THE SIDNEY BROOK
WATERSHED PROTECTION PLAN

HUC-14 02030105020070 Raritan River South Branch (River Road to Spruce Run)

Prepared for:

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Executive Summary

The Sidney Brook watershed is located in northern Hunterdon County, New Jersey and encompasses portions of Union and Franklin Townships. The studied watershed lies within HUC-14 subwatershed 02030105020070 and straddles both the Piedmont and Highlands physiographic provinces. As such, portions of the watershed are within the bounds of the region delineated in the Highlands Act. The approximately 3,500 acre watershed is largely rural, with agricultural, forest, and rural residential/single-family residential lands comprising the bulk of the watershed. There are over 22 miles of mapped streams in the tributary network.

The watershed and the stream have been historically noted for their overall high quality. Under the Surface Water Quality Standards Sidney Brook has dual classifications. The lower portions of Sidney Brook from the South Branch Raritan River to Route 513 is a Freshwater 2 Nontrout (FW2-NT) stream, while the upper portions of the brook west of Route 513 were re-classified as Freshwater 2 Trout Maintenance (FW2-TM) in 2007. The reclassification indicates the potential high quality of Sidney Brook in supporting trout, which are indicators of good water quality and have specialized demands for cool water, high dissolved oxygen concentrations, and a healthy macroinvertebrate community. In 2003, Sidney Brook was designated a Category One water, an antidegradation policy intended to protect designated waters from “any measurable changes in water quality”. This designation was achieved because Sidney Brook has known Bog Turtle habitat (federally threatened and state endangered) and the stream has had very good macroinvertebrate and fish assessments. Despite these indications, the stream had not hitherto been systematically studied and there was insufficient information to determine if there was attainment of designated uses.

The resulting study and this document was born of the need to systematically study Sidney Brook and its watershed in order to comply with the mandate to preserve, protect, and enhance the natural resources of the watershed. In 2005, the Union Township Environmental Commission with the assistance of Princeton Hydro, LLC and project partners Franklin Township, the New Jersey Water Supply Authority, and the Hunterdon County Planning Board responded to the request for proposal for SFY 2006 Section 319(h) Grants for Nonpoint Source Pollution Control and applied for a grant to develop this Watershed Protection Plan (WPP). The goals for this plan are relatively simple: to identify and inventory resource areas; to evaluate the integrity of each resource area; to establish resource protection measures specifically by identifying strategies and actions to protect Sidney Brook and reduce nonpoint source pollution (NPS); and to establish programs to promote consistent standards for the protection, restoration, and acquisition of important waters and Riparian Areas of the Highlands Region. The notification of the grant award was sent in February 2006, at which point work was initiated on developing the Quality Assurance Project Plan (QAPP) prior to the initiation of field work.

The defined goals have required a two-pronged approach in executing the project and in preparing the Watershed Protection Plan. The first phase of the project was the characterization and assessment of the watershed. This phase relied heavily on reviewing and compiling existing data, reports, maps, GIS databases, and other similar information. This information was then used to run various hydrology and pollutant load modeling to quantify these important elements. This was followed by intensive field investigations including a watershed wide visual assessment, water quality monitoring, benthic macroinvertebrate survey, fishery survey, sediment contaminant screening, and hydrology investigations. Most of the field work was conducted in 2008, although several tasks were completed as late as 2010. This phase was largely based on inventorying the natural resources of the watershed, and perhaps more importantly, identifying impairments and impacts to the ecological function of the system. As stated earlier, while the watershed and stream may be considered of high quality overall, like any other watershed that has some level of development including agriculture and rural residential land uses, this watershed is subject to a number of impairments, especially those related to nonpoint source pollutant loading. Identified impairments include: water temperature, total dissolved solids and specific conductance, total phosphorus, *E. coli*, benthic macroinvertebrates, erosion and sedimentation, invasive species, and streambank encroachment and buffer impairments. The degree of these impairments varied as well as their extent and some are of minor concern; however others, such as streambank encroachment and buffer impairments, are widespread and contribute to some of the other observed impairments.

With the inventory of the watershed completed and various impairments identified, the second phase of the project was initiated. This phase consists of formulating mitigation measures and management actions to address these impairments and ultimately it is this phase which is most powerful in protecting sensitive resources and improving water quality and ecological function on the whole. This was accomplished in several ways and at several scales. It is important to recognize that there are already many existing laws, regulations, technical rules, policies, and ordinances that exist to protect water quality and natural resources and these were explored to reinforce their importance and value. Next, a number of Best Management Practices (BMP's) were explored to limit NPS pollution. These BMP's cover a very wide variety of topics including: simple riparian buffer enhancements that could be implemented throughout the watershed; cultural BMP's covering water conservation, fertilizer use, and BMP maintenance among others; traditional and newer-design structural BMP's such as rain gardens, bioretention basins, and water quality swales; invasive species management; a variety of bed and bank stabilization techniques from riparian planting to toe protection and grade control; numerous agricultural BMP's and manure management; and, open space preservation. The generalized descriptions of these measures, along with technical and financial information required in the preparation of WPP's by the Environmental Protection Agency, can be used to understand and select the appropriate BMP for any given site. Given the very nature NPS pollution as a diffuse loading, opportunities exist throughout the entire tributary network and watershed for the implementation of these types of projects.

In addition to these generalized discussions of management actions, two separate lists of specific project sites were developed for the study. The first list was developed by Princeton Hydro and utilized the results of the Visual Assessment coupled with the other collected data, particularly water quality sampling, in selecting project candidate sites. These sites were then scored based on several parameters and ranked according to priority. The New Jersey Water Supply Authority (NJWSA) also developed a list of potential projects based on a pre-existing identification and ranking tool developed for use in the Raritan Basin that was GIS intensive. This was used to produce a series of maps highlighting areas of different priority for riparian restoration activities as well as the candidate sites. One of the sites was then selected as a demonstration project and constructed at the Milligan Farm site in June 2011. This project was a successful demonstration of the types of projects that can be easily and inexpensively constructed throughout the watershed.

To ensure that this WPP is utilized and to maintain compliance with required nine elements of a WPP additional information is discussed to focus on the implementation of the plan. These elements include the required technical and financial assistance of the recommended projects, a discussion of information and education elements including public meetings and dissemination of the plan, an implementation schedule, milestones to keep implementation on schedule, and finally monitoring criteria and monitoring plans to gauge success and determine corrective actions if needed.

The adoption and implementation of this plan will have far reaching implications for the Sidney Brook watershed as it outlines a pathway for the protection of water quality and watershed natural resources. This was accomplished through inventorying and characterizing the watershed, identifying impairments, and addressing those impairments at specific locations with specific techniques, even leading to actual implementation of a demonstration project. Overall, the WPP should preserve and protect the existing resources and actually improve their function in many key areas. Certainly, this document contains the keys to implementation and will provide a valuable tool in procuring funding. The most important recommendation is simply that this document be used and remain visible and public. Tthis document is only a starting point, but it contains the methods and techniques to initiate and advance projects to completion in order to reverse impairments and limit future NPS pollution impacts to the Sidney Brook Watershed.

1.0 Background

Sidney Brook is a tributary to the South Branch River located in the northern portion of Hunterdon County, New Jersey. The watershed encompasses portions of two municipalities: Union Township and Franklin Township. The Sidney Brook Watershed is largely coterminous with the United States Geological Survey (USGS) 14-digit Hydrologic Unit Code (HUC-14) 02030105020070. The Sidney Brook watershed is part of Watershed Management Area (WMA 8) or the North and South Branch Raritan WMA. The watershed encompasses approximately 5.50 square miles or 3,522 acres. Geographic Information System (GIS) analysis reveals that there are nearly 22.3 mapped linear stream miles within the tributary network.

The creek, and by extension the watershed, is an outstanding natural resource of these predominantly rural communities and is recognized for its ecological function, habitat value, aesthetic beauty, recreational opportunities, and unique geology, landscapes, and hydrology. These qualities have been preserved due to a variety of factors including the preservation of open spaces, such as intact contiguous forest and wetlands, sustained active agriculture, statutory and regulatory protections, and relatively low-level development. From a geological perspective the watershed is interesting as it lies on the boundary of the Highlands and Piedmont physiographic provinces which includes some calcareous geologic formations. The watershed is inhabited by a variety of sensitive plant and wildlife communities including threatened and endangered species and other species that merit special protection such as trout.

Despite the quality of the watershed and the stream Sidney Brook is not pristine and the characterization efforts of this study highlight these impairments. For the most part, the impairments in the stream are related to the generation of nonpoint source (NPS) pollution in stormwater runoff related to existing development patterns, the loss of buffer habitat or buffer quality, and increased hydraulic loading to the stream which contributes to bank erosion and sediment deposition.

Sidney Brook has dual designations under the NJDEP Surface Water Quality Standards (N.J.A.C. 7:9B, SWQS): the portion of the stream upstream or west of Route 513 is designated FW2-TM Category One, while the downstream portion of the stream and watershed east of Route 513 to the confluence with the South Branch is classified as a FW2-NT Category One waterbody. More specifically the stream has a general surface water classification as a Freshwater 2 (FW2). In 2007 the section of the stream in Union Township (upstream of Route 513) was re-designated as a Trout Maintenance (TM) stream based on evidence of holdover trout populations observed in the stream. Due to this designation Sidney Brook is held to higher water quality standards in the TM portions of the watershed than the Nontrout (NT) waters. As such, Sidney Brook shall maintain lower water temperatures, particularly during the summer months, and maintain higher dissolved oxygen concentrations necessary to sustain a coldwater fishery.

