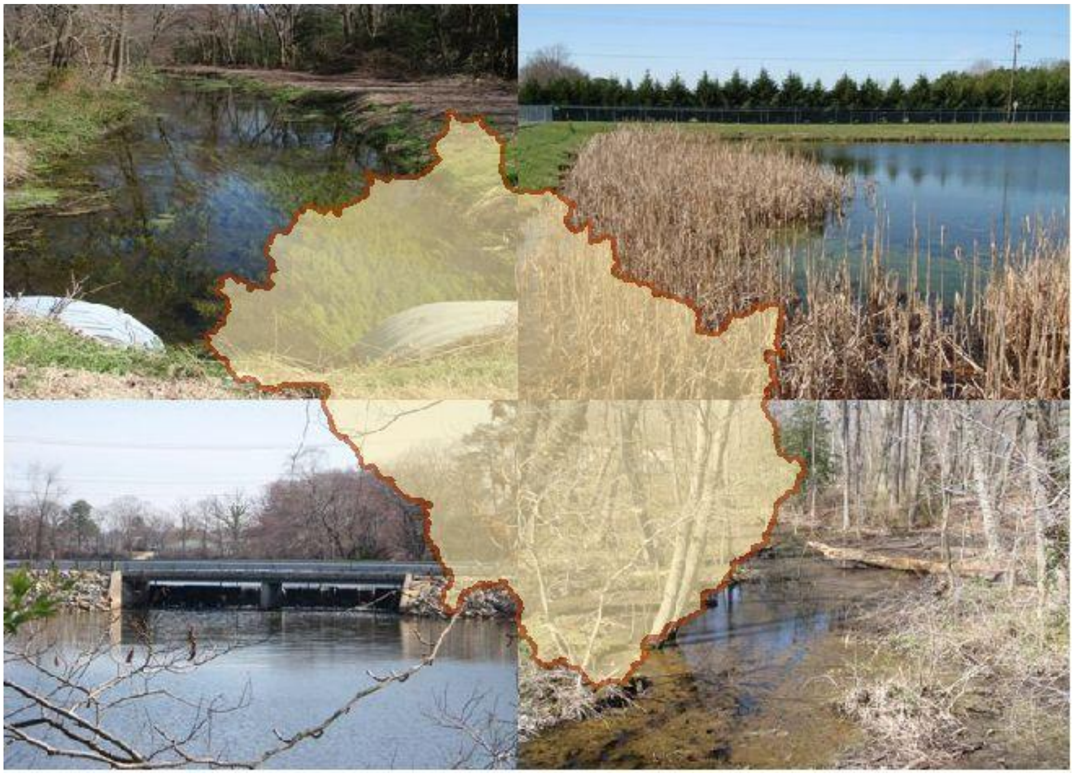
WILLIAMS POND WATERSHED MANAGEMENT PLAN



The Delaware Department of
Natural Resources and
Environmental Control

July 2014

URS

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WILLIAMS POND WATERSHED MANAGEMENT
(SUBWATERSHED OF THE NANTICOKE RIVER)

Prepared for

Delaware Department of Natural Resources and Environmental Control
Sediment and Stormwater Program
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July 2014

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AFO	Animal Feeding Operations
ARS	Agricultural Research Service
BEHI	Bank Erodibility Hazard Index
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operations
cfs	cubic feet per second
cfs/ac	cubic feet per second per acre
CN	Curve Number
CRWR	Center for Research in Water Resources
DelDOT	Delaware Department of Transportation
DEM	Digital Elevation Model
DGS	Delaware Geological Survey
DNREC	Delaware Department of Natural Resources and Environmental Control
EPA	Environmental Protection Agency
ESD	Environmental Site Design
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
ft	feet
ft^2	square feet
ft/ft	feet per foot
GIS	Geographic Information System
HEC	Hydrologic Engineering Center
HSG	Hydrologic Soil Group
LID	Low Impact Development
LiDAR	Light Detection and Ranging
LULC	Land Use/Land Code
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
SSURGO	Soil Survey Geographic database

SVAP	Stream Visual Assessment Protocol
SWAPP	Source Water Assessment and Protection Program
SWC	Division of Soil and Water Conservation (DNREC)
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
URS	URS Corporation
WIP	Watershed Implementation Plan

The Williams Pond Watershed is a subwatershed in Nanticoke Watershed and includes 22.45 square miles of area that drains to the Williams Pond near Seaford, located in western Sussex County, Delaware. The Delaware Department of Natural Resources and Environmental Control (DNREC) contracted URS Corporation to develop this Williams Pond Watershed Management Plan. The primary goal of the watershed management plan is to recommend flood control measures throughout the watershed and water quality improvements wherever feasible. Watershed conditions were evaluated available data. URS performed the following analyses:

- Hydrologic analysis was conducted to understand the hydrologic characteristics of the watershed and to provide the basis for what-if scenario analyses. Further, the flows from the hydrology model were used to evaluate the conveyance capacity of road crossings.
- Hydraulic computations were conducted for 28 culverts to determine conveyance capacities for the design storms under existing and future conditions. The culverts were categorized as green (passes the design storm with 1 foot of freeboard), yellow (passes the design storm with less than 1 foot of freeboard), and red (does not pass the design storm). Improvement measures are proposed for undersized culverts.
- URS assessed the drainage conditions for the part of Route 13 within the watershed to estimate the contributing drainage areas. URS categorized 366 drainage structures depending on the level of maintenance required, as “no” (observed to be in good condition), “minor”, or “major”. Maintenance recommendations were proposed to minimize drainage issues.
- Detailed stream assessments were conducted for ten stream segments including Herring Run, Atlanta Devonshire Tax Ditch, William H. Newton Tax Ditch, Middleford Tax Ditch, Clear Brook, and Tributary to Clear Brook, Bucks Branch, and Freidel Prong.
- The seven tax ditch systems in the watershed were analyzed and proposed measures were recommended.

Based on the above analyses, URS qualitatively ranked the subwatersheds. Subwatersheds ranked as “Good” (Upper Bucks Branch) and “Fair” (Gilbert Trivitts Ditch and Clear Brook Downstream) were located in the headwater reaches of the Williams Pond Watershed. Freidel Prong, Clear Brook Upstream, Lower Bucks Branch, Middleford Tax Ditch, William H. Newton Ditch, and Williams Pond subwatersheds received a “Poor” rating primarily due to the lack of adequate riparian buffer and high nutrient loads from the agricultural runoffs in the subwatersheds. The Atlanta Devonshire Tax Ditch and Herring Run subwatersheds received a “Very Poor” rating due to high number of undersized culverts, higher impervious cover and lack of adequate riparian buffers.

This Watershed Management Plan recommends improvement measures including structural projects (e.g., riparian buffer improvements, stream restoration, Best Management Practice/Low Impact Development projects, new stormwater ponds/wetlands, stormwater pond retrofits, and road crossing improvements) as well as management strategies and action items.

The recommended projects were prioritized based on their potential for improving the watershed. Implementation of these recommendations will help DNREC meet their goals of reducing flooding and improving the water quality conditions in the Williams Pond Watershed.

Section 1 Introduction

1.1 PROJECT PURPOSE

DNREC is faced with the challenge of urbanization in many parts of the state. To minimize the water quantity and quality problems in these developing areas, DNREC is in the process of changing their Sediment and Stormwater Regulations. Williams Pond Watershed is identified as one of the primary target areas for development, and as a part of its effort to restore the natural conditions in the watershed, DNREC has undertaken this watershed study. The primary goal of this study is to recommend flood control/protective measures throughout the watershed and water quality improvements wherever feasible.

The Williams Pond Watershed Management Plan characterizes the watershed through a review of existing data, field reconnaissance, and hydrologic and hydraulic modeling to address flooding and water quality concerns in the watershed. A subwatershed assessment, detailed stream assessment, and development of “what-if” scenario models were used to develop watershed recommendations to restore and maintain watershed health. The plan identifies and evaluates potential opportunities for flood protection measures, culvert improvement projects, new or retrofit stormwater management facilities, Best Management Practices (BMPs), Low Impact Development (LID) techniques, habitat improvements, stream restoration, tax ditch restoration, drainage improvements along Route 13, and non-structural management strategies.

1.2 AREA OF STUDY

The Nanticoke Watershed drains about one-third of Delaware’s land to the Chesapeake Bay and occupies a major portion of Sussex County. The study area for this watershed management plan is limited to the portion of the Nanticoke Watershed that drains to Williams Pond in western Sussex County. A vicinity map is provided as Figure 1.1. The watershed includes several significant streams, including Clear Brook, Bucks Branch, and Herring Run. The watershed also has several significant tax ditches that are designed to provide drainage for agricultural, commercial, and residential areas. Major tax ditches in the watershed include Atlanta Devonshire Tax Ditch, Freidel Prong Tax Ditch, Gilbert Trivitts Tax Ditch, Middleford Tax Ditch, and William H. Newton Tax Ditch. Significant water bodies include Hearns Pond and Williams Pond. The Williams Pond Watershed drains 22.45 square miles in a southern direction and discharges to the Nanticoke River at the Williams Pond Dam.

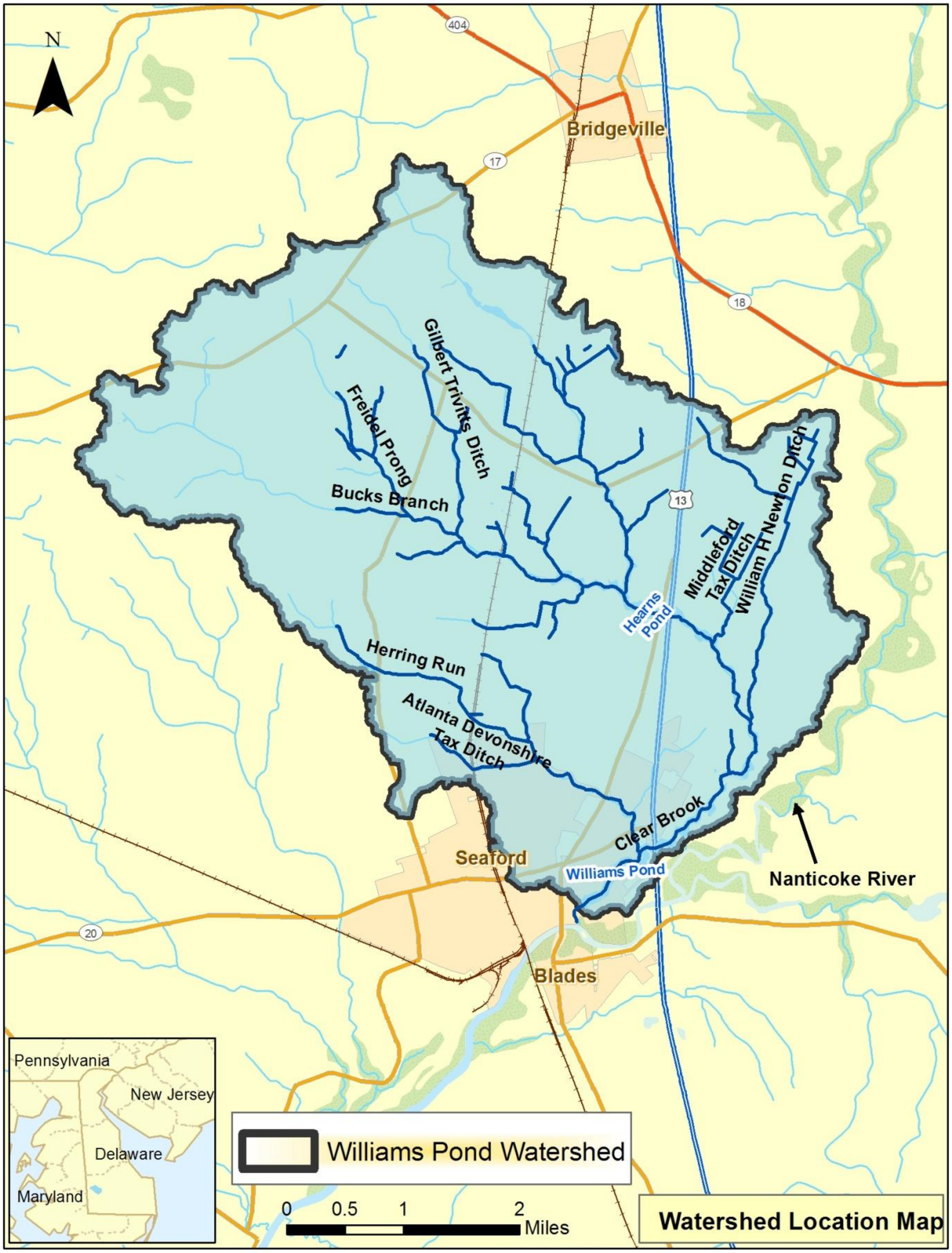


Figure 1.1: Williams Pond Watershed Location

Section 2 Data Collection, Review, and Analysis

2.1 PREVIOUS STUDIES

The purpose of this task was to collect and review existing data on the Williams Pond Watershed. Water quality data have already been collected and documented in previous studies. To avoid duplicating efforts, URS used the results from previous studies as a basis for the watershed management plan.

URS obtained previous studies, maps, aerial photographs, and geographic information system (GIS) data for the Williams Pond Watershed. The sources for the existing studies and data include DNREC, Sussex Conservation District, watershed groups, the Environmental Protection Agency (EPA), the Delaware Department of Transportation (DelDOT), and consultants. To understand the baseline conditions of the watershed, URS studied the results of previous watershed assessments (e.g., potential improvement measures, watershed conditions); comprehensive county, local, town, and city plans; and digital data, such as land use, soil cover, BMPs, and drainage boundaries that were used for the hydrologic modeling effort. A list of documents reviewed is provided in Section 14.

URS reviewed and evaluated previously completed studies to determine their applicability to the development of this watershed management plan. The existing data were also used to understand the baseline conditions of the watershed to identify potential restoration measures.

2.2 GIS DATA

The development of the Williams Pond Watershed Management Plan relies extensively on available GIS data. As part of this task, URS reviewed existing GIS data from DNREC, Sussex County, and other sources. Data were reviewed to perform hydrologic analysis, and identify field reconnaissance areas, existing outfalls, drainage areas, and potential restoration project areas. Table 2.1 below lists the data acquired.

Table 2.1: Summary of Acquired GIS Data

GIS Coverage	Source
2-foot contours, 2007	Delaware Department of Natural Resources and Environmental Control (DNREC)
Aerial photographs, 2007	U.S. Department of Agriculture Farm Service Agency (USDA-FSA) Aerial Photography Field Office
Annual rainfall data	National Oceanic and Atmospheric Administration (NOAA)
Community boundaries	Delaware DataMIL
Digital Elevation Model (DEM) (statewide)	Delaware Geological Survey
Development status	Sussex County
Existing land use (2008)	Delaware DataMIL
Future land use (zoning based on 2007 Comprehensive Plan)	Sussex County
Geology	Delaware Geological Survey
Growth zone based on Sussex County Growth Plan	Sussex County
Impervious surface	Sussex County

GIS Coverage	Source
Light Detection and Ranging (LiDAR) data	Delaware DataMIL
National Hydrography Dataset flow lines	U.S. Geological Survey (USGS)
Parcels	Sussex County
Railroads	DelDOT
Recharge potential maps	DNREC
Roads	Environmental Systems Research Institute (ESRI)
Soils	Natural Resources Conservation Service (NRCS)
Wetlands	Sussex County

2.3 FIELD RECONNAISSANCE

URS conducted field reconnaissance to obtain general watershed information, road crossing information, and information on Route 13 drainage facilities to supplement and update the existing GIS data. The field reconnaissance consisted of three parts: (1) conduct watershed overview, (2) evaluate road crossings and obstructions, and (3) assess drainage along Route 13 corridor. In addition stream assessments were conducted and are described in Section 7. An overview of conducted field reconnaissance is below:

(1) **Watershed overview:** The watershed reconnaissance was conducted with an emphasis on identifying sources of pollution, observing general conditions, and identifying potential restoration opportunities in the watershed. Prior to the field visit, URS identified target areas for field assessment based on a desktop review of GIS data. Since the field reconnaissance was limited to 5 days by the scope of services for this project, the entire 22.45 square mile watershed could not be assessed in detail; therefore, the field reconnaissance targeted 11 specific areas in the watershed that represented the various conditions throughout the watershed, including developed areas, undeveloped areas, and known problem areas. Criteria used for selecting the target areas included:

- Land use (e.g., open space)
- Property ownership (e.g., public/private)
- Stream buffers
- Areas of uncontrolled and controlled stormwater runoff

Photographs and notes were taken at each target site, and field assessment forms are included in Appendix A. Potential restoration sites identified in the field reconnaissance are described in Section 11of this report.

(2) **Field evaluation of road crossings:** Field evaluations of road and rail crossings having an opening of 36 inches or larger were conducted as a part of a hydraulic analysis of road crossings/obstructions to determine their capacity for approximate return periods. A total of 28 crossings were evaluated. Detailed information on the procedure adopted for this evaluation is described in Section 5 of this report. Photographs and notes taken at each crossing are included in Appendix A.

(3) **Field assessment of Route 13 drainage:** Drainage structures located along a portion of Route 13 within the watershed were surveyed as a part of the task to determine the drainage connectivity and identify contributing drainage areas and potential drainage

issues along the corridor. The drainage structures inspected included culverts, swales, outfalls, and pipes. Detailed information on the drainage systems surveyed, along with maps and proposed improvement recommendations, are described in Section 6 of this report. Photographs of the assessed drainage structures are included in Appendix A.

2.4 ESTABLISHMENT OF STUDY SUBWATERSHEDS

URS delineated the Williams Pond Watershed boundary using the DEM data provided by the Delaware Geological Survey (DGS). This watershed was further subdivided into 11 subwatersheds based on major tributary drainage courses, similar land use, and points of interest. The subwatershed boundaries were refined using a higher resolution topographic dataset, which was used for the detailed hydrologic analysis of the watershed. The establishment of the subwatersheds aided in the detailed investigation and characterization of the watershed because proposed improvement measures and strategies could be more focused and cumulative benefits on a subwatershed level. Figure 2.1 displays the 11 subwatersheds. An assessment of the study subwatersheds is provided in Section 8 of this report.

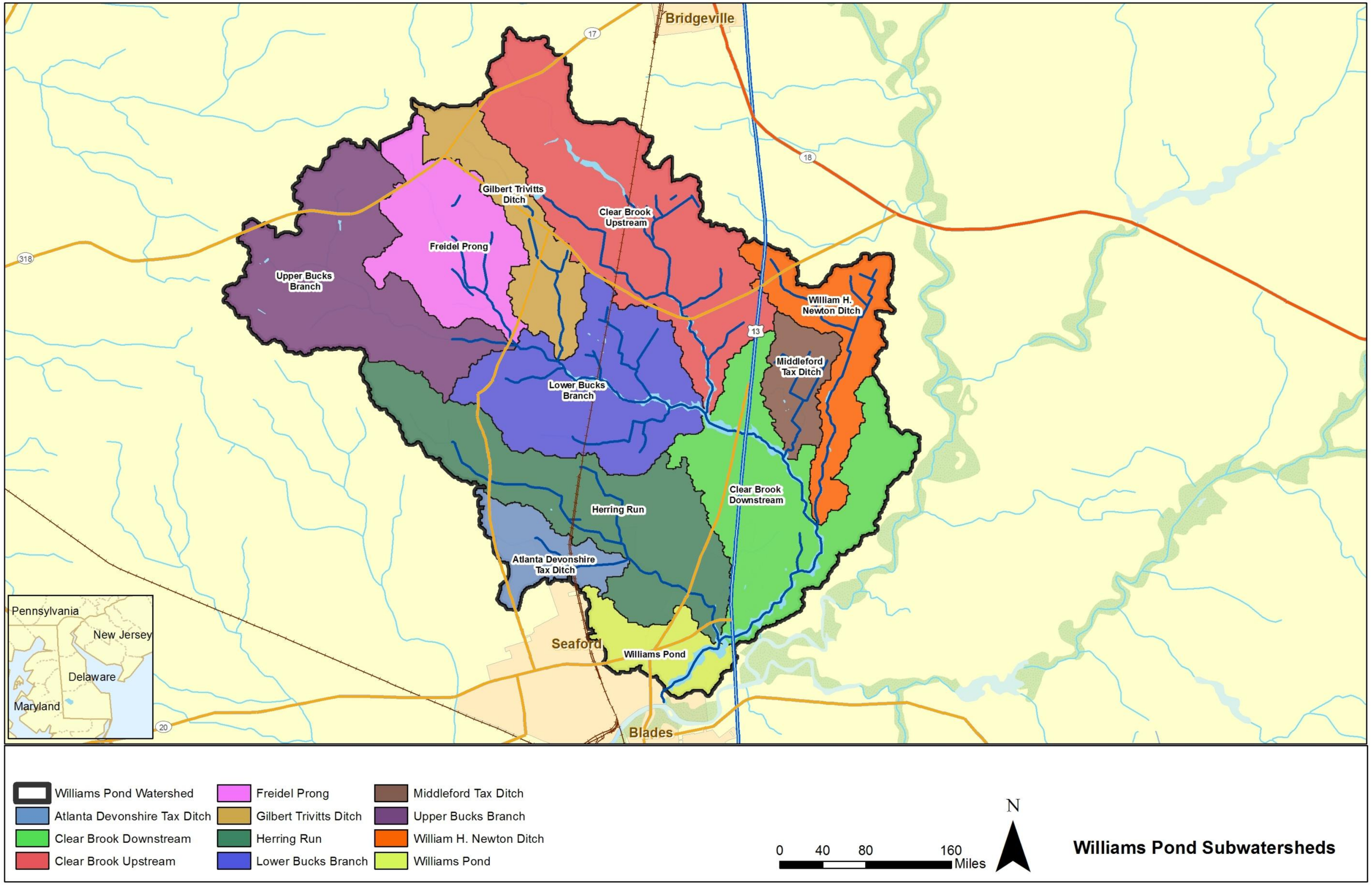


Figure 2.1: Major Subwatersheds in the Williams Pond Watershed

Section 3 Watershed Conditions

To better understand the conditions of the watershed, URS performed a baseline assessment of the watershed. The assessment included analyzing the existing and future land use, natural features, and community features. The results of the analysis are described in the sections below.

3.1 LAND USE

Existing conditions land use maps show that the watershed is primarily undeveloped with pockets of urbanized areas. Rural areas with farms, pasture, and cropland occupy more than half of the watershed. Forested wetlands occupy approximately 9 percent of the watershed. The impervious development in the watershed is distributed primarily in the City of Seaford and along the Route 13 corridor connecting City of Seaford and Town of Bridgeville. Single-family dwellings and commercial areas that encompass 14 percent and 3 percent, respectively, are the major impervious land use types in the watershed. The Sussex County Comprehensive Plan (2008) indicates that major development in the watershed is expected to occur around the City of Seaford and along the Route 13 corridor. Major development that is expected to occur includes highway commercial areas, mixed residential areas, municipalities, town centers, and developing areas. These areas are recognized as designated “growth areas” in the plan. Table 3.1, Table 3.2, Figure 3.1, and Figure 3.2 show the distribution of land use in the watershed for existing and future conditions.

Table 3.1: Existing Land Use Distribution

Land Use	Existing Conditions
Clear-cut	0.2%
Commercial	3.4%
Confined Feeding Operations/Feedlots/Holding	1.6%
Deciduous Forest	0.3%
Emergent Wetland – Tidal and Non-tidal	0.3%
Evergreen Forest	0.7%
Extraction and Transitional	0.2%
Farms, Pasture and Cropland	59.3%
Farmsteads	1.3%
Forested Wetland – Tidal and Non-tidal	8.6%
Impervious	0.5%
Industrial	0.4%
Institutional/Governmental	0.8%
Manmade Reservoirs and Impoundments	0.3%
Mixed Forest	4.7%
Mixed Urban or Built-up Land	0.4%
Mobile Home Parks/Courts	0.2%
Multi-Family Dwellings	0.1%
Open Water	0.9%
Orchards/Nurseries/Horticulture	0.1%
Rangeland	0.2%
Recreational	0.9%
Scrub/Shrub Wetland – Tidal and Non-tidal	0.1%
Shrub/Brush Rangeland	0.1%
Single-Family Dwellings	13.8%
Transportation/Communication/Utilities	0.2%

Table 3.2: Future Land Use Distribution

Land Use	Future Conditions
Clear-cut	0.2%
Commercial	3.6%
Confined Feeding Operations/Feedlots/Holding	1.6%
Deciduous Forest	0.2%
Developing Area	21.2%
Emergent Wetland – Tidal and Non-tidal	0.3%
Evergreen Forest	0.6%
Extraction and Transitional	0.04%
Farms, Pasture and Cropland	24.6%
Farmsteads	1.3%
Forested Wetland – Tidal and Non-tidal	3.7%
General Residential	0.5%
Impervious	0.5%
Industrial	0.3%
Institutional/Governmental	0.8%
Man-made Reservoirs and Impoundments	0.3%
Mixed Forest	1.2%
Mixed Urban or Built-up Land	0.4%
Mobile Home Parks/Courts	0.2%
Multi-Family Dwellings	0.1%
Municipal Boundary	13.8%
Open Water	0.9%
Orchards/Nurseries/Horticulture	0.1%
Rangeland	0.1%
Scrub/Shrub Wetland – Tidal and Non-tidal	0.0027%
Shrub/Brush Rangeland	0.1%
Single-Family Dwellings	2.6%
Town Center	20.4%
Transportation/Communication/Utilities	0.2%

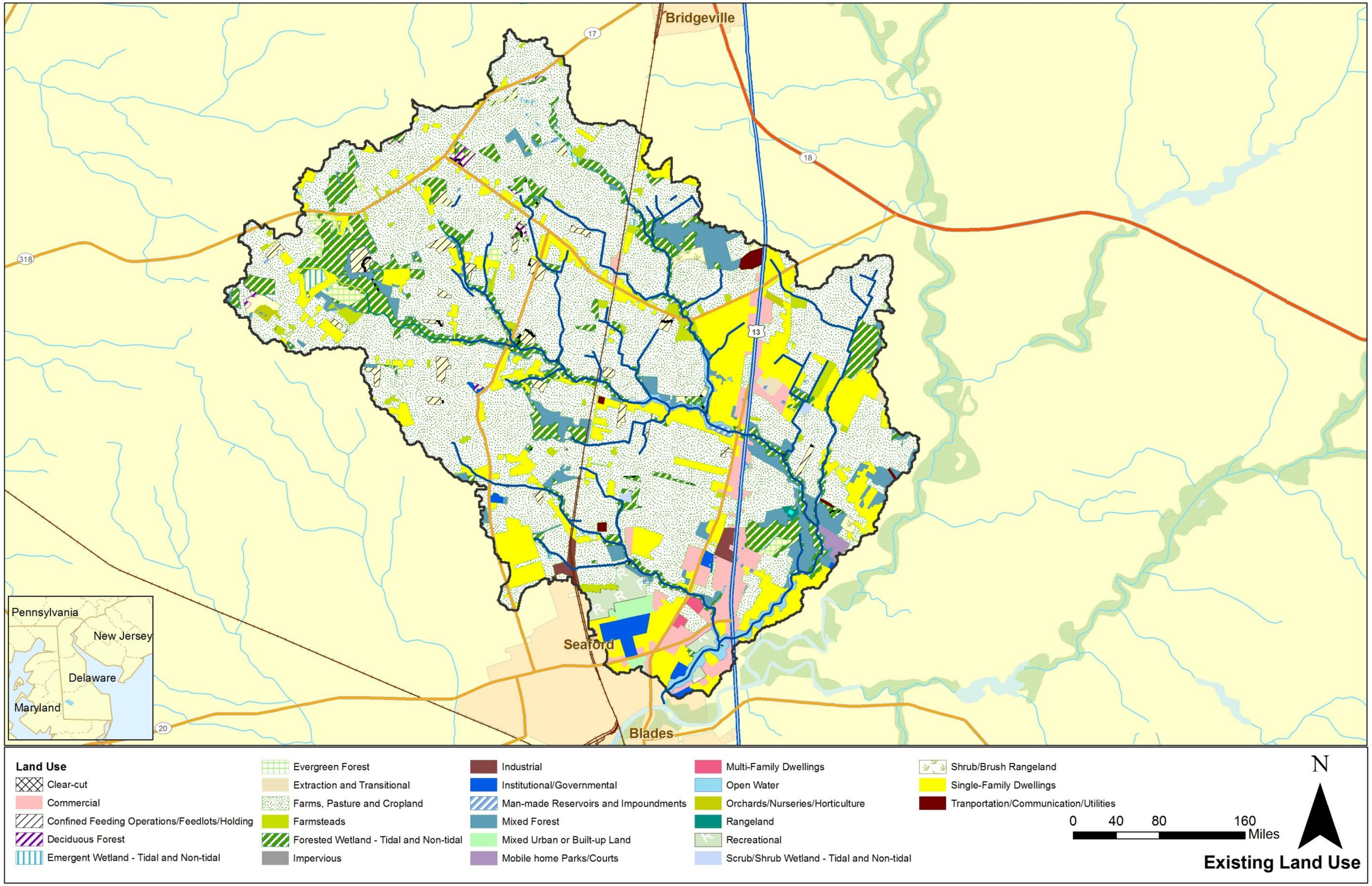


Figure 3.1: Williams Pond Watershed Existing Conditions Land Use Map

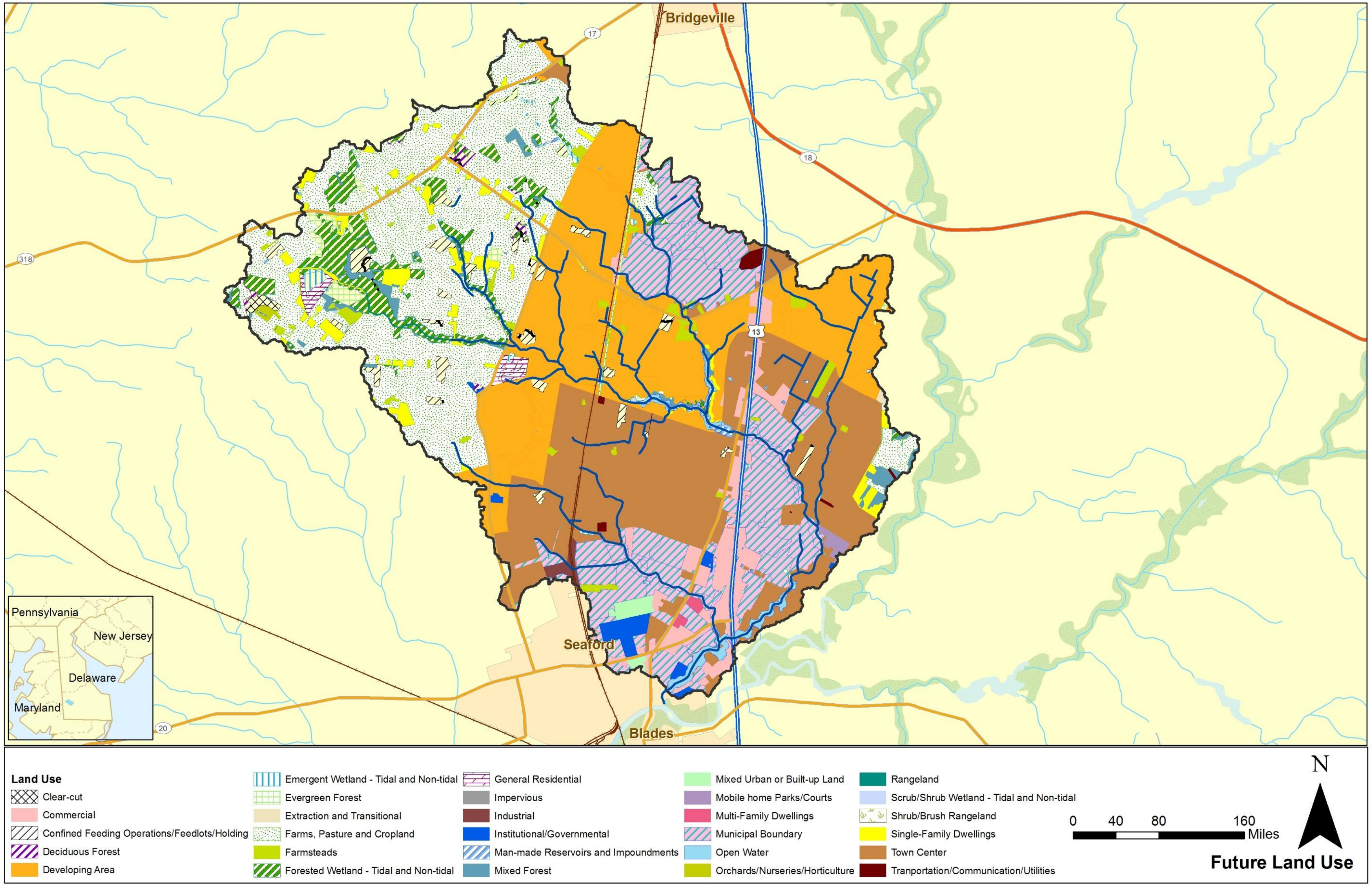


Figure 3.2: Williams Pond Watershed Future Conditions Land Use Map (Developed from Future Zoning in 2008 Sussex County Comprehensive Plan)

3.2 SOILS AND GEOLOGY

Hydrologic soil group type B (silt loam or loam) with moderate infiltration rates occupies approximately 33 percent of the watershed. Hydrologic soil group type A (sand, loamy sand) with highest infiltration rates occupy 25 percent of the watershed. Hydrologic soil group type C (sandy clay loam) with low infiltration rates and group D (silty clay loam, sandy clay, clay) with high runoff coefficients occupy 22 percent and 20 percent of the watershed, respectively. The distribution of the hydrologic soil group was used to develop the hydrologic model for the watershed.

