMPs
7. Waste water BMPs

The CAST documentation notes that some BMPs change the land use while other BMPs use an effectiveness value. Yet another type reduces the load delivered or the application of nutrients. The differences are important to understand as the services a given BMP performs with respect to nutrient or sediment reduction vary greatly. Important BMP terms excerpted from the CAST user's guide include the following:

Effectiveness values: An effectiveness value is a percentage of a pollutant that is removed when the BMP is applied. For example, Dry Extended Detention Ponds remove 20% of nitrogen that would have been delivered without the Detention Ponds. When a pass through value for a BMP is referred to, it is simply 100% minus the effectiveness value. In this case, the pass through value for Dry Extended Detention Ponds is 80%.

Land use change: Land use change BMPs simply change one land use to another. For example, the BMP Urban Growth Reduction changes an urban land use to agricultural and forest land in the proportion that agricultural and forest land exists in the geographical area. Another example is the BMP Forest Buffers that converts agricultural land uses to a forest land use.

Land use change with effectiveness values: Some BMPs work as both land use change and effectiveness value BMPs. In these cases, the land use change is calculated first, and then an effectiveness value is applied to an additional number of acres of the original land use. The land use change BMPs that also have an effectiveness value are grass buffers, forest buffers, enhanced nutrient management, decision agriculture, and wetland restoration. It is assumed that the presence of these BMPs reduces the amount of nutrients delivered from upland acres as water and nutrients move through the soil matrix. The figure below (source: Figure 16, pg. 41from the CAST user's guide) illustrates an example of a forest buffer applied to agricultural land. An agricultural forest buffer is applied to 10 acres, converting those 10 acres of agricultural land to forest land. There is a nitrogen efficiency that treats 4 times the acres converted. If this were illustrating phosphorus or sediment, only 2 times the acres are treated. When a BMP is put on a specific land use, the benefit of the effectiveness value is applied to all land uses within that group. For example, if put on pasture, then the benefit is to all agricultural land uses.



Load reduction: There are a few special BMPs that do not fit among the three categories of land use change, effectiveness, or land use and effectiveness BMPs. These are load reduction BMPs and include stream restoration, dirt and gravel roads, street sweeping, animal BMPs (e.g., Poultry Phytase), and manure transport. These are modeled in the Chesapeake Bay Program's Scenario Builder and the Watershed Model in various ways. Some are modeled as a decrease in the concentration of nutrients in various animals' manure. In other cases, the crop application rate or plant uptake is varied.
Load reduction BMPs are implemented in CAST differently than in the Chesapeake Bay Program's tool Scenario Builder. In CAST, all BMPs are modeled as a change in the load per land use. Since the application and load reduction BMPs take effect earlier in the Scenario Builder process than the distribution of loads to land uses, these BMPs are necessarily estimated in CAST. In CAST, these BMPs are calculated differently.

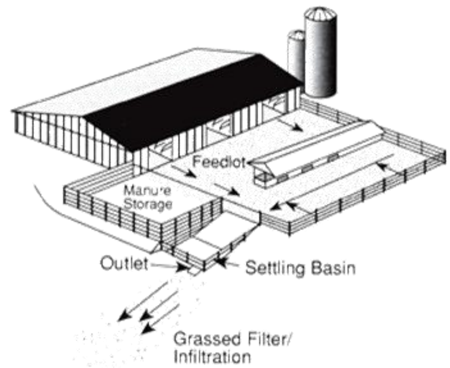
After reviewing CAST BMPs, an abbreviated list (updated as of June 8, 2012) was evaluated for possible use during field reconnaissance. The initial list included mostly agricultural BMPs and some urban and forest practices:

1. Barnyard Runoff Control
2. Commodity Cover Crop (early, late, planted, drilled and aerial)
3. Conservation Till w/o Nutrients
4. Continuous No Till
5. Cropland Irrigation Management
6. Dairy Manure Injection
7. Decision Agriculture
8. Enhanced Nutrient Management
9. Forest Buffers
10. Grass Buffers; Vegetated Open Channel
11. Horse Pasture Management
12. Irrigation Water Capture Reuse (nursery)
13. Loafing Lot Management
14. No Till allowing combinations with other practices
15. Off Stream Watering w/o Fencing
16. Poultry Litter Injection
17. Precision Intensive Rotational Grazing
18. Prescribed Grazing
19. Soil conservation and Water Quality Plan
20. Sorbing Materials in Ag Ditches
21. Streamside Forest Buffers
22. Streamside Grass Buffers
23. Water Control Structures
24. Wetland Restoration
25. Bioretention/raingardens
26. Bioswale
27. Dry Detention Ponds and Hydrodynamic Structures
28. Dry Entended Detention Ponds
29. Erosion and Sediment Control
30. Erosion and Sediment Control on Extractive
31. MS4 Permit-Required Stormwater Retrofit
32. Permeable Pavement – no sand, veg. with underdrain with AB soils
33. Permeable Pavement – with sand, veg. with underdrain with AB soils
34. Stormwater Management by Era
    a. 1985-2002
    b. 2002-2010
35. Stormwater to the Maximum Extent Practical
36. Street Sweeping 25 times a year
37. Urban Filtering Practices
38. Urban Forest Buffers
39. Urban Infiltration Practices – no sand\veg no underdrain
40. Urban Infiltration Practices – with sand\veg no underdrain
41. Urban Nutrient Management
42. Vegetated Open Channel – Urban
43. Wet Ponds and Wetlands
44. Forest Harvesting Practices

Possible BMP Opportunities for Potential Agricultural High Risk Pollution Transport Areas

Based on the CAST BMPs information, additional research and discussions with various experts, a greatly reduced annotated list of BMPs was compiled as a reference source for the study team and Nanticoke Watershed Alliance. This list follows:

<u>Effectiveness Value BMPs</u>



1. Barnyard Runoff Control
    a. Includes the installation of practices to control runoff from barnyard areas. This includes practices such as roof runoff control, diversion of clean water from entering the barnyard and control of runoff from barnyard areas. Different efficiencies exist if controls are installed on an operation with manure storage or if the controls are installed on a loafing lot without a manure storage.
    b. Pollution reduction effectiveness for CAFOs or animal feeding operations in Coastal Uplands/Lowland; Tidal/Nontidal settings:
        i. N effectiveness=20%
        ii. P effectiveness=20%
        iii. Sediment effectiveness=40%

2. Commodity Cover Crop
    a. Includes the planting of a variety of small grain (winter wheat, barley or rye) cover crops usually planted in September or early October, to uptake nutrients remaining in the soil after a crop is harvested (particularly nitrate) and minimize leaching to groundwater. In Maryland, must be planted before the cover crop planting program deadline of November 5, 2012.

    b. Effectiveness ranges vary with crop type, planting method, fertilizer/manure and dates. Some examples for Coastal Plain settings:
        i. Coastal Plain Lowland Nontidal; early aerial rye; lowtill with manure: N effectiveness=7%
        ii. Coastal Plain Lowland Nontidal; late drilled rye; nutrient management hightill with manure: N effectiveness=19%
        iii. Coastal Plain Uplands Nontidal; standard drilled rye; lowtill with manure: N effectiveness=41%

3. Phosphorus-sorbing Materials (Ditch Filter)
    a. The University of Maryland and the USDA Agricultural Research Service (ARS) have demonstrated through an existing research project at the University of Maryland-Eastern Shore the application of “Phosphorus-sorbing” materials to absorb available dissolved phosphorus in cropland drainage systems for removal and reuse as an agricultural fertilizer. These in-channel engineered systems can capture significant amounts of dissolved phosphorus in agricultural drainage water by passing them through phosphorus-sorbing materials, such as gypsum, drinking water treatment residuals, or acid mine drainage residuals. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive or do not receive manure.

    b. P-sorbing materials can convert dissolved P into particulate P; but they have finite sorption capacities, similar to eastern shore sub-soils. Depending upon the type of P-sorbing materials used (i.e. gypsum or steel slag) and flow rates—P removal efficiency can range from 20-65%. See: Phosphorous Sorbing Material (PSM) Filters Effective At Reducing Phosphorus Loading Rates From Agricultural Ditches; McGill, McGrath and Penn; October 23, 2012, Visions for a Sustainable Planet conference presentation sponsored by American Society of Agronomy, Crop Science Society of America, Soil Science Society of America.