Sidney Brook was designated a Category One or C1 waterway in 2003 based on a combination of exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resources. Each of these categories in turn has been narrowly defined and Sidney Brook was included in part because it is known bog turtle habitat and has outstanding benthic macroinvertebrate scores (either NJIS or HGMI) and fishery resource scores (FIBI). C1 designation is used as an antidegradation policy to protect such waters from "any measurable changes in water quality". C1 protection is implemented in several ways and through a variety of technical regulations and rules, however the most familiar protections are afforded through the establishment of 300 foot riparian buffers named Special Water Resource Protection Areas under the Stormwater Management Rules (N.J.A.C. 7:8) and the Riparian Zone buffers under the Flood Hazard Area Control Act (N.J.A.C. 7:13). It must also be noted that these regulations extend to all tributaries within the same subwatershed or HUC14 or upstream of the designated reach. These buffers are projected from both sides of the stream; in streams with well defined banks the buffer starts at top-of-bank and in poorly defined channels from the centerline of the stream.

The majority of the Sidney Brook watershed is also located in the Highlands as designated by the Highlands Water Protection and Planning Act (N.J.S.A. 13:20-1 et seq.). More specifically, this includes the portion of the watershed west of Rt. 513 and includes areas within both the Preservation and Planning areas. Union Township is included in the Highlands Region while Franklin Township is not. The Highlands Council designated the Sidney Brook watershed as a Low Value Watershed primarily based on the high percentage of agricultural uses and development. The watershed was also characterized as having Moderate Riparian Zone Integrity because the 300 foot riparian zones are primarily intact forest and wetlands with some agricultural uses.

In order to preserve, protect, and enhance the water quality and stream services of Sidney Brook and the watershed, Union Township, as the applicant in a partnership with various parties, sought and was awarded a 319(h) grant in response to a State Request for Proposal to develop, implement, and prepare the Sidney Brook Watershed Protection Plan. Project partners for the task include:

- Franklin Township Environmental Commission
- New Jersey Water Supply Authority
- Hunterdon County Planning Board

The overarching goals of the Sidney Brook Watershed Protection Plan are simple:

1. Identify and inventory each type of resource area.
2. Evaluate the integrity of each type of resource area:
   - Document the existing water quality and the ecological integrity of Sidney Brook, its riparian zone, and sensitive critical habitats
3. Establish resource protection measures:

- Identify strategies and actions to protect Sidney Brook and reduce non-point source pollution, and thereby improve the water quality of this Category One (C1) water resource.
- Promote the enhancement and mitigation of identified water quality and other environmental issues in the watershed.

4. Establish programs to promote consistent standards for the protection, restoration, and acquisition of important waters and Riparian Areas of the Highlands Region:
   - This watershed plan has utilized standards, policies and protocols established by the NJDEP, USEPA, Highlands Council, and the NJ Water Supply Authority to characterize the watershed resources, and to identify and prioritize potential protection and mitigation strategies.
   - In addition, the plan recommends additional public educational and outreach programs that specifically address the issues for the Sidney Brook Watershed including non-point source pollution and improved land stewardship practices.

The comprehensive characterization of Sidney Brook and its watershed is a crucial component in the formation of this document for a variety of reasons. Up to this point the stream had not been systematically studied or monitored, although the Bureau of Freshwater and Biological Monitoring has conducted both fish and benthic macroinvertebrate sampling at the creek, both of which confirmed high water quality and ecological value. As of this date, Sidney Brook has not been included in the recent *New Jersey Integrated Water Quality Monitoring and Assessment Report* (i.e., the 303(d) and 305(b) Integrated List), indicating insufficient information to determine designated use attainment.

The formal comprehensive monitoring performed by Princeton Hydro was accomplished from a period beginning in 2008 and continuing into 2010, although the vast majority of the work was completed in 2008. A variety of impairments were identified in the characterization phase. One of the most severe impairments was documented in the *Escherichia coli* (*E. coli*) data, an indicator of microbial/viral pathogen contamination associated with fecal coliform loading. Coliform loading is a widespread problem in the area and myriad sources, such as septic systems, livestock, and waterfowl, may be major contributors. In Sidney Brook excessive concentrations of *E. coli* were ubiquitous at all sampled stations and during the majority of events pointing to the seriousness of the issue as well as non-attainment of primary and secondary contact recreation. In-stream temperature exceedance of SWQS were recorded at several stations, especially those immediately downstream of online impoundments which represents significant thermal stressors on coldwater biota as well as barriers to migration. Other impairments were noted in Total Phosphorus concentrations, the primary indicator of anthropogenic eutrophication, as well as Nitrate, Soluble Reactive Phosphorus, and Specific Conductance in the headwaters.

The Visual Assessment of Sidney Brook was a major component in identifying on the ground impairments in the stream and riparian corridor. More specifically, a variety of components were surveyed in the field including wetland and riparian vegetation communities, riparian corridor integrity, bank stability, visual habitat assessment of in-stream habitat including substrate and cover, and stormwater infrastructure. A variety of impairments were noted including extensive erosion, the accumulation of debris, sedimentation, numerous stormwater outfalls, impacted buffers with a variety of developed land uses including residential and agricultural, numerous invasive species, and several online impoundments. This thorough knowledge of the condition of the stream corridor is crucial to developing tailored solutions to address specific, identified issues and will be strongly utilized in the development of management measures.

While impairments are noted in the function of Sidney Brook, water quality and other processes including biological utilization is in fact generally good in the watershed and the creek. Despite moderately high water quality coupled with policy and regulatory protections Sidney Brook stands at a critical stage. While stream quality has only been loosely assessed up to the start of this project it does seem that the available indices may indicate a decline in water quality over time that is commensurate with increasing development in the watershed. Furthermore, small increases in nutrient loading, thermal regime, and modifications to channel morphology and sediment transport in the stream could spell major changes in water quality and physical changes to the habitat which would alter biological communities. Looking ahead there is mounting development pressure in Hunterdon County which could threaten stream health and make mitigation of the stream more difficult, although regional planning efforts embodied by the *Highlands Regional Master Plan* (Highlands Water Protection and Planning Council, 2008), which this plan seeks compliance with, should help alleviate some of these pressures.

This Watershed Protection Plan therefore functions as a guide to satisfy the third goal above: resource protection from degradation and enhancement. This document will be formatted to address in order the nine elements of a Watershed Protection Plan as laid out by the EPA. These nine elements are meant to address all phases of a protection plan from characterization to conceptual mitigation and practical design, costing, and implementation and evaluation. The following list represents a summarized and abbreviated description of the nine elements as outlined in the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA, 2008).

1. Identification of causes of impairments and pollutant sources
2. An estimate of load reductions expected from management measures
3. A description of NPS management measures and implementation sites
4. Estimate the amount of technical and financial assistance to implement
5. Information and education of the public and inclusion in plan development
6. Schedule for implementing the NPS management measures
7. A description of interim measurable milestones for implementation
8. Developing criteria to determine loading reduction and achievement of standards
9. Monitoring to evaluate implementation effectiveness utilizing developed criteria

By addressing these elements a thorough and comprehensive plan can be created that in the end will affect improvements in water quality and ultimately improve stream function. This document is therefore based on several key concepts that are implicit in the stated nine elements: characterization and assessment is based on the best available science and data, public participation of residents and stakeholders is tantamount to success, design and implementation must be thoroughly addressed and planned, and the proper performance and implementation of management measures is met through monitoring and adaptive management.

2.0 Watershed Characterization

This section begins to describe in detail some of the pertinent characterizations of the watershed, such as geology, soils, and land use, as well as regulatory considerations such as municipal environmental ordinances and environmental policies. This section in particular acts in part as an environmental resource inventory. This section, in conjunction with following sections, serve to document the impairments in the watershed and roughly correspond with the first of the nine USEPA elements for a watershed protection plan, identification of impairments. Section 8.0 will succinctly summarize the identified impairments outlined in Sections 2.0 through 7.0 that will serve as the basis to develop mitigation strategies to the environmental function and value of Sidney Brook and its watershed.

2.1 Study Area

Sidney Brook is an FW2-TM(C1) and FW2-NT(C1) steam located in Hunterdon County, New Jersey that discharges directly to the South Branch Raritan River within Franklin Township (Appendix I Figure 1). The watershed encompasses portions of Union and Franklin Townships for a total watershed area of nearly 3,522 acres or 5.50 square miles. The watershed of the creek drains portions of the HUC14 subwatershed 02030105020070. The watershed is located directly south of Interstate 78 and is bisected by County Route 513.

2.2 Municipal Environmental Ordinances

The municipalities in the Sidney Brook watershed have been proactive in protecting and preserving the environment as policy and codifying this in ordinance and regulation. NJDEP adopted Phase II Stormwater Rules in 2004 which issued a series of Statewide Basic Requirements (SBR) that seek to minimize NPS pollution and impacts. Both municipalities in the watershed are characterized as Tier B for smaller municipalities. These municipalities have adopted a variety of measures that meet or exceed Tier B SBRs. These municipalities have also adopted ordinances to a greater or lesser degree, which will be discussed in greater detail elsewhere, concerning the following topics:

- Stream Corridor Protection
- Stream Buffers
- Floodplain Protections
- Woodlands Protection
- Steep Slopes
- Threatened and Endangered Species/Critical Habitats
- Groundwater Protection

2.3 Demographics

The following demographic assessment for Union and Franklin Township represent the entire area of the respective townships including portions of the municipalities outside the Sidney Brook watershed (Table 1). Based on the US Census Bureau and the Hunterdon County Planning Department data, the population in Union Township grew by 1,082 from 1990-2000 to a total 6,160, representing an increase of 21%. From 2000 to 2010 the population actually declined by 4% in Union Township, in contrast to the County predictions of 20% growth. Growth was lower in Franklin Township, with a 5% population increase to 2,990 from 1990-2000. In the following decade the population grew by 7%, relatively close to the 5% projected growth. Overall Hunterdon County experienced a population growth of 13% from 1990-2000 and was predicted to grow by 12% by 2010, but instead only achieved a growth of 5%. The differences between actual demographics versus population projections are likely related to the economic downturn in the latter part of the last decade. The 2004 Build-Out Estimate, which is based on potential development relative to zoning and other land use ordinances and regulations still indicate the potential for significant population growth in the area. In any case the continued growth of both Franklin Township and Hunterdon County as a whole indicate the continuing development pressure related to the regional proximity to the New York metropolitan area and major infrastructure corridors, as well as the desirability of the area. It is important to note that the census data for Union Township may include inmate populations within the Hunterdon County Developmental Center and Edna Mahan Correctional Center.