The watershed lies entirely on the Atlantic coastal plain, which is primarily made up of sediments, silt, sand, and gravel that have eroded off the Piedmont and adjacent Appalachian Mountains. Geologically, the watershed can be divided into five distinct areas classified as:

- Beaverdam Foundation
- Nanticoke Deposits
- Alluvial Deposits
- Swamp Deposits
- Upland Bog Deposits

Distribution of hydrologic soil groups and geological units in the Williams Pond Watershed is shown in Figure 3.3.

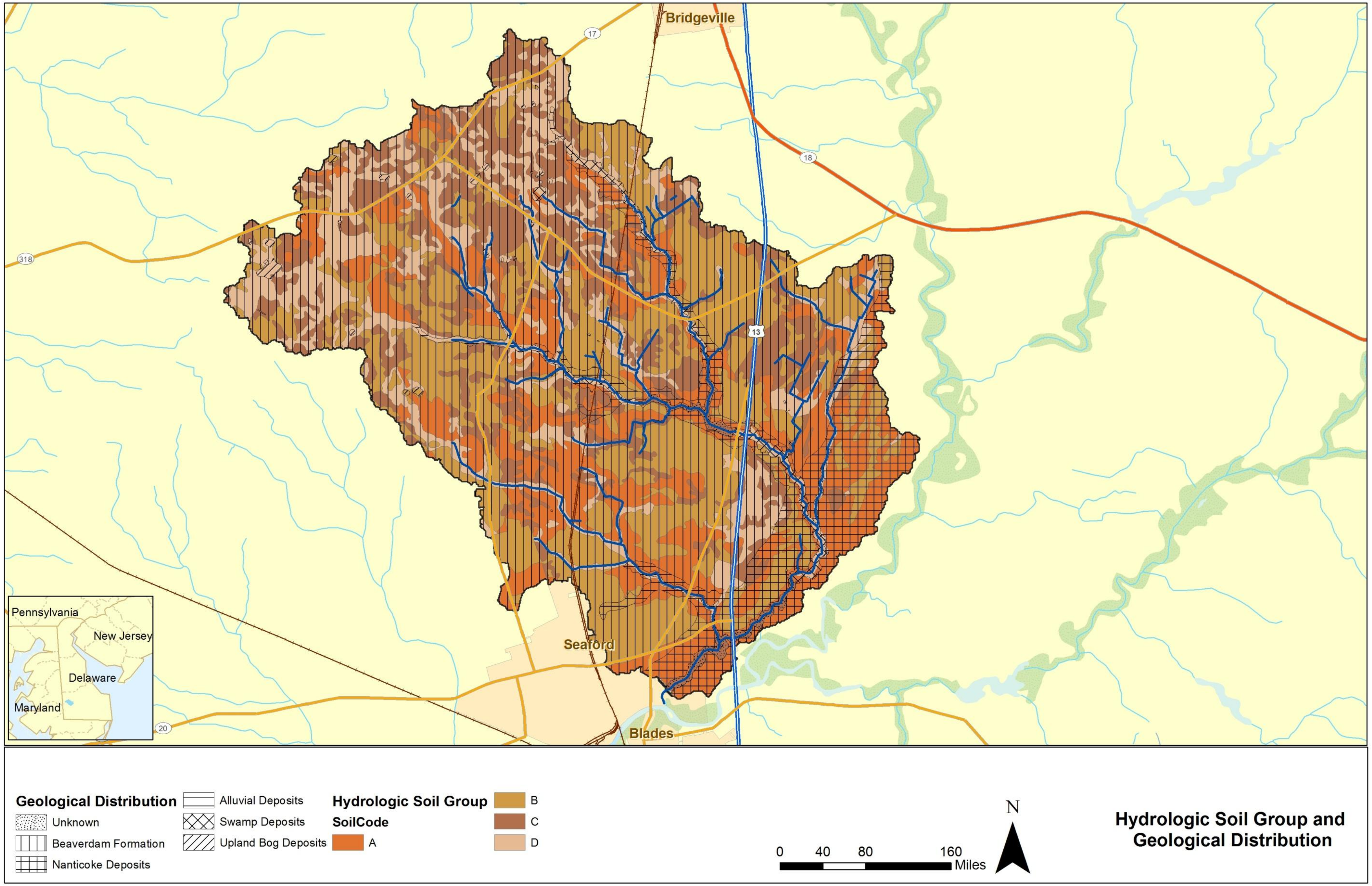


Figure 3.3: Hydrologic Soil Group and Geologic Distribution

3.3 HYDROLOGY

The watershed contains approximately 49 miles of stream network. Major streams in the watershed include Bucks Branch, Clear Brook, Freidel Prong, Gilbert Trivitts Ditch, Herring Run, and William H. Newton Ditch. Approximately 0.24 square mile of the watershed is occupied by lakes and ponds. Significant lakes and ponds in the watershed include Hearns Pond and Williams Pond, both state-owned. The dam embankments and hazard classifications for these facilities have recently been evaluated by DNREC, as listed in Table 3.3. This information aided in the development of the hydrologic model, which is described in Section 4.

Figure 3.4 shows the stream network and location of lakes and ponds with the dams in the watershed.

Table 3.3: Dams in Williams Pond Watershed

Pond/Lake	Owner	Dam Class	Location	Hazard Classification
Hearns Pond	DNREC Division of Fish and Wildlife	A	Hearns Mill Road	Significant
Williams Pond	DelDOT	B	Poplar Street	Low

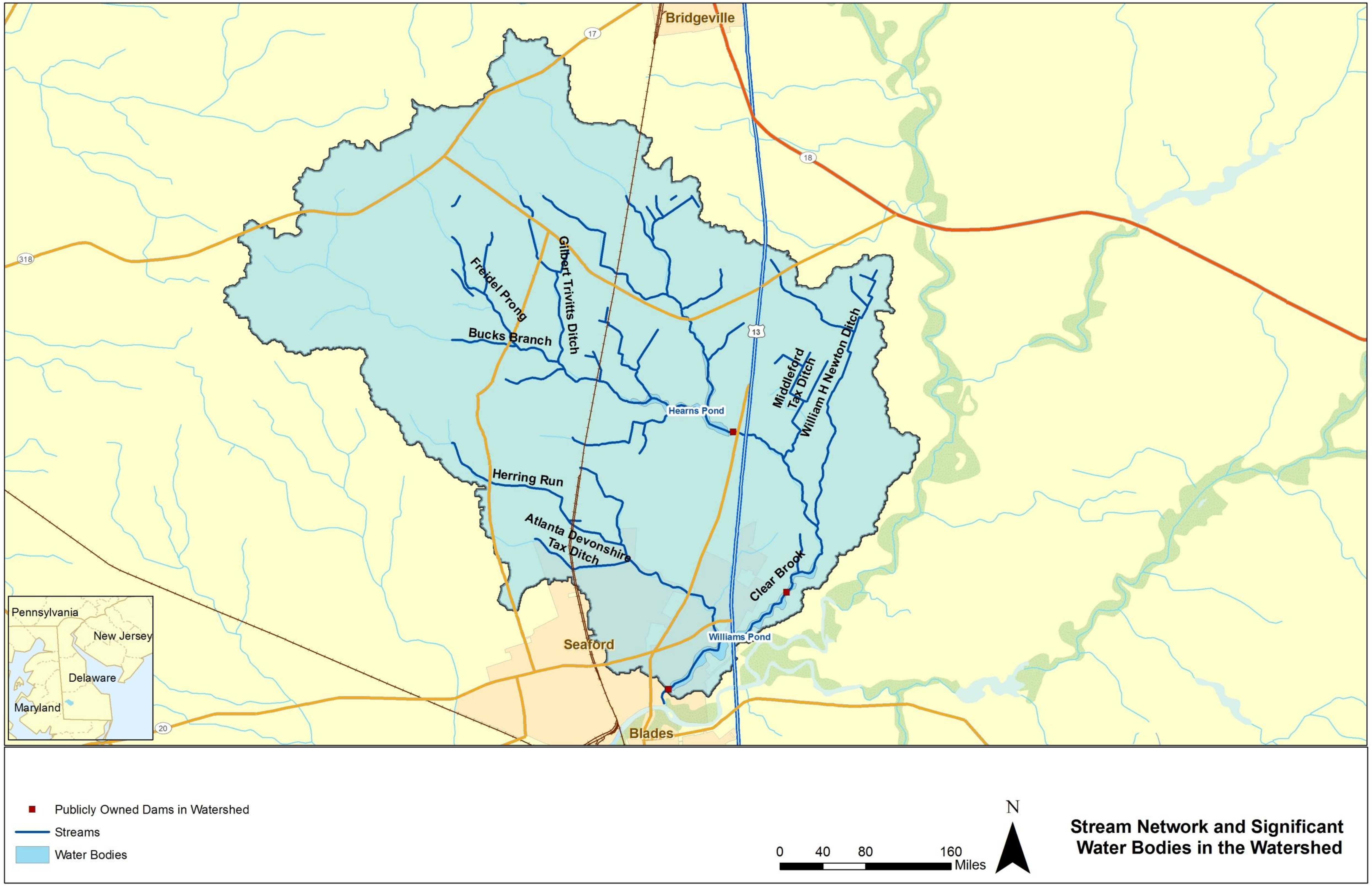


Figure 3.4: Stream Network and Location of Significant Water Bodies

3.4 SOURCE WATER ASSESSMENT AND PROTECTION PROGRAM

The Delaware Water Resources Agency along with the Delaware Division of Public Health promotes the protection of waters in streams and aquifers in the State of Delaware through their "Source Water Assessment and Protection Program (SWAPP)." In their April 2007 publication, *protecting the Sources of Your Drinking Water*, DNREC stated that all of Sussex County relies solely on ground water for drinking water supplies and that it is important to protect these areas from ground water contamination. According to SWAPP, the Source Water Protection Areas are classified as follows:

- Well Head Areas
- Excellent Ground Water Recharge Potential Areas
- Surface Water Supply Areas

Approximately 8 percent of the land in Sussex County is classified as "Excellent Ground Water Recharge Potential Areas." Ground water is recharged by infiltration of rainfall through land surface; therefore, changes in land use distribution would affect the quality of runoff infiltrating, which in turn affects the ground water quality. Hence, it is critical to protect these ground water recharge areas from development/activities that cause detrimental effects on the quality of ground water. Recommendations for protecting ground water recharge potential areas classified as excellent are presented in Section 13 of this report.

Table 3.4 gives the distribution of the recharge potential areas in Williams Pond Watershed, and Figure 3.5 shows the distribution of potential ground water recharge areas in the watershed.

Table 3.4: Distribution of Recharge Potential Areas in Williams Pond Watershed

Recharge Potential	Percent of Watershed
Excellent	6.9%
Fair	60.2%
Good	28.3%
Poor	1.8%

The rest of the 2.7% of the area is in the watershed is classified as "Water Areas".

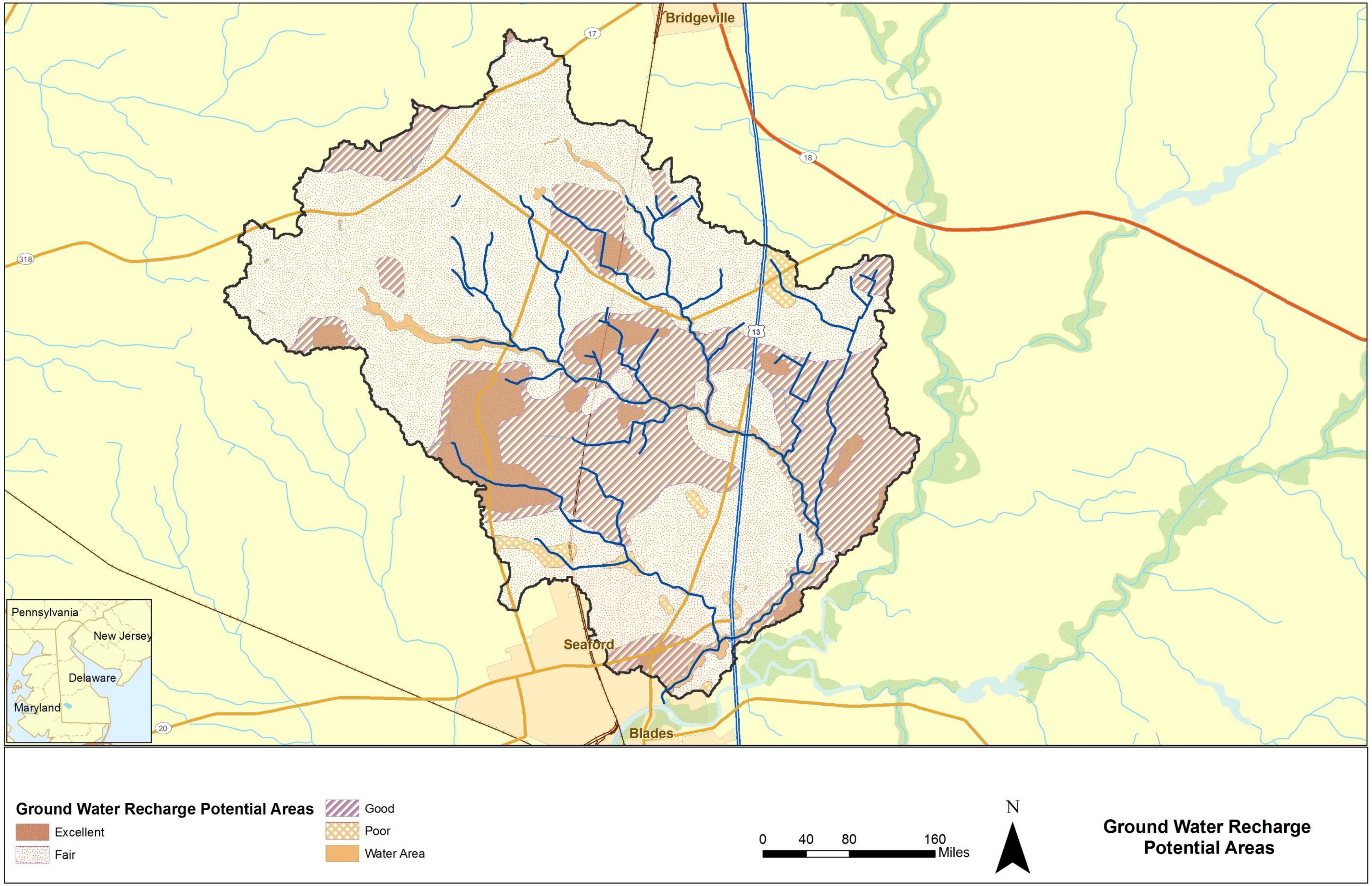


Figure 3.5: Distribution of Ground Water Recharge Potential Areas

3.5 WATER QUALITY

The Williams Pond Watershed's most significant environmental issues are high nutrient loading, bacteria, and low dissolved oxygen. A water quality assessment performed by Nanticoke Watershed Alliance in 2007 (NWA, 2007) concluded that high level of nitrogen, phosphorous, and bacteria in the Nanticoke River watershed is an indicator of inputs from sewage plants, septic system leaks, and agricultural runoff. The major non-point sources of pollution in the Nanticoke Watershed are observed to be surface water runoff from agriculture and other land use activities; septic tanks, and ground water discharges containing nutrients such as nitrogen. The major point sources of pollution in Nanticoke Watershed are from wastewater treatment plants. There are nine wastewater treatment facilities in the Sussex County part of the Nanticoke Watershed; however, none of them are located in the Williams Pond Watershed.

3.6 STORMWATER MANAGEMENT REQUIREMENTS

Traditionally, the Williams Pond Watershed has been primarily a rural watershed with agriculture as its major land use. However, in the last decade the watershed has faced significant development. In general, development results in increased impervious cover, which results in increased peak flow and total volume of runoff. Development also affects the water quality of the runoff entering the streams, as it contains pollutants such as nutrients, pathogens, and sediments. Stormwater management facilities play an important role in reducing the volume of runoff and amount of pollutants entering the streams. Stormwater management facilities provide water quality treatment, volume reduction, or both, depending on the type of facility.

The Sediment and Stormwater Program of DNREC require erosion and sediment control permits during the construction of any development projects that disturbs more than 5,000 square feet of the area. In addition post-construction stormwater quality and quantity control is also required to be implemented by the program. These programs are applicable statewide for any new development or re-development.

Sussex County and DNREC emphasize using stormwater management facilities to treat runoff from new development in the county. Williams Pond Watershed currently has a number of stormwater management facilities that treat runoff from existing developed land. However, information on the distribution of the facilities and the areas they treat was not available to be included in the Williams Pond Watershed Management Plan.

In addition, the Williams Pond Watershed, which is a part of the Nanticoke River Watershed, drains to the Chesapeake Bay and is included in the Chesapeake Bay Program. The State of Delaware has developed Watershed Implementation Plans, Phase I (DNREC, 2010) and Phase II (DNREC, 2012) to meet the Chesapeake Bay Total Maximum Daily Load Allocations (TMDL) for nutrients and sediments. The WIP includes a description of the approach that will be adopted by the State to achieve the TMDL goals. The approach described in the WIPs includes a combination of structural, non-structural and regulatory restoration efforts that focus in the areas of urban/suburban stormwater, land use, wastewater, on-site wastewater, agriculture, and air.

3.7 TAX DITCHES

"Tax ditches" are political subdivisions of the State of Delaware. They are designed to provide watershed-based drainage for agricultural, commercial, and residential areas. The DNREC Division of Soil and Water Conservation (SWC) administers the planning, design, and maintenance of these tax ditches. The size of tax ditches range from 6 to 80 feet wide and 2 to 14 feet deep, depending on the drainage area. Their operations are overseen by designated ditch managers and a secretary/treasurer, who are landowners in the tax ditch drainage areas and are elected annually. The Williams Pond Watershed has approximately 30 miles of tax ditches that serve residential, agricultural, and commercial areas. Figure 3.6 shows the network of tax ditches in the watershed. Detailed information on the existing conditions of the tax ditches in the watershed and proposed restoration and management strategies are provided in Section 10 of this report.

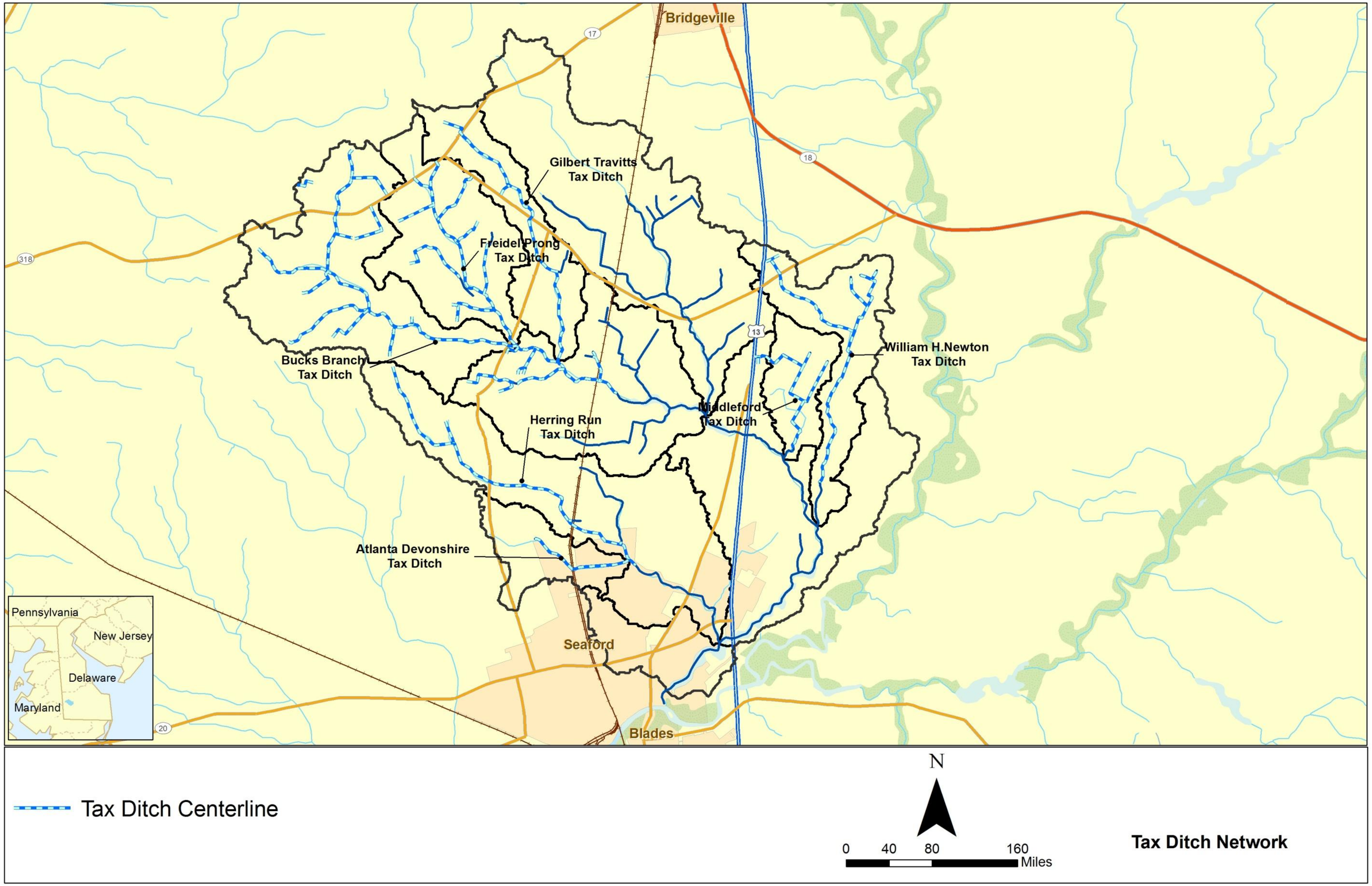


Figure 3.6: Tax Ditch Network in the Watershed

3.8 DRAINAGE COMPLAINTS DATABASE

Flooding and drainage issues are major concerns in the Williams Pond Watershed. Rapid urbanization along with aging stormwater management facilities and undersized culverts has caused an increase in flooding in the watershed. DNREC maintains a Drainage Complaint Database that compiles complaints received regarding drainage issues. These complaints are usually made by residential property owners. A total of 26 drainage complaints were recorded in the Williams Pond Watershed between 2007 and 2012, of which,

- 12 were categorized under “Private Drainage Concern,”
- 3 under “Sediment and Stormwater Concern,”
- 7 under “Tax Ditch Concern,”
- 2 under “Legislative Requests.”
- 2 complaints were miscellaneous relating to other categories.

According to the Drainage Complaint Database provided by DNREC, 20 of the 26 complaints appear to be resolved. A table with the list of these complaints is provided in Appendix B of this report.

Figure 3.7 shows the distribution of drainage complaints throughout the watershed.

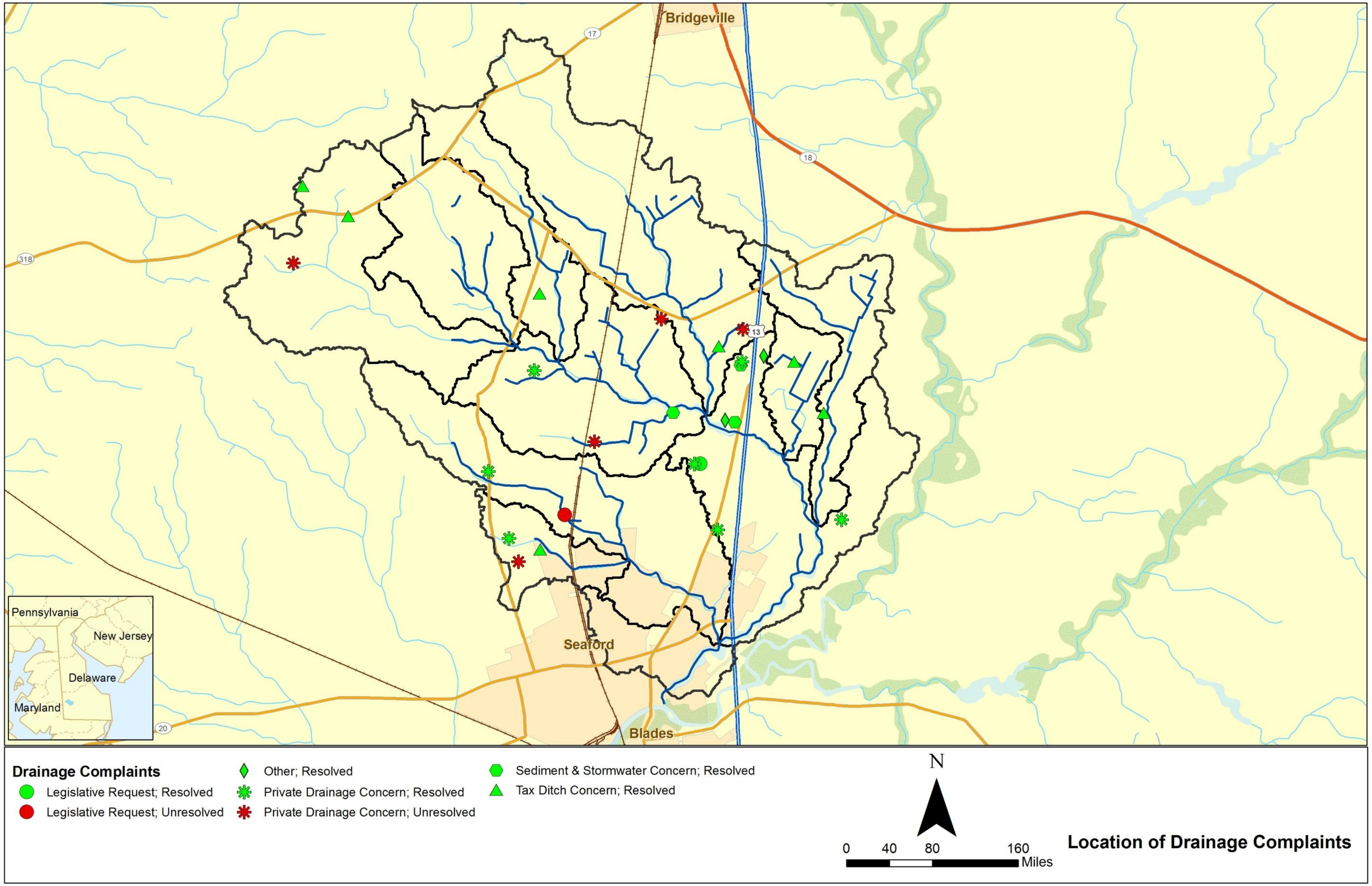


Figure 3.7: Distribution of Drainage Complaints in the Watershed

Section 4 Hydrologic Analysis

URS conducted a hydrologic analysis of the Williams Pond Watershed as a part of the watershed management plan to better understand the watershed's hydrologic characteristics and aid in the development of a "what-if" scenario model for providing recommendations for the restoration of the watershed.