Land Use Change Value BMPs

1. Conservation Tillage
    a. Conservation tillage is especially suitable for erosion-prone cropland. Pieces of crop residue shield soil particles from rain and wind until new plants produce a protective canopy over the soil. Conservation tillage methods include no-till, strip-till, ridge-till and mulch-till. The no-till BMP is a crop planting and management practice in which soil disturbance by plows, disk or other tillage equipment is eliminated for all crops for a minimum of five years. Planting of a cover crop might be needed to maintain residue levels. When an acre is reported under no-till, it is eligible for additional reductions from the implementation of other practices such as cover crops or nutrient management planning, unlike *continuous* no-till. No-till and strip-till involve planting crops directly into residue that either hasn't been tilled at all (no-till) or has been

tilled only in narrow strips with the rest of the field left untilled (strip-till). Ridge-till involves planting row crops on permanent ridges about 4-6 inches high. The previous crop's residue is cleared off ridge-tops into adjacent furrows to make way for the new crop being planted on ridges. Maintaining the ridges is essential and requires modified or specialized equipment. Mulch-till is any other reduced tillage system that leaves at least <u>one third</u> of the soil surface covered with crop residue.

a. Pollution reduction potential of various conservation tillage types for erosion-prone cropland <u>reduces soil erosion by as much as 60-90%</u> depending on the method. (MDA)

<u>Land Use Change Value BMPs with Additional Effectiveness Values</u>

1. Streamside Forest Buffers
    a. Agricultural riparian forest buffers are linear wooded areas along rivers, stream and shorelines. Forest buffers help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width for riparian forest buffers (agriculture) is 100 feet, with 35 feet minimum width required.
    b. Forest Buffers pollution removal effectiveness examples:
        i. hay with nutrients; Coastal Plain Uplands Tidal: N effectiveness =19%; P effectiveness=45%; Sediment effectiveness=60%
        ii. nutrient management pasture; Coastal Plain Uplands Non Tidal: N=31%, P=45, Sediment=60%

2. Streamside Grass Buffers; and Vegetative Open Channel (Grass Waterway)
    a. Agricultural riparian grass buffers are linear strips of grass or other non-woody vegetation *maintained between the edge of fields and streams, rivers or tidal waters* that help filter nutrients, sediment and other pollutants from runoff. The recommended buffer width for riparian forests buffers (agriculture) is 100 feet, with 35 feet minimum width required. Vegetated open channels are modeled identically to grass buffers. Grass waterways are a type of conservation buffer; they direct water downhill to grassed channels, generally broad and shallow, designed to prevent soil erosion while draining runoff water from adjacent cropland. As water travels down the waterway, the grass vegetation prevents erosion

that would otherwise result from concentrated flows. Grass waterways also help prevent gully erosion in areas of concentrated flow.

   b. Streamside grass buffers pollution removal effectiveness examples:
      i. Streamside Grass Buffers Trp; pasture; Coastal Plain Uplands Non Tidal: N=21%, P=45%, Sediment=60%
      ii. Streamside Grass Buffers Trp; nutrient management pasture; Coastal Plain Lowlands Non Tidal: N=39%, P=39%, Sediment= 52%

3. Wetland Restoration
   a. Agricultural wetland restoration activities re-establish the natural hydraulic condition in a field that existed prior to the installation of subsurface or surface drainage. Projects may include restoration, creation and enhancement acreage. Restored wetlands may be any wetland classification including forested, scrub-shrub or emergent marsh.

   b. Wetland Restoration pollution removal effectiveness examples (same values for Coastal Plain settings):
      i. Wetland Restoration; alfalfa; Coastal Plain Lowlands Non Tidal effectiveness: N=25%, P=50%, Sediment=15%
      ii. Wetland Restoration; hay without nutrients; Coastal Plain Uplands Non Tidal effectiveness: N=25%, P=50%, Sediment=15%

<u>Load Reduction BMPs</u>

1. Non-Urban Stream Restoration (interim)
   a. This is an interim BMP and the units may change depending on the outcome of the expert panel, anticipated in Fall 2012. This BMP maintains the integrity of shorelines by preventing or controlling erosion. The reduction is 0.2 lbs. nitrogen per foot, 0.068 lbs. phosphorus per foot, and 310 lbs. sediment per foot.

<u>Other BMPs Not Identified from Bay Program Sources</u>

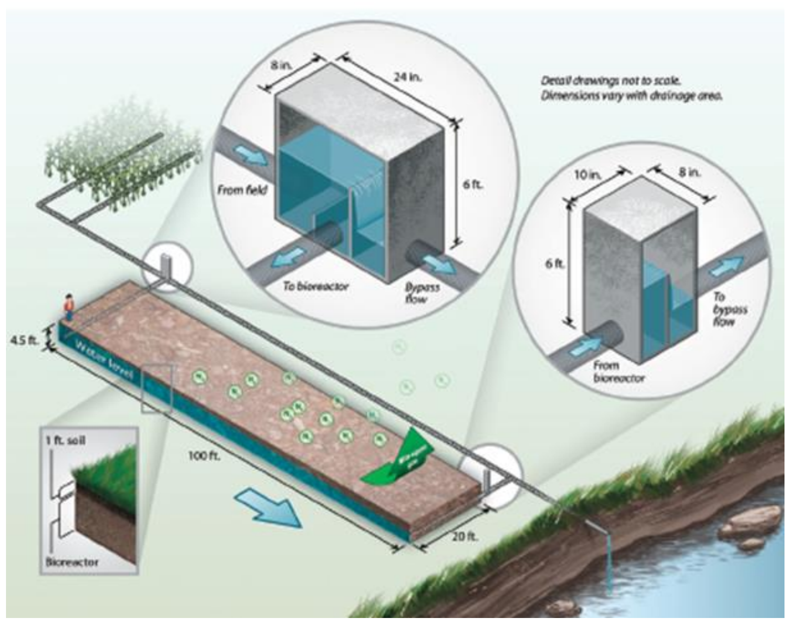
1. Water and Sediment Control Basin

   a. A water and sediment control basin (WASCOB) is a small earthen ridge-and-channel or embankment built across (perpendicular to) a small watercourse or area of concentrated flow within a field. They are commonly built in a parallel series with the first ridge crossing the top of the watercourse and the last ridge crossing the bottom, or nearly so. They are designed to trap agricultural runoff water and sediment as it flows down the watercourse; this keeps the watercourse from becoming a field gully and reduces the amount of runoff and sediment leaving the field.