Table 1: Sidney Brook Watershed Demographics

	1990	2000	2010	% Change 1990 to 2000	% Change 2000 to 2010	Estimate 2020	% Change 2000 to 2020
Union Township	5,078	6,160	5,908	**21%**	**-4%**	8,958	**45%**
Franklin Township	2,851	2,990	3,195	**5%**	**7%**	3,289	**10%**
Hunterdon County	107,776	121,987	128,349	**13%**	**5%**	152,889	**25%**

Source: U.S. Census, 1990, 2000, 2010. Calculations by Hunterdon County Planning Board, 2003
Revised per Build-Out Estimates by the Hunterdon County Planning Board, May 2004
http://www.co.hunterdon.nj.us/pdf/hcpb/databook/Population.xls

2.4 Geology

The Sidney Brook watershed is located along the margin of the Piedmont and Highlands physiographic provinces. The bedrock geology of the Highlands and Piedmont is variable and complex. The Highlands Physiographic Province is characterized by a series of parallel ridges and valleys. The ridges are composed primarily of igneous and metamorphic rock including gneiss, a very hard and weather resistant rock that tends to form broad, flat topped ridges. With the exception of fractured or weathered areas, these rocks are generally unproductive aquifers. The valleys are composed of softer rocks including limestone (carbonate rock) and shale and tend to have steep slopes but are relatively narrow (Hunterdon County Smart Growth Plan, 2007). A majority of the formations and rock types in the Piedmont Province are a part of the Newark basin supergroup and include the Passaic formation, the Lockatong formation, the Stockton formation, and basalt and diabase. The majority of the watershed lies within the Piedmont Province where formations of weathered shale, mudstone, sandstone, and their cemented conglomerates form the bedrock with overlying glacial deposits. Along the border of the Highlands and Piedmont regions, the Stockton, Lockatong and Passaic formations grade into conglomerates. Conglomerates are rocks composed of gravel and stone cemented together by other material. Most contacts and form lines are oriented NE-SW.

The western and southern portion of the watershed includes the Lockatong Sandstone Formation and Sandstone Conglomerates (Trlcq and Trls) (Appendix I Figure 2). The eastern and southeastern section includes the Stockton Formation and Cobble conglomerates (Trss and Trscq). The central and northern section of the watershed includes the Jutland Klippe Sequence (OCjta and OCjtb). A klippe is a remnant portion of a mountain or ridge, where over time erosion has removed the connection to the original ridge isolating the remnant klippe. The Jutland Klippe Sequences includes interbedded red and green shales, siltstones, quartz pebble conglomerates, and dolomites, and limestone conglomerates. Carbonate formations, including dolomites and limestone, are generally good sources of well water. However, the unique easily weathered nature of these formations creates opportunities for ground water contamination. In addition, carbonate rock poses risks to buildings and infrastructure because of the potential for land surface collapse and sinkhole formation.

The Stockton Formation is the coarsest-grained formation in the section, consisting of medium to coarse-grained arkose sandstones, which can be purple, white, and red sandstone, siltstone and quartzite conglomerates of the Stockton formation. The Lockatong Formation consists of mostly gray and black shale and siltstone, with subordinate purple and red mudstone (shale + siltstone). The lower Stockton Formation is a mostly fluvial deposit (that is, it was deposited by rivers). The upper Stockton and lower Lockatong formations represent lacustrine strata in which the lake deposits got progressively deeper.

Due to faulting along the contact zones between the Highlands and Piedmonts, several unique formations can be found including the weathered carbonate rock, glacial till, upper and lower terrace deposits, alluvium and colluvium deposits. The weathered carbonate rock formations are the least abundant and correlate directly to the limestones of the Beakmantown group and the Allentown formation. The glacial till deposits are generally pockets of the Port Murray Formation, and the materials are deeply weathered and thin. Upper and Lower Terrace deposits include mixtures of glacial outwash, till deposition, and latter age erosional deposits (alluvium and colluvium). In the Piedmont areas, the alluvium deposits include bedded, sands, silts, clays, and gravels related to flooding and river course meandering. These deposits can be to 20 feet thick.

2.5 Groundwater Aquifers

An aquifer is a geologic formation capable of storing water, which is frequently accessed via wells to supply potable water in many rural communities including the Sidney Brook watershed. Groundwater is stored in fissures, fractures, and voids in the rock. The permeability of the bedrock and its ability to serve as an aquifer of significance largely depends on the extent and degree of interconnection or the porosity of the formation. More permeable formations facilitate the travel of groundwater. Conversely "tighter" formations, lacking extensive or well defined interconnection in the rock, are considered non-porous.

The Sidney Brook watershed primarily overlies three aquifers, the Lockatong Formation conglomerate, the Stockton conglomerate, and the Martinsburg Formation aquifer (Appendix I Figure 3). The quality of water is generally suitable for drinking and other uses, but locally can be high in iron, manganese, and sulfate (Trapp and Horn, 1997). The sandstone, siltstone, shale, and limestone formations, including the Kittany Limestone, Jacksonburg Limestone, the Martinsburg shale, and Stockton Formation, are relatively soluble and will provide water with relatively high concentrations of dissolved solids with hardness averaging 160 mg/$CaCO_3$ (indicative of hard water), and a median pH of 7.6. Moderate to large supplies of water can be obtained from the Stockton Formation and Hardyston Quartzite (Kasabach, 1966). Aside from the drinking water quality, this type of rock may also contribute to somewhat elevated solutes concentrations in surface waters, particularly tributary baseflow.

Well yields tend to be better in the glacial sand and gravel till than those in the Lockatong formation, but not as good as the Stockton or Brunswick shale formations. As with the Stockton formation, conglomerates tend to occur in moderately sloping, topographically high areas. Aquifers in this province yield water from the fractures in the bedrock, and productive sand and gravel aquifers in the glacial deposits.

- The Lockatong Formation will usually produce very low yields, and the chance of obtaining yields greater than 50 gallons per minute (gpm) is slight. The less soluble formations, including those containing igneous and metamorphic rocks, and Lockatong argillite, will provide water that has a lower dissolved solids concentration with hardness averaging 63 mg/L CaCO3, and a pH of 6.7. The Kittany Limestone aquifers have the potential to yield large amounts of water if wells intersect solution cavities. However, as discussed previously, carbonate formations are susceptible to contamination.
- The Martinburg Formation-Jutland Sequence includes claystone slate, siltstone, and sandstone, with minor limestone and dolomite formations, where groundwater is stored and transmitted through fractures.
- The Stockton Formation Conglomerate includes predominantly medium to coarse grained arkosic sandstone with some silty mudstone, argillaceous siltstone, and shale sandstone formations, where water is stored and transmitted through fractures. Moderate to large supplies of water can be obtained from the Stockton Formation and Hardyston Quartzite (Kasabach 1966).

The USGS reports that aquifers present in the Piedmont Physiographic Province and Newark Basin consist of shale, siltstone and sandstone. Water generally is present in weathered joint and fracture systems in the upper 200 or 300 feet. Below a depth of 500 feet, fractures are fewer and smaller, and water availability is reduced, depending on rock type. In coarse-grained sandstones, groundwater also is present in intergranular pore spaces. These shale and sandstone aquifers are generally productive aquifers.

The New Jersey Geology Survey (NJGS) defines sole source aquifers as those aquifers that contribute more than 50% of the drinking water to a specific area, and would be difficult to replace if the source was lost through contamination or a change in hydrology. The guidelines for sole source aquifers were developed by the USEPA and are authorized in section 1424(e) of the Safe Water Drinking Act of 1974. The USEPA is required to review all proposed federally funded projects that could affect groundwater in a sole source aquifer. All of the aquifers in the watershed are within the boundaries of the New Jersey 15 Basin Sole Source Aquifer. The New Jersey 15 Basin Sole Source Aquifer is 1,735 square miles and contains portions of Hunterdon, Mercer, Middlesex, Morris, Passaic, Somerset, Sussex, and Warren Counties New Jersey and Orange County New York (USEPA, 1988).

2.6 Groundwater Recharge

Groundwater recharge represents the net amount of water that infiltrates through the soil below the root zone, being technically defined as groundwater once reaching the saturated zone. The ability for water to infiltrate through soils into the underlying aquifer is directly influenced by the amount of impervious cover that includes roof tops, parking areas, and roadways, which can preclude infiltration. Infiltration is also influenced by the type and density of vegetation, slope, and soil properties including the presence of confining layers such as fragipans or clay lenses. The quantity of groundwater that ultimately infiltrates into the aquifer is based on the characteristics of the underlying geology, such as the permeability and porosity of the formation.

Groundwater recharge depicted in Appendix I Figure 4 is obtained from the New Jersey Geological Survey (NJGS) GSR-32 methodology. This methodology estimates groundwater recharge based upon modeling using land use, soil characteristics, and precipitation data to estimate of groundwater recharge in inches per year. A single soil unit may have several rates based on slope, proximity to wetlands, and land use. Hydrogeologists recognize that the volume of water that will actually recharge the deeper potable groundwater aquifers is considerably less than the volumes estimated using the GSR-32 method. Most infiltrated water in this area seeps or discharge as baseflow into streams and surface water features including wetlands. As such, the data presented in is not a reflection of the amount of bedrock aquifer recharge, but merely the potential shallow recharge through the upper soil horizons to a point below the root zone. Indeed, baseflow in streams, the normal discharge regime not fed by surface runoff during storm events, is entirely sustained by shallow groundwater flows thus necessarily reducing recharge to bedrock aquifers. General hydrology modeling in the area further indicates that most shallow groundwater is discharged to stream systems and that relatively little enters the aquifer.