The hydrologic model was developed using GIS mapping tools and the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) Version 3.3 (USACE, 2008), ArcGIS 9.2 (ESRI, 2006), ArcHydro (CRWR, 2007), and HEC-GeoHMS (USACE, 2003) models. The hydrologic model was developed using data obtained from previous studies as well as data gathered from field reconnaissance of Delaware dams, current GIS datasets, and NOAA Atlas 14 precipitation data (NOAA, 2009).

The hydrologic analysis involved developing the model for two scenarios:

- Existing conditions: the existing conditions land use information was obtained from the State of Delaware DataMIL (State of Delaware, 2008).
- Future conditions: the future conditions land use information was developed by merging the existing land use data with the future zoning data as identified in the Sussex County Comprehensive Plan of 2008.

The Soil Survey Geographic (SSURGO) database available at http://SoilDataMart.nrcs.usda.gov/ was used to obtain the GIS coverage of soils for the watershed. Data for dams at Williams Pond and Hearns Pond were obtained from a previous evaluation study performed by McCormick Taylor (2009) and were included in the model.

Seventy smaller basins were delineated using 3-meter DEM data. The model was run for the 24-hour, and 1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval rainfall events to estimate the flood magnitudes for the respective events. In addition, a 2-inch event, which is defined as the "water quality event" by DNREC, was also simulated in the hydrologic model.

Typically, gage data are used to conduct calibration analysis; however, insufficient gage data were available to conduct calibration for Williams Pond Watershed. For the one existing gage in the watershed at Herring Run (USGS Gage 01487195), insufficient peak flow data exists on record for the various return intervals. Therefore, the obtained discharges were compared to the regression discharges for calibration purposes. The 100-year peak discharge results from the most recent regression equation developed by Ries et al. (USGS, 2006a) were compared to the model results to calibrate the developed hydrology model. In addition, at DNREC's request, the results of the hydrology model were also compared with Delaware GIS Hydro (Moglen, 2007) discharge results.

The results obtained from the hydrologic analysis were compared to the effective discharges in the Federal Emergency Management Agency's (FEMA's) Flood Insurance Study (FIS) for Sussex County, Delaware (FEMA, 2005), to the values calculated by McCormick Taylor in their dam analysis study (2009), and also to discharges obtained from the StreamStats website (USGS, 2009). Detailed descriptions of the model development along with the results and conclusions are included in Appendix C (Hydrologic Analysis) of this report.

The hydrologic analysis for the Williams Pond Watershed was approved by DNREC in January, 2010, and more detail on this analysis is included in Appendix C. The flows from the hydrologic model were used to analyze the conveyance capacity of the road crossings (Section 5), and in the development of "what-if scenario" models (Section 9).

Section 5 Hydraulic Analyses of Road Crossings

Streams that flow under a road or railroad are conveyed by engineered structures such as culverts or bridges. Depending on the road's level of service, for example, high-capacity arterial or local residential, water conveyance structures are usually designed for storms with recurrence periods of 50, 25, or 10 years plus 1 foot of freeboard. Table 5.1 summarizes the Delaware classification of roads and the associated recurrence period design storm.

Table 5.1: Classification of Roads and Design Storm Event

Type of Road	Design Recurrence Period Storm Event
Collector	50-Year
Arterial	50-Year
Local	25-Year
Rural Collector	25-Year

Road overtopping, significant damage to roads and traffic interruption occur during a flood event if there is a deficiency in the conveyance capacity of the structure. Structures with deficient capacities also decrease the stability of the stream channel, thereby causing erosion and sedimentation, which affects water quality and aquatic life.

URS performed hydraulic analysis of the stream crossings in the watershed to identify their conveyance capacities and deficiencies. Twenty-eight structures with an opening larger than 36 inches were analyzed. Procedures adopted in performing the analysis are described in the following sections.

5.1 FIELD EVALUATION OF ROAD CROSSINGS

The first part in the hydraulic analysis of the structures consisted of field evaluation of the crossings. Prior to conducting the field evaluation, URS obtained available crossing information from the DelDOT bridge maintenance group. URS then conducted field visits to road and railroad crossings that have openings of 36 inches or larger to collect the following data:

- Structure opening data (e.g., type, culvert size, culvert material, headwall material/configuration, culvert skew)
- Distance from the top of the opening to the minimum overtopping elevation
- Configuration of downstream channel (to compute outlet control discharges)
- Distance from the downstream invert to the low-flow elevation below the culvert (to determine whether a blockage to fish passage exists; other downstream conditions such as bank erosion, over-widening, and bed degradation were noted)
- Digital photographs
- GPS location of upstream and downstream ends of culverts
- Potential for conveyance improvements

- Other pertinent data necessary for hydraulic computations

For the purposes of this planning level study, the information was obtained using a tape measure and field observation rather than a detailed field survey. Field assessment sheets were developed to ensure consistent data collection, and are included in Appendix A, and Appendix D includes hydraulic computations performed for the existing conditions, future conditions, and proposed improvements for all the undersized crossing.

5.2 EVALUATION OF THE HYDRAULIC CAPACITY

After obtaining the measurements of the structures in the field, the capacities of the structures were evaluated. The *Hydraulic Design of Highway Culvert* (USDOT, May 2005) approach was adopted and Microsoft Excel was used to conduct the analysis. Culvert capacities for all the structures were computed for inlet control and outlet control scenarios. The maximum capacity of the culvert under inlet control conditions was calculated from the field observations using equation 5.1:

$$Q = [(A*D^{0.5})/K_u]* [((HW_i/D)-Y+0.5*S^2))/C]^{0.5} \text{-----------------------} \quad (5.1)$$

Where,

Q = Discharge, cubic feet per second (cfs)

A = Full cross-sectional area of culvert barrel, square feet (ft^2)

D = Interior height of culvert barrel, feet (ft)

HW_i = Headwater depth above inlet control section invert, ft

S = Culvert barrel slope, feet per foot (ft/ft)

K_u, Y ,C = Constants for inlet control design equations (obtained from Table 9 of the *Hydraulic Design of Highway Culverts* manual, USDOT, May 2005)

The maximum flow, Q, obtained from equation 5.1 was then used to determine the critical depth (d_c) of the culvert using the nomographs. The obtained critical depth was in turn used to determine the capacity of the culvert with outlet control condition using equation 5.2:

$$Q = A*[(2*H*g)/(1+K_e+(29*n^2*L)/R^{1.33})]^{1/2} \text{------------------------} \quad (5.2)$$

Where,

Q = Discharge, cfs

A = Full cross-sectional area of culvert barrel, ft^2

H = Headloss computed from outlet control equation, ft

L = Length of the culvert barrel, ft

n = Pipe (culvert) Manning's coefficient

g = Acceleration due to gravity, 32.2 ft per second per second

R = Wetted perimeter, ft

K_e = Entrance loss coefficients (obtained from Table 12 of the *Hydraulic Design of Highway Culverts* manual, USDOT, May 2005)

A worst-case assumption for tailwater equal to bankfull condition was used. The discharges for both inlets and outlets were compared, and the lowest discharge was selected to determine the flow regime of the structure.

Culvert capacity was estimated for two scenarios:

1. With 0 foot of freeboard to the top of road
2. With 1 foot of freeboard to the top of road

The subbasins containing the culverts were identified, and the peak flows for storm events were obtained from the existing and future conditions hydrology model. A raster analysis was performed in GIS using the Flow Direction Grid and Flow Accumulation Grid to determine the area draining to each crossing. The flows at each crossing were obtained using drainage area ratio estimates (equation 5.3):

$$Q_c = [A_c/A]^b * Q \text{--} \quad (5.3)$$

Where,
Q_c= Estimated flow at the crossing, cfs
A_c= Drainage area of the crossing, acres
Q = Subbasin flow from hydrology model, cfs
A = Drainage area of subbasin, acres
b = Exponent of drainage area

Based on the report *Magnitude and Frequency of Floods on Nontidal Streams in Delaware* (USGS, 2006a), it can be inferred that a value of 0.6 is used for the exponent of drainage area, "b," in the Piedmont, and a value of 0.7 is used in the coastal plain in the State of Delaware. Since the Williams Pond Watershed is located entirely in the coastal plain, a value of 0.7 was used as the exponent for the drainage area. For crossings located higher in the subbasins, flows were estimated using the upstream subbasin.

URS considered the DelDOT road classification to determine the design storm. Roads categorized as Local and Rural Collector roads were assigned the 25-year design storm, and Collectors and Arterials were assigned the 50-year design storm. Roads that were not in the DelDOT system were classified as local roads and assumed to have a 25-year design storm. The results of the analyses are categorized as follows:

- Green: Culvert passes the design storm with 1 foot of freeboard
- Yellow: Culvert passes the design storm with less than 1 foot of freeboard
- Red: Culvert does not pass the design storm

The conveyance capacity of the crossings was analyzed for existing and predicted future condition flows. Figure 5.1 and Figure 5.2 summarize the results of the analyses. Table 5.2 through Table 5.4 show the summary of the hydraulic analysis and capacity of the structures expressed in terms of percent design flow conveyed through the structure. The results are also summarized by subwatershed in Section 8.

Table 5.2: Summary of Culvert Analysis

	Green	Yellow	Red
Existing	50%	29%	21%
Future	50%	14%	36%

Table 5.3: Culvert Capacity for Existing Conditions

Crossing ID	Location	Subwatershed	Design Storm (Year)	Capacity with 1' freeboard	Capacity with 0' freeboard	Classification
URS15	Park Avenue	Atlanta Devonshire	25	78%	100%	
URS17	Ross Station Road	Atlanta Devonshire	50	96%	100%	
236	Elks Road	Clear Brook U/S	25	100%	100%	
URS2	Elks Road	Clear Brook U/S	25	37%	46%	
URS23	Conrail Road	Clear Brook U/S	25	96%	100%	
URS24	Conrail Road (railroad tracks)	Clear Brook U/S	25	100%	100%	
URS25	Conrail Road	Clear Brook U/S	25	87%	100%	
URS10	Baker Road	Freidel Prong	25	100%	100%	
URS8	Bucks Branch Road	Freidel Prong	25	80%	100%	
URS9	Baker Road	Freidel Prong	25	88%	100%	
230	Cannon Road	Gilbert Trivitts Ditch	50	100%	100%	
URS11	Atlanta Road	Herring Run	50	56%	72%	
URS12	Briarbrook Road	Herring Run	25	100%	100%	
URS20	Conrail Road	Herring Run	25	66%	90%	
URS21	Conrail Road (railroad tracks)	Herring Run	25	100%	100%	
URS3	Herring Run Road	Herring Run	25	100%	100%	
URS4	Herring Run Road	Herring Run	25	100%	100%	
URS5	Station Lane	Herring Run	25	100%	100%	
URS6	Ross Station Road	Herring Run	25	90%	100%	
URS7	Owls Nest Road	Herring Run	25	0%	90%	
224	Conrail Road	Lower Bucks Branch	25	100%	100%	
225	Wesley Church Road	Upper Bucks Branch	25	100%	100%	
228	Bucks Branch Road	Upper Bucks Branch	25	100%	100%	
229	Baker Road	Upper Bucks Branch	25	100%	100%	
URS13	Federalsburg Road	Upper Bucks Branch	50	67%	87%	
URS14	Atlanta Road	Upper Bucks Branch	50	61%	82%	
URS1	Old Furnace Road	William H. Newton	50	100%	100%	
URS16	Eskridge Road	William H. Newton	25	87%	100%	

Table 5.4: Culvert Capacity for Future Conditions

Crossing ID	Location	Subwatershed	Design Storm (Year)	Capacity with 1' freeboard	Capacity with 0' freeboard	Classification
URS15	Park Avenue	Atlanta Devonshire	25	81%	100%	
URS17	Ross Station Road	Atlanta Devonshire	50	100%	100%	
236	Elks Road	Clear Brook U/S	25	100%	100%	
URS2	Elks Road	Clear Brook U/S	25	30%	36%	
URS23	Conrail Road	Clear Brook U/S	25	88%	100%	
URS24	Conrail Road (railroad tracks)	Clear Brook U/S	25	100%	100%	
URS25	Conrail Road	Clear Brook U/S	25	72%	91%	
URS10	Baker Road	Freidel Prong	25	100%	100%	
URS8	Bucks Branch Road	Freidel Prong	25	72%	95%	
URS9	Baker Road	Freidel Prong	25	78%	96%	
230	Cannon Road	Gilbert Trivitts Ditch	50	100%	100%	
URS11	Atlanta Road	Herring Run	50	47%	61%	
URS12	Briarbrook Road	Herring Run	25	100%	100%	
URS20	Conrail Road	Herring Run	25	52%	71%	
URS21	Conrail Road (railroad tracks)	Herring Run	25	100%	100%	
URS3	Herring Run Road	Herring Run	25	100%	100%	
URS4	Herring Run Road	Herring Run	25	100%	100%	
URS5	Station Lane	Herring Run	25	100%	100%	
URS6	Ross Station Road	Herring Run	25	71%	88%	
URS7	Owls Nest Road	Herring Run	25	0%	71%	
224	Conrail Road	Lower Bucks Branch	25	100%	100%	
225	Wesley Church Road	Upper Bucks Branch	25	100%	100%	
228	Bucks Branch Road	Upper Bucks Branch	25	100%	100%	
229	Baker Road	Upper Bucks Branch	25	100%	100%	
URS13	Federalsburg Road	Upper Bucks Branch	50	62%	80%	
URS14	Atlanta Road	Upper Bucks Branch	50	57%	76%	
URS1	Old Furnace Road	William H. Newton	50	90%	100%	
URS16	Eskridge Road	William H. Newton	25	62%	100%	

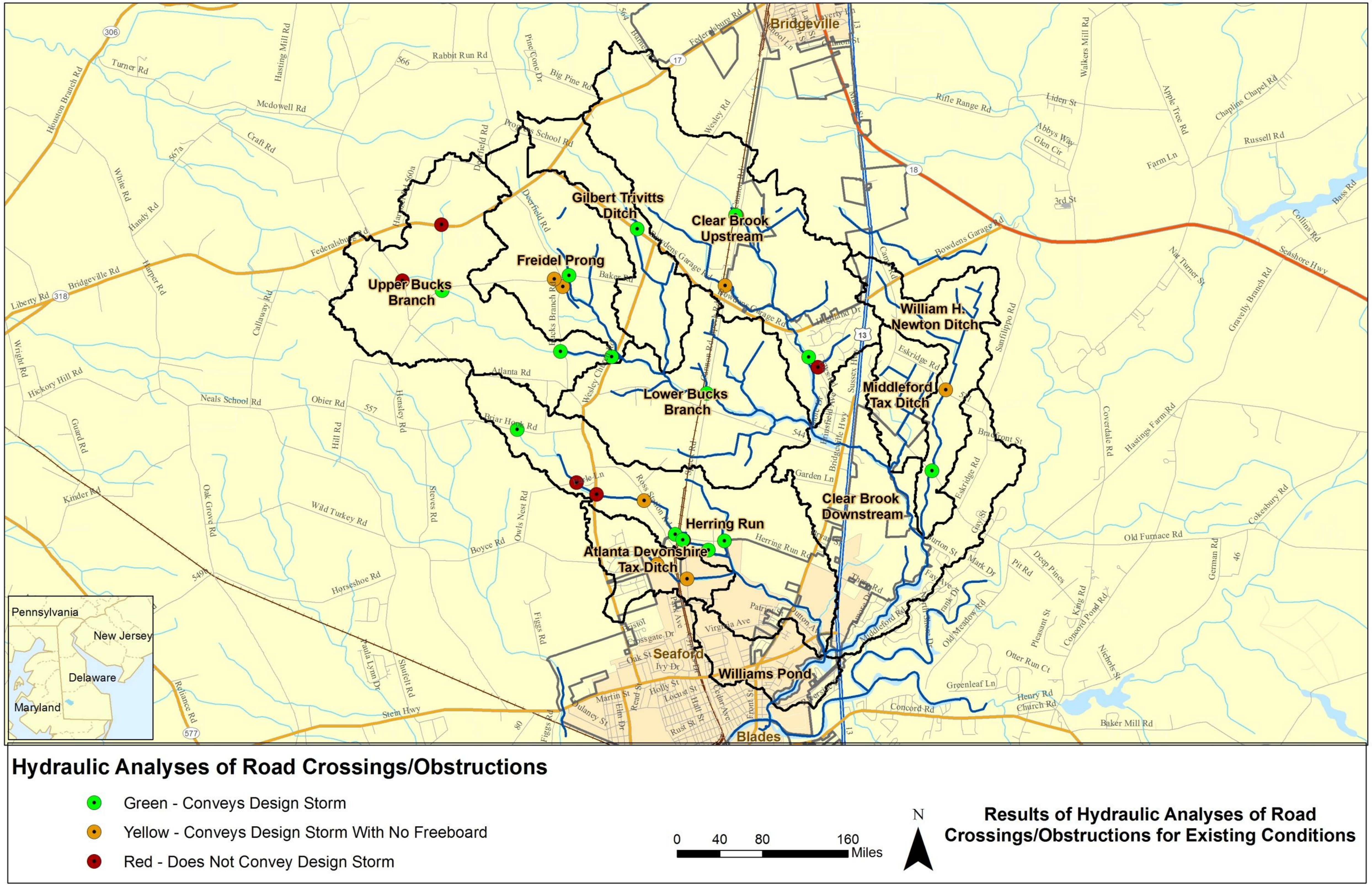


Figure 5.1: Results of Hydraulic Analyses of Road Crossings and Obstructions for Existing Conditions

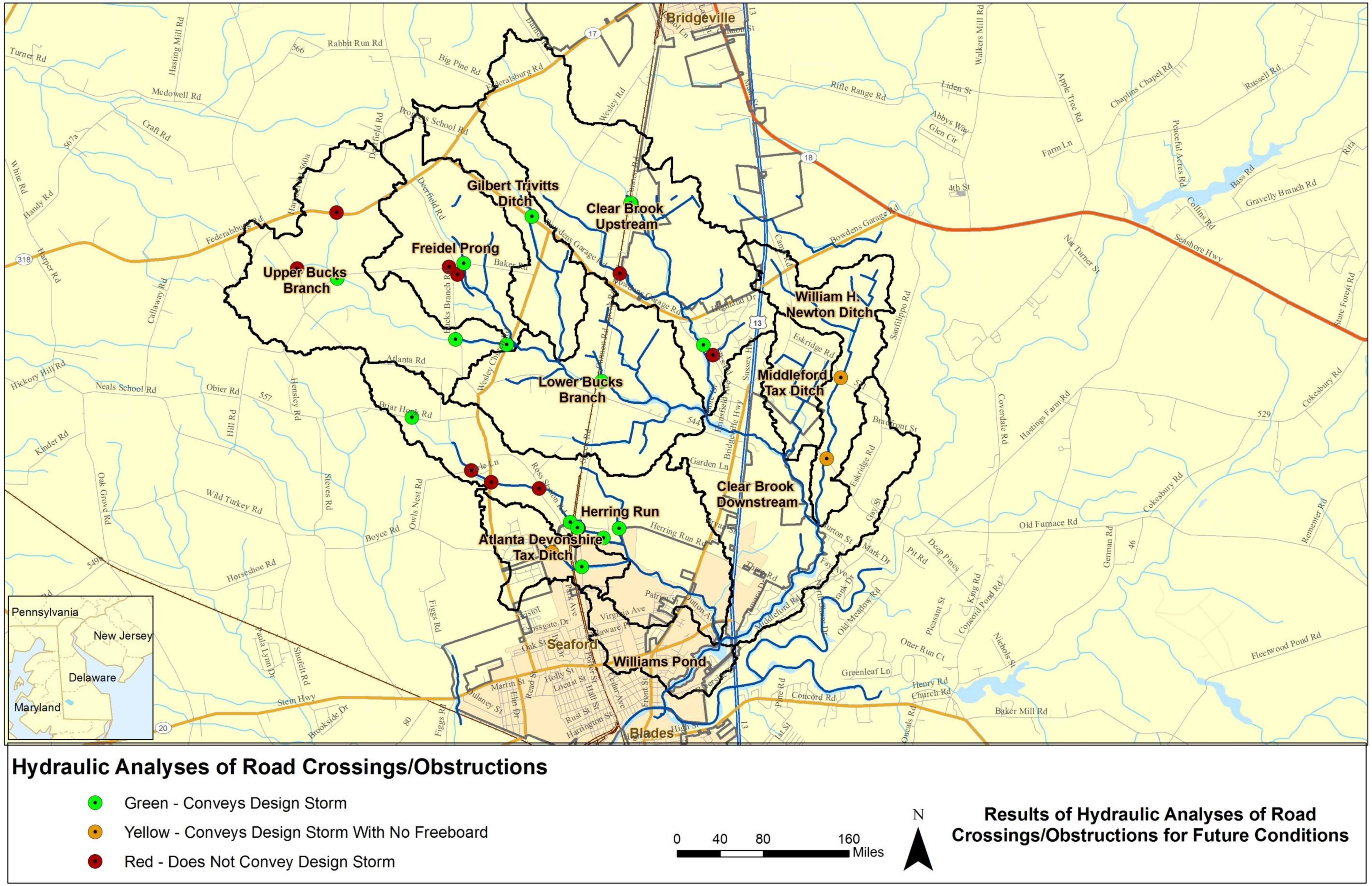


Figure 5.2: Results of Hydraulic Analyses of Road Crossings and Obstructions for Future Conditions

Section 6 Route 13 Drainage Assessments

Route 13, which connects the City of Seaford and Town of Bridgeville, runs through the Williams Pond Watershed. Both sides of Route 13 are primarily occupied by commercial areas and single-family dwellings. Based on the Sussex County Comprehensive Plan (2008), a major portion of future development will be concentrated along the Route 13 corridor. Drainage problems such as flooding, ponding water, sediment, and stormwater issues are identified as existing major concerns along Route 13. However, to propose measures that would improve drainage conditions, knowledge of existing drainage system connectivity is required, and as of August 2012, DelDOT has not mapped the drainage system associated with this portion of Route 13 in the Williams Pond Watershed.

As a part of the watershed management plan, URS performed a field reconnaissance of the drainage facilities along the portion of Route 13 in the Williams Pond Watershed to:

- Assess the contributing drainage structures along Route 13 by identifying locations of inlets and determining the drainage system connectivity
- Determine the contributing drainage areas and relate them to known and potential drainage issues
- Recommend maintenance and improvement projects to minimize drainage issues

6.1 IDENTIFICATION OF DRAINAGE SYSTEM COMPONENTS

The first part of the drainage assessment included identifying various components of the drainage system along the 4-mile stretch of Route 13 in the watershed. This task involved locating and photographing culverts, swales, drainage inlets, and outfalls along the Route 13 corridor and determining their connectivity and contributing drainage areas. The following data were collected in the field as a part of the assessment:

- Inlet locations, tops, and inverts
- Pipe sizes and materials
- Open channel dimensions and surface materials
- Details of inflow locations (e.g., open swale, culvert, storm drain)
- Digital photographs
- GPS location of drainage points
- Potential for conveyance improvements

In addition, locations of drainage problems such as standing water, and clogged culverts were also identified.

URS traced drainage system discharging to the Route 13 conveyance system. Table 6.1 summarizes the types and number of identified structures that contribute to the Route 13 drainage system.

Table 6.1: Summary of Drainage Structures along Route 13

Drainage Component	Number
Culverts	76
Structures	76
Outfalls	31
Swales	122
Pipes	61

Twenty one drainage systems with contributing drainage areas were identified along the Route 13 corridor. Figure 6.1 shows the schematic map of the drainage systems along the north and south ends of the Route 13. Tables and figures providing information on the drainage systems identified in the field, their connectivity, and contributing drainage areas are also provided in Appendix E. Results are provided for the field-identified discharge points along the Route 13 corridor in the watershed.

Drainage connectivity of some of the structures could not be identified during the field assessment due of the flat terrain in the area and the accumulation of debris in the structures. A table providing information on the drainage structures for which connectivity could not be established is provided in Appendix E. Many of the drainage structures along Route 13 appeared to be partially or fully clogged. The level of maintenance required for each drainage structure was assessed during the field assessment and summarized. See Section 6.2 for details on recommended maintenance for these structures. Appendix A includes photographs of the field-identified drainage structures.

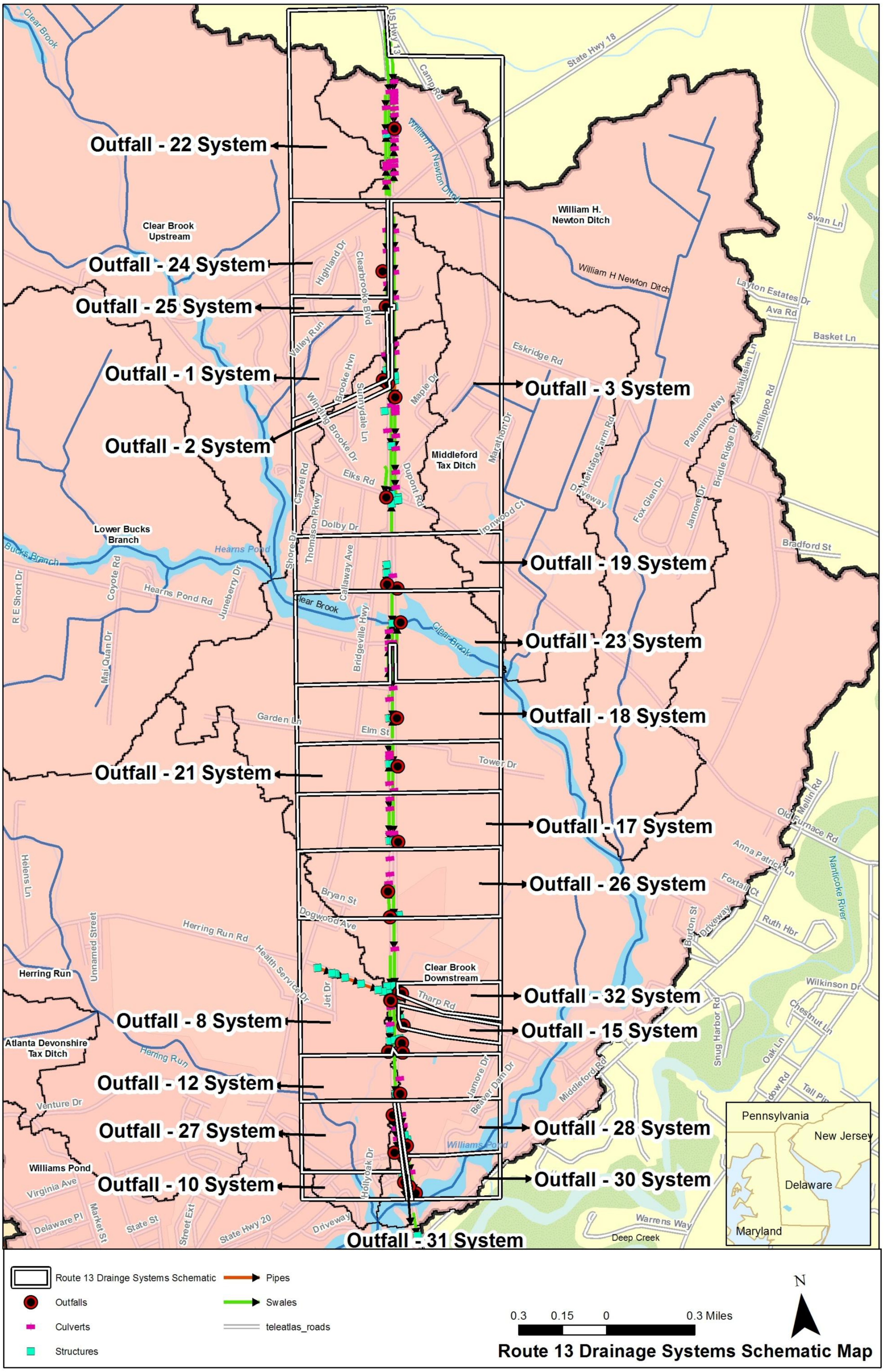


Figure 6.1: Schematic Map of Route 13 Drainage System

6.2 PROPOSED MAINTENANCE

Field assessments of Route 13 identified several drainage structures that do not appear to be functioning at capacity. This was primarily due to the accumulation of debris and detritus that obstructed the flow through structures. In addition, some pipes were observed to be crushed or collapsed. These factors appeared to contribute to the localized drainage issues such as ponding or standing water.

Many of the culverts along Route 13 appeared to be partially or near fully clogged with debris, and small sinkholes were noted adjacent to some of the drainage inlets. This prevented the collection of system-wide culvert inverts necessary to perform a hydraulic analysis to evaluate the capacity of drainage system. Below are two representative photos of the clogged culverts.

Outfall on northbound Route 13 on the property south of Food Lion

Completely collapsed culvert on Southbound Route 13 at Herr's Foods

Based on observed conditions, URS categorized the maintenance requirements for drainage components along Route 13 as follows:

- No – Drainage components were observed to be in good condition
- Minor – Drainage components require minor maintenance such as removing accumulated sediment and debris, or cutting overgrown vegetation
- Major – Drainage components require major efforts such as replacing crushed/collapsed culverts

Table 6.2 provides information on the distribution of level of maintenance efforts required for all the drainage components.

Table 6.2: Distribution of Level of Maintenance Requirements for Route 13 Drainage Components

Drainage Component	Percent Requiring Major Maintenance (%)	Percent Requiring Minor Maintenance (%)	Percent Requiring No Maintenance (%)
Culverts	30.0	17.0	53.0
Outfalls	6.0	23.0	71.0
Structures	3.0	26.0	71.0

Activities such as removing debris and replacing the crushed/collapsed pipes are recommended as a part of maintenance items along Route 13. In addition, maintenance that will improve the capacity of the system is recommended. Figure 6.2 and Figure 6.3 show drainage structures along Route 13 that were classified based on the level of maintenance required.

Section 4 includes hydraulic analyses of all the culverts in the Williams Pond Watershed with an opening of 36 inches or greater. Based on the field assessments, all the culverts along Route 13 have an opening of less than 36 inches. Therefore, none of the culverts along Route 13 were included as a part of the hydraulic analyses.