WASCOBs are similar to terraces in form and function, but the two practices are not interchangeable. Whereas terraces (and other contour practices, such as contour strip-cropping and contour buffer strips) work best on relatively uniform slopes, WASCOBs are generally reserved for fields with irregular topography where contour practices would be difficult to implement or likely to fail.

While terraces generally extend all the way to field edges, following the contour of a slope in a ribbon-like pattern, WASCOBs from a distance look more like short, straight slivers, just long enough to bridge an area of concentrated flow. WASCOBs are generally grassed. The runoff water detained in a WASCOB is released slowly, usually via infiltration or a pipe outlet and tile line.

b. WASCOP pollution removal efficiencies for agricultural settings are not available from Bay Program sources. Some values from the Iowa Stormwater Management Manual for dry extended detention basins may provide a rough approximation of effectiveness: TSS=50-80%; N=10-30%, P=10-50%

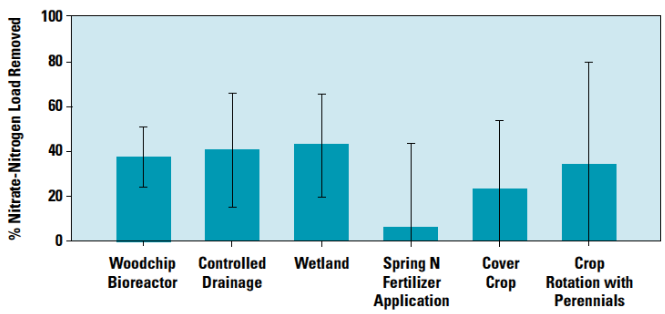


2. Woodchip Bioreactor for Nitrate in Agricultural Drainage (source: Iowa State University-Extension & Outreach, Woodchip Bioreactors for Nitrate in Agricultural Drainage, October, 2011)
    a. A woodchip bioreactor is made by routing drainage water through a buried trench filled with woodchips. (Author note: the drainage water source could be from subsurface tile drains or shallow groundwater draining into a ditch adjacent to an agricultural field). Woodchip bioreactors also are known as denitrification bioreactors. Denitrification is the conversion of nitrate (NO_3) to nitrogen gas (dinitrogen, N_2) that is carried out by

bacteria living in soils and in the bioreactor. These good bacteria, called denitrifiers, use the carbon in woodchips as their food and use the nitrate as part of their respiration process. Providing these denitrifiers an ample supply of carbon to eat and giving them anaerobic conditions in the bioreactor offers them a perfect environment to remove nitrate from drainage. At least twice per year the outlet control structure needs to have gates either raised or lowered to allow adequate residence time for treated water to react with the chips. Higher water flows, typically in spring, should have raised gates—lower water flows, in summer, should have unimpeded flow through the bioreactor.

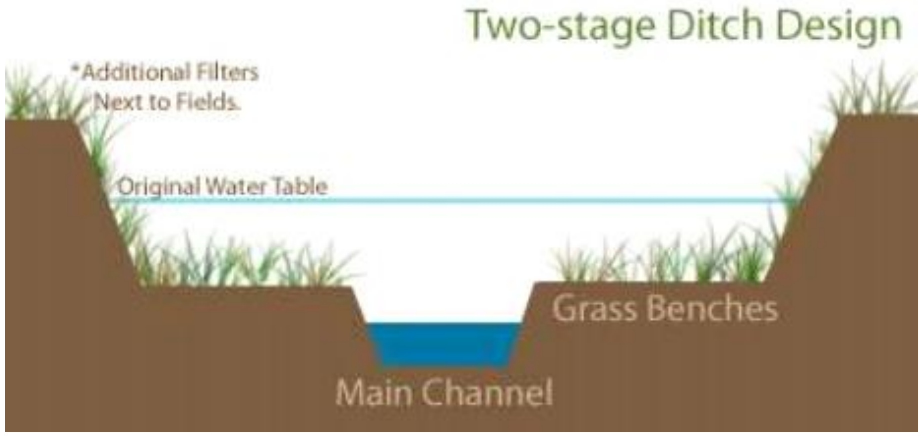
Figure 6. Covering the woodchips with a geo-textile fabric before laying the soil cover at a bioreactor installation (courtesy of the Iowa Soybean Association Environmental Programs and Services)

b. Based on research from Iowa, Illinois and Minnesota, most bioreactors show performance of about 15 to 60 percent nitrate load removed per year. Current bioreactor designs have successfully reduced the amount of nitrate in drainage from 30 to over 100 acres. The estimated lifespan of a bioreactor is 15 to 20 years, after which the woodchips must be replaced. The cost is $7,000-$10,000.



Comparison of nitrate removal from bioreactors and other practices; bar shows the average removal with the whisker showing plus and minus one standard deviation (adapted from data from the authors)

3. Two-Stage Ditch Design Applied to Agricultural Drainage Ditches (sources: Two-Stage Ditch Design research paper by Andy Ward and Dan Mecklenburg http://www.glc.org/basin/pubs/projects/wi_WtSedCoBs_pub1.pdf; and Sarah Roley et. al, 2012. Floodplain restoration enhances denitrification and reach-scale nitrogen removal in an agricultural stream. Ecological Applications 22:281-297; http://www.nature.org/idc/groups/webcontent/@web/@indiana/documents/document/prd_034167.pdf.)
   a. The two-stage ditch is a practice in which floodplains (elevated grass benches) are constructed alongside channelized ditches. During high flows, water moves across the benches, increasing benthic surface area and stream water residence time, as well as



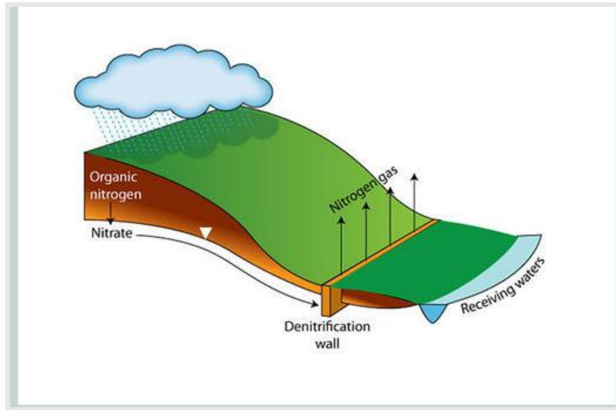
the potential for nitrogen removal via denitrification. Other benefits of a two-stage ditch over a conventional ditch include increased ditch stability and significantly reduced maintenance. The benches provide wildlife habitat, trap fine sediments and result in courser material forming in the bed which benefits aquatic life. The Nature Conservancy states 2-stage ditches: require less maintenance (30yr. plus life expectancy), increase denitrification rates by 350%, reduce sediments by nearly 60% have an expected life span of 30 years. Several pilot projects have been built over a number of years in the Great Lakes Region see: http://greatlakeswater.uwex.edu/two-stage-ditch-design-concept.

b. Research at Shatto Ditch in Kosciusko County, Indiana by Roley et. al showed the two-stage design reduces sediment and N export, is a self-maintaining practice and its performance improves significantly over time (≥4 years). The benches augment the in-stream nitrogen removal process but did not exceed observed annual in-stream N removal rates during the 2 year study period at Shatto Ditch. The design works best at removing nitrogen during wetter years and moderate storm flow conditions where the duration of bench inundation is maximized. During wet-year conditions N removal rates on the benches approached in-stream N removal rates. The two-stage ditch's effectiveness at reducing downstream N loading is best coupled with efforts to reduce N inputs in adjacent fields. This practice can also be used in conjunction with water filtration at the edge of the field using grass buffers, through woodchip bioreactors or phosphorus-sorbing materials.