New Jersey receives approximately 45 inches of precipitation each year and approximately 50% can return to the atmosphere through evaporation and through transpiration from plant leaves. Surface runoff also accounts for a large fraction of total precipitation leaving a small percentage that infiltrates. The data provided by NJGS indicates groundwater recharge in the majority of the watershed ranges from 12 to 18 inches per year; bedrock aquifer recharge is expected to be considerably less.

2.7 Soils

Soils are derived largely from the weathering of underlying geologic formations. Soil characteristics such as particle size (e.g., sand, silt, and clay), water-holding capacity, and nutrient content are factors determined by the underlying bedrock, topography, and hydrology. In turn, microorganisms, plants and other biotic communities, and climate, collectively referred to as soil forming factors, affect and contribute to soil formation. The Soil Survey Geographic Database (SSURGO) is maintained by the Natural Resources Conservation Service (NRCS), an office within the US Department of Agriculture (USDA). The corresponding soil figure (Appendix I Figure 5) depicts the SSURGO soil unit data for the watershed. The soil characterization process is directed by nationwide uniform procedures that account for particulate composition and size (clay, silt, and sand), stratification, and topography. These soil units are also characterized by crop suitability, compaction, strength, shrink-swell potential, available water capacity, erodibility, and permeability.

The soils of the watershed belong to four soil associations. The Rowland-Birdsboro-Raritan association, described as deep, nearly level to gently sloping soils that are somewhat poorly to well-drained, and located on floodplains and terraces. The Parker-Edneyville-Califon association soils are deep, gently to steeply sloping, somewhat poorly to excessively drained, gravely, cobbly, or stony soils located on uplands. The Pattenburg association consists of deep, gently to steeply sloping soil, well drained, gravelly soils located on uplands. Finally, the Washington-Berks-Athol association is composed of moderately to deep, gently sloping to steep, well-drained soils that are found on uplands.

Many of the soils of the watershed that are associated with wetlands or are adjacent to surface waters have a shallow (< 3 feet) depth to seasonal high water table. Such soils include alluvial, Bowmansville, Califon, Chalfont, Lansdowne, Raritan, Rowland, and Turbotville. The soils of the watershed, with the exception of Klinesville and Penn soils, have a moderately deep to deep depth to bedrock (3 feet to 10+ feet). Klinesville and Penn soils have a depth to bedrock of 1 to 1.5 and 1.5 to 3.5 feet respectively.

The Hunterdon County Soil Conservation District lists 32 prime farmland soils in Hunterdon County. Among these are a number of soils that commonly occur in the watershed including: Annandale, Bedington, Birdsboro, Bucks, Califon, Duffield, Edneyville, Meckesville, Norton, Pattenburg, Penn, Quakertown, Raritan, Riverhead, Turbotville and Washington.

The Hunterdon County Soil Conservation District lists 36 soils of statewide importance in the county. The watershed contains 20 of them including several mapping units of the following series: Annandale, Bedington, Berks, Birdsboro, Bowmansville, Bucks, Califon, Chalfont, Duffield, Edneyville, Hazleton, Lansdowne, Meckesville, Norton, Parker, Pattenburg, Penn, Quakertown, Riverhead and Washington.

Chapter 30 Land Use Ordinances for Union Township regulate development on prime agricultural soils. The Township divides the agricultural soils into three classes with differing development restrictions on each class. Development is limited to 10% of the area containing Class I soils. Class II soils have development restricted to 15% of the area on which they are contained. Finally, no more than 20% of the area containing Class III soils can be developed. The Township's Land Use Ordinances, in §30-2, defines agricultural soils as those classified in the Hunterdon County Soil Survey of November 1974 as land capability classes I, II, and III. Such soils may be considered prime agricultural soils.

2.8 Erodible Soils

Appendix I Figure 6 depicts erodible soils, which also generally correspond with the areas of steep slopes. The NRCS utilizes the Universal Soil Loss Equation (USLE) model to predict soil erodibility. The USLE utilizes six different variables to predict erodibility including: Rainfall and Runoff Erosivity Factor, Soil Erodibility Factor, Slope Length Factor, Slope Steepness Factor, Cover Management Factor and Erosion Control Factor. The NRCS groups soil erodibility in four categories: Highly Erodible Land (HEL), Potentially Highly Erodible (PHE), Not Highly Erodible (NHE), and Unclassified or Not Available (NA). In general, areas of Highly Erodible soils correspond with the areas of steep slopes. Not Highly Erodible and undefined soils are found along the low lying floodplains. The vast majority of the watershed is comprised of Potentially Highly Erodible soils followed by Highly Erodible soils. Not Highly Erodible soils were confined to floodplains.

Agriculture, construction, and development can exacerbate erosional problems. Erosional problems can reduce agricultural productivity, cause streambank instability, and deposit sediment in streams and ponds. Erosion and sedimentation degrades water quality causing streams, lakes, and ponds to be turbid. Suspended sediments can impair gill function in fish and aquatic insects, smother spawning beds, fill interstitial habitats in the sediment, and decrease light penetration thereby imposing a negative effect on photosynthesis by phytoplankton, benthic algae and aquatic plants (macrophytes). Turbidity can also contribute to heat absorption which can affect sensitive aquatic species such as trout. Resuspension of the resulting sediments deposited in streams can exacerbate the scour and erosion of the stream channel and promote the physical degradation of flowing waters. Finally, eroded soils serve as vectors for certain pollutants, often transporting adhered or absorbed contaminants such as metals, pesticides and nutrients. The transport of phosphorus in particular is closely linked to sediment transport in streams and is usually the greatest contributing source.

Soil Erosion and Sediment Control Plans are addressed in §30.25 of the Union Township Land Use Ordinances. According to this section, such plans are required to minimize erosion and sedimentation promoted by development and caused by water runoff, soil disturbance, destruction or removal of ground cover or plant life, and grading and filling. Minimizing soil erosion and sedimentation can help maintain the useful life of reservoirs by limiting infilling, reduced flooding in catch basins and other stormwater BMP's, preserve recreational uses and maintain stream and lake biota among other benefits. Erosion can be minimized by restricting development and disturbances on steep slopes greater than 15-20% and maintaining vegetative cover, in accordance with the Highlands and municipal policies. Soil Erosion and Sediment Control Plans must be reviewed and certified by the Township Engineer and approved by the Planning Board.

2.9 Septic Suitability

The residents in the watershed are primarily served by individual on-site septic systems; however the local soils, slopes, shallow water tables, and shallow bedrock can pose various limitations for septic suitability. The NJDEP utilizes the NRCS classifications to describe soil properties that limit septic suitability within N.J.A.C. 7:9A. Septic Restrictions are classified as slight, moderate, severe, or undefined based on six specific limitations as follows: fractured rock or excessively coarse substrata, massive rock or hydraulically restrictive substrata, hydraulically restrictive horizon or permeable substratum, excessively coarse horizon, regional zone of saturation, or perched zone of saturation. Appendix I Figure 7 is based upon these NRCS classifications and depicts areas where development may be constrained by septic limitations based on the NRCS soil classifications for septic suitability.

Septic system performance is limited by a variety of factors, most of which are linked to local soils and geologic properties including: proximity to surface waters, slope, depth to seasonal high water tables, depth to bedrock, and soil composition. Soil composition is an important factor in determining wastewater percolation rates, which is the movement of water infiltrating the soil to groundwater sources. Soil percolation can be limited by heavy clay content, which reduces permeability, a fragipan or a stratified dense clay layer, coarse rock fragments or compaction. Septic restrictions are based upon the factors that limit the performance of septic systems.

The majority of the watershed, particularly the Union Township portion, is designated as having severe restrictions. The watershed areas designated with the most severe restrictions for septic suitability include: Main Street, the Wolf Farm Road Development, Race Street, Grandin Road and much of the lower watershed located in Franklin Township. High fecal coliform levels were recorded in the stream by these roadways. It should be noted that the occurrence of soils limited for septic suitability does not preclude the development of such areas. Special septic designs and the construction of septic leach fields using imported, select fill, and raised mounds will likely be required in these areas in order for the septic system to satisfy County health codes and State design regulations. The septic systems servicing developments that pre-date the advent of State and County septic design requirements may be sub-standard and could be impacting local surface and groundwater resources.

Onsite septic systems need to be properly maintained and septic tanks should be pumped out routinely. Septic effluent is nutrient rich, high in minerals and salts, has elevated organic content, and is laden with pathogens. If improperly treated, the seepage of wastewater into surface waters can negatively impact water quality and recreational uses. Septic discharge is also regarded as a threat to drinking water, including both surface water and groundwater sources, due to the presence of bacteria and linked pathogens that pose a risk to human health.

2.10 FEMA Floodplains

The Federal Emergency Management Agency (FEMA) issues floodplain maps that describe flood events in the 100-year and 500-year flood zones (Appendix I Figure 8). These areas are based upon exceedance probabilities and not explicit periodicity of flood events. The 100-year floodplain is also known as the Special Flood Hazard Area, and these areas are also split into two designations. Zone AE represents the 100-year floodplain for which Base Flood Elevations (BFE) have been established; the BFE is based on detailed area-specific hydraulic analyses and is tied to vertical datum. Zone A, which has no BFE, is based on area topographic models of flooding.