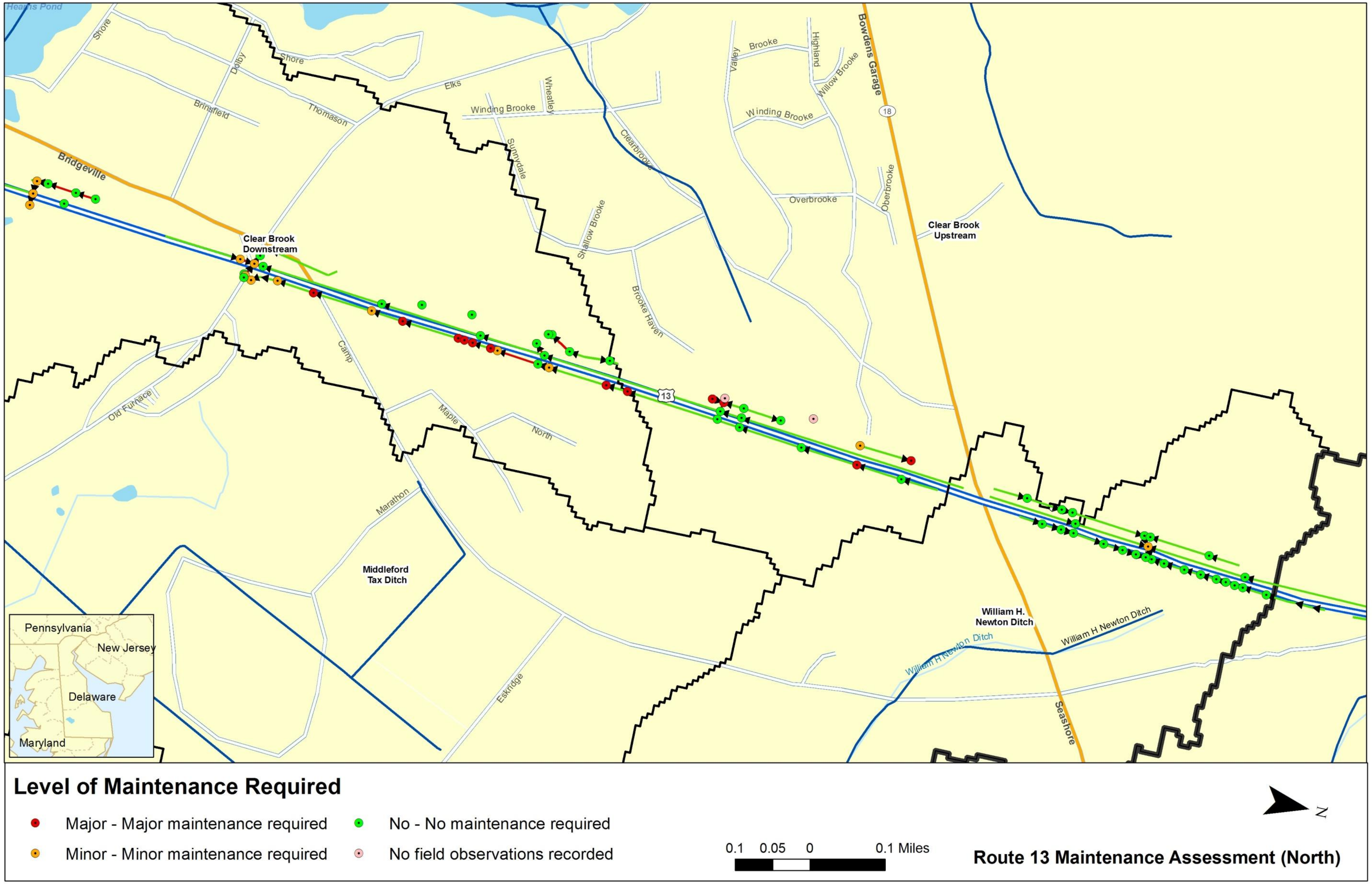


Figure 6.2: Route 13 Maintenance Assessment (North)

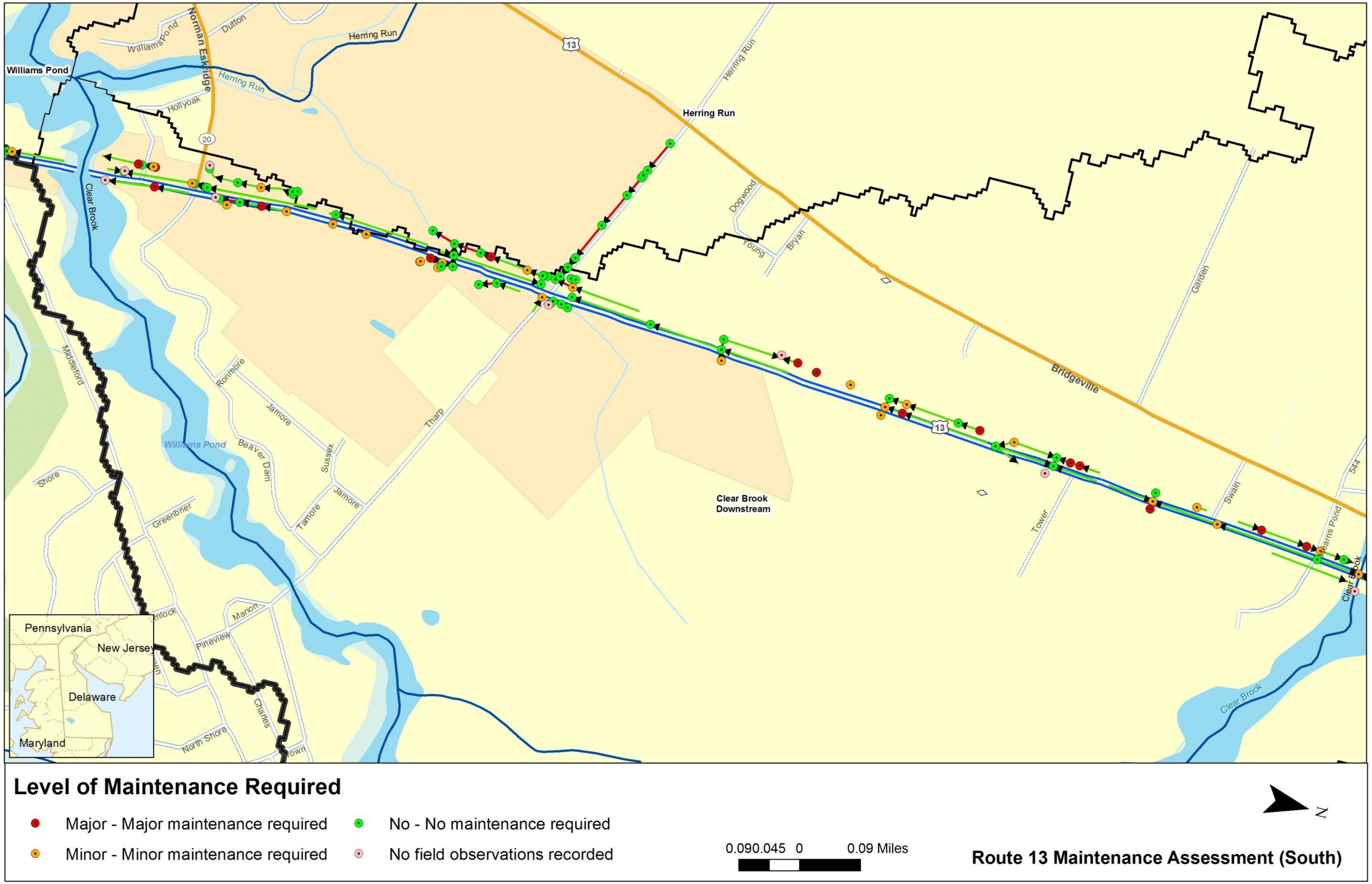


Figure 6.3: Route 13 Maintenance Assessment (South)

Section 7 Stream Assessment

URS conducted stream assessments for selected reaches along Nanticoke River and its tributaries as a part of the watershed management plan to characterize the stream conditions throughout the watershed. Field assessments were performed to:

- Conduct geomorphic assessment to classify the streams based on Rosgen classification
- Estimate the bankfull discharge and bankfull geometry based on field measurements for the channel for successful design of restoration projects
- Assess the stream stability, water clarity, habitat conditions, and other physical conditions of selected stream segments and conduct a Stream Visual Assessment Protocol (SVAP) evaluation
- Identify potential restoration measures that could be adopted in future watershed management decisions

Potential sites for future restoration projects were identified by DNREC staff and URS from:

- A pool of candidate sites that were representative of developed and undeveloped areas in the watershed
- Sites that were defined as problem areas in previous studies

The project team selected 10 sites with different stream health conditions in both developed and rural areas. Five thousand feet of streams were assessed in total as a part of this watershed management plan. Figure 7.1 shows the locations of stream assessment sites in the watershed.

The selected sites were assessed with regard to stream stability, condition of riparian zone, aquatic habitat, fish blockages, infrastructure conflicts, water clarity, and trash. Field assessments for the sites also included measurement of stream profiles and cross-sections using a laser level and surveyor’s rod. The assessed streams were then assigned Rosgen classifications based on the hydrogeomorphology of the stream. Measurements were obtained for all the sites except for the two sites on Clear Brook Tributary as one of the sites was not wadable (Site 6 – Clear Brook Downstream of Hearns Pond) and the other site was a wetland system with many shallow channels (Site 7 – Clear Brook Upstream of Hearns Pond) . These measurements were used to estimate bankfull geometry and bankfull discharge, and these estimates were compared to the published U.S. Fish and Wildlife Service regional equations, for which drainage area is the only independent variable.

The second part of the stream assessment included an SVAP evaluation of the stream site to assess the physical conditions in the stream segment for 15 different physical elements as listed below in Table 7.1.

Since all stream segments were fresh water bodies, salinity was not assessed as a part of SVAP evaluation. Observed macroinvertebrates in the stream was not considered an important parameter in characterizing the health and stability of the stream, so sampling and identification of macroinvertebrates was not included in the scope of this project.

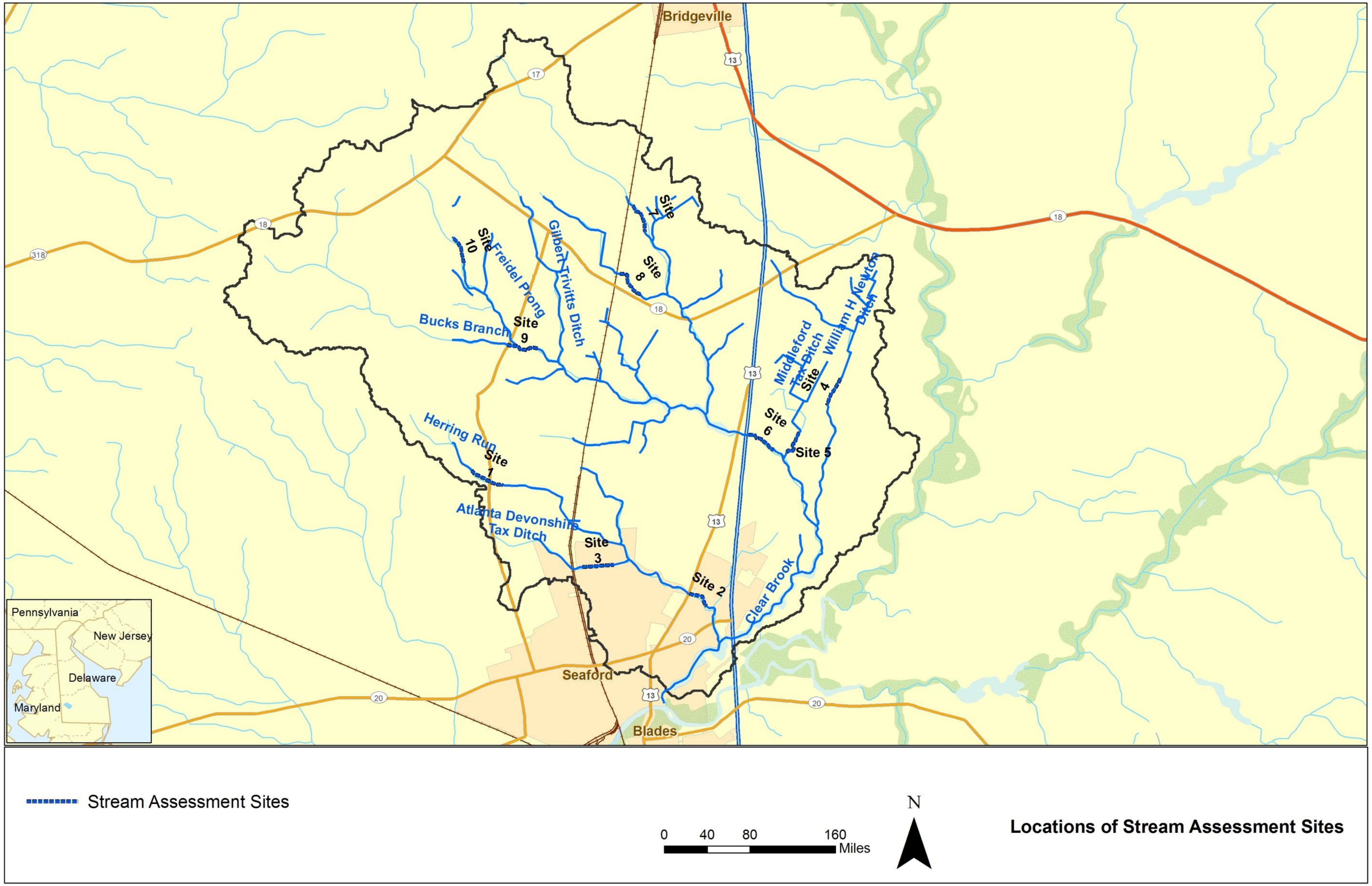


Figure 7.1: Locations of Stream Assessment Sites

Table 7.1: SVAP Evaluation Categories

SVAP Element	Evaluated (Y/N)	SVAP Element	Evaluated (Y/N)	SVAP Element	Evaluated (Y/N)
Channel	Y	Nutrient enrichment	Y	Canopy cover	Y
Hydrologic alteration	Y	Barriers to fish movement	Y	Manure presence	Y
Riparian zone (buffers)	Y	In-stream fish cover	Y	Salinity	N
Bank Stability	Y	Pools	Y	Riffle embeddedness	Y
Water Appearance	Y	Invertebrate habitat	Y	Macroinvertebrates	N

Information on the location, drainage area, Rosgen classifications, and SVAP scores are provided in Table 7.2.

Table 7.2: List of Stream Assessment Sites

Site No	Name	Location	Drainage Area (sq. mi)	Rosgen Classification	SVAP Score
Site 1	Herring Run Upstream (W1080)	West of US, 13 near the intersection of Atlanta Road and Owls Nest Road	0.7	G5	3.6-Poor
Site 2	Herring Run Downstream (W1370)	Along Bridgeville Highway between Eskridge and Herring Run Road	3.6	C4	5.8-Poor
Site 3	Atlanta Devonshire Tax Ditch (W1170)	Downstream of Ross Station Road between Herring Run Road and Market Street	0.6	G5	2.5-Poor
Site 4	William H. Newtown Tax Ditch (W880)	Downstream of Eskridge Road	0.9	F5	2.4-Poor
Site 5	Middleford Tax Ditch (W990)	Downstream of Old Furnace Road	0.8	G5	2.4-Poor
Site 6	Clear Brook downstream of Hearns Pond (W1040 and W1070)	Downstream of US 13	13.1	-	6.6-Fair
Site 7	Clear Brook upstream of Hearns Pond (W1410)	Downstream of Wilson Farm Road	1.3	-	6.3-Fair
Site 8	Tributary to Clear Brook (W790)	Downstream of Wilson Farm Road	0.7	F5	1.2-Poor

Site No	Name	Location	Drainage Area (sq. mi)	Rosgen Classification	SVAP Score
Site 9	Bucks Branch (W860 and W900)	Downstream of Wesley Church Road	3.0	C5	4.7-Poor
Site 10	Freidel Prong (W680)	Upstream of Baker Road	0.9	F5	4.0-Poor

A detailed description of the field procedures adopted, analyses performed and proposed recommendations is provided in Appendix F (Stream Assessments) of this report. Proposed recommendations resulting from the stream assessments are also summarized in Section 10.

Section 8 Assessment of Subwatersheds

This section provides an overview of the conditions of the major subwatersheds in the Williams Pond Watershed based on analyses described in Section 1 through Section 7. The Williams Pond Watershed was delineated into 11 subwatersheds to evaluate specific watershed characteristics. As part of the hydrologic analyses (Section 4), the subwatersheds were further divided into smaller "basins" to ascertain more detail about the subwatersheds.

The goal of the subwatershed assessment was to examine the extent of the flooding, water quality and other related problems in the subwatersheds and identify target areas for proposed management projects. The subwatershed assessment was also used to identify watersheds for "what-if" scenario modeling.

Based on available data, discussions with DNREC, Sussex County, and the Sussex Conservation District; the field and stream assessments; and analyses discussed previously in this watershed plan, the URS team developed a qualitative approach to evaluate the subwatersheds. Subwatersheds were qualitatively ranked as Good, Fair, Poor, or Very Poor. The evaluated with respect to numerous factors such as:

- Hydrologic and hydraulic analysis results
- Field reconnaissance observations
- Stream assessment results
- Ground water recharge potential areas
- Percent of streams with inadequate or no forested buffer
- Percent existing impervious cover of subwatershed area
- Percent existing forest cover
- Future development potential

Table 8.1 and Figure 8.1 summarize the results of the subwatershed assessment. The following sections summarize the assessment of each subwatershed.

Table 8.1: Qualitative Subwatershed Assessment

Subwatershed	Area mi^2 (HEC-HMS)	Percent Impervious (2007)	Percent Forest Cover (2007 land use)	Percent of Streams that Lack Riparian Buffers (DNREC, 2004)	SVAP Classification	Total Number of Undersized Culverts (Existing Conditions)	Percent Excellent Ground Water Recharge Potential	Percent in Growth Zone (Sussex County Comprehensive Plan, 2008)	Main Observed Issues	Overall Assessment
Atlanta Devonshire Tax Ditch	0.7	10.4	4.9	100	Poor	2 of 2	5.5	90.1	New development, inadequate forest buffers	Very Poor
Clear Brook Downstream	3.1	12.3	20.9	8.5	Fair	N/A	3.8	71.3	Poor drainage system, new development, dam overtopping	Fair
Clear Brook Upstream	3.9	5.7	13.6	52.7	Fair	3 of 5	2.6	62.9	Poor drainage system, new development, inadequate forest buffers	Poor
Freidel Prong	1.9	3.9	12.0	57.8	Poor	2 of 3	0.0	1.1	Inadequate forest buffers	Poor
Gilbert Trivitts Ditch	1.3	3.6	8.2	62.1	N/A	0 of 1	0.3	36.9	Inadequate forest buffers, water quality	Fair
Herring Run	3.1	10.1	8.5	36.7	Poor	4 of 9	18.1	65.5	New development, inadequate forest buffers	Very Poor
Lower Bucks Branch	2.7	3.7	14.1	53.6	Poor	0 of 1	20.8	88.9	Inadequate forest buffers, new development, water quality	Poor
Middleford Tax Ditch	0.7	7.3	6.5	60.0	Poor	N/A	4.8	89.4	Inadequate forest buffers, new development, water quality	Poor
Upper Bucks Branch	2.9	3.5	26.1	18.1	Poor	2 of 5	2.3	2.0	Inadequate forest buffers, excess algal growth, water quality	Good
William H. Newton Ditch	1.4	5.6	14.8	49.5	Poor	1 of 2	2.7	94.3	Poor drainage system, new development, inadequate forest buffers	Poor
Williams Pond	0.8	35.6	0.5	N/A	N/A	N/A	4.1	46.8	Dam overtopping	Poor

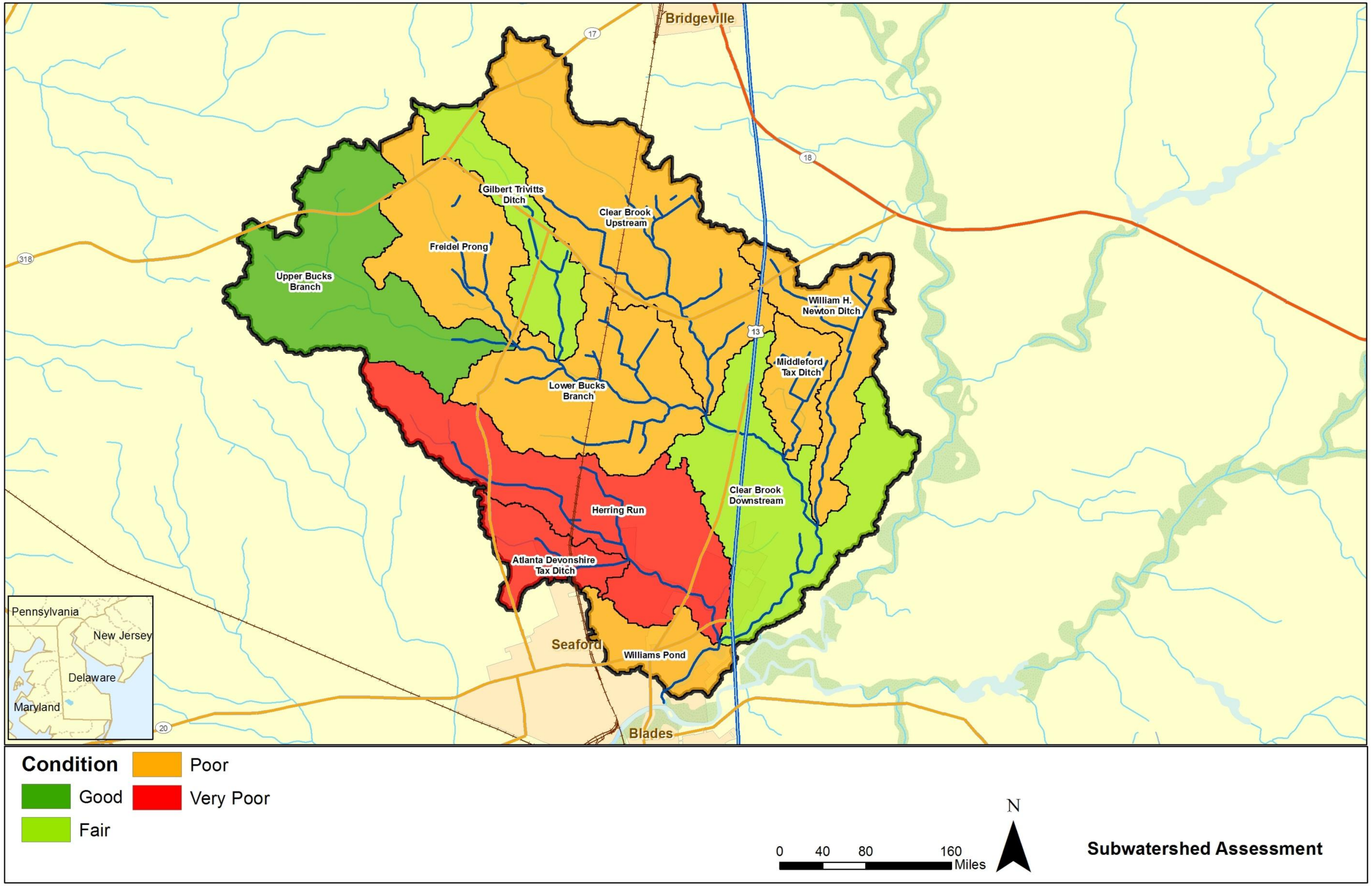
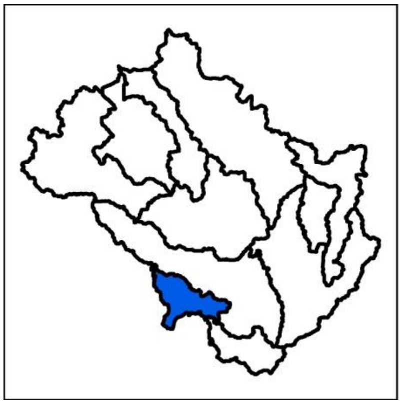


Figure 8.1: Results of Subwatershed Assessment

Atlanta Devonshire Tax Ditch Subwatershed:

Subwatershed conditions:

- Drainage area – 0.7 sq. mile
- Existing impervious area – 10.4%
- Existing forest cover – 4.9%
- Percent streams with deficient riparian buffer – 100.0%
- Number of undersized culverts – 2
- SVAP score – Poor
- Overall URS assessment – Very Poor



Existing land use distribution and future development: Farms, pastures, and cropland occupy more than half of the land use distribution (55.7 percent) in the Atlanta Devonshire Tax Ditch Subwatershed. Single-family dwellings percent are the second most prevalent land use in the subwatershed (28.8). The subwatershed has an impervious cover of 10.4 percent, which ranks it third highest among the 11 subwatersheds. It has an existing forest cover of 4.9 percent, ranking it the second lowest among the subwatersheds. Approximately 90 percent of the subwatershed is located in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: Atlanta Devonshire Tax Ditch Subwatershed has 1.0 mile of stream network. The entire reach length has either deficient or no riparian buffer along the banks. URS conducted an assessment of this reach in the field and concluded that the channel lacks natural riffle-pool complexes and that there are large sediment deposits in the channel. The left bank of the channel appeared to be sloughing into the channel in several places along the reach length. A lack of in-stream habitat was observed. An overall SVAP rating of "Poor" was assigned to the reach.

Ground water recharge potential areas: According to the DNREC SWAPP the subwatershed area is categorized as:

- 5.5% - Excellent ground water recharge potential
- 6.9% - Good ground water recharge potential
- 68.8% - Fair ground water recharge potential
- 18.8% - Poor ground water recharge potential

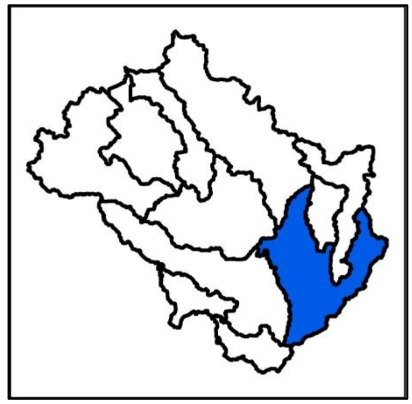
Undersized culverts: Two crossings were analyzed to estimate their conveyance capacity for the design storm. Both convey the design storm under existing conditions, but with no freeboard.

Subwatershed assessment summary: Atlanta Devonshire Tax Ditch Subwatershed has a high probability of future development, as it includes areas just outside the City of Seaford. Approximately 90 percent of the subwatershed falls in the Sussex County Growth Zone. The subwatershed ranks third in the area in terms of percent impervious and tenth in terms of percent forest cover among the 11 studied subwatersheds. Based on these observations, an overall rating of "Very Poor" was assigned to the subwatershed. For the streams in the subwatershed having inadequate buffer, improving the riparian buffers would help restore the health of the subwatershed. The road crossings analyzed in the subwatershed overtopped for the design storms with 1 foot of freeboard. Improving the hydraulically deficient structures would increase their conveyance capacity during storm events. Constructing stormwater management facilities that would treat the runoff for water quality/quantity is recommended in the developed areas.

Clear Brook Downstream Subwatershed:

Subwatershed conditions:

- Drainage area – 3.1 sq. miles
- Existing impervious area – 12.3%
- Existing forest cover – 20.9%
- Percent streams with inadequate/no riparian buffer – 8.5%
- Number of undersized culverts – N/A
- SVAP score – Fair
- Overall URS assessment – Fair



Existing land use distribution and future development: Farms, pastures, and cropland with 37.5 percent cover and single-family dwellings with 21.2 percent cover occupy the majority of the land use in the subwatershed. The subwatershed ranks second among the 11 subwatersheds for overall impervious (12.3 percent) and forest cover (20.9 percent). Approximately 71.0 percent of the subwatershed is in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: Clear Brook Downstream Subwatershed has approximately 3.9 miles of stream network. Approximately 8.5 percent of the subwatershed has deficient or no riparian buffers along the streams. URS conducted a stream assessment of Clear Brook Branch in the subwatershed and observed that the stream and forest wetlands in the area comprise a high quality wetland system. Deposits of sand, and deep pools under tree roots and at scour holes were observed along the stream length. An overall SVAP rating of "Fair" was assigned to the stream for its water quality, pools, fish cover, and invertebrate habitat.

Ground water recharge potential areas: According to the DNREC SWAPP, the subwatershed area is categorized as:

- 3.8% - Excellent ground water recharge potential
- 39.5% - Good ground water recharge potential
- 49.7% - Fair ground water recharge potential
- 0.7% - Poor ground water recharge potential

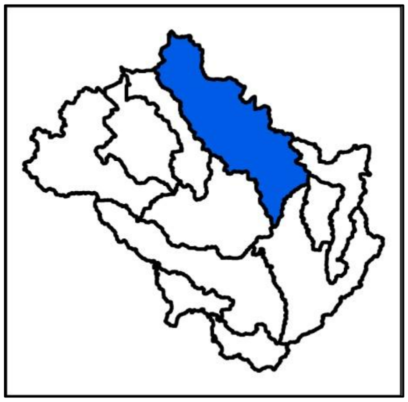
Undersized culverts: No crossings were analyzed in this subwatershed as the subwatershed did not include culverts with an opening greater than 36 inches.

Subwatershed assessment summary: Clear Brook Downstream Subwatershed has the second highest impervious cover and forest cover among of all the subwatersheds. The subwatershed has the second highest forest cover (20.9 percent) among all the subwatersheds. Seventy-one percent of the subwatershed is in the Sussex County Growth Zone. Most of the impervious area in the subwatershed is concentrated along the Route 13 corridor, where major drainage problems were observed. The subwatershed has the lowest percent (8.5 percent) of streams lacking forested buffers. Based on these parameters, an overall rating of “Fair” was assigned to the subwatershed. Recommendations to restore the quality of the subwatershed include: performing maintenance of drainage structures along Route 13, implementing stormwater management facilities to treat the runoff from the existing and future impervious areas, and preserving existing forested buffers.