4. Denitrification Wall (sources: http://researchcommons.waikato.ac.nz/ Long Term Nitrate Removal in a Denitrification Wall. Thesis paper by Lauren M. Long. 2011, University of Waikato, New Zealand; and Reducing Nonpoint Source Loss of Nitrate within the Santa Fe Basin: Efficacy of Container Nursery BMPs and Denitrification Wall. Clark, Schmidt, Yeager, 2012. University of Florida).

   Denitrification walls have been shown to be effective in reducing nitrogen in groundwater in the form of NO_3 in New Zealand, Iowa and Canada. Measurements of denitrifying enzyme activity (DEA) in a denitrification wall in New Zealand that had been in place for 14 years showed reductions in NO_3 were nearly as high as the first year it was constructed, with a 92% NO_3 removal rate. A predictive model was also run to estimate the longevity, through decay rates, of the carbon in the wall. The model suggested the wall could effectively reduce NO_3 for several decades without any maintenance.

Denitrification wall diagram



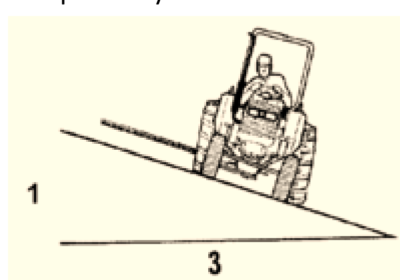
a. Denitrification walls are used in areas of high N loading and with water tables near the land surface. N walls are constructed perpendicular to the groundwater flow using sawdust mixed with soil/sand or 100% wood chips to intercept the nitrogen. The wall location must be situated relative to the hydraulic gradient on the site and where NO_3 flow is most concentrated. Typically, carbon material is no deeper than a few meters, to be most cost effective. The conductivity of the wall must not impede groundwater flow at a greater rate than the surrounding soils or water flow; or the flow will bypass the wall—moving under or around it. The detention time of water within the wall must be long enough to create anaerobic conditions and reduce excess N, this will determine the required width of the wall.

Figure 2 – (A) An image of the sand and sawdust used in the wall. (B) A trench was excavated to the desired depth and was immediately backfilled with the sand and sawdust mixture. (C) the final trench before backfill of surface soils.

5. Poultry Heavy Use Area Protection (HUA). A poultry HUA is a stabilization pad, usually cement, installed at one or both ends of a poultry house that is frequently and intensively used in order to abate pollution of waterways due to poultry handling equipment, waste cleanout and transport operations. In Maryland a poultry HUA is typically 40'x40' or not larger than 1,600 square feet. No manure may be stored on the poultry HUA for any period of time, including manure enrolled in a Manure Transport Program. In Maryland, poultry HUAs are eligible for up to 87% cost share.

6. Designed Bioswales (sources: NRCS, 2005 Bioswales fact sheet (Iowa); and edited excerpts from BIOFILTERS --Bioswales, Vegetative Buffers, & Constructed Wetlands for Storm Water Discharge Pollution Removal. State of Oregon Department of Environmental Quality. Dennis Jurries, PE, NWR Storm Water Engineer. January 2003).

Loosely termed, a bioswale is any vegetated swale, ditch, or depression that conveys storm water. Two basic bioswales are the fully vegetated and open channel types—based on the amount of vegetation. Some subtypes of bioswales are based upon their general cross sectional shape, i.e. "U", "V", and "trapezoid". Generally, the "U" and "V" shaped swales are just ditches that have become naturally vegetated and they are usually open channeled. Open channels do not add much more than infiltration to the process of removing pollutants. The parabolic or trapezoidal fully vegetated bioswale is the most effective at removing pollutants. Selecting the right plants is probably the most critical aspect of designing a bioswale that functions correctly.



NRCS recommends deep-rooted native plants for superior infiltration and reduced maintenance. Native grasses and forbs resist local pests and diseases and are adapted to local rainfall patterns and climate conditions. Soil infiltration rates should be greater than one-half inch per hour and a parabolic or trapezoidal shape with side slopes no steeper than 3:1. Soil compaction should be avoided during installation and swales should be sized to convey at least a 10-year storm.

These results can be obtained for a bioswale at least 200 feet in length with a maximum runoff velocity of 1.5 ft. /sec., a water depth of from one to four inches, a grass height of at least 6 inches, and a minimum contact (residence) time of 2.5 minutes: Total Suspended Solids – 83 to 92%; Turbidity (with 9 minutes of residence) – 65%; Total Phosphorus – 29 to 80%; Nitrate-N – 39 to 89%.

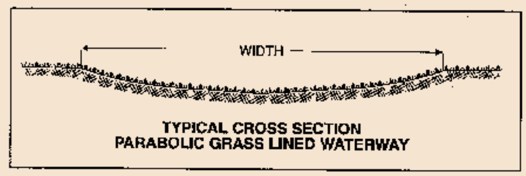


Figure 2.
Typical cross section parabolic grass lined waterway

b. Bioswales can be enhanced to perform greater pollution reduction functions through the addition of bioretention media such as woodchips or mulch and sand beneath the swale to improve water quality, reduce the runoff volume, and peak runoff rate. The use of bioretention media enhances infiltration, water retention, nutrient and pollutant removal through a variety of physical, chemical, and biological processes.

Field Work and Study Assessment Findings

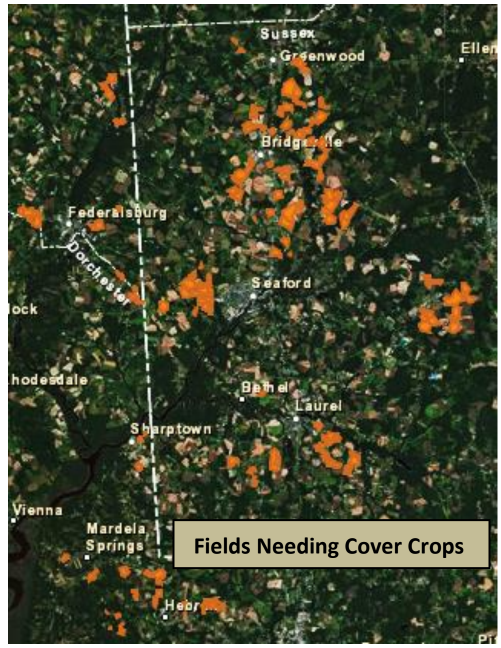
The assessment team's field work and study results encompassed two categories of investigation—priority watersheds and non-priority watersheds. The priority watersheds or "Ag enhancement priorities" represent 98 HUC 14 watersheds of an average acreage size of 597 acres. The size varied considerably from 3,435 acres to as small as 17 acres. A total of 47 of 294 non-priority watersheds were also examined by recording 985 observation points and 17 potential restoration practices. Non-priority watershed information is available for viewing on ArcGIS online files, but is not the subject of this report. The information still has value for watershed management planning purposes, particularly the 17 potential restoration practices sites and observations regarding cover crops and conservation tillage.