In Sidney Brook, Zone A encompasses a relatively small section of the stream, specifically the section of the stream immediately upstream of the railroad crossing southwest of Jutland Lake and continuing along the southern branch and extending slightly past the Perryville Road crossing. The remainder of the main stem of Sidney Brook (downstream of the rail crossing) is classified as Zone AE indicating established base flood elevations, but is described only along the USGS Blue Line streams and not the mapped Soil Conservation Service (SCS, now called NRCS) streams. Zone X500 or 500-year floodplains have also been established for portions of the main stem. It is interesting to note that agreement between the mapped stream layers and the flood zones are not perfect; this is especially evident in the area around Hilltop Lane and near the mouth of Sidney Brook where the channel is outside the flood zone. This type of error is likely an error of scale and outdated data. The streams layer can be safely assumed to be correct with the deficiency in accuracy attributed to the FEMA maps, which indicates that FEMA mapping is not a definitive reference for establishing flood areas.

2.11 Steep Slopes

The Highlands RMP recommends that development and disturbances are restricted on areas with slopes greater than 20%. Vegetation holds the soils in place and intact mitigating the erosive forces of precipitation and wind. When development and regrading occurs, vegetation is removed and soils on steep slopes become prone to erosion. Erosion in turn can degrade water quality through high turbidity/poor clarity, sediment deposition, and additional pollutant loads of contaminants bound to soil particles. Areas of steep slope should remain forested in order to minimize erosion, stormwater concerns and habitat loss. Appendix I Figure 9 identifies those areas in the watershed with slopes greater than 10-20%, which are located primarily in Union Township. Based on this mapping the majority of the watershed is gently rolling with slopes less than 10%. Upon review of the land use land cover mapping, much of these steeply sloping areas remain as forest.

The Township of Union's Chapter 30, Land Use Ordinance, regulates development on sloped land. According to Section 30-6, lands with slopes equal to or greater than 10% are considered steep. For land with slopes of 10%-15%, the ordinance mandates that no more than 35% of these areas be developed and/or re-graded and stripped of vegetation. Development of areas with 15%-20% slopes is limited to no more than 20%. Finally, development is limited to 10% in those areas characterized by slopes of 20% or greater. Detailed grading plans including runoff calculations must be provided for development in areas with slopes greater than or equal to 15%.

2.12 Land Use/Land Cover

Land Use/Land Cover (LU/LC) is a two-tiered classification system that systematically defines similar land areas according to land utilization and vegetative structure. The NJDEP, like the USEPA, uses a modified Anderson Classification schema (Anderson 1976). The dataset was created by combining existing information about land use and photo-interpretation of aerial photographs. Information presented in this report is based on the 2002 aerial and database, the most current available coverage (Appendix I Figure 10). The age of the data is of some concern and new developments have been completed or are underway including the Union Township Elementary School and the Renaissance Development. Despite these issues the level of change in the watershed is relatively modest and no significant change in general land uses patterns is expected. As a point of comparison the NJDEP 2007 aerial map is enclosed as Appendix I Figure 1. The 2007 LU/LC is currently being developed, but has not yet been publically released.

Land use and land cover (LU/LC) is usually the primary determinant of water quality in most stream systems. Water quality deteriorations are usually closely associated with the level of development in a watershed and are specifically tied to the amount of pervious surface, disturbed soils, non-native vegetation, and the generation of a variety of pollutants that are then delivered via stormwater runoff that contribute to erosion, sedimentation, nutrient enrichment, and a general increase in the concentration of pollutants thereby resulting in a loss of ecologic and hydrologic function. Typically, development is simply thought of as urban land uses, such as residential, commercial, and industrial development as well as supporting infrastructure such as roadways and utilities, although the degradation of water quality is observed when there is any deviation from natural LU/LC such as forest and wetlands, and therefore a discussion of the level of development must account for other land uses that qualify as disturbances or alteration to natural LU/LC such as agriculture. While the Sidney Brook watershed may be rightly thought of as a rural watershed, there are a variety of land uses, including agriculture, barren land and urban lands at 58% of the land mass, which have accelerated pollutant loading relative to forests and wetlands. This is an indication of the potential elevation of pollutant loading within the watershed.

Table 2: Watershed LU/LC

Land Use/Land Cover	LU/LC Type	Area (Acres)	Percent Area (%)
Cropland and Pastureland	Agriculture	1087.78	30.9
Deciduous Forest	Forest	805.55	22.9
Residential, Rural, Single Unit	Urban	612.63	17.4
Wooded/Scrub/Shrub Wetlands	Wetlands	218.44	6.2
Brush/Shrubland	Forest	151.30	4.3
Commercial/Services	Urban	95.75	2.7
Old Field	Forest	94.37	2.7
Other Built-Up Land/Basins/Cemetaries	Urban	83.00	2.4
Mixed Forest	Forest	55.25	1.6
Current and Former Agricultural Wetlands	Wetlands	44.49	1.3
Other Agricultural Areas	Agriculture	43.54	1.2
Herbaceous Wetlands	Wetlands	40.14	1.1
Barren Lands including Extractive Mining	Barren	37.30	1.1
Plantation (Forest)	Forest	28.86	0.8
Recreational Land	Urban	26.54	0.8
Transportation/Utilities/Rights-of-Way	Urban	26.20	0.7
Water	Water	24.15	0.7
Residential, Single Unit, Low Density	Urban	18.70	0.5
Industrial	Urban	8.95	0.3
Managed Wetlands	Wetlands	6.41	0.2
Residential, Single Unit, Medium Density	Urban	4.64	0.1
Orchard/Vineyard/Horticultural Area	Agriculture	4.54	0.1
Coniferous Forest	Forest	3.85	0.1

As evidenced above (Table 2) Sidney Brook is rural agricultural watershed. On the whole, forested land uses account for 32.34% of the total watershed just above agricultural uses at 32.25%, however the single largest LU/LC code is for Cropland and Pastureland which accounts for 30.9% of the watershed. The next largest LU/LC code is Deciduous Forest at 22.9% and Rural Residential at 17.4%; all other individual LU/LC types account for less than 7% of the watershed. While urban, commercial, and industrial land uses are often implicated as the main contributors to NPS loading these less urbanized uses can also degrade stream quality and contribute to pollutant loading. It is generally true that these less intensely developed watersheds do have smaller loads of toxics such as metals and petroleum hydrocarbons, but rural watersheds are more likely to contribute nutrient pollutants and solids. Where agriculture is an important component of the makeup of the land it is typically the primary loader of phosphorus and nitrogen and may contribute large solids loads as well. Similarly, low density residential development may act in a similar fashion although the unit areal load may be smaller than agricultural uses. In the end, the loading related to residential and agricultural uses can contribute to eutrophication in streams as well as deposition of solids. Likewise, while the amount of impervious cover is low, even low amounts can affect the delivery of pollutants via stormwater and increased hydraulic loading which can lead to streambank erosion. The role of LU/LC will be examined in further detail in the pollutant load analysis and hydrologic modeling later in the document.

The analysis of watershed land uses also looked at lands within the projected 300 foot buffers adjacent to the entirety of the mapped tributary network (Table 3). While the overall land use of the watershed is important in determining stream function, the buffer areas are the most critical as they offer a variety of ecological services, including bank stabilization, stream shading, pollutant capture and habitat. Deviations from forested or wetland cover in these areas can lead to significant loss of these functions and should therefore be accounted. In the Sidney Brook watershed the area contained in stream buffers accounts for over 42% of the total land mass (Appendix I Figure 11). For the most part the general land use in these areas mirrors that in the rest of the watershed when expressed as a percentage; however there was a significant reduction of agriculture in the buffer areas, a smaller reduction in urban lands and a large increase of wetlands. Overall, the composition of the riparian buffers is somewhat better than the watershed as a whole, but disturbed or developed land uses still account for nearly 45% of the buffer areas, which represents a significant disturbance of these buffers.

Table 3: Buffer LU/LC

Land Use/Land Cover	LU/LC Type	Area (Acres)	Percent Area (%)
Cropland and Pastureland	Agriculture	338.41	22.8
Deciduous Forest	Forest	333.67	22.4
Residential, Rural, Single Unit	Barren	212.30	14.3
Wooded/Scrub/Shrub Wetlands	Agriculture	203.98	13.7
Brush/Shrubland	Wetlands	97.61	6.6
Mixed Forest	Urban	36.48	2.5
Herbaceous Wetlands	Forest	35.54	2.4
Old Field	Forest	33.95	2.3
Current and Former Agricultural Wetlands	Urban	30.13	2.0
Other Built-Up Land/Basins/Cemetaries	Water	28.05	1.9
Barren Lands including Extractive Mining	Wetlands	26.74	1.8
Commercial/Services	Forest	26.43	1.8
Water	Urban	23.57	1.6
Other Agricultural Areas	Urban	16.65	1.1
Transportation/Utilities/Rights-of-Way	Urban	9.39	0.6
Plantation (Forest)	Forest	8.83	0.6
Residential, Single Unit, Low Density	Wetlands	8.57	0.6
Managed Wetlands	Wetlands	5.37	0.4
Industrial	Urban	3.56	0.2
Residential, Single Unit, Medium Density	Agriculture	3.15	0.2
Coniferous Forest	Urban	3.15	0.2
Orchard/Vineyard/Horticultural Area	Forest	1.01	0.1
Recreational Land	Urban	0.21	0.0

2.13 Landscape Project

In 1994, the NJDEP Division of Fish and Wildlife's (NJDFW) Endangered & Non-game species program adopted the Landscape Project approach for the protection of imperiled species within five distinct landscape region or habitat type including: grassland, forest, forested wetland, emergent wetland and beach/dune. The Landscape Project utilizes land cover data, an extensive database of rare species' locations, and their conservation status to delineate critical habitat patches. These Landscape Project maps were updated in 2008 to assist with the development of the Highlands Regional Master Plan and document the occurrences of rare, threatened, or endangered species using the most current LU/LC coverage (2002). Landscape Project Version 3.0 takes a somewhat different approach and utilizes the species-based patch approach in conjunction with habitat requirements rather than broader vegetation communities as the base metric.