Clear Brook Upstream Subwatershed:

Subwatershed conditions:

- Drainage area – 3.9 sq. miles
- Existing impervious area – 5.7%
- Existing forest cover – 13.6%
- Percent streams with inadequate/no riparian buffer – 52.7%
- Number of undersized culverts – 3
- SVAP score – Fair
- Overall URS assessment – Poor



Existing land use distribution and future development: Farms, pastures, and croplands cover 65.9 percent of the land use distribution in the Clear Brook Upstream Subwatershed. Single-family dwellings occupy 11.7 percent, which ranks it second in the subwatershed. Clear Brook Upstream Subwatershed has an existing imperviousness of 5.7 percent, which places it in the sixth among the Williams Pond subwatersheds. With 13.6 percent of forest cover, the subwatershed ranks fifth among the 11 subwatersheds. Based on Sussex County Comprehensive Plan, approximately 63.0 percent of the subwatershed lies in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: Clear Brook Upstream Subwatershed has 9.6 miles of stream network. Approximately 52.7 percent of the stream has inadequate or no stream buffer. URS conducted an assessment of this reach in the field and observed that the channel is a braided system and supports forested wetland. Sand deposits were observed along the reach length. An overall SVAP rating of “Fair” was assigned to the reach due to the presence of good wetland habitat.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 2.6% - Excellent ground water recharge potential
- 20.3% - Good ground water recharge potential
- 74.6% - Fair ground water recharge potential

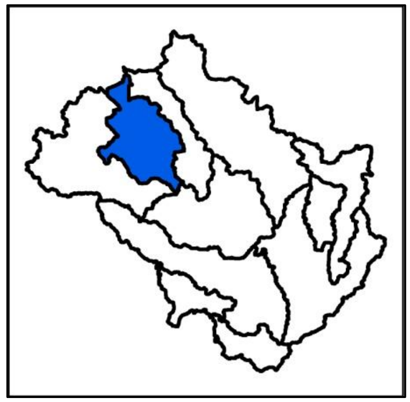
Undersized culverts: Five crossings were analyzed to estimate their conveyance capacity for the design storm. Two of the five crossings convey the design storm with 1 foot of freeboard under existing conditions. Two convey the design storm with no freeboard, and one crossing does not convey the design storm. Clear Brook Upstream Subwatershed has the second highest number of overtopped crossings in the Williams Pond Watershed.

Subwatershed assessment summary: An overall assessment score of “Poor” was assigned to Clear Brook Upstream Subwatershed. With an impervious cover of 5.7 percent, the subwatershed ranks sixth, and with a forest cover of 13.6 percent, it ranks fifth highest among the other subwatersheds. Approximately 52.7 percent of the streams in the subwatershed lack forested buffers; therefore, projects that improve the riparian buffers are recommended. Clear Brook Upstream Subwatershed has the second highest number of crossings (60.0 percent) that overtop during the design storms. Improvements that increase the conveyance capacity of the crossings are recommended. Sixty-three percent of the subwatershed falls in the Sussex County Growth Zone; therefore, stormwater management facilities that treat the runoff from new development are recommended.

Freidel Prong Subwatershed:

Subwatershed conditions:

- Drainage area – 1.9 sq. miles
- Existing impervious area – 3.9%
- Existing forest cover – 12.0%
- Percent streams with inadequate/no riparian buffer – 57.8%
- Number of undersized culverts – 2
- SVAP score – Poor
- Overall URS assessment – Poor



Existing land use distribution and future development: Freidel Prong Subwatershed is largely undeveloped with farms, pastures, and croplands (74.4 percent) and tidal and non-tidal forested wetland (9.3 percent) occupying major land use distributions in the subwatershed. Single-family dwellings, which occupy 7.5 percent of the subwatershed, ranks third in the land use distribution. The subwatershed has an existing imperviousness of 3.9 percent. Based on the Sussex County Comprehensive Plan, only 1 percent of the subwatershed is in the Growth Zone.

Field reconnaissance and stream assessment: Freidel Prong Subwatershed has approximately 4.6 miles of stream network. More than half of the stream network in the subwatershed has either deficient or no buffer. URS conducted an assessment of this reach and concluded that the channel is heavily vegetated with bright green macrophytes, indicating high nutrient loadings. The channel was observed to be experiencing severe bank erosion along both banks. An overall SVAP rating of “Poor” was assigned to the reach.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 10.8% - Good ground water recharge potential
- 89.0% - Fair ground water recharge potential

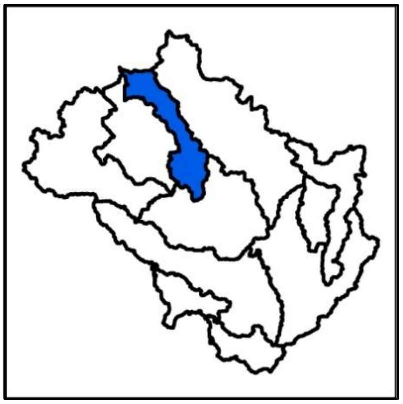
Undersized culverts: Three crossings were analyzed to estimate their conveyance capacity for the design storm in Freidel Prong Subwatershed. One of the three crossings conveys the design storm with 1 foot of freeboard under existing conditions, and the remaining two crossings convey the design storm with no freeboard.

Subwatershed assessment summary: Freidel Prong Subwatershed, which is located almost entirely outside the Sussex County Growth Zone, is one of the least developed subwatersheds. With an impervious cover of the 3.9 percent, the subwatershed ranks fourth lowest among the subwatersheds. The subwatershed has a forest cover of 12.0 percent, which places it in the middle among the 11 subwatersheds. The subwatershed has inadequate buffer cover along the streams, with 57.8 percent of the streams having inadequate riparian buffer zones. The stream assessment of the Freidel Prong Subwatershed concluded that the stream has high nutrient loads, and both banks are experiencing severe erosion. Two of three road crossings are expected to overtop during the design storm. An overall score of "Poor" was assigned to the subwatershed. Some of the improvement measures to restore the health of the subwatershed include: improving the conveyance capacity of the culverts to convey the design storm, providing grade control for streams to prevent further bed degradation, and planting trees to improve riparian buffers along the stream.

Gilbert Trivitts Ditch Subwatershed:

Subwatershed conditions:

- Drainage area – 1.3 sq. miles
- Existing impervious area – 3.6%
- Existing forest cover – 8.2%
- Percent streams with inadequate/no riparian buffer – 62.1%
- Number of undersized culverts – 0
- SVAP score – N/A
- Overall URS assessment – Fair



Existing land use distribution and future development: Farms, pastures, and cropland (80.3 percent) and forested wetland-tidal and non-tidal (5.8 percent) are the major land use types in the Gilbert Trivitts Ditch Subwatershed. The subwatershed has only 3.6 percent impervious cover, the second lowest impervious cover of all the subwatersheds. Approximately 37.0 percent of the subwatershed is in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: Gilbert Trivitts Ditch Subwatershed has approximately 3.29 miles of stream network. Approximately 62.1 percent of the stream network in the subwatershed has inadequate or no buffers. No stream assessments were conducted for this subwatershed.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 0.3% - Excellent ground water recharge potential
- 7.2% - Good ground water recharge potential
- 92.5% - Fair ground water recharge potential

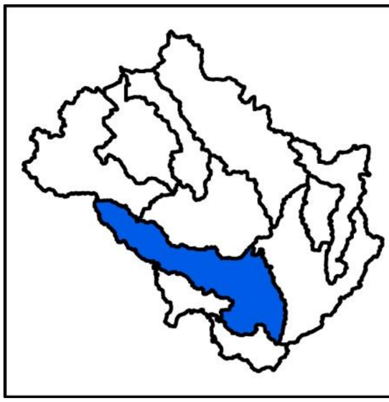
Undersized culverts: One crossing was analyzed in the subwatershed to estimate its conveyance capacity. The crossing conveys the design storm under existing conditions.

Subwatershed assessment summary: Gilbert Trivitts Ditch Subwatershed, which is primarily covered by farms, pastures, and croplands, is the second least developed, with an impervious cover of only 3.6 percent. Approximately 37.0 percent of the subwatershed is in the Sussex County Growth Zone. The one crossing analyzed in the subwatershed conveys the design storm; therefore, no improvements are recommended for the crossings. The subwatershed has the second lowest buffer cover, with 62.1 percent of the streams lacking good riparian buffer; therefore, implementing riparian buffer zones along the streams with inadequate forested buffers is recommended. Based on these observations, an overall rating of "Fair" was assigned to the subwatershed.

Herring Run Subwatershed:

Subwatershed conditions:

- Drainage area – 3.1 sq. miles
- Existing impervious area – 10.1%
- Existing forest cover – 8.5%
- Percent streams with inadequate/no riparian buffer – 36.7%
- Number of undersized culverts – 4
- SVAP score – Poor
- Overall URS assessment – Very Poor



Existing land use distribution and future development: Herring Run Subwatershed, with an impervious cover of 10.1 percent, is third highest developed subwatersheds. Farms, pastures, and cropland (66.3 percent), commercial (6.4 percent), and single-family dwellings (11.5 percent) are the three major land uses in the subwatershed. Approximately 66.0 percent of the subwatershed is included in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: Herring Run Subwatershed has approximately 5.9 miles of stream network. Approximately 36.7 percent of the stream network has inadequate or no riparian buffer zones. URS conducted an assessment of Herring Run, and an overall SVAP rating of "Poor" was assigned to the reach. Down-cutting in the channel, scour along the banks, and excessive growth of aquatic plants indicating high nutrient loads and extensive sand deposits within the floodplain were observed to be major problems in the subwatershed.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 18.1% - Excellent ground water recharge potential
- 25.6% - Good ground water recharge potential
- 53.5% - Fair ground water recharge potential
- 2.6% - Poor ground water recharge potential

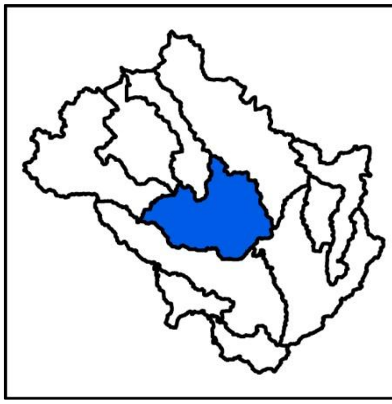
Undersized culverts: Nine crossings were analyzed in the subwatershed, of which five convey the design flows. Three crossings do not convey design flows, and one crossing conveys design flows with no freeboard. Herring Run Subwatershed has the highest number of overtopping crossings in the watershed.

Subwatershed assessment summary: Herring Run Subwatershed was assigned an overall assessment rating of "Very Poor." The subwatershed has the fourth highest impervious cover of 10.1 percent. Approximately 65.5 percent of the subwatershed is in the Sussex County Growth Zone. Providing stormwater management for existing and future development areas is recommended. Forty-four percent of crossings that were analyzed in the subwatershed overtopped for the design storm; hence, improvements that increase the conveyance capacity of the crossings are recommended. Assessments of the streams indicate they have severe down-cutting in the channel, scour along banks, and high nutrient loadings. Approximately 36.7 percent of the streams lack buffer around them. Stream restoration projects that reduce the sediment loads in the stream and improve the riparian buffers are recommended. Herring Run Subwatershed has the second highest percentage of excellent ground water recharge potential areas; therefore, it is recommended that these areas be protected.

Lower Bucks Branch Subwatershed:

Subwatershed conditions:

- Drainage area – 2.7 sq. miles
- Existing impervious area – 3.7%
- Existing forest cover – 14.1%
- Percent streams with inadequate/no riparian buffer – 53.6%
- Number of undersized culverts – 0
- SVAP score – Poor
- Overall URS assessment – Poor



Existing land use distribution and future development: Lower Bucks Branch Subwatershed is relatively less developed than the other subwatersheds, with farms, pastures, and cropland occupying more than two-thirds (70.7 percent) of the land use distribution in the watershed. The subwatershed has a forest cover of 14.1 percent, which ranks it fourth highest among the 11 subwatersheds. However, 89.0 percent of the subwatershed is located in the Sussex County Growth Zone and has a high probability of development.

Field reconnaissance and stream assessment: Lower Bucks Branch Subwatershed has 6.4 miles of stream network. Approximately 53.6 percent of the streams in the subwatershed have inadequate or no riparian buffers. URS conducted an assessment of this reach in the field and observed that the channel contained minimal pools, invertebrate habitat, and in-stream fish cover. The channel banks appeared to be over-widened due to bank erosion caused by excess sedimentation from upstream land uses. An overall SVAP rating of "Poor" was assigned due to lack of habitat features.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 20.8% - Excellent ground water recharge potential
- 58.0% - Good ground water recharge potential
- 17.8% - Fair ground water recharge potential

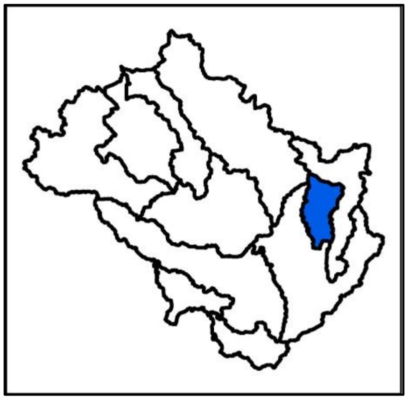
Undersized culverts: One crossing was analyzed in this subwatershed, and the crossing conveys design flows.

Subwatershed assessment summary: Lower Bucks Branch Subwatershed, with an impervious cover of 3.7 percent, has the fourth lowest impervious cover of the Williams Pond subwatersheds. The subwatershed also ranks fourth highest for forest cover (14.1 percent). Eighty-nine percent of the subwatershed is located in the Sussex County Growth Zone; therefore, stormwater management projects that provide water quality and quantity treatment for impervious runoff should be implemented. Assessment of Bucks Branch concluded that the stream banks are widened due to severe bank erosion and the stream has minimal habitat. More than half of the streams in the subwatershed have inadequate stream buffer; therefore, projects that would restore the buffers along the streams should be implemented. One road crossing analyzed in the subwatershed conveys the design flows. Lower Bucks Branch Subwatershed has the highest percentage (20.8 percent) of excellent ground water recharge potential areas; therefore, it is recommended that these areas be protected. Based on these parameters, an overall rating of “Poor” was assigned to this subwatershed.

Middleford Tax Ditch Subwatershed:

Subwatershed conditions:

- Drainage area – 0.7 sq. mile
- Existing impervious area – 7.3%
- Existing forest cover – 6.5%
- Percent streams with inadequate/no riparian buffer – 60.0%
- Number of undersized culverts – N/A
- SVAP score – Poor
- Overall URS assessment – Poor



Existing land use distribution and future development: Farms, pasture, and cropland (52.4 percent) and single-family dwellings (24.9 percent) are the major land use types in the Middleford Tax Ditch Subwatershed. The subwatershed has an impervious cover of 7.3 percent, which ranks it fifth highest among the 11 subwatersheds. Approximately 89.0 percent of the subwatershed is located in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: Middleford Tax Ditch Subwatershed has 2.1 miles of stream network. Approximately 60.0 percent of the stream network has inadequate or no stream buffer. URS conducted an assessment of this reach in the field and assigned an overall SVAP rating of “Poor” to the reach due observed severe bank erosion, deep pools, undercut banks and lack of riparian buffers.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 4.8% - Excellent ground water recharge potential
- 60.8% - Good ground water recharge potential
- 33.9% - Fair ground water recharge potential

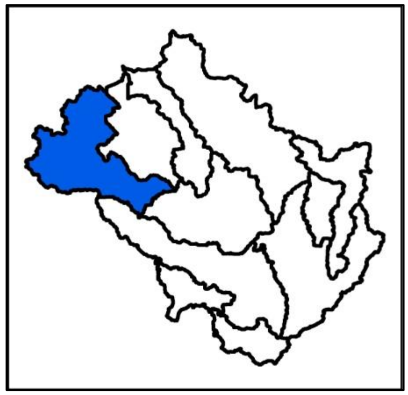
Undersized culverts: No crossings were analyzed in this subwatershed.

Subwatershed assessment summary: Middleford Tax Ditch with a forest cover of 6.5 percent has the third lowest cover compared to the other subwatersheds. Almost the entire subwatershed is located in the Sussex County Growth Zone and has a high probability of development. Sixty percent of the streams in the subwatershed lack stream buffers. Assessment of the Middleford Tax Ditch indicates that the channel lacks riparian buffer zones and experiences severe bank erosion that has caused deep pools and undercut banks. Based on these parameters, an overall rating of "Poor" was assigned to the subwatershed. Recommendations to restore the quality of the subwatershed include: constructing stormwater management facilities to treat the runoff from developed areas, improving the riparian buffers for the streams that have inadequate buffers, and implementing stream restoration projects to reduce the sediment loads and improve the habitat.

Upper Bucks Branch Subwatershed:

Subwatershed conditions:

- Drainage area – 2.9 sq. miles
- Existing impervious area – 3.5%
- Existing forest cover – 26.1%
- Percent streams with inadequate/no riparian buffer – 18.1%
- Number of undersized culverts – 2
- SVAP score – Poor
- Overall URS assessment – Good



Existing land use distribution and future development: Upper Bucks Branch Subwatershed is relatively undeveloped compared to the other subwatersheds. This subwatershed has the highest tree cover, with 26.1 percent of the watershed occupied by forest. The other predominant land use in the watershed includes farms, pasture, and cropland. The subwatershed is unlikely to be developed, as only 2.0 percent of it falls in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: Upper Bucks Branch Subwatershed has approximately 6.5 miles of stream network. Approximately 18.0 percent of the stream network has inadequate or no stream buffer. URS conducted the field assessment of the stream and observed minimal riparian zone and channel sedimentation along right bank. An overall SVAP score of "Poor" was assigned to the stream.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 2.3% - Excellent ground water recharge potential
- 11.7% - Good ground water recharge potential
- 81.1% - Fair ground water recharge potential

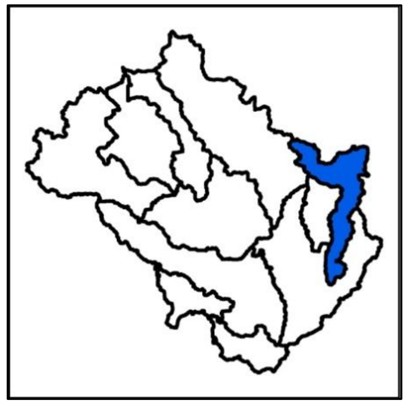
Undersized culverts: Five crossings were analyzed in the Upper Bucks Branch Subwatershed to estimate their conveyance capacity for the design storm. Three crossing convey the design storm and the remaining two crossings do not convey the design flows under existing conditions.

Subwatershed assessment summary: An overall assessment score of "Good" was assigned to Upper Bucks Branch Subwatershed. With an impervious cover of 3.5 percent, the subwatershed is the least developed and has the highest forest cover (26.1 percent). Only 2.0 percent of the subwatershed falls in the Sussex County Growth Zone; therefore, it has a very low probability of development. Approximately 81 percent of the streams in the subwatershed have good riparian buffer; therefore, projects that maintain existing buffers and implement additional buffers along the streams that lack buffers are recommended.

William H. Newtown Ditch Subwatershed:

Subwatershed conditions:

- Drainage area – 1.4 sq. miles
- Existing impervious area – 5.6%
- Existing forest cover – 14.8%
- Percent streams with inadequate/no riparian buffer – 49.5%
- Number of undersized culverts – 1
- SVAP score – Poor
- Overall URS assessment – Poor



Existing land use distribution and future development: William H. Newton Ditch Subwatershed has approximately 5.6 percent impervious cover, with farms, crops, and pastures occupying 57.9 percent of the subwatershed. Single-family dwellings, with a cover of 20.5 percent, rank second in the land use distribution in the subwatershed. Almost the entire subwatershed is located in the Growth Zone and has a high likelihood of future development.

Field reconnaissance and stream assessment: William H. Newton Ditch Subwatershed has approximately 4.4 miles of stream network. Approximately 49.5 percent of the stream network has inadequate or no stream buffer. URS conducted a field assessment for this stream and concluded that the stream has no riparian protection along its right bank, lacks in-stream fish cover, pools, and riffles, and has a thick bed of submerged plants, indicating high nutrient loading. An overall SVAP score of "Poor" was assigned to the reach.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 2.7% - Excellent ground water recharge potential
- 45.9% - Good ground water recharge potential
- 39.7% - Fair ground water recharge potential
- 11.4% - Poor ground water recharge potential

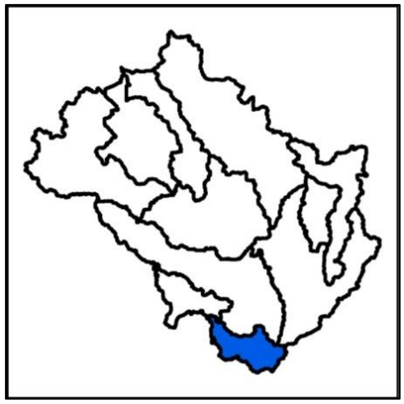
Undersized culverts: Two crossings were analyzed in the subwatershed. One of the two crossings conveys the design flows with no freeboard and the one of them conveys the design flows under existing conditions.

Subwatershed assessment summary: The William H. Newton Ditch Subwatershed is located almost entirely in the Sussex County Growth Zone. The subwatershed ranks as the seventh lowest and third highest compared to the subwatersheds in the areas of percent impervious and percent forest cover, respectively. With 49.5 percent of the streams having inadequate buffer, the subwatershed ranks fourth lowest when compared to other subwatersheds. One of the two road crossings analyzed to estimate the conveyance capacity overtopped for the design flows. Based on these observations, an overall rating of "Poor" was assigned to the subwatershed. Improvement measures for the hydraulically deficient structure is recommended to increase its conveyance capacity during storm events. Addition of riparian buffers along the streams that lack buffers is recommended.

Williams Pond Subwatershed:

Subwatershed conditions:

- Drainage area – 0.8 sq. mile
- Existing impervious area – 35.6%
- Existing forest cover – 0.5%
- Percent streams with inadequate/no riparian buffer – N/A
- Number of undersized culverts – N/A
- SVAP score – N/A
- Overall URS assessment – Poor



Existing land use distribution and future development: Williams Pond Subwatershed includes the City of Seaford, and hence is the most developed subwatershed. Single-family dwellings (31.9 percent), commercial (21.6 percent), and institutional/governmental (15.4 percent) are the three major land use distributions in the subwatershed. The subwatershed has a forest cover of only 0.5 percent, ranking it the lowest among the 11 subwatersheds. Approximately 47.0 percent of the subwatershed is in the Sussex County Growth Zone.

Field reconnaissance and stream assessment: The Williams Pond Subwatershed does not have any streams, and hence no stream assessment was conducted for this subwatershed.

Ground water recharge potential areas: Based on the DNREC SWAPP, the subwatershed area is classified as:

- 4.1% - Excellent ground water recharge potential
- 33.9% - Good ground water recharge potential
- 52.6% - Fair ground water recharge potential
- 1.3% - Poor ground water recharge potential

Undersized culverts: No crossings were analyzed for this subwatershed.

Subwatershed assessment summary: An overall assessment score of "Poor" was assigned to Williams Pond Subwatershed. With an impervious cover of 35.6%, the subwatershed has the highest impervious cover among all the subwatersheds. Almost half of the subwatershed is located in the Sussex County Growth Zone. Stream assessments and road crossing were not performed for this subwatershed. The entire subwatershed is very urbanized; therefore, addition of stormwater management facilities that would treat the runoff from existing and future developed areas before it enters Williams Pond is recommended.

Section 9 What-If Scenario Models

Based on discussions with DNREC, the URS team developed "what-if" scenario models as part of the Williams Pond Watershed Management Plan. These models were developed to assist DNREC and other stakeholders in making watershed management decisions. The final scenarios were outlined in a memo dated January 18, 2011, and approved by DNREC in discussions on February 22, 2011. In total, nine different what-if scenarios were evaluated for the Williams Pond Watershed. Each what-if scenario modeled the application of a stormwater management measure to estimate the resulting reduction in flow or pollutant loads due to that measure. Some of the what-if scenarios were used to illustrate the result of enforcing post-construction stormwater management measures described in the Working Draft Sediment and Stormwater Regulations, DNREC, June 2011. These scenarios were modeled to evaluate the impact of various stormwater management options on current and future subwatershed conditions. The scenarios that were modeled based on DNREC's recommendations include:

- Scenarios 1 and 2: evaluated the effectiveness of determining the allowable peak discharge for the 10-year event based on standard unit peak discharge for forested areas within the subwatershed.
- Scenarios 3 and 4: evaluated the effectiveness of determining the allowable peak discharge for the 100-year event based on standard unit peak discharge for forested areas within the subwatershed.
- Scenarios 5 and 6: evaluated the benefits that could be achieved by the implementation of runoff reduction practices that mimic predevelopment conditions in the developed areas.
- Scenarios 7 and 8 evaluated the effectiveness of adding 100-foot riparian buffers to streams to reduce pollutants and peak flow.
- Scenario 9: evaluated the effectiveness of adding 160-foot riparian buffers to the Herring Run Tax Ditch to reduce pollutants and peak flow.

Two of the 11 subwatersheds were selected for the what-if scenarios: Herring Run and Lower Bucks Branch. These subwatersheds were chosen based on having a high growth potential and Very Poor or Poor conditions based on the assessment of subwatersheds (Section 8).

9.1 SCENARIOS 1 AND 2: STANDARDS-BASED UNIT DISCHARGE APPROACH – 10-YEAR

Based on criteria in the proposed new draft Delaware Sediment and Stormwater regulations, the allowable peak discharge from the conveyance event (10-year, 24-hour) was calculated by determining the total area of three land use/soil categories in the subwatershed and applying a pre-determined unit discharge rate to the total area of each category. The categories and their associated 10-year unit discharges rates are:

- Wooded/Forested area based on 2007 Land Use/Land Code (LULC) and Hydrologic Soil Group (HSG) A : 0 cubic feet per second per acre (cfs/ac)
- Wooded/Forested area based on 2007 LULC and HSG B, C, and D: 0.375 cfs/ac
- Non-Wooded/Forested area based on 2007 LULC: 0.75 cfs/ac

This standards-based approach was used to apply a unit discharge rate to each subwatershed for both existing and future conditions. The unit discharge results were initially obtained for the two selected subwatersheds by determining the total area of the three land use/soil categories in each subwatershed and applying the unit discharge, which resulted in a large difference from the HEC-HMS discharge values. This large difference was most likely because the unit discharge method is solely a function of area and intended to be applied at a site scale level, not for an area as large as the selected subwatersheds. The time for flow to travel through the subwatershed was not accounted for.

To account for the large difference in discharges that was initially obtained with the unit discharge to the entire subwatershed area, a time factor coefficient was developed by using the ratio of the HEC-HMS discharge results from both existing and future conditions and the discharge obtained from the unit discharge rate to each total area of land use/soil category in the subwatershed based on the existing conditions. The average ratio from the two selected subwatersheds, as well as this ratio for subwatersheds in a similar DNREC study conducted in the Murderkill River watershed, was used to obtain an average time factor coefficient that could be applied to other similarly sized subwatersheds. The calculated average time factor coefficients are listed in Table 9.1. After applying these time factor coefficients, the discharge results from the unit discharge method were more consistent with the results of the HEC-HMS model for each subwatershed. These coefficients were applied to the initial unit discharge results to obtain the values in Table 9.1.

Table 9.1: Time Factor Coefficient Used for Unit Discharge Results

Time Factor Coefficient	
Existing Conditions Discharge	0.165
Future Conditions Discharge	0.215

The result of applying the 10-year unit discharge with a time factor coefficient was compared with the existing and future conditions discharge results from the HEC-HMS model for each subwatershed. These results are shown in Table 9.2.

Table 9.2: Comparison of Results from Applying Unit Discharge for the 10-Year, 24-Hour Conveyance Event and HEC-HMS

	Lower Bucks Branch (1,705 ac)	Herring Run (1,985 ac)
Unit Discharge Result: Existing Conditions (cfs)	191.33	229.41
HEC-HMS Discharge: Existing Conditions (cfs)	153.40	286.30
Unit Discharge Result: Future Conditions (cfs)	249.27	298.88
HEC-HMS Discharge: Future Conditions (cfs)	209.30	395.30

A standards-based approach of applying a unit discharge to a select subwatershed in order to set maximum allowable peak discharges for the subwatershed can be used if a few adjustments are made. Applying the unit discharges provided in the *Draft Stormwater and Sediment Regulations* (DNREC, 2011) to large subwatershed areas produces results that are much higher than results produced from HEC-HMS modeling. However, when the unit discharge method was applied to a smaller area, the results were similar to the discharges obtained from the HEC-HMS model. If the standards-based unit discharge method will be used in the regulations, the area that it is applied to should be limited. Further investigation is needed to determine the maximum drainage area to which the current method should be limited. Otherwise, a more reasonable flow rate can be obtained for peak discharges by applying a time factor coefficient.

9.2 SCENARIOS 3 AND 4: STANDARDS-BASED UNIT DISCHARGE APPROACH – 100-YEAR

Scenarios 3 and 4 are similar to Scenarios 1 and 2. However, for Scenarios 3 and 4, the unit discharge analysis was completed for the flooding event (100-year, 24-hour). The allowable 100-year peak discharge for the selected subwatersheds was determined using the following categories and associated unit discharges:

- Wooded/Forested area based on 2007 LULC and HSG A: 0.25 cfs/ac
- Wooded/Forested area based on 2007 LULC and HSG B, C, and D: 1.25 cfs/ac
- Non-Wooded/Forested area based on 2007 LULC: 2.25 cfs/ac

The results of applying the 100-year unit discharge for each subwatershed was compared with the existing and future conditions discharge results from the HEC-HMS model. The unit discharge results were obtained the same way for Scenarios 3 and 4 as for Scenarios 1 and 2, and a time factor coefficient was obtained and applied in a similar manner. These results are shown in the Table 9.3.

Table 9.3: Comparison of Results from Applying Unit Discharge for 10-Year, 24-Hour Conveyance Event and HEC-HMS

	Lower Bucks Branch (1,705 ac)	Herring Run (1,985 ac)
Unit Discharge Result: Existing Conditions (cfs)	690.73	825.30
HEC-HMS Discharge: Existing Conditions (cfs)	644.20	935.10
Unit Discharge Result: Future Conditions (cfs)	770.92	921.12
HEC-HMS Discharge: Future Conditions (cfs)	738.30	1,071.50

The conclusions for Scenarios 3 and 4 are the same as for Scenarios 1 and 2 in that the applicability to large watersheds is not appropriate. Further, investigation is needed to determine the minimum drainage area to which this method should be limited.

9.3 SCENARIOS 5 AND 6: EFFECTIVE IMPERVIOUSNESS OF 0 PERCENT

The DNREC Regulatory Advisory Committee proposed a new performance criterion in the Draft Sediment and Stormwater Regulations (DNREC, 2011) that focuses on implementing runoff reduction practices for post-development areas to achieve an effective imperviousness of 0 percent. This criterion was based on the 1-year, 24-hour storm event. The purpose of proposing this regulation was to mimic pre-development conditions as closely as possible in developing watersheds. These scenario models were completed by converting land use identified as growth areas in the Sussex County Comprehensive plan to open space. As a result, the Curve Number (CN) values for each subwatershed were adjusted based on the conversion of growth areas to open space. The CN is a parameter used to predict runoff and infiltration during a rain event. For more information on CNs and their selection, refer to Appendix C. The future conditions hydrologic model was run with new CN values obtained from the conversion of land use to open space.