Ag Enhancement Priority Watershed Results

The Ag enhancement priority watersheds (a.k.a. priority watersheds) consist of 23 high priority watersheds, 53 medium and 22 low priority watersheds. Although the rating scale contains a "low" category, it should be noted that this category is still within the top 25% of all 392 Nanticoke basin watersheds that present management challenges. So, while, the classification scheme helps provide a rationale for targeting workload priorities—any conservation actions taken in watersheds included in the top 25% is worth doing. Highlights of the study results are organized under 6 categories and are discussed below.

<u>Cover Crops and Conservation Tillage</u>
The use of cover crops and conservation tillage practices are widely regarded as some of the most efficient and cost effective BMPs to prevent off-farm transport of excess nitrogen, phosphorus and sediment. Thus, the study team examined 47% or nearly half of the priority watersheds to determine how widely these practices were being used. The team found that out of all fields assessed (14,742

acres) approximately 34% appeared to be using cover crops and 76% appeared to be using conservation tillage practices. In the highest ranked priority watersheds (i.e. those of greatest concern) only 32% of the assessed fields used cover crops. In the medium ranked priority watersheds (i.e. those of moderate concern) 58% of the assessed fields used cover crops. In the lowest ranked priority watersheds (i.e. those of lesser relative concern) 63% of the assessed fields used cover crops. While it is interesting to note that these practices were more prevalent in watersheds of medium and lower concern, we did not attempt to determine any statistical correlation given the non-randomized nature of the field survey procedure and the limited sample size. This information can be used to focus outreach efforts in high concern watersheds where low cover crop participation is evident. A goal could be set to achieve 2-3 times the current participation rates in these areas.

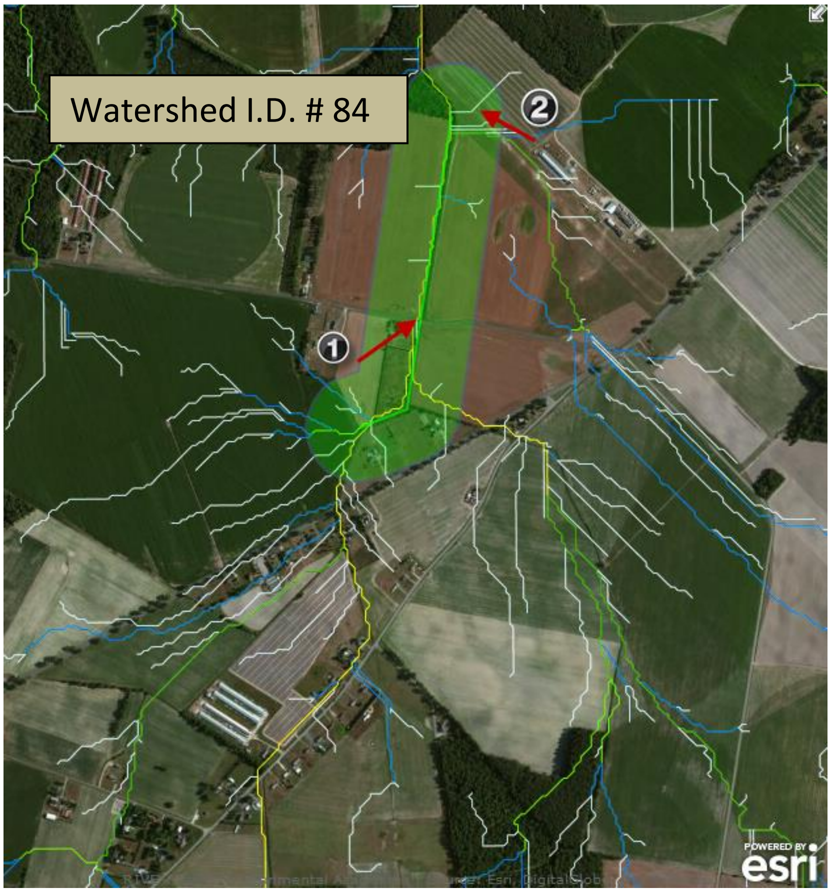


<u>Linear Conservation Practices</u>

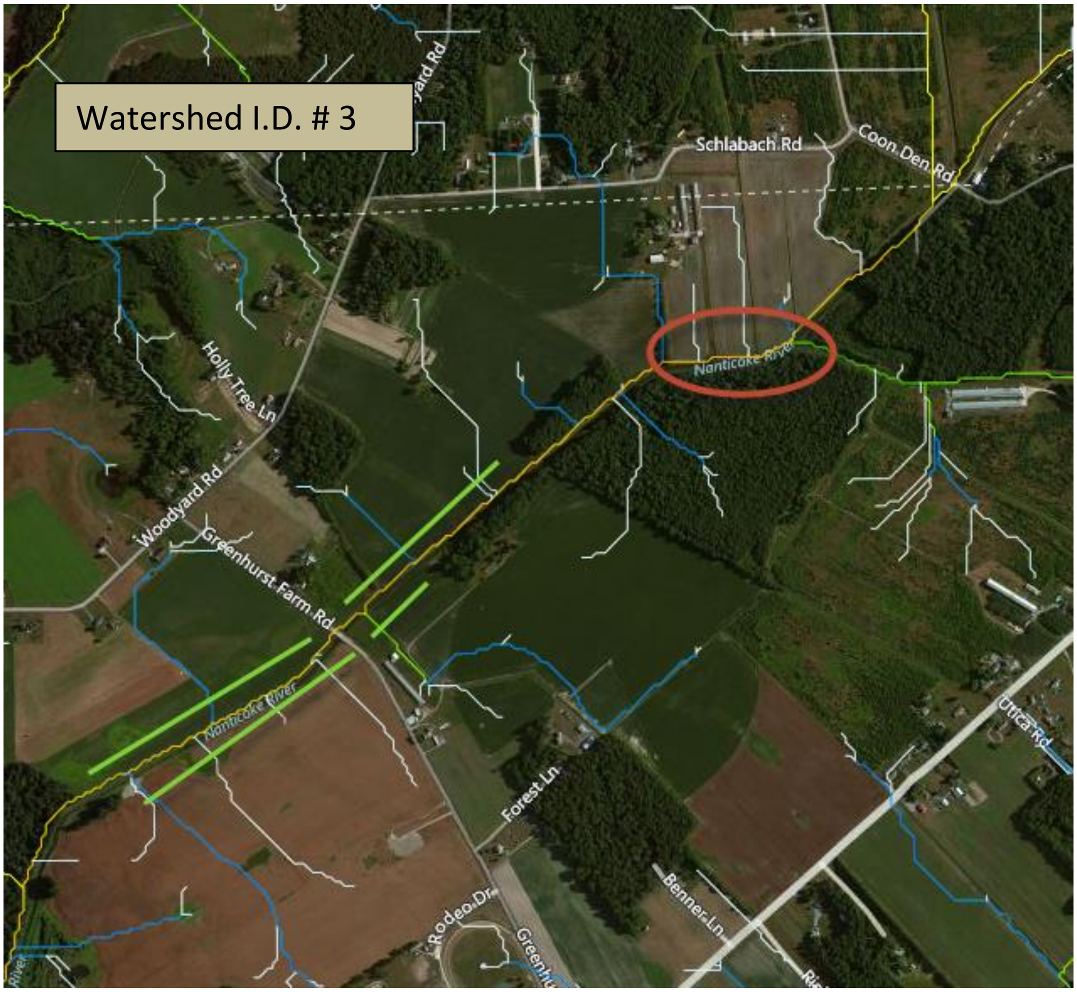
In six medium priority watersheds, 10,654 linear meters of potential demonstration practices were identified and are shown in the table below. The column titled Waterway Nutrient Reduction could take the form of a two stage ditch project, phosphorus sorbing materials, a woodchip bioreactor or other practices identified in the menu of BMP practices listed above in Other BMPs Not Identified from Bay Program Sources. Other potential demonstration areas are identified in "non-priority watersheds" field observations data in ArcGIS online. Additional field reconnaissance and team evaluations should be conducted to determine what project(s) could be pursued.