The Landscape Project delineates critical habitat patches based on the species present and their conservation status which are ranked from common to most rare. Areas with federally threatened or endangered species receive the highest ranking (5), followed by state endangered (4), state threatened (3), state species of priority concern (2), and finally suitable habitat for more common species (1). This ranking system is described in Table 4 below and Figure 12 in Appendix I. Ultimately, this information can assist state, local and private agencies in prioritizing areas that could be preserved to protect habitat for rare species. This information also serves to alert officials to ensure that any future development minimizes disturbances to these critical habitat areas.

The NJDFW defines *Endangered Species* as those species whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance, or contamination. The NJDEP defines *Threatened Species* as those who may become endangered if conditions surrounding them begin to or continue to deteriorate. These threatened and endangered species are identified and protected in accordance with the Nongame Species Conservation Act. (N.J.S.A. 23:2A-1 et seq.) www.nj.gov/dep/fgw/spclspp.htm

Table 4: Landscape Ranks and Description

Rank	Title	Description
0	Non-suitable Habitat	Patches that do not contain any species occurrences and do not meet any habitat-specific suitability requirements
1	Suitable Habitat	Patches that meet habitat-specific suitability requirements such as minimum size criteria for endangered, threatened or priority wildlife species, but that do not intersect with any confirmed occurrences of such species
2	Priority Concern	Patches containing one or more occurrences of at least one non-listed State priority species
3	State Threatened Species observed	Patches containing one or more occurrences of at least one State threatened species
4	State Endangered Species observed	Patches with one or more occurrences of at least one State endangered species
5	Federally Listed Species observed	Patches containing one or more occurrences of at least one wildlife species listed as endangered or threatened on the Federal list of endangered and threatened species

Over 60% of the Sidney Brook watershed is mapped in the Landscape Project (Table 5). The largest single mapping unit is Rank 4 (State Endangered Species Observed) at 40.7% followed by Rank 0 or unmapped habitats. All ranks with the exception of Rank 2 were mapped in the watershed including Rank 5 for the occurrence of the Federally listed bog turtle (*Glyptemys muhlenbergii*). The preponderance of ranked lands in the Sidney Brook indicates that the watershed is critical habitat to many species including sensitive species, that a variety of distinct habitat types are located within the watershed, and that crucial habitat features, such as patch size and water quality, are sufficient to meet the needs of many species and of generally high quality. At the same time, nearly 40% of the watershed is unranked indicating that the level of development is high enough to discourage the use of a large portion of the watershed by imperiled species.

Table 5: Landscape Rank Area

Rank	Title	Area (acres)	Area (%)
0	Non-suitable Habitat	1398.97	39.72
1	Suitable Habitat	512.64	14.55
2	Priority Concern	0.00	0.00
3	State Threatened Species observed	134.73	3.83
4	State Endangered Species observed	1434.05	40.71
5	Federally Listed Species observed	41.98	1.19

The following table (Table 6) lists the animals found in the watershed. The diversity of taxa is remarkable and includes mammals, birds, reptiles, and amphibians. The habitat requirements of these listed species are also diverse and include forest, grassland, and wetland. This list is another indication of the mosaic of landscape types within the watershed as well the quality of these habitat types. Further strengthening the case for the quality of the watershed is that over 76% of the ranked areas are based on sightings of these imperiled species.

Table 6: Landscape Project Species and Rank

Common Name	Binomial Name	Rank
Bobcat	*Lynx rufus*	4
Bobolink	*Dolichonyx oryzivorus*	3
Bog Turtle	*Glyptemys muhlenbergii*	5
Cooper's Hawk	*Accipiter cooperii*	3
Eastern Meadowlark	*Sturnella magna*	3
Longtail Salamander	*Eurycea longicauda*	3
Savannah Sparrow	*Passerculus sandwichensis*	3
Vesper Sparrow	*Pooecetes gramineus*	4
Wood Turtle	*Glyptemys insculpta*	3

2.14 State Plan Designations and Consistency

Conformance in the Highlands Planning Areas is voluntary and development can comply with the Highlands RMP or the State Plan Policies. The New Jersey State Development and Redevelopment Plan, commonly known as the State Plan (Appendix I Figure 13), is a planning tool promulgated by the State Planning Commission and the Department of Community Affairs Office of Smart Growth. The State Plan is designed to provide a comprehensive development projection that balances growth and conservation. The State Planning Act states that, "environmental resources should be conserved because the protection of environmental qualities is vital to the quality of life and economic prosperity". New Jersey officials are encouraged to modify their plans to be consistent with the provisions of the State Plan.

The State Plan established five distinct Planning Area designations to help guide future growth based on natural resources, development patterns, and infrastructure. Planning Areas 1 to 5 include:

- Areas for Growth include: Metropolitan Planning areas (Planning Area 1), Suburban Planning Areas (Planning Area 2) and Designated Centers in any planning area.
- Areas for Limited Growth: Fringe Planning Areas (Planning Area 3), Rural Planning Areas (Planning Area 4), and Environmentally Sensitive Planning Areas (Planning Area 5). In these planning areas, planning should promote a balance of conservation and limited growth—environmental constraints affect development and preservation is encouraged in large contiguous tracts.

- Areas for Conservation: Fringe Planning Area (Planning Area 3), Rural Planning Areas (Planning Area 4), and Environmentally Sensitive Planning Areas (Planning Area 5).

The area north of Race Street, east of Perryville Road/Main Street, and west of Rt. 513, which lies within Planning Area 2, designated for suburban growth, while it is nearly evenly split between Protection and Conservation zones in the Highlands scheme.

The area south of the Highlands Preservation Area in Union Township and the western parts of Franklin Township moving east to Sidney Road is designated as Planning Area 4B- Rural/Environmentally Sensitive. This area is intended to support continued agricultural development. Residential homes are serviced by individual on-site septic systems, and a large area is preserved farmland and open space by Franklin Township. Therefore, future growth in this area is limited.

The remainder of the watershed in Franklin Township east of Sidney Road is designated as Planning Area 5-Environmentally Sensitive. The majority of this area includes floodplains, wetlands with the confluence of Sidney Brook and the South Branch of the Raritan River. Limited residential homes in this area are serviced by individual on-site septic systems. Much of this area is either preserved as open space or restricted floodplains, and therefore, future growth in this area is limited.

2.15 Open Space

Open space preservation has been a key planning tool in both Union and Franklin Townships to preserve the rural characteristics of the municipalities and maintain the ecological integrity and environmental services associated with open spaces. Open space preservation works through several means to protect the integrity of the watershed. Primarily, it preserves natural features that have important ecologic and hydrologic functions, including species diversity, habitat, pollution mitigation, groundwater recharge and stream baseflow. Second, it limits further development which is intrinsically tied to water quality and other ecological impairments. Third, it benefits the public by providing recreational opportunities and preserving the rural character of the watershed.

Open space preservation is accomplished through a variety of means and programs and may be sponsored at multiple levels of government. One of the major programs fostering open space preservation in Hunterdon County is the NJDA Farmland Preservation Program which encourages the sustained, active practice of agriculture on historic agricultural properties. Other open space preservation measures practiced on a municipal or county level include the outright purchase of targeted properties identified in open space plans for historic, recreational, or environmental reasons, and the creation of conservation easements or the transfer of development rights which do not include the actual purchase of the land but limit future uses or development.

In the Sidney Brook watershed, as of early 2009, 668 acres are preserved in farmland, open space, or conservation easements. While the open space in Franklin Township follows the main stream corridor upstream of Sidney Road, open space in the Union Township portion of the watershed is located mostly along the tributaries and, as a percentage, incorporates less riparian buffer area. The open space holdings are depicted in Appendix I Figure 14.

3.0 Highlands

The Highlands Water Protection and Planning Act (Highlands Act, HWPPA N.J.S.A. 13:20-1 et seq.) was signed into law in August 2004 to preserve open space and protect the state's greatest diversity of natural resources including the vital drinking water resources in this region. The Highlands Region is a vital source of drinking water for over half of New Jersey's 8.5 million residents, yielding approximately 379 million gallons of water daily for approximately 5.4 million people or 65% of New Jersey residents and businesses. In addition, over 70% of this region includes environmentally sensitive forests, wetlands, streams, and wildlife habitats, and hosts over 30 of the state's threatened and endangered wildlife species. The region also includes many sites of historic significance and provides abundant recreational opportunities.

The Highlands Act requires municipalities and counties to modify planning documents and regulations to conform to the Highlands Regulations (December, 2006) and the Highlands Regional Master Plan (RMP) adopted in July 2008. In the Preservation Area new major development must conform to very stringent environmental standards and zoning restrictions. These measures are voluntary for development in the Planning Area. In 2008, Union Township accepted a non-binding grant to determine potential measures and ramifications for Highlands compliance in their community.

Over-development is threatening the region's natural resources and critical drinking water supplies. The NJDEP reported that within a five year period (1995-2000), the Highlands lost 17,000 acres of forests and 8,000 acres of farmland to development, and regional growth pressures consumed approximately 3,000 acres a year. Regulations implementing the Highlands Act were adopted in June 2005 and re-adopted in December 2006 (N.J.A.C. 7:38-1 et seq.).

This watershed plan will address goals and objectives of the Highlands Act and Regional Master Plan (RMP). The Highlands Act was adopted to protect, enhance, and restore Highlands open waters and their associated riparian buffers in order to sustain water quality, water supply, and ecosystem integrity. The Highlands Council, working with the NJDEP, has determined that waterbodies in 119 of the 183 subwatersheds or 65% of the subwatersheds in the Highlands are impaired or threatened. A high priority of the Highlands Council is for municipalities to develop and implement a Stream Corridor Protection/Restoration Plan that achieves the policies and objectives outlined in the Highlands RMP to be refined utilizing local data and incorporating local planning goals. The Highlands RMP states that this Stream Corridor Protection/Restoration Plan will be used as a basis for both development review and restoration activities.