As a basis of comparison, the future conditions hydrologic model was also run with 50 percent of the growth area converted to open space and 50 percent left as a growth area. To determine the CN values for this portion, the average of the future conditions and what-if CN values were used. This method was chosen because there were no definitive specifications from the Sussex County Comprehensive Plan or DNREC on which land parcels or specific areas would or would not be developed. In the Comprehensive Plan, land with development potential was simply included in the growth area. The 1-year recurrence interval storm was computed for these scenarios. The results are shown in Table 9.4.

Table 9.4: Results for Hydrologic Modeling Using Future Conditions and Growth Zone Converted to Open Space

Subwatershed	1-Year, 24-Hour Storm Event Discharge (cfs)			
	Existing Conditions	Future Conditions	Growth Areas Modeled as 100% Open Space	Growth Areas Modeled as 50% Open Space
Herring Run	54.0	140.3	106.7	140.3
Lower Bucks Branch	9.8	29.9	28.4	29.9

These values show the hydrologic impact that development could have on each of the selected subwatersheds. Furthermore, the comparison of discharges shows the effect of implementing stormwater management practices that reduce imperviousness from future development in potential growth areas. In general, the flow rates are reduced as a result of converting the entire land use marked as growth areas to open space. However, the flows are similar to the future condition flows when 50 percent of the growth areas are converted to open space.

The criterion of implementing stormwater management features to achieve 0 percent effective imperviousness seems to be an effective regulation. It could be a good way to enforce land use regulations in developing areas in the watershed. By requiring the post-development hydrology to mimic conditions for open space land use, flow rates would be reduced in developing subwatersheds.

9.4 SCENARIOS 7 AND 8: ADDING 100-FOOT RIPARIAN BUFFERS

Another what-if scenario that was investigated was how adding a 100-foot riparian buffer on either side of the centerline of all streams in the two selected subwatersheds would affect land and hydrology in the watershed. The riparian buffer area would serve as a transition between a stream and the land adjacent to the stream. Riparian buffer areas improve water quality and quantity by allowing runoff to be absorbed or infiltrated into the ground before it reaches the stream. The following were determined from the analysis of Scenarios 7 through 8:

- The amount of land area that would be affected
- The number of trees that would be planted in the buffer areas
- The area of land planned for future development that would instead be with trees
- The impact on the percent imperviousness
- The estimated pollutant load reduction based on readily available data
- The impact on existing and future conditions

GIS analysis for the what-if subwatershed scenarios yielded the results shown in Table 9.5 based on existing and future land use.

Table 9.5: Results from GIS Analysis of the Addition of Buffers to All Streams in the Modeled Subwatersheds

Subwatershed	Sub-Watershed Area (ac)	Area of Buffer (ac)	Number of Trees Planted (320 per ac)	Future Development Area Impacted (ac)	Impervious Surface Area Impacted (ac)
Lower Bucks Branch	1,705	175.1	56,032	155.6	2.9
Herring Run	1,985	150.4	48,128	108.8	2.8

A few assumptions were made to complete the hydrologic analysis. The land use of the riparian buffer was assumed to be Forested Wetland. Furthermore, the HSG was assumed to be "B." To be consistent with the existing and future hydrologic models, the CN values were reduced based on the method used previously for the hydrologic analysis. The Manning's n values for the overbanks were increased from between 0.12 and 0.15 to 0.25 to account for the forested area, and for channels, they were increased from 0.05 to 0.06 to account for storage due to the addition of buffers. Also, the percentage of imperviousness was reduced in the model by the percent of impervious surface impacted affected by the addition of riparian buffer. Based on these assumptions and the model runs for the riparian buffers, small reductions in discharges were observed as a result of addition of buffers, as seen in Table 9.6 and Table 9.7.

Table 9.6: Discharge Results with the Addition of Buffers for Existing Conditions

Subwatershed	Existing Conditions HEC-HMS Discharge (cfs)	Existing Conditions Discharge with 100-ft Buffer (cfs)	Percent Decrease
Lower Bucks Branch	644.2	615.6	4.7
Herring Run	858.4	816.6	5.1

Table 9.7: Discharge Results with the Addition of Buffers for Future Conditions

Subwatershed	Future Conditions HEC-HMS Discharge (cfs)	Future Conditions Discharge with 100-ft Buffer (cfs)	Percent Decrease
Lower Bucks Branch	738.3	716.8	3.0
Herring Run	1065.7	1011.4	5.4

Although adding 100 feet buffer areas to streams does not markedly reduce flows, the potential for pollutant reduction is high. The estimated pollutant load reduction that would result from adding a riparian buffer to the streams would be:

- 65% reduction in ground water nitrogen
- 60% reduction in surface water nitrogen
- 70% reduction in surface water phosphorus

This pollutant load reduction is based on the study *Riparian Buffers in the Murderkill Watershed*, DNREC, 2002, which attempted to replicate the effect of installing riparian buffers on natural waterways. Buffer effectiveness rates from a Maryland Lower Eastern Shore agricultural study were used along with calculated nutrient loading rates to determine the percentage of pollutant load reduction. This study was based on the buffer width being 100 feet. The actual pollutant load reduction from installing buffers in the selected subwatersheds could potentially be lower than the estimated percentages from the DNREC 2002 study because it is unrealistic to convert 100 percent of the area that is 100 feet on each side of each stream into a riparian buffer area.

9.5 SCENARIO 9: ADDING 160-FOOT RIPARIAN BUFFERS TO THE CURRENT RIGHT-OF-WAY FOR HERRING RUN TAX DITCH

The current right-of-way for the Herring Run Tax Ditch is approximately 160 feet wide. Scenario 9 looked at expanding the Herring Run Tax Ditch width into the floodplain. The expansion of the Herring Run floodplain was modeled for future conditions by applying a 160-foot buffer on either side of the tax ditch centerlines. This would effectively double the right-of-way width of the existing tax ditch. The area of this buffer was modeled as Forested Wetland with HSG “B.” Manning’s “n” values were lowered similar to Scenarios 7 and 8. The resulting discharge from the width increase was compared to the future conditions model discharge as shown in Table 9.8.

Table 9.8: Discharge Results for Future Conditions with the Addition of 160-foot Buffers to Herring Run Tax Ditch

Subwatershed	Future Conditions Discharge (cfs)	Future Conditions Discharge with 160-ft Buffer (cfs)	Percent Decrease
Herring Run Tax Ditch	1,065.7	986.80	8.0

The larger riparian buffer area in this scenario accounts for a larger decrease in future conditions discharge than in Scenario 7 and 8. Additionally, pollutant load reduction rates would be expected to be similar to the buffer areas investigated in Scenarios 7 and 8. The conclusion regarding the Scenario 9 is that adding 160 feet of riparian buffers results in reduction in flow and potential for pollutant removal.

9.6 SUMMARY OF WHAT-IF SCENARIO ANALYSES

Based on the results of the what-if scenario analyses, the regulation criteria modeled for Scenarios 5 and 6, attaining an effective imperviousness of 0 percent, seem to be the most appropriate. By substituting open space land use for Growth Zone areas, or even portions of the Growth Zone areas, the future conditions discharge would be closer to the existing conditions flow rates. This criterion could be modeled more accurately once it is determined what specific parcels within the subwatersheds are planned for development.

Though not recommended as the most appropriate criteria, the standards-based unit discharge approaches analyzed in Scenarios 1 and 2 could be used for subwatershed analysis as long as a time factor coefficient is applied to the unit discharge flow rates. The standards-based methodology proposed in the *Draft Sediment and Stormwater Regulations* (DNREC, 2011) is more applicable at the site-specific level. Further investigation should be performed to determine the maximum applicable drainage area for applying the unit discharge directly without a time factor coefficient.

Adding a 100-foot buffer area to streams in the subwatersheds resulted in reduction of flows. Applying a 160-foot buffer area to Herring Run Tax Ditch, resulted in a greater reduction of flow than a 100-foot buffer area. The addition of buffer areas could be used in conjunction with other stormwater management measures that provide storage (discussed in Sections 10 and 11) to achieve a greater reduction in flow and also reduce pollutants from runoff.

Based on the Delaware Phase II Watershed Implementation Plan (WIP, DNREC, 2012) developed by the State of Delaware to meet the Chesapeake Bay TMDL goals, there are currently 2,226 acres of streamside forest buffers in the state. The State of Delaware's goal is to increase the forest buffer cover to 5,571 acres by the year 2025. With pollutant removal efficiencies in the range of 60% - 70%, addition or increasing the width of forest buffers along the streams will be one of the most efficient strategies in the Williams Pond Watershed to meet the Chesapeake Bay TMDL goals.

Section 10 Tax Ditch Restoration and Management

The State of Delaware has a series of community- and privately-owned drainage ditch systems that date back to the colonial era. These ditches were constructed to manage soil and water resources for agricultural purposes and to provide flood protection.

Based on the information provided on the DNREC website on the origin of tax ditches, in 1951 the Delaware General Assembly enacted the Drainage Law to establish, finance, and maintain drainage organizations referred as Tax Ditch Organizations. Based on this law, formation of a tax ditch can only be initiated by landowners who petition the Delaware Supreme Court to resolve drainage or flooding concerns in their area. This petition results in an investigation by DNREC's Division of Soil and Water Conservation (SWC) to determine the feasibility/practicability of constructing a tax ditch system in the interest of public safety, health, and welfare. SWC then prepares a report on the proposed tax ditch that includes information on its proposed location, associated costs, needed rights-of way, etc. Upon landowner approval of the formation of tax ditch, a court order is issued establishing the tax ditch organization and permanent rights-of-way for construction and maintenance operations. The court order also gives the organization the authority to collect from all affected landowners a taxation amount established by the court for construction and maintenance. Thus, tax ditches are governmental subdivisions of the state and are watershed-based landowner organizations formed by a prescribed legal process in court. The operations of tax ditches are overseen by designated ditch managers and a secretary/treasurer who are the landowners within the tax ditch drainage areas and elected annually. The design, planning, and maintenance of these tax ditches are overseen by DNREC's SWC.

Tax ditches are mainly concentrated in the western part of the State of Delaware along the southern boundary with Maryland. There are 228 tax ditch organizations in the State of Delaware that provide water management for one-third of the land in the state. The areas draining to the tax ditch systems range from 2 acres to 56,000 acres and, depending on the on the area draining to them, the tax ditches are 6 to 80 feet wide and 2 to 14 feet deep.

10.1 EXISTING PROBLEMS

DNREC estimates that approximately 90 percent of the streams in the state have been modified to support agricultural, residential, and commercial activity. Construction of tax ditches modified the existing land use conditions, including riparian forests and natural streams. This led to the degradation of natural resources, and in turn resulted in poor water quality and flooding problems.

- **Water Quality:** According to Delaware Phase I Watershed Implementation Plan (WIP, DNREC, 2010), most of the tax ditch channels in the state have been listed on Delaware's Clean Water Act 303 (d) impaired water list for high nitrogen and phosphorus loads. Due to the lack of forested buffers, the runoff from agricultural and developed areas rich in sediment and nutrient loads is not filtered; it is directly conveyed to the tax ditch, and, in turn, to the downstream water bodies.
- **Flooding:** The State of Delaware is urbanizing, and one of the primary land use changes is conversion of agricultural areas into residential subdivisions. As a result, there is an increase in the existing impervious cover, and as a result increase in the runoff volume. According to a study by DNREC's Delaware Surface Water Management Programs titled *Analysis of the*

Pepper Creek Tax Ditch Channels to Convey Increased Runoff from Urbanized Lands (DNREC, 2008) existing channels do not have the capacity to convey the higher runoff resulting from an increase in impervious area in the watershed, as they were primarily designed to convey runoff from agricultural areas. As a result, flooding is a common problem in these areas.

10.2 RESTORATION AND MANAGEMENT

DNREC SWC has been developing numerous practices that would reduce the ecological impacts resulting from the construction and maintenance of tax ditches. It has developed mitigation programs that would help create or restore natural habitats along tax ditch corridors.

Based on the case study *Converting Drainage Ditches and Nonproductive Farmland into Functioning Streams and Wetlands* (Browning et al., 2010) and the publication *Delaware's Drainage and Water Management Practices*, some of the best management practices (BMPs) currently being adopted by DNREC for the restoration of tax ditches include:

- **Implementation of BMPs to provide water quality treatment and flood protection:** BMPs that treat runoff draining into the tax ditches from agricultural and urban areas reduce impacts to fresh water and tidal wetlands. These BMPs are aimed at controlling flood flows and treating the runoff by filtering nutrients and sediment. Some of the BMPs currently being adopted by DNREC include:
  - Sediment traps that decrease the velocity and reduce sediment loads
  - Water control structures that limit flow in ditches
  - Reverse berms along channels with a side inlet pipe that is set at the historical water level in adjacent wetlands.
  - Bioreactors or biological curtains to provide sources of organic matter to convert nitrate-nitrogen to a gaseous form of nitrogen
  - Phosphorus absorbing materials to sequester dissolved phosphorus and trace materials from ditch water
  - Redesigning drainage ditches as low-flow sinuous channels with natural floodplains to provide more storage and reconnect with adjacent wetlands
  - Introducing in-stream wetlands or re-routing portions of drainage channel through created, longitudinal wetland cells that decrease stream flow and increase residence time of water within a stream system
- **Maintenance of tax ditches:** Maintenance of tax ditches includes removing accumulated sediments that have deposited over time at the channel bottom and removing weeds along the ditch. Below are the maintenance activities currently performed by DNREC:
  - Dipping out channel bottoms using a hydraulic excavator for 1 or 2 feet to restore its design capacity
  - Performing vegetative maintenance using a weed wiper bar that applies herbicide to targeted species without harming the desirable species

- **Public outreach:** DNREC is currently implementing public outreach and education programs that increase awareness of landowners and tax ditch managers. Some of the outreach programs include:
  - Conducting training sessions and workshops that provide information on environmental impacts from construction of tax ditches and more environmentally friendly approaches to ditch maintenance
  - Educating landowners and tax ditch organizations on the importance of implementing BMPs that provide ecological benefits
  - Working closely with landowners and tax ditch organizations to offer financial assistance to support the implementation of new BMPs and environmentally friendly maintenance techniques
- **Construction of new tax ditches:** The primary impacts of channel construction are due to the clearing of forests and wetlands. DNREC recognizes the environmental impacts caused by the construction of these tax ditches and has developed environmentally friendly practices that minimize the environmental impacts of tax ditch construction. The following are the BMPs DNREC uses for the construction of new tax ditches:
  - Performing one-sided construction or minimizing clearing widths through forested areas to reduce the impact and retain the ecologically valuable trees, which minimizes forest fragmentation
  - Saving trees in construction zones
  - Minimizing construction of downstream outlets
  - Blocking off old channels that drain wetlands
  - Relocating channels around sensitive habitat or wetlands

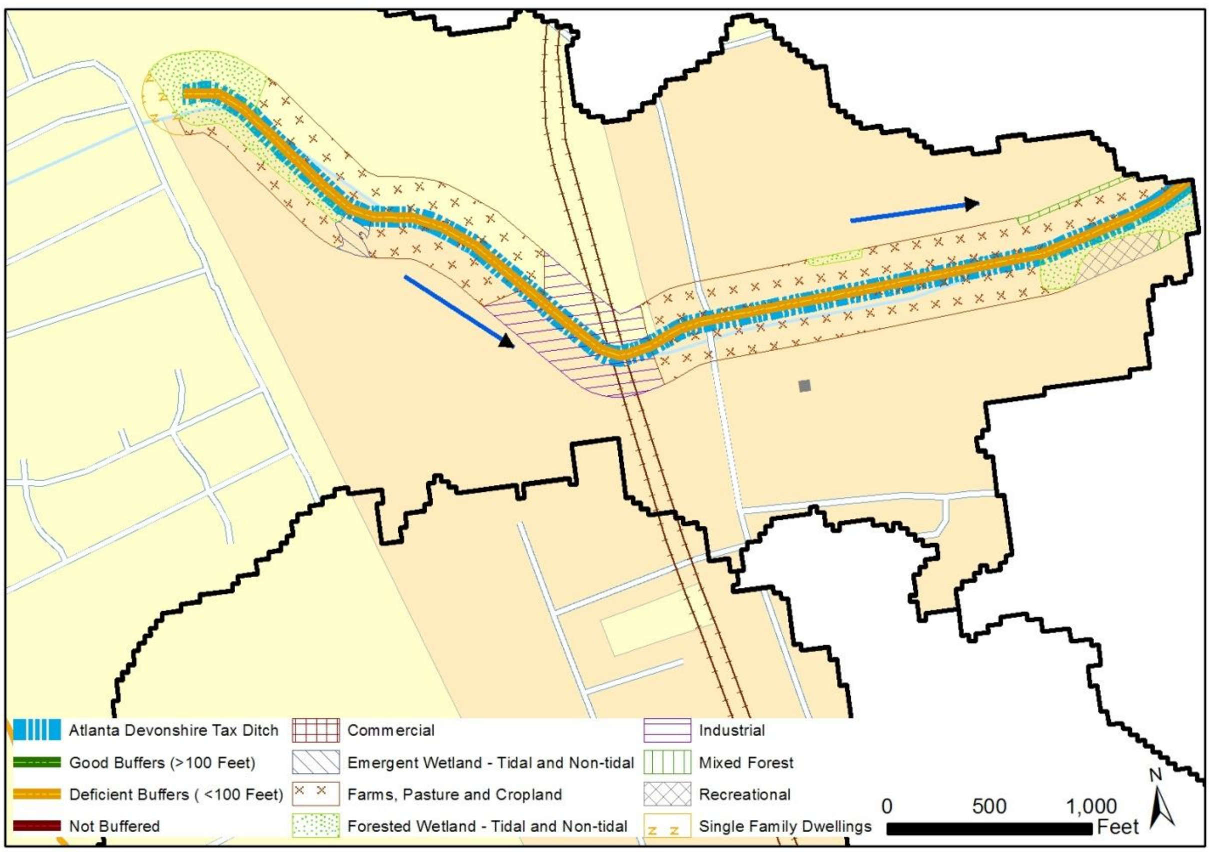
As stated in the Nanticoke Restoration Group's, "State of Nanticoke Watershed" in 2009, conversion of channelized streams into natural flowing streams is identified as one of the potential restoration opportunities to benefit the watershed as a whole. However, based on review of the GIS shapefiles provided by The Nature Conservancy for the 2009 study, none of the priority projects identified as a part of restoration measures in the State of Nanticoke Watershed Report are located inside the Williams Pond Watershed.

10.3 TAX DITCHES IN WILLIAMS POND WATERSHED

The Williams Pond Watershed has approximately 30 miles of tax ditches that help drain agricultural, commercial, and residential areas. There are seven major tax ditches in the watershed. The sections below describe the location, existing conditions and proposed potential improvement measures that can be implemented at all the seven tax ditch systems in the Williams Pond Watershed.

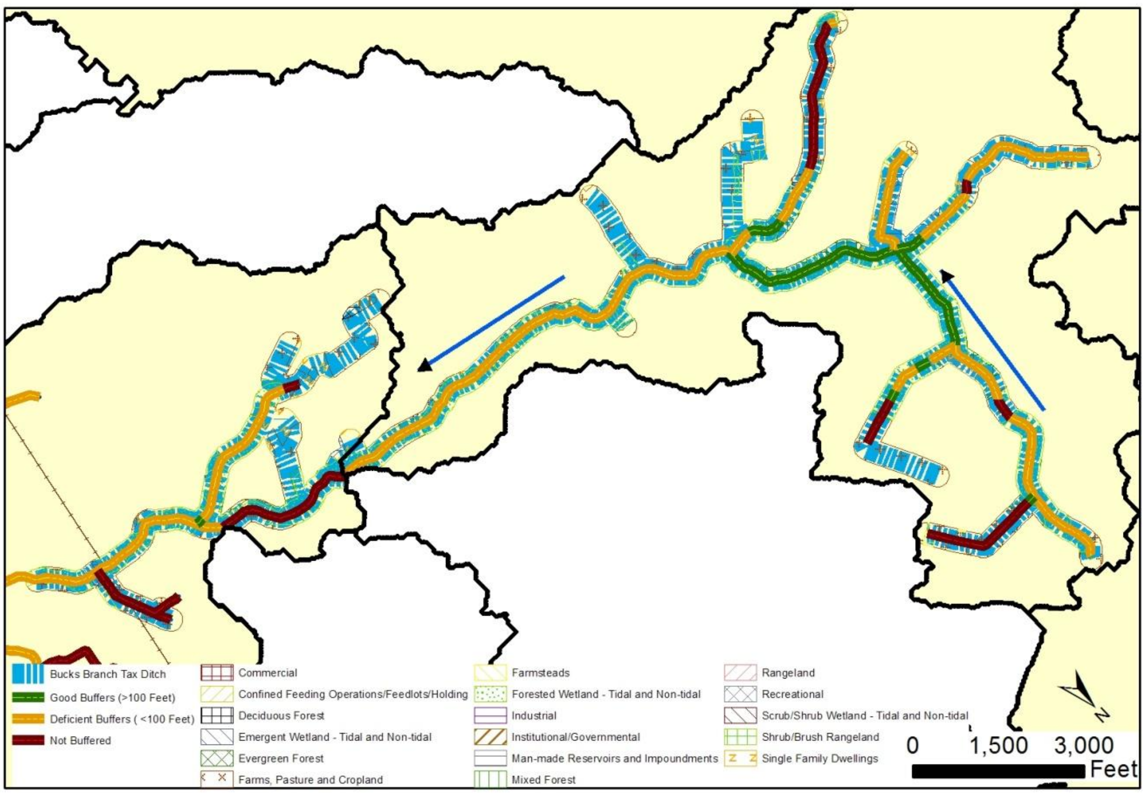
1. Atlanta Devonshire Tax Ditch

- **Description:** Atlanta Devonshire Tax Ditch is a 1.1-mile tax ditch that begins east of Atlanta Circle and continues east of Ross Station Road until it merges with Herring Run Tax Ditch. Farms, industrial areas, and single-family dwellings are the major land uses along the tax ditch. This tax ditch is in the Atlanta Devonshire Tax Ditch subwatershed.
- **Existing conditions:** The headwaters of the tax ditch are surrounded by some forest area, but the rest of the tax ditch is deficient in riparian buffers (i.e., less than 100 feet). Lack of aquatic habitat and excessive growth of macrophytes due to nutrient runoff from the adjacent agricultural fields were identified to be the major concerns in the tax ditch. Severe erosion along the left bank was observed in some locations.
- **Potential for improvements:** Adding riparian buffers would protect/anchor the channel banks. It would also help improve water quality and aquatic habitat and provide flow attenuation. Installing sediment traps that decrease the velocity and reduce sediment loads would reduce the existing erosion problems in the tax ditch. In addition, using BMPs that capture the agricultural runoff and filter nutrients before they are conveyed into the tax ditch would improve water quality.



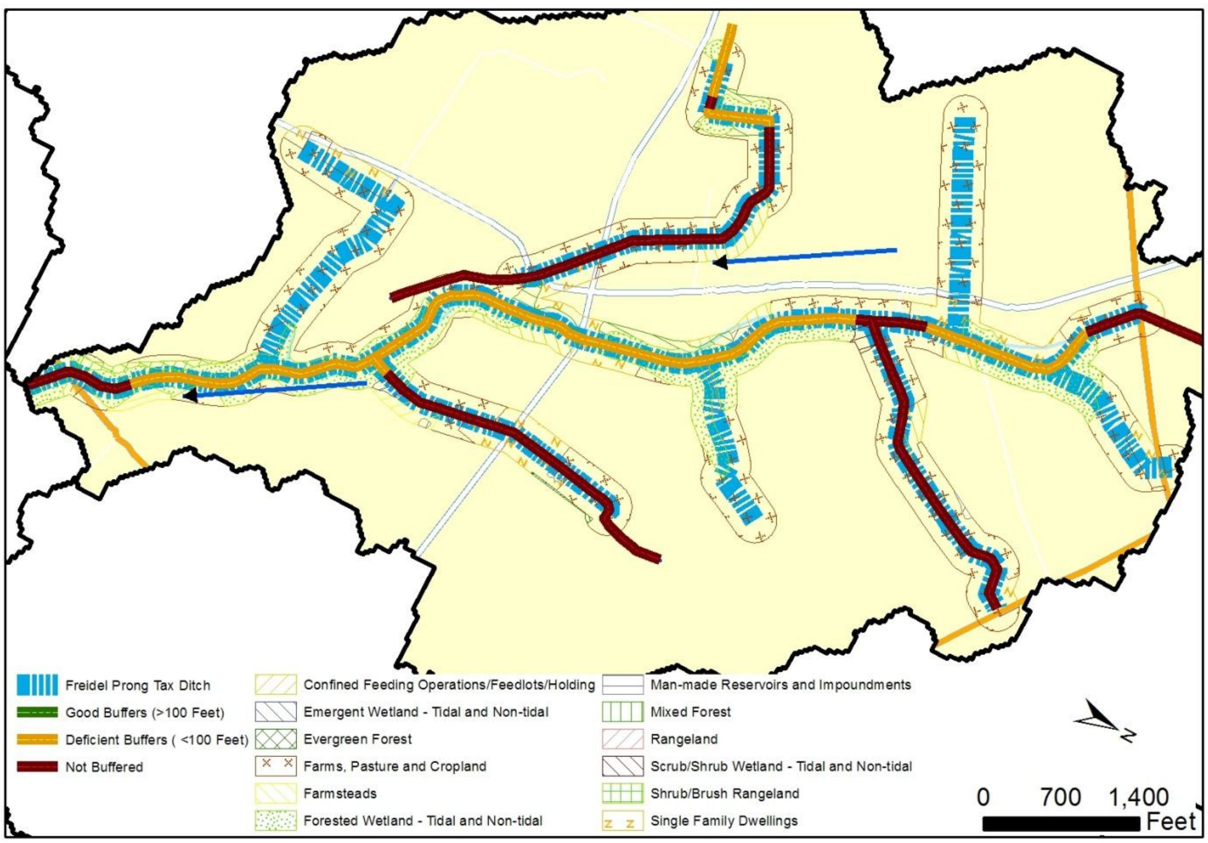
2. **Bucks Branch Tax Ditch**

- **Description:** Bucks Branch Tax Ditch begins northwest of Federalsburg Road and continues south of Conrail Road until it flows into Hearns Pond. Bucks Branch Tax Ditch, along with its 14 prongs, has a total length of 11.0 miles. Farms, forests, and single-family dwellings are the major land uses along the tax ditch. This tax ditch is in the Upper and Lower Bucks Branch subwatersheds.
- **Existing conditions:** The tax ditch has a fair riparian buffer along most of its banks; however, the upstream prongs lack riparian buffers. A field assessment of the tax ditch indicated that the ditch in general lacked geomorphic bed features. Sandy bottoms with vegetated algae were observed along the ditch, potentially due to the runoff rich in nutrients from adjacent agricultural fields. Minimal in-stream fish and microinvertebrate population were observed. The ditch appeared to be over-widened at certain sections, potentially due to bank erosion caused by excess sedimentation from upstream land uses.
- **Potential for improvements:** dredging the channel bottom along the channel where sandy bottoms and excess algae were observed would provide additional storage. Addition of tree canopy along the prongs and main ditch along the banks lacking riparian buffers would help improve water quality and provide flow attenuation. Implementation of BMPs such as in-stream wetlands along the down gradient side of the farms would reduce the nutrient loads from agricultural runoff. Redesigning the sections of ditch prone to flooding as low-flow sinuous channels with natural floodplains would provide more storage and reconnect with the floodplain.



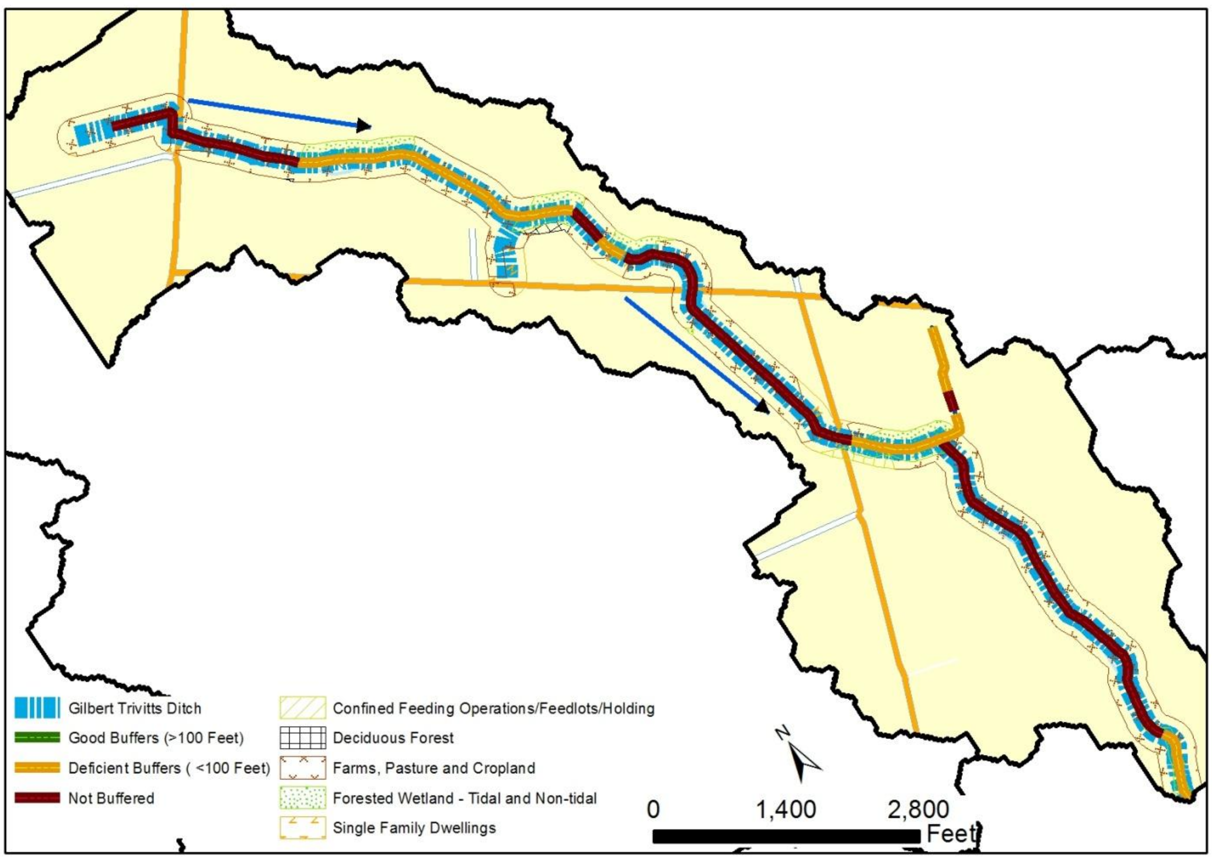
3. Freidel Prong Tax Ditch

- **Description:** The Freidel Prong Tax Ditch begins northeast of Federalsburg Road and continues south of Wesley Church Road until it merges with Bucks Branch Tax Ditch. The main tax ditch, along with its six prongs, has a total length of 5.4 miles. Farms, forests, and single-family dwellings are the major land uses along the tax ditch. This tax ditch is in the Freidel Prong subwatershed
- **Existing conditions:** Freidel Prong Tax Ditch was observed to be a deeply incised channel with high, steep banks at certain sections along the channel. The bottom of the ditch was observed to be heavily vegetated, indicating nutrient loads from runoff from adjacent agricultural areas. The entire length of the tax ditch lacks or has deficient riparian buffers.
- **Potential for improvements:** Vegetative maintenance that includes dipping out the channel bottom to provide additional storage is recommended along the channel where heavily vegetated channel bottoms were observed. Establishing riparian buffers along the banks would improve the water quality and provide some flow attenuation. Implementation of BMPs such as in-stream wetlands along the downgradient side of the adjacent agricultural fields and re-stabilization of the tax ditch to connect with the natural floodplain is recommended where incised channel was observed.