Ag priority class	Watershed I.D #	Total Length in Meters	Waterway Nutrient Reduction	Bioswale	New Forest Buffer	Grass Swale	Linear Wetland Restoration
Medium	3	4,254.51			3,780.11		474.40
Medium	6	338.21		338.21			
Medium	8	1,769.29		1,769.29			
Medium	9	915.08	915.08				
Medium	47	2,113.95		1,612.58		501.38	
Medium	84	1,263.35	1,263.35				
Total meter length		10,654.39					

The two maps below show the locations for two potential demonstration practices identified from the field work and GIS targeting study. The first exhibit corresponds to the linear conservation practice listed as Watershed I.D. # 84 and the second graphic refers to Watershed I.D. #3. All of the practices shown in the table and others can be seen in ArcGIS online, where a copy of these and other files from the study can be hosted in a separately accessible account.



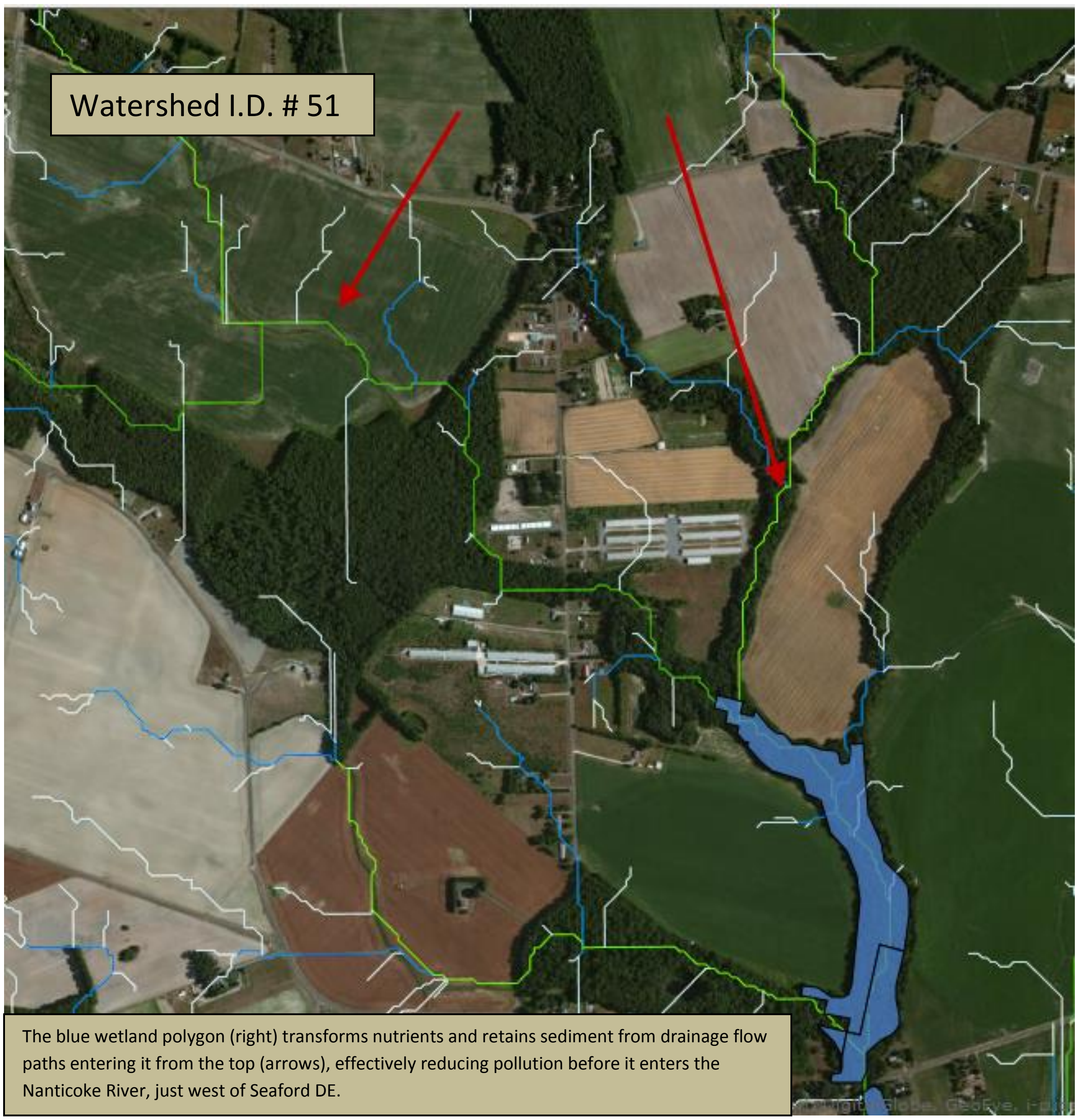
The map above, depicting a portion of watershed I.D. 84, shows a green highlighted ditch which collects runoff from several area farms. A natural nutrient and sediment reduction system called a "two-stage ditch" is one type of best management practice that could be demonstrated at this site, possibly in conjunction with an artificially created wetland treatment system --photo 2, where flow from the ditch could be treated prior to it reaching Broad Creek to the north. The two photo numbers show the locations and orientation of the image taken. The colored lines depict drainage path networks where runoff follows topographic changes in the terrain. Photo 1 shows the view looking northbound along the green highlighted ditch. The small bridge structure is one of several that allow an irrigation system to pass freely over the drainage ditch.



The map above, depicting a portion of watershed I.D. 3, shows four green lines and a red oval location adjacent to the Nanticoke River. At the time this aerial image was captured (2011), it appeared that a significant opportunity to plant wooded buffer along the Nanticoke exists where the green lines are shown. Inside the red oval, farm drainage ditches appear to drain directly into the Nanticoke River. At these and other locations (e.g. potentially at Coon Dent Rd. in the northeast portion of the image) linear wetland systems could be constructed to treat runoff before it empties into the Nanticoke. The colored lines depict drainage path networks where runoff follows topographic changes in the terrain.

High Nutrient Transformation Sediment Retention Wetlands

There are nearly 1,000 acres of wetlands that function at “high” ranked levels for nutrient transformation and sediment retention in the Ag enhancement priority watersheds. About 95% of the time, when a wetland performed in the “high” category for nutrient transformation it also ranked “high” for sediment retention. The table below shows where high NT/SR wetlands total more than 20 acres of a high/medium priority watershed that is also in a top nitrogen or phosphorus loading watershed. This combination suggests that these watersheds should be targeted for potential wetland conservation easements. This is especially the case for the large contiguous wetland complexes east of Bridgeville in watersheds 12 and 22.