This Sidney Brook Watershed Protection Plan has been developed and organized to satisfy these Highlands regional objectives (in addition to the nine elements of a watershed protection plan promulgated by the USEPA), to characterize and assess the conditions and integrity of the watershed, and to provide a comprehensive approach to protect, maintain and enhance water quality and the sensitive resources in this watershed in accordance with guidance from the NJDEP, the Highlands Council, and the USEPA. Detailed protection strategies that address the Highlands Policies and Rules are outlined in this section and should be referenced in the Highlands RMP.

3.1 Highlands Boundaries

The Sidney Brook Watershed spans areas that are regulated by varying regional land use policies which will affect land development and water quality. Appendix I Figure 13 depicts the regional planning designations in Union and Franklin Townships defined by the Highlands Water Protection and Planning Act (HWPPA), which includes portions of the Highlands Preservation, the Highlands Planning, and non-Highlands areas within Franklin Township. Within Union Township the Preservation Area includes all lands between Cooks Cross Road to the south, Race Street to the north, and west of Perryville Road/Main Street; the remaining land in the township is within the Planning Area. Interestingly, most of the northern tributaries, except near their respective confluences with Sidney Brook, are located within the Planning area.

3.2 Highlands Land Use Capability Zone

The Highlands RMP created the Highlands Land Use Capability Zone Map, which defines overlay designations in order to assist communities plan for future development in an appropriate manner and implement the policies in the Regional Master Plan. These overlay designations are based on existing patterns of development and land use, sensitive environmental resources, existing infrastructure such as water supply, wastewater management, and transportation infrastructure, and the natural resource carrying capacity (e.g., water supply source, pollutant assimilative capacity, ecological viability). Overlay zones are based upon existing zoning and policies intended to address public interest such as watershed management area, open space preservation, historic preservation, and urban enterprise zone. The technical basis and additional background information on land use can be found in the Highlands Council's *Land Use Capability Zone Map Technical Report*.

Each of the capability zones was designed with their own purpose, application, and development criteria. These zones apply within both the Preservation and Planning Areas with distinct policies and standards in compliance with Highlands Act requirements. The Highland Land Use Capability overlay zones are depicted on the Policy Map and defined below in accordance with the Highlands RMP, July 2008.

- Three primary overlay zones include the Protection Zone, Conservation Zone, and Existing Community Zone - a 75 acre mapping threshold was used to delineate the three primary overlay zones

- Four sub-zones include the Wildlife Management Sub-Zone, Conservation Zone-Environmentally Constrained, Existing Community Zone-Environmentally Constrained, and Lake Community

The Protection Zone consists of high natural resource value lands that are important to maintaining water quality, water quantity and sensitive ecological resources. Land acquisition is a high priority in the Protection Zone and development activities will be extremely limited; any development will be subject to stringent limitations on consumptive and depletive water use, degradation of water quality, and impacts to environmentally sensitive lands.

The Wildlife Management Sub-Zone consists of both areas managed by the United States Fish and Wildlife Service (USFWS) as part of the National Wildlife Refuge System and Wildlife Management Area System administered by the NJDEP Division of Fish and Wildlife's Bureau of Land Management. These conservation areas permit compatible wildlife-dependent recreational uses such as hunting, fishing, wildlife observation and photography, and environmental education and interpretation.

The Conservation Zone consists of areas with significant agricultural lands interspersed with associated woodlands and environmental features that should be preserved when possible. Non-agricultural development activities will be limited in area and intensity due to infrastructure constraints and resource protection goals.

The Conservation Zone-Environmentally Constrained sub-zone consists of significant environmental features within the Conservation Zone that should be preserved and protected from non-agricultural development. Development activities will be limited and subject to stringent limitations on consumptive and depletive water use, degradation of water quality, and impacts to environmentally sensitive lands.

The Existing Community Zone consists of areas with regionally significant concentrated development signifying existing communities. These areas may have existing infra-structure that can support development and redevelopment, provided that such development is compatible with the protection and character of the Highlands environment, at levels that are appropriate to maintain the character of established communities.

The Existing Community Zone-Environmentally Constrained sub-zone consists of significant contiguous Critical Habitat, steep slopes and forested lands within the Existing Community Zone that should be protected from further fragmentation. They serve as regional habitat "stepping stones" to larger contiguous Critical Habitat and forested areas. As such, they are not appropriate for significant development, and are best served by land preservation and protection. Development is subject to stringent limitations on consumptive and depletive water use, degradation of water quality, and impacts to environmentally sensitive lands.

The Lake Community Sub-Zone consists of patterns of community development that are within the Existing Community Zone within 1,000 feet of lakes. The Highlands Council focused on lakes that are 10 acres or greater and delineated lake management areas consisting of an area of up to 1,000 feet (depending on the protection focus) from the lake shoreline in order to protect water quality, resource features, shoreline development recreation, scenic quality and community character. The Highlands RMP proposes unique policies to prevent degradation of water quality, lake ecosystems and aesthetics.

In the Highlands portions of the Sidney Brook watershed three of these zones are predominant: Protection, Conservation, and Conservation-Environmentally Constrained. The Protection zone roughly follows the course of the stream until expanding along the northwestern margin. Despite the higher level of protection founded on presumably higher quality environments associated with this zone, this area represents the most densely populated portion of the watershed including all of the village of Jutland and the other large developments in the watershed. The remainder of the watershed is generally split between Conservation and Conservation-Environmentally Constrained Zones; the Conservation zone is more prevalent around the periphery of the watershed. Small intrusions of the Existing Community zone irrupt along the northern boundary. Alternative designations in the Highlands Planning area and in Franklin Township based on the State Plan are discussed in the following section.

3.3 Watershed Resource Value

The protection, enhancement, and restoration of water resources are fundamental goals of the Highlands Act. As such the Highlands Regional Master Plan (RMP) selected a number of watershed indicators to evaluate each of the HUC14 subwatersheds including: percent land developed, habitat quality, percent total forest and percent core forest areas. Based on these criteria the Council created the following watershed value classes for the Highlands subwatersheds:

- High Resource Value Watershed –A high resource value watershed contains predominantly forest lands and includes a significant portion of the watershed that is high quality habitat. A high value watershed typically consists of limited pre-existing developed land within the watershed;
- Moderate Resource Value Watershed –A moderate resource value watershed contains forest lands and some habitat suitable for rare, threatened, or endangered species, but typically also contains developed lands; and
- Low Resource Value Watershed –A low resource value watershed contains a low proportion of forest lands, a low proportion of habitat suitable for rare, threatened, or endangered species, and typically consists of higher levels of developed lands.

The Highlands Council analyzed the relative resource value for each of the 183 subwatersheds and determined that the total acreage of High Resource Value Watersheds is nearly 70 percent of the Highlands Region. The total acreage of Moderate Resource Value Watersheds and Low Resource Value Watersheds are each roughly 15% of the

Highlands Region. Based on the criteria listed above the Sidney Brook watershed was identified by the Highland Council as a Low Resource Value Watershed**,** likely because of the high percent of development and agricultural uses.

It is important to note that many of these Highlands resource maps or classifications are seemingly at odds between different coverages. This is in part based on shifting definitions of the resource being evaluated and the resolution of the GIS maps that serve as the base of these maps. The issue of map resolution is of particular concern in the Sidney Brook watershed which is situated along the Highlands boundary. The HUC14 that Sidney Brook is located in actually extends past the Highland bounds, which are consistent with municipal boundaries, and extends into not only Franklin Township, but the Town of Clinton and Clinton Township. As the base mapping unit for these evaluations is the HUC14, the evaluation of this HUC14 includes portions outside of the Sidney Brook watershed that are highly urbanized and degrade what would likely be a considerably higher score of the watershed proper.

3.4 Critical Wildlife Habitat

Building off the Landscape Project (3.0) results, a Highlands Conservation Rank index was also assigned to each species occurrence based upon how critical the Highlands Region is to the continued existence of the species within the state. Following are the Highlands Conservation Ranks that were used:

- Critically Significant (Rank 3) –If habitats in the Highlands Region were lost, that species would not exist in the State;
- Significant (Rank 2) –Highlands Region habitats play a significant role for that species' existence in the State; and
- Low Significance (Rank 1) –Highlands Region habitats do not play an important role for that species' existence in the State.

There are three categories of Critical Habitat in the Highlands Region:

- Critical Wildlife Habitat - habitat for rare, threatened, or endangered species.
- Significant Natural Areas - regionally significant ecological communities, including habitat for documented threatened and endangered plant species.
- Vernal Habitats - confined, ephemeral wet depressions that support distinctive, and often endangered, species that are specially adapted to periodic extremes in water pool levels.

A high priority addressed in the Highlands RMP is for municipalities to develop and implement a Council-approved Critical Habitat Conservation and Management Plan that satisfies the policies of the RMP, utilizes local data and incorporates local planning goals. The Critical Habitat Conservation and Management Plan will be used for both development review and stewardship or restoration activities.

In the Sidney Brook watershed the Critical Wildlife Habitat is consistent with Landscape Rank 4 lands. There are no Significant Natural areas in the watershed. While the original maps published in the HRMP and available on the Highlands Council website indicate there are no vernal habitats within the watershed newer updates from NJDEP include portions or the entirety of four potential vernal habitats including 1000 foot buffers in Union Township. In Franklin Township there is one potential vernal habitat as well as a cluster of certified vernal habitat near the mouth of Sidney Brook.