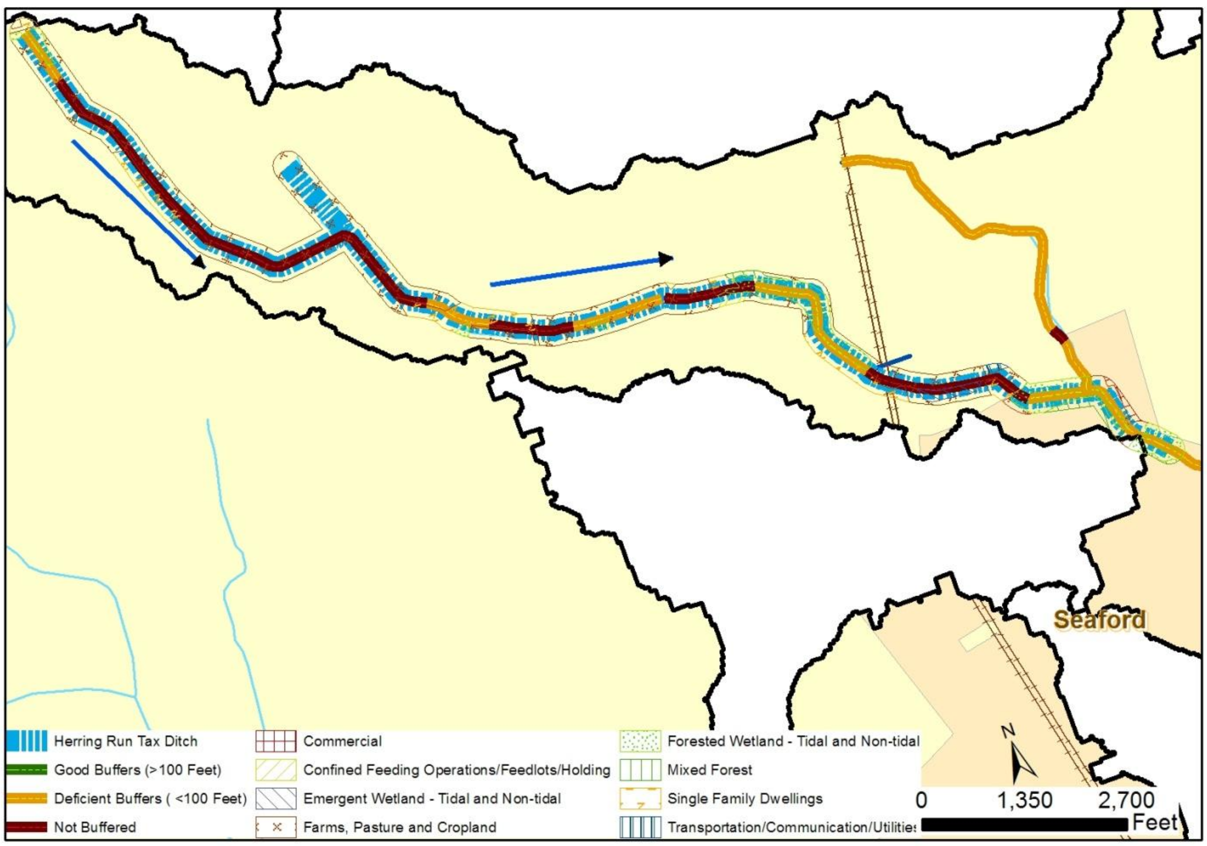
4. **Gilbert Trivitts Tax Ditch**

- **Description:** Gilbert Trivitts Ditch begins northeast of Federalsburg Road and flows south until it merges with Bucks Branch Tax Ditch. The main tax ditch has one prong that drains to it and has a total length of 3.1 miles including the prong. Farms, forests, and single-family dwellings occupy the major land uses along the tax ditch. This tax ditch is located in the Gilbert Trivitts Ditch subwatershed.
- **Existing conditions:** The majority of the tax ditch lacks riparian buffers. Some sections of the tax ditch have buffers but they are very minimal. The entire tax ditch receives runoff from agricultural farms, which contribute runoff rich in nutrients.
- **Potential for improvements:** In order to reduce the impact of nutrients in the channel, implementation of a BMP such as in-stream wetlands along the downgradient side of the adjacent agricultural fields is recommended. Adding riparian buffers along the tax ditch would improve the water quality and also provide flow attenuation.



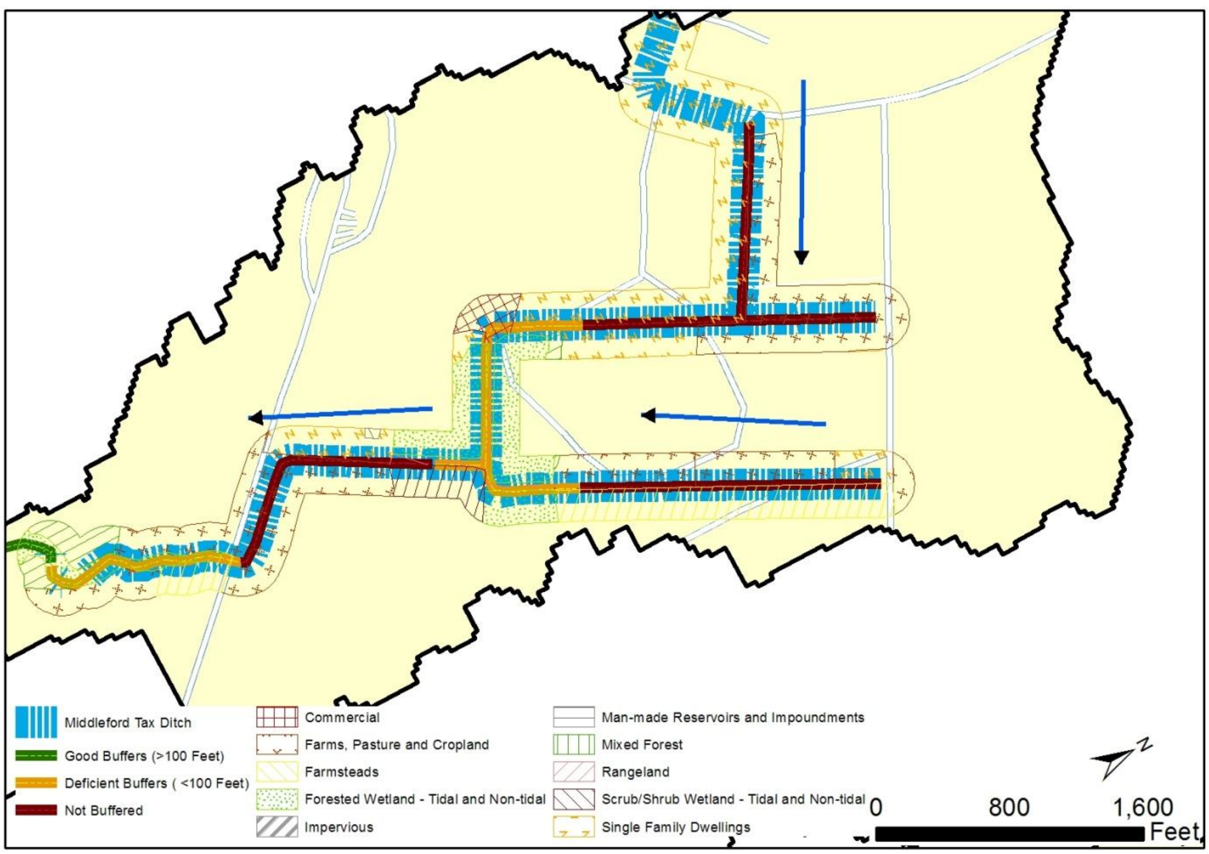
5. Herring Run Tax Ditch

- **Description:** Herring Run Tax Ditch begins south of Atlanta Road and transitions to a natural channel south of Herring Run Road. The tax ditch, including one prong, has a length of 3.7 miles. Farms, forests, and single-family dwellings are the major land uses along the tax ditch. This tax ditch is located in the Herring Run subwatershed.
- **Existing conditions:** The headwaters of the tax ditch completely lack riparian buffers. The rest of the tax ditch transitions between areas with deficient buffers to no riparian buffers. Scouring and extensive sand depositions at the channel bottom were observed along the tax ditch length. Aquatic plants and decaying organic matter that may cause low dissolved oxygen conditions were observed at certain sections of the tax ditch.
- **Potential for improvements:** Vegetative maintenance that includes dipping out the channel bottom for algae and sediments to provide additional storage is recommended along the channel where sand depositions and organic matter were observed. Addition of tree canopy along the prongs and main ditch in areas lacking riparian buffer would help improve water quality and provide flow attenuation. Implementation of BMPs such as in-stream wetlands along the downgradient side of the farms would help reduce the nutrient loads from agricultural runoff.



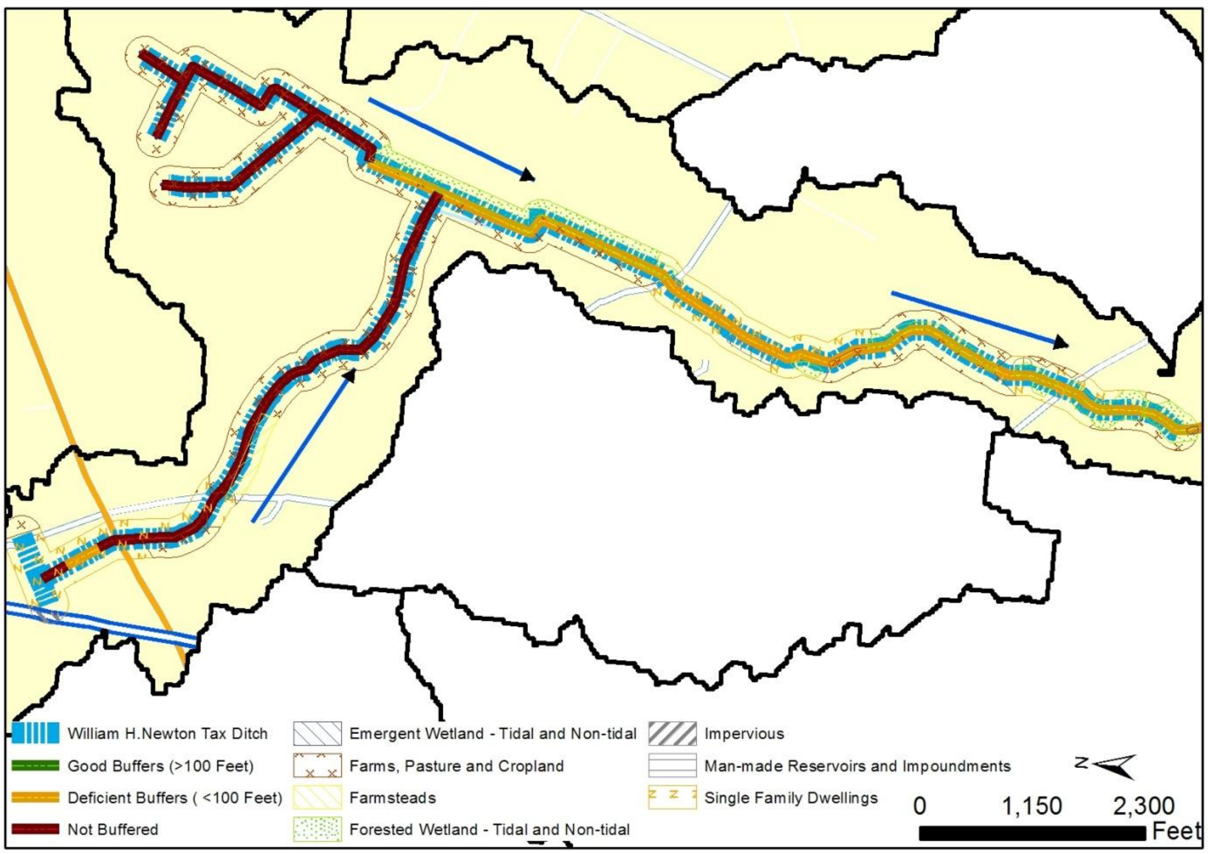
6. Middleford Tax Ditch

- **Description:** Middleford Tax Ditch begins east of Sussex Highway and flows southeast and transitions into a natural channel. It has four prongs draining to it. The majority of the tax ditch collects runoff from residential areas. Some of the tax ditch also collects runoff from agricultural areas. The main tax ditch along with its four prongs has a length of 2.2 miles. This tax ditch is located in the Middleford Tax Ditch subwatershed.
- **Existing conditions:** Almost the entire length of the tax ditch lacks riparian buffers. Field assessment of the tax ditch concluded that Middleford Tax Ditch is a deeply incised channel with mass wasting from adjacent agricultural areas observed in sections of the ditch.
- **Potential for improvements:** A BMP that would capture the runoff from residential areas and treat it for water quality is recommended. Similarly, BMPs such as in-stream wetlands rerouting along the downgradient side of the farms would help minimize the impact of agricultural runoff on the tax ditch. Addition of riparian buffers along the banks of the tax ditch and its prongs would improve the water quality and dissolved oxygen concentration, and also provide flow attenuation. Re-stabilizing the tax ditch to connect with the natural floodplain is recommended where incised channel was observed.



7. William H. Newton Tax Ditch

- **Description:** William H. Newton Tax Ditch begins northeast of Federalsburg Road and flows south until it transitions to a natural channel and merges with Williams Pond. Farms, forests, and single-family dwellings are the major land uses along the tax ditch. This tax ditch is located in the William H. Newton Ditch subwatershed
- **Existing conditions:** William H. Newton Tax Ditch has good riparian habitat at some sections, but the majority of the tax ditch lacks riparian buffers. The tax ditch was observed to have a thickly vegetated channel bottom, indicating nutrient loads from adjacent agricultural areas, and lacked in-stream fish cover, pools, or riffles.
- **Potential for improvements:** Adding riparian buffers along the banks of the ditch would improve the water quality and also provide flow attenuation. Implementation of BMPs such as in-stream wetlands on the down gradient side of the farms that drain to the tax ditch would reduce the nutrient loads from agricultural runoff. Vegetative maintenance that includes dipping out the channel bottom for vegetation to provide additional storage is recommended along the channel where vegetated channel bottoms were observed.



10.4 SUMMARY OF TAX DITCH ASSESSMENT

The sections above provide an overall assessment and general recommendations for all the seven tax ditches systems in the Williams Pond Watershed based on observed field conditions. In general majority of the tax ditch system have deficient or no riparian buffers along the banks. Addition of forested buffers is recommended along the tax ditches lacking riparian buffers to promote the uptake of nutrients from agricultural/urban runoff.

DNREC has developed a series of conservation strategies for the restoration of tax ditches in the State of Delaware. The Phase II Watershed Implementation Plan (WIP, DNREC, 2012) indicates that a suite of innovative alternative practices designed to enhance the removal of nutrients from agricultural runoff are being implemented by DNREC to meet the Chesapeake Bay TMDL. Some of the alternative practices considered by DNREC include increasing vegetative buffers, reengineering of tax ditches to reestablish floodplains or create wetland areas to redirect the storm flows.

In order to the implement the suite of restoration measures developed by DNREC for the restoration of tax ditches in the Williams Pond Watershed, it is recommended that a detailed site specific assessment to be performed to assess the feasibility of specific restoration measures.

Section 11 Proposed Improvement Measures

As a part of this project, site-specific structural management alternatives are recommended to improve, restore, and enhance the natural resources of the Williams Pond Watershed. The potential improvement measures were identified based on hydraulic analysis of crossings (Section 5), stream assessment (Section 7), and subwatershed assessments (Section 8). A cursory assessment of each measure was performed based on the following factors:

- Relative effectiveness or level of improvement
- Environmental impacts
- Cost considerations
- Constructability

Figure 11.1 shows the locations of proposed improvement projects. The proposed structural improvement projects were divided into two categories:

  - Water quality improvement projects
  - Culvert improvement projects

11.1 WATER QUALITY IMPROVEMENT PROJECTS

Water quality improvement projects would benefit the Williams Pond Watershed by reducing the total nitrogen, phosphorous, and sediment levels in the runoff. Because of the large size of the watershed and the scope of effort for this study, the water quality improvement measures proposed in this section do not represent an exhaustive list of potential measures. Future targeted studies could be conducted to identify additional potential water quality improvements. Types of water quality projects recommended in the watershed include:

- Adding riparian buffers
- Stream restoration
- New BMP/LID projects
- New stormwater ponds and wetlands, stormwater pond retrofits, drainage improvements, and dam improvements

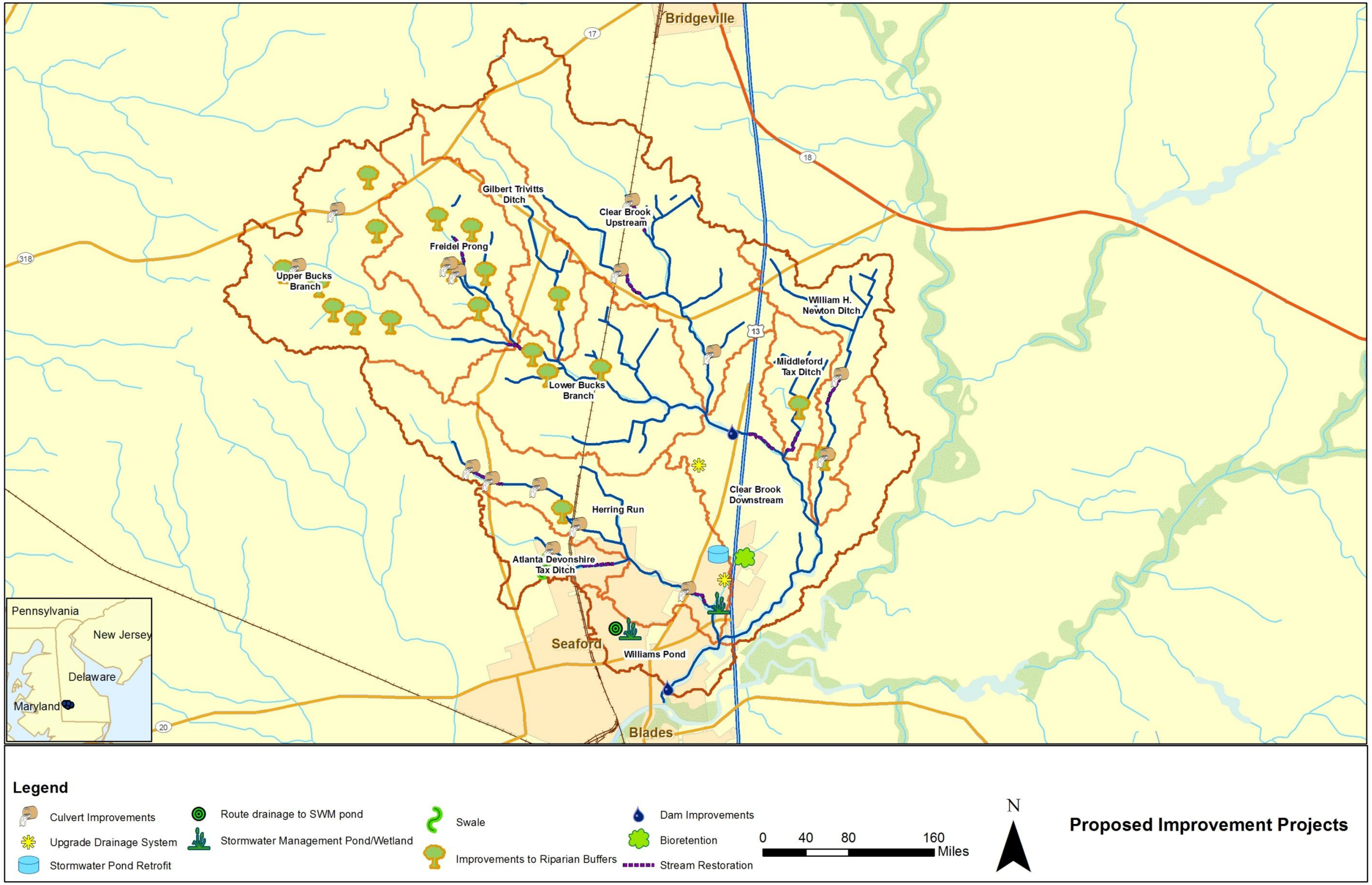


Figure 11.1: Locations of Proposed Structural Improvement Projects

Adding riparian buffers: Based on the subwatershed assessment (Section 8), streams with inadequate buffers were identified and projects that would improve/restore the riparian buffers were proposed. Adding riparian buffers to the selected project sites would reduce pollutant loads from the upstream land uses, thereby improving the water quality. Implementation requires minimum design efforts, and thus relatively low costs are anticipated for these projects. Nine sites for buffer improvements were identified throughout the Williams Pond Watershed. Four of the nine project sites (Project IDs 1, 2, 3, and 4) are located on privately owned land; therefore, approval from the property owners will be required during project implementation. The other project sites (Project IDs 15, 16, 17, 18, and 19) are located in an existing right-of-way; therefore, no ownership constraints are anticipated for those five sites. All project sites can be accessed from adjacent roads. Table 10.1 summarizes the proposed buffer improvement projects in the watershed.

Stream restoration: Based on the stream assessment (Section 7) and subwatershed assessment (Section 8), 10 stream segments were identified for potential stream restoration projects. Table 10.2 summarizes the proposed stream restoration projects in the watershed.

BMP/LID projects: BMP/LID projects would improve the water quality of the runoff from the upstream land uses in the drainage area by filtering pollutants such as nutrients and sediment before water reaches the stream system. Two types of BMP/LID projects are proposed for the watershed:

- Bioretention areas
- Grass-lined/vegetated swales with underdrain

Moderate costs are anticipated for the implementation of these projects, as they incorporate design elements and require engineering design. Significant environmental impacts and permit requirements are not anticipated for these projects. Most of the project sites are located on private property; therefore, approval from property owners or easement/property acquisition will be required for project implementation. Inclusion of check dams to control erosive velocities should be considered during the design of grass-lined/vegetated swales to ensure that the flow velocities are not erosive. Table 10.3 summarizes the proposed BMP/LID projects in the watershed.

New stormwater ponds/ and wetlands, stormwater pond retrofits, drainage improvements, and dam improvements: One stormwater pond retrofit project, two new stormwater ponds/wetlands, two drainage improvement projects, and one dam improvement are proposed based on the subwatershed assessment (Section 8). Information on the proposed projects is provided in Table 10.4.

Table 11.1: Proposed Riparian Buffer Improvement Projects

Project ID	Subwatershed	Drainage Area and Land Use	Proposed Project Location and Description
1	Lower Bucks Branch	270 acres; Agricultural, Residential, Wetland	Improvement to approximately 5,400 linear feet of riparian buffers for the tributary of Lower Buck Branch from Atlanta Road to the confluence with Lower Bucks Branch.
2	Lower Bucks Branch	72.3 acres; Agricultural	Improvements to approximately 1,700 linear feet of riparian buffers for the tributary of Lower Bucks Branch near Conrail Road.
3	Lower Bucks Branch	16.3 acres; Agricultural, Residential	Improvements to approximately 2,000 linear feet of riparian buffers for the tributary of Lower Bucks Branch from Hearns Pond Road to the confluence with Lower Buck Branch.
4	Herring Run	873.6 acres; Agricultural, Non-tidal Forested Wetlands, Residential	Improvements to approximately 3 linear miles of riparian buffers for Herring Run from Atlanta Road to Herring Run Road.
15	William H. Newton	901.4 acres; Agricultural, Residential (within existing tax ditch right-of-way)	Improvements to approximately 3 linear miles of riparian buffers for the William H. Newton Tax Ditch from upstream of State Highway 18 to Old Furnace Road.
16	Middleford	433.3 acres; Agricultural, Residential (within existing tax ditch right-of-way)	Improvements to approximately 2 linear miles of riparian buffers for the Middleford Tax Ditch and its tributaries from Eskridge Road to the confluence with Clear Brook.
17	Freidel Prong	1,127.8 acres; Agricultural, Residential (within existing tax ditch right-of-way)	Improvements to approximately 3.6 linear miles of riparian buffer for portions of Freidel Prong and its tributaries.
18	Upper Bucks Branch	1,460.4 acres; Agricultural, Residential, Woodland (within existing tax ditch right-of-way)	Improvements to approximately 3.8 linear miles of riparian buffer for portions of Upper Buck Branch and its tributaries.
19	Gilbert Trivitts Ditch	798.6 acres; Agricultural, Residential, Woodland (within existing tax ditch right-of-way)	Improvements to approximately 2.7 linear miles of riparian buffer for portions of Gilbert Trivitts Ditch.

Table 11.2: Proposed Stream Restoration Projects

Project ID	Subwatershed	Drainage Area and Land Use	Project Location and Description	Cursory Project Assessment
SR-1	Herring Run	546 acres; Agricultural, Pasture, Residential	Restoration of approximately 500 feet of Herring Run from Owls Nest Road to 500 feet downstream of Owls Nest Road. Project includes restoration of the riparian zone and native plantings on the stream bank.	This project would improve water quality and reduce nutrients downstream. Moderate implementation costs are anticipated. The project site can be accessed from Owls Nest Road. This property is in the tax ditch right-of-way.
SR-2	Herring Run	2,012 acres; Mixed Forest, Non-tidal Forested Wetland, Residential	Restoration of approximately 500 feet of Herring Run from Bridgeville Highway to 500 feet downstream of Bridgeville Highway. Recommended improvements include channel realignment and stabilization of the stream bed. Additionally, planting shrubs and trees would improve water quality and stabilize stream banks.	This project would improve water quality and reduce nutrients downstream. Moderate implementation costs are anticipated. The project site can be accessed from Bridgeville Highway. Parts of the project site are located on private property. Coordination with landowners will be required for easement/property acquisition.
SR-3	Atlanta Devonshire	462 acres; Agricultural	Restoration of approximately 500 feet of the Atlanta Devonshire Tax Ditch from Ross Station Road to 500 feet downstream of Ross Station Road. Recommended improvements include restoring riparian buffers.	This project would improve water quality and reduce nutrients downstream. Additionally, these improvements would potentially reduce channel erosion. The project site can be accessed from Ross Station Road. Easement/property acquisition would be required, as most of the project area is on private property.
SR-4	William H. Newton	653 acres; Residential	Restoration of approximately 500 feet of the William H. Newton Tax Ditch from Eskridge Road to 500 feet downstream of Eskridge Road. Restoration opportunities would include replacing invasive species with native shrubs. Additionally, the source of a pipe that discharges in the tax ditch should be investigated.	This project would prevent the degradation of habitat in the adjacent natural woodland community. Additionally, it could prevent water quality and quantity issues from the pipe that discharges into the tax ditch. The project site can be accessed from Eskridge Road. The entire project area is within the tax ditch right-of-way.
SR-5	Middleford	429 acres; Agricultural, Mixed Forest, Non-tidal Forested Wetland	Restoration of approximately 500 feet of the Middleford Tax Ditch from Old Furnace Road to approximately 500 feet downstream of Old Furnace Road. Restoration opportunities would include planting native vegetation. Additionally, regrading the channel and banks was proposed.	This project would potentially prevent further erosion of the stream bank as well as promote healthy vegetation. The project site can be accessed from Old Furnace Road. The project is located in the tax ditch right-of-way.

Project ID	Subwatershed	Drainage Area and Land Use	Project Location and Description	Cursory Project Assessment
SR-6	Clear Brook D/S	8,736 acres; Mixed Forest, Non-tidal Forested Wetland	Restoration of approximately 500 feet of Clear Brook from Route 13 to approximately 500 feet downstream of Route 13. The cause of excess sedimentation should also be investigated.	This project would potentially reduce the risk of wetland degradation, as well as decrease flooding risks. This project site can be accessed from Route 13. Easement/property acquisition would be required, as most of the project area is on private property.
SR-7	Clear Brook U/S	853 acres; Agricultural, Non-tidal Forested Wetland	Removal and treatment of invasive species downstream of Cannon Road.	This project would potentially enhance the ecological benefits of this wetland system. This project site can be accessed from Cannon Road. Easement/property acquisition would be required, as most of the project area is on private property.
SR-8	Tributary to Clear Brook	516 acres; Agricultural, Residential	Restoration of approximately 500 feet of the tributary of Clear Brook from Wilson Farm Road to approximately 500 feet downstream of Wilson Farm Road. Restoration opportunities include removing invasive species and restoring riparian buffer zones.	This project would address water quality concerns including managing nutrient loads entering the channel from adjacent agricultural fields. This project site can be accessed from Wilson Farm Road. Easement/property acquisition would be required, as most of the project area is on private property.
SR-9	Upper and Lower Bucks Branch	3,148 acres; Non-tidal Forested Wetland	Restoration of approximately 500 feet of Bucks Branch from Wesley Church Road to 500 feet downstream of Wesley Church Road. Restoration opportunities include planting native species in the riparian buffer areas.	This project would potentially improve water quality, stabilize stream banks, and provide channel shading. This project can be accessed from Wesley Church Road. The entire project is located in the tax ditch right-of-way.
SR-10	Freidel Prong	413 acres; Mixed Forest, Non-tidal Forested Wetland	Restoration of approximately 500 feet of Freidel Prong from 500 feet upstream of Baker Road to Baker Road. Restoration opportunities include planting native species in the buffer areas and grade control. Additionally, the cause of excess nutrient should be investigated.	This project would potentially reduce erosion and excess nutrient enrichment. This project can be accessed from Baker Road. The entire project is located in the tax ditch right-of-way.