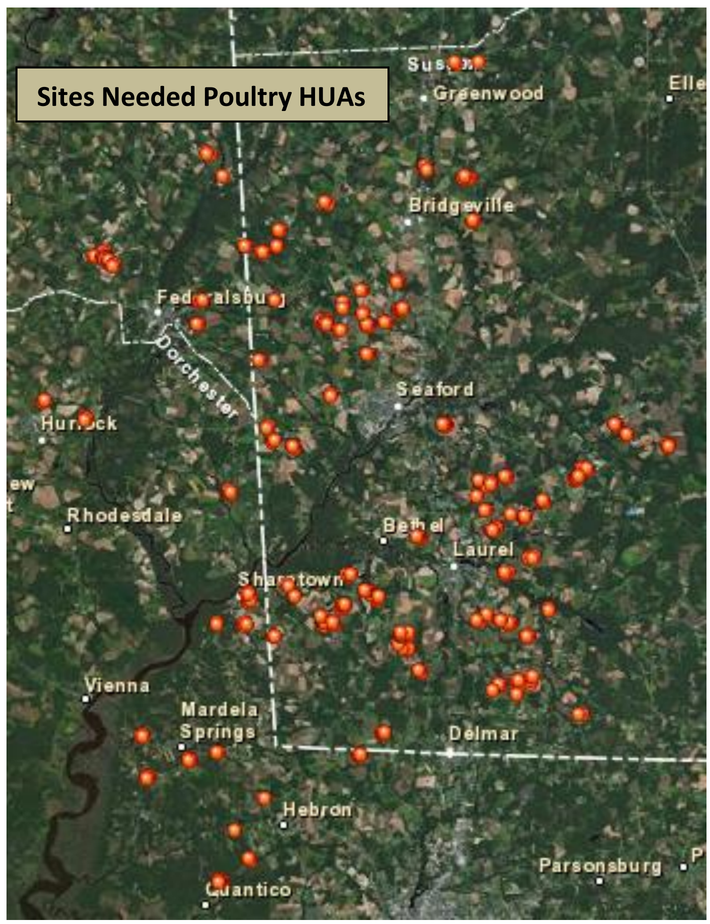
The blue wetland polygon (right) transforms nutrients and retains sediment from drainage flow paths entering it from the top (arrows), effectively reducing pollution before it enters the Nanticoke River, just west of Seaford DE.

Ag priority class	Watershed ID #	Acres of High NT Wetlands	Acres of High SR Wetlands	Top N and P Quartile Class
High	12	39.31	39.31	High
High	22	58.07	58.07	High
High	28	20.04	20.04	High
High	23	30.52	29.68	Medium
Medium	38	33.14	33.14	High
Medium	75	28.62	28.62	High
Medium	63	37.18	33.79	Medium
Medium	69	20.96	20.96	Medium

<u>Poultry Heavy Use Area Protection Pad</u>

All poultry houses in all Ag priority enhancement watersheds where examined through aerial imagery and/or through field observations. The study team found that it was sometimes difficult to determine if a poultry house was active or not. Therefore, it is likely there are some errors in the reported numbers. The accuracy of these numbers could be enhanced by a cross check of other records that may be publicly available. Nonetheless, the results show, on average, 60% of the poultry houses appear to be lacking or need a larger size poultry HUA protection pad to help to abate pollution of waterways due to poultry handling equipment, waste cleanout and transport operations. The map above shows locations within priority watersheds where poultry heavy use area protection pads may be needed (see online maps for details).

Ag priority class	# of Poultry Houses Needing a HUA	Total # of Poultry Houses	As a % of all Poultry Houses
High	46	79	58.23%
Medium	209	299	69.90%
Low	60	114	52.63%
Total/Avg.	315	492	60.25%



Wetland Restoration Sites

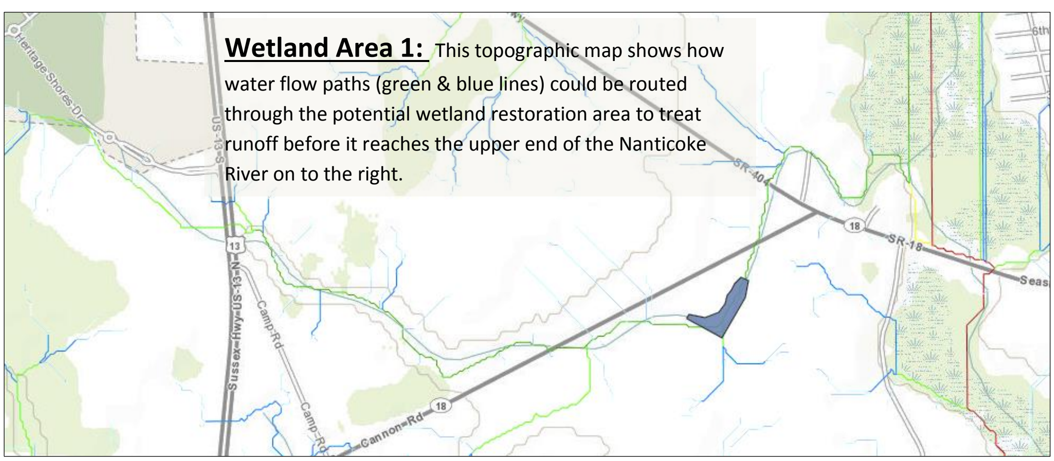
In addition to the "linear" wetland restoration acreage listed above, 15.39 acres of wetland restoration may be possible in 3 different sites. The sites are shown below with the light blue outline representing surrounding hydric soils and the dark outlined area showing the approximate potential wetland restoration area. On-site verification of appropriate conditions and landowner permission is needed.

Ag priority class	Shed ID	Wetland Restoration Area	Acres
Medium	26	1	3.58
Medium	56	2	2.16
Low	58	3	9.65
		Total acres 15.39	

Wetland Area 1

Wetland Area 2

Wetland Area 3



Wetland Area 1: This topographic map shows how water flow paths (green & blue lines) could be routed through the potential wetland restoration area to treat runoff before it reaches the upper end of the Nanticoke River on to the right.