Table 11.3: Proposed BMP/LID Projects

Project ID	BMP/LID Type	Subwatershed	Drainage Area and Land Use	Project Description and Location	Accessibility to Project Site
5	Bioretention	Clear Brook D/S	N/A; Commercial	Conversion of tree boxes to bioretention facilities in the Walmart parking lot near the intersection of Route 13 (Sussex Highway) and Tharp Road.	The project site has good access from Route 13.
8	Wetland/Grass Lined Swale Improvements	Herring Run	N/A; Commercial	The existing site is in need of maintenance. Grass-lined swales should be kept clear of debris. The wetland at this site should be routinely maintained. It is recommended that a maintenance plan be implemented for grass-lined swales and the wetland at this site. The swales and wetland collect drainage from the parking lot of the Sears off of Route 13.	The project has good access from Route 13, as well as Herring Run Road.
9	Grass Lined/ Vegetative Swale	Atlanta Devonshire	77.0 acres; Industrial, Residential	There is a ditch that causes flooding problems at the eastern edge of the Heritage Village community. It is recommended that this ditch be tied in to the Herring Run Tax Ditch through implementation of a grass or vegetative swale.	The project has limited access from Heritage Drive. The site would most likely need to be accessed from the industrial building on Park Avenue.
20	Stringent Development Criteria	All	N/A	Most of the subwatersheds have large areas of potential growth. Strict development and LID measures should be enforced to keep hydrologic conditions as close to pre-developed as possible.	N/A

Table 11.4: Proposed Stormwater Pond and Lake Management Projects

Project ID	Project Type	Subwatershed	Drainage Area and Land Use	Project Description and Location	Cursory Project Assessment
6	Stormwater Pond Retrofit/Improvements	Herring Run	19.0 acres; Commercial	Retrofit of the existing stormwater facility located along Herring Run Road that is collecting runoff from the Loews. The proposed recommendation includes replacing the existing trash rack on the facilities riser with a water quality rack.	Retrofitting this facility would provide low- cost water quality treatment. The site is easily accessed from Herring Run Road or from the Loews parking lot off Route 13.
7	New Stormwater Management Facility	Herring Run	396.0 acres; Commercial	The open space behind the Days Inn on Route 13 is proposed to be converted to a stormwater management pond or wetland.	A new pond or a wetland would treat runoff and manage flooding in this area. Due to significant engineering construction costs, implementation cost of this project would be relatively high. This site has easy access from the Days Inn parking lot. Ownership constraints could potentially be a problem because this site is on commercial property.
10	Upgrade Drainage System	Clear Brook D/S	43.5 acres; Residential	Upgrading the drainage system in Green Acres Village to alleviate flooding problems. This would include constructing larger grass swales to transport runoff. Additionally, culverts under driveways should be cleared out so that drainage is not blocked.	The project sites are easy to access off Garden Lane.

Project ID	Project Type	Subwatershed	Drainage Area and Land Use	Project Description and Location	Cursory Project Assessment
11	New Stormwater Management Facility	Williams Pond	91.1 acres; Institutional	Possible opportunities for implementation of stormwater management facilities to treat and store runoff from Seaford Senior High School.	Depending on the type of stormwater management facility constructed, the proposed project would provide water quality treatment and quantity control for the runoff from the campus and surrounding area of Seaford Senior High School. Implementation cost of the project would be relatively high because it would include soil removal and engineering techniques. The project site can be accessed from School Lane.
12	Route Drainage to Existing Stormwater Management Pond	Williams Pond	25.4 acres; Institutional	Route the drainage from Seaford Central Elementary to the existing stormwater management pond next to the Seaford School District building off Delaware Place.	Routing the drainage would require digging and regrading elementary school land. Implementation cost of the project would be relatively high because it would include soil removal and engineering techniques. The project site can be easily access from North Market Street.
14	Dam Improvements	Clear Brook D/S and Williams Pond	N/A; Residential, Commercial	Dam improvements need to be made to both Hearns Pond and Williams Pond. Both dams have been overtopped in recent storms. Studies are currently being conducted for both dams.	A new spillway has been constructed for the Williams Pond Dam to provide discharge capacity for the 100-year storm. There are also plans to implement overtopping protection at the Williams Pond Dam. Similar improvements should be investigated for Hearns Pond Dam.

11.2 CULVERT IMPROVEMENT PROJECTS

The hydraulic analysis identified the culverts and bridges that were overtopped for the roads' design storms (25-year or 50-year, depending on the road classification) for existing and future conditions (Section 5). Improvement measures were recommended for the structures calculated to overtop during the design storm in order to address the structures' deficiency in conveyance capacity. Fourteen overtopped structures were identified from hydraulic analysis for which improvements have been recommended.

These 14 crossings selected for improvements were categorized as follows:

- Crossings that pass the design storm with no freeboard, but do not have capacity to pass the design flow under either existing or future conditions with 1 foot of freeboard (Yellow category)
- Crossings that overtop the road under either existing or future conditions (Red category)

Table 11.5 summarizes the proposed improvements recommended for each crossing.

Table 11.5: Proposed Culvert Improvements

Crossing ID	Field Observations of the Crossings	Conveys Design Storm with 0' Freeboard		Conveys Design Storm with 1' Freeboard		Recommended Improvement Measures
		Existing Conditions	Future Conditions	Existing Conditions	Future Conditions	
URS1	Twin 48" x 72" elliptical corrugated metal pipes located under Old Furnace Road	Yes	Yes	Yes	No	The culvert is recommended to be replaced with twin 48"x76" elliptical reinforced concrete pipes along with headwalls to stabilize the soil conditions around inlet and outlet areas. Implementation of the proposed improvement would involve disturbing the existing headwall.
URS11	A 42" diameter circular corrugated metal pipe located under Atlanta Road	No	No	No	No	The existing culvert has an available deck height of 4 feet; therefore, it is proposed to be replaced by a 60" diameter circular corrugated metal pipe along with headwalls to stabilize the soil conditions around inlet and outlet areas.
URS13	A 42" diameter circular corrugated metal pipe located under Federalsburg Road	No	No	No	No	The existing culvert has an available deck height of 3 feet; therefore, the crossing is proposed to be replaced by a 54" diameter circular corrugated metal pipe with a headwall to stabilize the soil conditions around inlet and outlet areas.
URS14	A 42" diameter circular corrugated metal pipe located under Atlanta Road	No	No	No	No	Another 42" diameter circular corrugated metal pipe is proposed to be added to the existing pipe to increase the conveyance capacity. Implementation of the proposed improvement would involve disturbing the existing concrete headwall.
URS15	A 48" diameter circular corrugated metal pipe located under Herring Run Road	Yes	Yes	No	No	Another 48" diameter circular corrugated metal pipe is proposed to be added to the existing pipe to increase the conveyance capacity.
URS16	Twin 42" x 60" elliptical corrugated metal pipes located under Eskridge Road	Yes	Yes	No	No	The culvert is proposed to be replaced by a 48"x76" elliptical reinforced concrete pipe along with the implementation of square edge with headwalls to stabilize the soil conditions around inlet and outlet areas.
URS2	A 36" diameter corrugated plastic pipe located under Elks Road	No	No	No	No	The existing culvert is proposed to be replaced with twin 54" diameter corrugated metal pipes along with implementation of headwalls to stabilize the soil conditions around inlet and outlet areas.
URS20	A 42" diameter circular corrugated metal pipe located under Conrail Road	No	No	No	No	Another 42" diameter circular corrugated metal pipe is proposed to be added to the existing pipe to increase the conveyance capacity.

Crossing ID	Field Observations of the Crossings	Conveys Design Storm with 0' Freeboard		Conveys Design Storm with 1' Freeboard		Recommended Improvement Measures
		Existing Conditions	Future Conditions	Existing Conditions	Future Conditions	
URS23	Twin 42" diameter circular corrugated plastic pipes located under Conrail Road	Yes	Yes	No	No	The existing culvert is proposed to be replaced with twin 48" diameter corrugated plastic pipes with headwall to stabilize the soil conditions around inlet and outlet areas.
URS25	A 36" diameter circular reinforced concrete pipe located under Conrail Road	Yes	No	No	No	The existing culvert has an available deck height of 2.7 feet; therefore, it is proposed to be replaced with a 48" diameter, circular reinforced concrete pipe.
URS6	A 42" diameter circular corrugated metal pipe located under Ross Station Road	Yes	No	No	No	Another 42" diameter circular corrugated metal pipe is proposed to be added to the existing pipe to increase the conveyance capacity.
URS7	A 36" diameter circular reinforced concrete pipe located under Owls Nest Road	No	No	No	No	The crossing is proposed to be replaced with twin 54" diameter circular reinforced concrete pipes to increase the conveyance.
URS8	A 36" diameter circular corrugated metal pipe located under Bucks Branch Road	Yes	No	No	No	The existing culvert has an available deck height of 4 feet; therefore, the culvert is proposed to be replaced with a 48" diameter, circular, corrugated metal pipe along with headwalls to stabilize the soil conditions around inlet and outlet areas.
URS9	A 36" diameter circular corrugated metal pipe located under Baker Road	Yes	No	No	No	Another 36" diameter circular corrugated metal pipe is proposed to be added to the existing pipe to increase the conveyance.

Section 12 Management Strategies and Action Items

This section focuses on a list of watershed-wide improvement measures and strategies that are being adopted by DNREC to achieve pollutant load reductions; In addition, it also includes improvements measures and strategies that could be adopted for managing the watershed and improving the quality of stormwater runoff. These are programmatic types of practices involving outreach activity, community education, policy changes, and economic instruments; they do not require traditional fixed permanent facilities. The primary goal of these management strategies is to control the transportation of pollutants through runoff by either reducing the volume of runoff or by reducing the opportunity of stormwater to pick up pollutants. These improvement measures, along with the structural management and LID projects, represent a holistic approach to watershed management.

Below are the watershed-wide management measures that are recommended for implementation in Williams Pond Watershed.

- **Septic systems:** Williams Pond Watershed has primarily rural residential homes, and it is assumed that approximately half of the homeowners in the watershed are on a septic system. According to Delaware Phase I Watershed Implementation Plan (WIP, DNREC, 2010), septic tank nutrient leaching is one of the main sources of non-point source pollution draining to the Chesapeake Bay Watershed. Nitrogen leaks can occur even from a properly functioning septic system. Leaching nitrogen from these systems poses a threat to ground water quality and also to surface water quality. Implementation of the following strategies would help reduce the impact of septic leaching on water quality:
    - **Regular cleanout of the septic system:** On-site wastewater treatment and disposal systems are required to have the septic tank pumped out once every 3 years. Regular cleanout of the septic system would help prevent the contamination of water quality due to seepage of septic effluent. Therefore, better enforcement of this requirement would help reduce the seepage of septic effluent.
    - **Retrofitting existing septic system:** Existing septic systems that are failing contribute to the nitrogen leaching into the ground water system. Retrofitting the failing septic tanks with supplemental treatment would reduce impacts on ground water. Water bodies that have been impaired by failing septic systems should be identified, and septic systems close to the water bodies should be retrofitted to avoid further degradation of water quality.
    - **New septic system:** Installation of new septic systems should be certified by a professional who performs a site assessment of ground water conditions and proposes a suitable design for the new system. Installing an alternative supplemental treatment system to reduce pathogens and nutrients is recommended.
    - **Centralized sewer service:** The Sussex County Comprehensive Plan (2008) indicates that the Growth Zones in the watershed are primarily the result of conversion of agricultural areas to residential areas. Installation of septic tanks in porous agricultural lands would degrade the quality of streams and ground water due to nutrient leaching from them. Implementation of a centralized sewer service that would convey household discharges to wastewater treatment plants could be an alternative to individual home septic systems. This would eliminate the expense of

regular maintenance and pumping out of septic tanks and reduce septic leachate contamination of ground water. This alternative could be very effective in urban developing areas like the City of Seaford where homes are closer to each other.

- **Stormwater management:** The Sussex County Comprehensive Plan (2008) indicates that the population of the County could increase by 25 percent by the year 2020. The subwatersheds Atlanta Devonshire Tax Ditch, Clear Brook Upstream, Freidel Prong, Herring Run, William H. Newton Ditch, and Williams Pond are located in the Growth Zones of the County. Residential development increases the impervious cover in the subwatershed, which results in increased surface runoff. The following are some of the management strategies that would help reduce runoff and nutrient loads due to residential development:
    - **Environmental Site Design:** Environmental Site Design is a comprehensive approach of using small-scale stormwater management practices, non-structural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources. Adopting Environmental Site Design principles in planning the layout for new development would provide more benefits with fewer impacts on natural resources.
    - **Erosion and sediment control:** All new construction activities involve disturbing an area of earth. If proper erosion and sediment control measures are not adopted, sediment may be transported into the downstream conveyance system through surface runoff. Current Delaware erosion and sediment control regulations require an approved sediment and stormwater plan for any construction activity that disturbs 5,000 square feet or more. More stringent measures should be adopted by local municipalities, and effects of downstream conveyance systems should be analyzed before any new construction activity. Clustering any new development would also minimize the area of disturbance.
    - **Adopting green infrastructure/Low Impact Development:** Green infrastructure and low impact development refers to techniques for infiltration, capture, and reuse of stormwater to mimic predevelopment conditions in developed areas. Bioretention ponds, green roofs, and rain gardens are some examples. These techniques can be applied to new development, re-development, or retrofit of existing development. Delaware Phase II Watershed Implementation Plan (WIP, DNREC, 2012) has updated the number of existing green infrastructure/LID practices in the Chesapeake Bay Watershed since the Phase I WIP (WIP, DNREC, 2010); however wet/dry ponds are the primary stormwater management practices adopted to treat urban stormwater runoff. DNREC, along with County government and local municipalities, should adopt and encourage the use of green infrastructure and LID techniques for the treatment of urban stormwater runoff.
    - **Preserving Source Water Protection areas by land conservation/acquisition programs:** Land conservation programs for the preservation of areas identified as having "excellent ground water recharge potential" by the SWAPP should be adopted. These protected areas could be converted to public parks, forested areas, or easements to conserve wildlife habitat and protect them from urban development.
    - **Large landowners:** GIS analysis of the parcel database concluded that there are approximately 18 landowners who own parcels greater than 100 acres, and 2 owners

who own parcels greater than 200 acres. The state and local authorities could work with large landowners in the watershed to implement stormwater management facilities on their property by providing them with suitable incentives.

- **Street sweeping and catch basin cleanout:** Street sweeping programs involve sweeping roads, gutters, and parking lots to remove trash, debris, and dirt from the surface to prevent its washing off into the streams. The Delaware Phase II WIP (DNREC, 2012) reports that DelDOT currently can report only the curb miles that were nominally swept and the agency hopes to have GPS units installed on the sweepers to report the pollutants removed. DelDOT and the local governments could develop a comprehensive plan for street sweeping activities for the watershed that would involve keeping a log of the number of miles swept, frequency of sweeping, and amount of waste collected. If efficiently performed, street sweeping could be used as a primary treatment for the pollutants. Another alternative to street sweeping is catch basin cleanout, which involves periodic cleaning of storm drain inlets to remove accumulated materials that would clog the drain and reduce its efficiency. Regular cleanout schedules for the storm drains could be established to retain their performance.
- **Reduction of future impervious surface:** Williams Pond Watershed has 7.6 percent imperviousness, of which the majority is occupied by roads. As new residential development occurs in the watershed, there is a need for newer roads to be constructed to access the residential areas. This further increases the imperviousness of the watershed. Elimination of curbs and gutters is an alternative for reducing the impervious development in the watershed. Clustering all new development to contain them at one site would also help decrease the impervious cover of the watershed. Practices like shared driveways, and reducing the length of driveways and area of parking lots in commercial areas would also reduce the impact of impervious cover on the watershed.
- **Identification of potential commercial hot spots:** Williams Pond Watershed has pockets of commercial/business areas, especially along Route 13. These commercial/business places often contribute to high levels of pollutants in stormwater runoff due to activities like vehicle maintenance, loading and unloading operations, outdoor material storage, waste management, etc., which could be potential risks for spill, leaks, or illicit discharges. Hot spots are identified as potential stormwater pollution sources. Site investigations should be conducted at commercial/business sites to evaluate and identify their potential pollution producing behaviors. Thus identified hotspots could be assessed and suitable mitigation can be proposed.

- **Community outreach and education:** Outreach and education programs educate the public on potential pollutants and how misusing them affects our water resources. These programs are intended to change pollutant-causing behaviors, thereby reducing pollutant loads in the watershed.
  - **Lawn care, turf management, and pet waste:** Low-density residential land use occupies most of the developed land use in Williams Pond Watershed. Lawn care activities like excess use of fertilizers, insecticides, and herbicides are common practices adopted by homeowners. However these chemicals and nutrients are washed

into streams through stormwater runoff. Proper lawn care practices help prevent nitrogen, phosphorous, insecticides, and herbicides from entering water bodies. Homeowners should be educated on practices like soil testing, fertilizer application, and pesticide use. Excess nutrients and harmful bacteria from pet waste enter streams through runoff. Outreach programs should include educating the public on the effects of pet waste on streams and lakes, posting signs, and installing publicly available disposal containers for pet waste. Even though the Williams Pond Watershed is primarily an agricultural-based watershed, these programs can be effectively implemented in the residential areas and future residential areas of the watershed.

- **Impervious disconnections and rain garden/rain barrel programs:** DNREC can consider practices that reduce runoff by decreasing runoff from impervious area with such methods as small-scale storage, infiltration, or redirection to pervious areas. Rain barrels, downspout disconnection, and rain gardens are some of the practices that could be adopted to achieve impervious disconnection. Programs could be established to educate the public on the effects of these practices on water quality, and incentives could be awarded to property owners for adopting these green technologies.
- **Involvement of watershed groups:** Williams Pond Watershed is a part of the Nanticoke Watershed. The Nanticoke Watershed Alliance is a watershed group that is actively working toward conservation of natural and aquatic resources of the watershed through various activities like outreach, volunteer, and education programs. State and local governments could team with watershed restoration groups to develop long-term implementation plans.
- **Storm drain stenciling programs:** A storm drain stenciling program involves marking storm drain inlets with information that deters people from dumping trash and pollutants into the drains such as “Chesapeake Bay Drainage”. Local municipalities could adopt this program in residential areas to educate the public on the consequences of illegal dumping and its effects on water quality.

- **Forestry management:** Williams Pond Watershed is approximately 14 percent forested that includes mixed, deciduous, evergreen forests, and forested wetlands. It was reported in Section 9.4 that implementation of 100-foot buffers along streams could reduce 60 percent and 65 percent of nitrogen from ground water and surface water, respectively, and 70 percent of phosphorous in surface water. Increasing forest or tree cover in the watershed would play a vital role in reducing the nutrient runoff into streams.
  - **Homeowner tree planting program:** This program would encourage planting tree cover on a residential lots. Programs could be developed that would encourage planting and preserving trees on private properties, both residential and rural.
  - **Timber management programs:** Delaware Forest Service currently keeps track of all timber harvesting done in the state. Permits are required for the conversion of forested area to development and agriculture. The Delaware Forest Service issues permits for all logging activity on more than 1 acre. Programs that address erosion and runoff issues due to forest harvesting should be implemented. Adopting a timber

stand improvement program would promote diversity; maintain wild life corridors, stream sides, and buffer zones; and preserve natural ecosystems.

- **Trees on public/state lands:** A cursory assessment of the existing tree cover on public/state-owned land is recommended so that tree planting programs can be recommended for these properties.

- **Agricultural and livestock operations:** Agriculture is the major land use type in Williams Pond Watershed. Agricultural activities such as excessive application of pesticides and fertilizers, cultivation, and animal feeding operations contribute to the contamination of surface and ground waters. Pollutants like nutrients, sediment, and pesticides enter the streams through surface runoff and cause eutrophication. Listed below are some of the non-structural BMPs that could be implemented to improve the quality of agricultural runoff.

  - **Adopting a nutrient management plan:** The State of Delaware currently has a nutrient management law that limits the use of phosphorous in agricultural applications. Further improvements that would emphasize the application procedures, amounts, and timing of fertilizer application could be made to the existing law.

  - **Soil testing:** Farmers should be encouraged to assess the fertility of soil by getting the soil tested in a laboratory. A soil test report indicates the composition of nutrients and pH, thus limiting the over-application of nutrients leading to ground and surface water contamination. More research needs to be done in order to develop suitable programs that would include educating farmers on the advantages of soil testing and providing incentives to participate in the program.

  - **Animal feeding operations:** DNREC oversees the National Pollutant Discharge Elimination System (NPDES) permits for concentrated animal feeding operations. In their Phase II WIP (DNREC, 2012), it was indicated that the state will identify the number of animals confined in CAFOs by County and that it is currently working with EPA to modify the state's current CAFO regulations in response to changes in the federal regulations A watershed-wide accurate assessment of the CAFOs and AFOs is recommended so that suitable BMPs can be implemented at these facilities.

  - **Erosion and sediment control practices:** Sediment enters streams and lakes through erosion and transports nutrients that are attached to it. Erosion and sediment control practices such as use of grass filter strips or buffer areas between agricultural lands and adjoining water bodies that reduce the transportation of nutrients through erosion should be recommended.

  - **Education program:** Local and state governments, along with soil conservation districts, should focus on outreach programs that provide technical and financial assistance to farmers by educating them on the implementation of agricultural BMPs such as cover crops, use of bio-fertilizers, and waste management programs.

Section 13 Implementation Recommendations

The recommendations for Williams Pond Watershed are a compilation of numerous structural improvement projects and various management strategies. Specific recommendations are described in Section 10 (Tax Ditch Restoration and Management) Section 11 (Proposed Improvement Measures) Section 12(Management Strategies and Action Items). These recommendations were identified by analyzing the current conditions of the subwatershed and considering possible future development conditions in each of them. The sections below discuss the implementation prioritization.

13.1 SUBWATERSHED PRIORITIZATION

Based on the subwatershed assessment, Herring Run and Atlanta Devonshire Tax Ditch were assessed as “Very Poor,” and Freidel Prong, Clear Brook Upstream, Lower Bucks Branch, Middleford Tax Ditch, William H. Newton Ditch, and Williams Pond were assessed as “Poor” in terms of overall health of the subwatershed. Except Freidel Prong, all of the above-mentioned subwatersheds have a high potential for future development because they are in the Sussex County Growth Zone. URS gave priority to these subwatersheds when developing recommendations for projects that would help achieve a quantifiable improvement. The remaining subwatersheds, Upper Bucks Branch and Gilbert Trivitts Ditch, Clear Brook Downstream were assessed as “Good”, “Fair” and “Fair,” respectively. The types of projects proposed and prioritization of the subwatersheds are provided in Table 13.1.

Table 13.1: Subwatershed Prioritization

Subwatershed	Priority	Type of Projects				Comments on Prioritization
		Improvement of Riparian Buffers	Improvement of Crossings/ Obstructions	Implementation of Stormwater Management Facilities	Implementation of Stream Restoration Projects	
Atlanta Devonshire Tax Ditch	High		X	X	X	High probability of future development, overtopping structure, no tree canopy along the ditch, and stormwater management.
Clear Brook Downstream	Low			X	X	Low probability of future development, poor drainage system, stormwater management, and dam improvements.
Clear Brook Upstream	Medium		X	X	X	Low probability of future development, three structures that overtop design storm, replacement of invasive species along the channel with native species, poor drainage system, and stormwater management.
Freidel Prong	Medium	X	X		X	Two undersized culverts and nutrient loads.
Gilbert Trivitts Ditch	Low	X				Inadequate forest cover and nutrient runoff.
Herring Run	High	X	X	X	X	Highest number of undersized culverts, low probability of future development, stormwater management, and nutrient loads.
Lower Bucks Branch	Medium	X			X	High probability of future development, high sediment loads.
Middleford Tax Ditch	Medium	X			X	High probability of future development and stream with eroded banks.
Upper Bucks Branch	Low	X	X		X	Least developed subwatershed, inadequate buffers, and two undersized culverts.
William H. Newton Ditch	Medium	X	X		X	High probability of future development, inadequate buffers, poor drainage system, stormwater management, nutrient loads, and one overtopping crossing.
Williams Pond	Medium			X		Highest impervious cover, dam improvements at Williams Pond.

13.2 PRIORITIZATION OF ROAD CROSSING IMPROVEMENT PROJECTS

As discussed in Section 5, 28 crossings were hydraulically analyzed in the Williams Pond Watershed to estimate their conveyance capacity for the design storm. Fourteen out of 28 crossings convey the design storms. Improvements were proposed to 14 of the 28 hydraulically deficient structures. Culverts that convey less than 90 percent of the design storm (with no freeboard under future conditions) should be prioritized during project implementation. Seven crossings have been identified under this category. All of these crossings are for roads owned by DelDOT; therefore, coordination with DelDOT is recommended to further analyze the capacity of the crossings and the feasibility of including them in the project. Table 13.2 lists the highest priority culverts in the Williams Pond Watershed and their locations.

Table 13.2: Priority Road Crossing Improvement Projects

Crossing ID	Location	Subwatershed	Road Classification	Design Storm	Conveyance Capacity with 0' Freeboard (Future Conditions; %)
URS11	Atlanta Road	Herring Run	Collector	50-year	61
URS13	Federalsburg Road	Upper Bucks Branch	Collector	50-year	80
URS14	Atlanta Road	Upper Bucks Branch	Collector	50-year	76
URS2	Elks Road	Clear Brook Upstream	Local	25 -year	36
URS20	Conrail Road	Herring Run	Local	25-year	71
URS6	Ross Station Road	Herring Run	Local	25-year	88
URS7	Owls Next Road	Herring Run	Local	25-year	71

13.3 PRIORITIZATION OF ROUTE 13 MAINTENANCE ACTIVITIES

Based on the field assessment of Route 13 drainage systems (Section 6), it was concluded that the drainage problems in the area are primarily due to the lack of maintenance of drainage structures. URS categorized the field-identified drainage structures based on the level of maintenance required. Of these, 27 structures were found to be completely destroyed, and URS recommends their replacement. Route 13 is owned by DelDOT; therefore, DNREC should coordinate with DelDOT to perform or schedule any maintenance activities along the route. Table 13.3 provides information on the number of culverts, structures and outfalls that need major maintenance to improve drainage conditions along Route 13.

Table 13.3: Priority Route 13 Drainage Improvements

Drainage Component Type	No. of Components that Require Major Maintenance
Culverts	23
Structures	2
Outfalls	2

A detailed information on the location and existing conditions of all the drainage components that need major maintenance are included in Appendix E of this report.

13.4 GROWTH AND DEVELOPMENT RECOMMENDATIONS

Based on the subwatershed assessment, Herring Run and Lower Bucks Branch were identified to having a high potential for future development and poor subwatershed conditions. Therefore, these subwatersheds were selected to model the "what-if" scenarios. The what-if scenarios were used to illustrate the result of enforcing post-construction stormwater management regulations in these watersheds. Based on the results of the what-if scenarios, URS concluded that implementation of new Delaware Sediment and Stormwater Regulation criteria that focus on enforcing runoff reduction practices for post-development areas to achieve an effective 0 percent imperviousness would be the most effective in maintaining the quality of the subwatershed for future development conditions.

These subwatersheds have 18 to 20 percent of their area classified as "excellent ground water recharge potential" areas. Per the publication, *Protecting the Sources of Your Drinking Water* (DNREC, 2007), these Source Water Protection areas should be preserved as open space and parks by acquisition/conservation easements. According to the publication, if development occurs in the Source Water Protection areas, it is recommended that the impervious cover of the new development be limited to 20 percent in the Source Water Protection areas.

13.5 IMPLEMENTATION OF WATERSHED-WIDE MANAGEMENT STRATEGIES

Section 12 identifies management strategies that could be adopted in addition to the existing strategies currently adopted by DNREC to help achieve the water quality goals for the Williams Pond Watershed. The management strategies target the areas of septic systems, stormwater management, community outreach and education, forestry management, and agricultural/livestock operations. They promote education, cooperation, and recreation to increase the awareness of the people who live in the watershed of how their actions affect the health of the watershed. The management strategies and actions described in Section 12 can be implemented without major capital investments, as they do not involve any construction activities. DNREC could implement these management strategies statewide by partnering with the counties, municipalities, and various watershed groups to improve their effectiveness.

13.6 OPPORTUNISTIC RECOMMENDATIONS

Sections 13.1 through 13.5 describe structural projects and management strategies that could be adopted based on the prioritization of the subwatersheds. Although a general priority of implementation is recommended in this watershed plan, we recommend that DNREC consider implementing improvement projects other than the highest priority projects in conjunction with other activities in the watershed such as:

- Improving culverts as a part of road improvement/widening projects to accommodate higher flows that could result from future development.
- Addressing stormwater quality and quantity issues during the design of proposed transportation projects.
- Working with developers to provide additional stormwater controls for adjacent untreated existing impervious areas; State regulations currently require implementing stormwater management as part of new development.
- If new development occurs in a subwatershed that would impact the streams and wetlands, prioritizing implementation of stream restoration/wetland mitigation projects to provide water quality benefits to the subwatershed.

13.7 CONCLUSIONS

Williams Pond Watershed, which is a mix of developed and undeveloped areas, experienced rapid growth in recent years (i.e., 2002-2007), although this growth has significantly stalled since then. The conditions in the watershed vary on a subwatershed level. To enhance and preserve watershed conditions, projects and management strategies that address flooding and water quality issues in the watershed are identified in this report. Further, it is recommended that future development in the watershed be strategically planned through implementation of regulations and ordinances and by avoiding disruption of sensitive areas in the watershed.

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