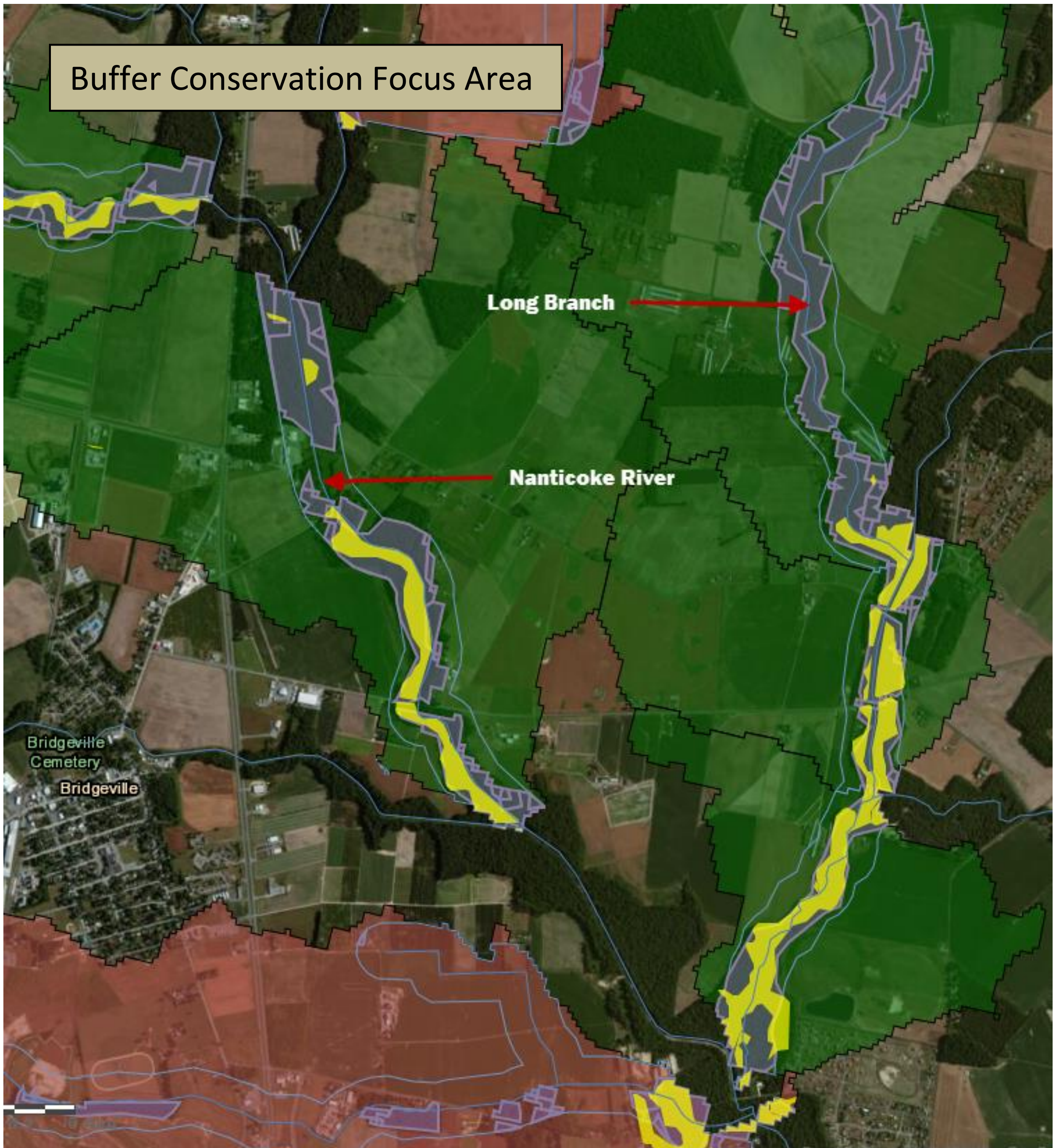
Riparian Buffers

In the table below, about 1,024 acres of riparian area buffers have been identified as priorities for conservation and additional restoration. In the ArcGIS online maps many other potential restoration areas can be easily identified. Streams with intact riparian forest buffers are more likely to sustain the health of their biological communities even in the presence of other watershed stressors. While many factors play a role in the stream health, Bern Sweeney of the Stroud Water Research Center has noted that stream bottoms in a forested area can process 10 to 40 times more in-stream nutrients than a grass-bordered stream.

Another recent study suggests watersheds with less than 10% impervious surface, more than 45% forest cover and greater than 60% of the streams with forest cover tend to achieve good to excellent biological integrity ratings. Of the 98 priority watersheds evaluated for forest buffer coverage (i.e. 500ft. forest cover on either side of the functional stream network) eight watersheds ranked in the top 10% of all watersheds. The watersheds identified in the table below are close to or exceed a 60% buffer coverage threshold and range from 61 to 256 acres of natural buffer in the measured corridor area. These buffered stream corridors and those identified previously as high nutrient transformation and sediment retention wetlands will greatly assist in the reduction of nitrogen and other pollutants downstream to the Nanticoke River and to the Bay. Maintenance of these buffers and others mapped in the top 25% quartile of all priority watersheds should be maintained whenever possible and targeted for conservation easements and restoration projects in areas where significant gaps are obvious and can be closed.

To gain an appreciation for the relative stream impairments in Wicomico, Sussex and Dorchester counties—it is interesting to note that a study performed by the authors of this document, found that Wicomico County was among the top 10 counties in the Chesapeake Bay Watershed with the greatest percentage of watersheds with impaired streams. All counties in the watershed were placed in one of five tiers (highest to lowest) of stream impairments. Wicomico was in the highest tier, Sussex fell in the second and Dorchester in the third highest, or “middle”, tier.

Ag priority class	Shed ID	Acres of Natural Buffer in 500ft Measured Area	Acres of 500ft Measured Area	Percent Buffer
High	10	61.99	117.99	52.54%
High	12	61.16	99.98	61.17%
High	22	78.77	127.99	61.55%
Medium	6	256.85	433.87	59.20%
Medium	9	164.07	253.55	64.71%
Medium	52	190.58	292.89	65.07%
Medium	63	61.14	112.17	54.50%
Low	43	149.35	289.71	51.55%



The map above shows buffer conditions in four of the eight watersheds identified in the riparian buffer table above (to the right—6, 12 & 22; to the left—watershed 9). The dark green colored watersheds are in the top ranked buffer coverage quartile. The lavender colored areas show forested buffers, the yellow colored areas are forested wetland buffers with high capacities to transform nutrients and retain sediment, effectively reducing pollution in the headwaters of the Nanticoke River, just east of Bridgeville, DE. Buffers in this area are important and should be conserved to maintain their contribution to improving water quality in these watersheds. An examination of protected lands records in this area shows only a minimal amount of these buffers are currently protected.

Concluding Thoughts

The Nanticoke Watershed Targeting Innovations and BMP Tracking study leaves behind more than a proverbial "plan on the shelf." The investigation has established an innovative, low-cost data collection, recording and analysis framework that can be used in various ways by the Nanticoke Watershed Alliance (NWA) and/or other organizations to track and plan water quality management activities through an internet accessible, working group hosted on ArcGIS Online.

During the course of the study, it became increasingly obvious that there are many challenges and opportunities for improving the health of local waterways and the Nanticoke River. This report points to a number of locations where Best Management Practices, conservation and restoration efforts can potentially be implemented to enhance or maintain the watershed in the face of different water quality threats. Some of these opportunities lend themselves to direct action by NWA in partnership with other organizations that could bring needed financial and technical expertise to convert "possibilities" into real on-the-ground-results. Other conservation challenges, such as promoting broader use of cover crops in key areas or encouraging landowners to install poultry house heavy use area protection pads, where needed, will require more thought about how realistic goals can be achieved.

Most of the locations selected for specific BMPs such as bioswales, 2-stage ditches or wetland restoration are obviously not "shovel read" for implementation. Outreach to appropriate landowners and organizations will be necessary to validate the "desk top" analysis and arms reach field assessments, which only offered the opportunity for a quick visual inspection from public right-of-ways. Fortunately, there are a number of funders who may be willing to support innovative implementation projects. At the same time, these types of projects offer great learning opportunities for NWA and landowners alike. We hope the Alliance is pleased with the study and views it as a strong complement to the excellent work that is now underway.