3.5 Riparian Integrity

The integrity of Riparian Areas may be defined by that area's ability to provide water protection and ecological function, including nutrient and sediment filtration, streambank stabilization, wildlife migration corridors and habitat, stormwater and flood water storage, and stream water quality protection (NJWSA, 2000). The Highlands Council selected the following five integrity indicators to evaluate each of the 183 subwatersheds in the Highlands:

- Impervious Coverage –The percentage of the Riparian Area that includes impervious surfaces;
- Agriculture Land Use –The percentage of the Riparian Area that is in agricultural use;
- Number of Road Crossings per Linear Stream Mile – The number of road crossings per linear stream mile;
- Vegetation Condition – The percentage of the Riparian Area that features urban and agricultural lands (as a means to determine the percent of natural vegetation);
- Water/Wetland Dependent Species Habitat –The amount of habitat suitable for one or more water/wetland dependent wildlife species of concern including rare, threatened, or endangered species.

Based on a cumulative assessment of these indicators the Council assigned a Riparian Area integrity value class to each subwatershed as follows:

- High Integrity Riparian Area –These areas include subwatersheds with Riparian Areas that exhibit predominantly natural vegetation, including high quality habitat for water/wetland dependent species and a generally low incidence of impervious area, agricultural uses, and road crossings;
- Moderate Integrity Riparian Area –These areas include subwatersheds with Riparian Areas that contain a higher incidence of impervious area, agricultural uses, and road crossings, and a reduced proportion of natural vegetation, including high quality habitat for water/wetland dependent species
- Low Integrity Riparian Area –These areas include subwatersheds with Riparian Areas that contain a high proportion of impervious area, agricultural uses, and road crossings, and minimal natural vegetation, including high quality habitat for water/wetland dependent species.

The Highlands Council determined that the total acreage of subwatersheds in High Resource Value Riparian Areas includes half of the Highlands Region. The total acreage of subwatersheds in Moderate Resource Value Riparian Areas includes nearly 40% of the Region and in Low Resource Value Riparian Areas includes slightly more than 10% of the Highlands Region. The Sidney Brook Watershed was identified by the Highland Council as a Moderate Integrity Riparian Area. A more thorough characterization of the riparian corridors is provided in the Visual Assessment section and in the Land Use/Land Cover discussion (Section 2.12).

3.6 Forest Resource Area and Forest Integrity

Forest cover is perhaps the best indicator of overall watershed quality in New Jersey. Forests offer a variety of benefits to water quality including naturally low levels of pollutant generation, capacity to remove solids and nutrients in contaminated runoff, pervious surfaces, groundwater infiltration and aquifer recharge, and shade to limit stream warming among others. Besides the benefits to water quality and hydrology forests of course are vital habitat to a vast array of species across nearly all major taxa represented in New Jersey including animals and plants. Other important benefits of forests include economic benefits through the production and sale of forest products and the provision of recreational opportunities for birding, hiking and hunting. In the Highlands Region forest communities of varying composition provide these essential ecosystem services and strongly contribute to the character of the region.

For these reasons forests are carefully considered in the HRMP. Some of the actions outlined in the document include the identification of forest resources, develop protection strategies, develop indicators of forest health, and integrate these components into stewardship policies. One effort to meet these goals was the delineation of Forest Resource Areas. In some senses Forest Resources Areas track the most crucial functions of forests to provide water quality mitigation and habitat. Perhaps the primary issue affecting forests in the Highlands is the fragmentation of forests caused by roadways, disjointed development, and sprawl and a general disconnect of contiguous forested tracts. Core or interior forests provide the crucial habitat required by a number of threatened species as well as providing the best water quality benefits. Forest Resource Areas therefore track these forests based on the following requirements: 500 acres or more of contiguous forest, or greater than 250 acres of contiguous core forest at least 300 feet from an altered edge. Throughout the Highlands Forest Resource Areas largely coincide with the Preservation Area boundaries. No Forest Resource Areas were identified in the Sidney Brook watershed despite watershed LU/LC composition in which forests represent in excess of 32% of the land mass. Overall this seems to indicate a fair amount of fragmentation in the forested lands in the watershed or a lack of core forest.

A more precise finding of forest health is assessed in the Forest Integrity indicators. Like other resource evaluations forest integrity was assessed in each HUC14 subwatershed and classified as the following integrity value:

- High Integrity Forest – A subwatershed that is predominantly forested, including a high proportion of forest cover consisting of high core area, large patch size, and a low distance to the nearest patch
- Moderate Integrity Forest – A subwatershed that is predominantly forested, but does not exhibit a high proportion of forest cover, core area or patch size, and an increase in distance to nearest patch
- Low Integrity Forest – A subwatershed that is predominantly non-forested or include low values for proportion of forest cover and patch size, or a high distance to the nearest patch

The Sidney Brook HUC14 is designated a Moderate Integrity Forest indicating, as stated above and consistent with a lack of Forest Resources, poor patch size or proportion of cover or core forest. This finding can be further extrapolated to show that despite relatively abundant forest cover in the watershed some of the ecological functions served by core habitat is reduced in the subwatershed.

3.7 Surface Water Quality

The Highlands Council also assessed surface water quality in each of the HUC14s. Ultimately the findings were based on the 2006 *Integrated Water Quality Monitoring and Assessment Report* (Integrated List) which combines the 303(d) and 305(b) list. This report, in turn, is based on extensive water quality monitoring conducted or sponsored by the NJDEP which also includes evaluations of recreational, fish consumption, and other use designation assessments. The following table (Table 7) represents the placement conditions on each of the sublists, which act as use attainment ranks.

In the Highlands Region 119 of 183 HUC14s are classified as impaired or threatened. The HUC14 in which Sidney Brook is located is classified as Non-Impaired. While this is positive news this assessment is skewed somewhat. It seems likely that this non-impaired designation as based on the Integrated Reports is likely to refer to assessment unit 02030105020070-01 (based on the HUC14 number) which actually is assigned to South Branch Raritan River (River Road to Spruce Run), the receiving waterbody for Sidney Brook. Most of designated uses in this assessment unit are listed as Sublist 2 indicating use attainment for assessed uses and insufficient to data to assess other uses; Fish Consumption and Primary Contact Recreation uses are on Sublist 3 indicating insufficient information. In reality, Sidney Brook is not assessed and has not been specifically listed in any of the published Integrated Reports. This report is intended in part to address the lack of assessment for this waterbody.

Table 7: Sublist Placement Conditions

Sublist	Placement Conditions
Sublist 1	The designated use is assessed and attained and all other designated uses in the assessment unit are assessed and obtained. (Note: The fish consumption use is not used for this determination based on USEPA guidance).
Sublist 2	The designated use is assessed and attained but one or more designated uses in the assessment unit are not attained and/or there is insufficient information to make a determination.
Sublist 3	Insufficient data is available to determine if the designated use is attained.
Sublist 4	The designated use is not attained or is threatened; however development of a TMDL is not required for one of the following reasons:
	A. A TMDL has been completed for the pollutant causing non-attainment.
	B. Other enforceable pollution control requirements are reasonably expected to result in the conformance with the applicable water quality standard(s) in the near future and the designated use will be attained.
	C. Non-attainment is caused by something other than a pollutant (e.g., "pollution").
Sublist 5	The designated use is not attained or is threatened by a pollutant(s) and a TMDL is required.

3.8 Additional Highlands Assessments

A variety of other environmental assessments are included in the HRMP which will be discussed in brief in the following sections. Taken collectively these assessments serve to further characterize the watershed and to provide the information needed to characterize and evaluate the resources and to provide the basis upon which to foster stewardship practices.

Water resources are at the heart of the Highlands legislation. Net water availability describes the quantity of available groundwater in the watershed after subtracting for consumptive and depletive uses. The Sidney Brook watershed is actually ranked among the highest having surplus water availability from 0.10 to 0.30 MGD (million gallons per day). Much of the Highlands region shows a deficit in water availability indicating withdrawals in excess of recharge capacity. This is likely related to the low amount of impervious surfaces and relatively light population density in the watershed. Prime Ground Water Recharge Areas describe those parts of the watershed that have higher recharge capacities and account for over 40% of the groundwater recharge capacity. In the Sidney Brook watershed Prime Ground Water Recharge Areas are primarily centered in the riparian corridor surrounding the tributary network.

Wellhead Protection Areas describe buffer areas for Public and Non-Public Community Water Supply Wells. Three tiered buffers are applied around the wellheads that correspond to different pollutant Times of Travel (TOT) that represent protections from pathogens, volatile organics, and other pollutants that have different groundwater mobility rates or persistence in groundwater. Since the Sidney Brook watershed is almost exclusively served by onsite potable supply wells Wellhead Protection Areas encroach into the watershed only in the northern corner where there is small cluster of wells serving the correctional facility and other buildings in the area.

Agricultural Resource Areas are established to identify high quality agricultural lands in need of preservation. Identification of these areas is then used to develop the economic and regulatory conditions to promote sustained agriculture in the area. The loss of agricultural areas in the Highlands Region has been significant over the last several decades and a variety of benefits to the community and the environment are associated with farmland preservation activities. The entirety of the Sidney Brook watershed is identified as an Agricultural Resource Area. The majority of these areas in the Highlands is located in the southern third of the region and include most of this area.

Impervious Areas were also identified in the HRMP. The areas serve as proxies for development levels and are indicative of a host of problems including reduced groundwater recharge capacity, increased pollutant loading, and excessive runoff generation contributing to stream erosion and sedimentation and the mobilization of pollutants. Impervious Areas are mapped throughout the watershed; however, the highest concentration is recorded in Jutland and the adjacent lands. Relative to other areas in the Highlands the occurrence of impervious surfaces in the Sidney Brook watershed is relatively modest but are still found at a concentration high enough to impact the watershed and stream function.

A Developed Land Analysis was also conducted for the entire region to identify areas of development in each of the HUC14s to be used in development planning and environmental conservation activities. In the Sidney watershed developed lands are fairly scarce. The highest concentration of developed lands occurs near the village of Jutland which is classified as Rural Developed Areas. Core Developed Areas are located along the northern margin of the watershed. Despite these modest classifications, which are based in part on an assumed land use density, the LU/LC discussion in Section 2.12 indicates that a majority of the watershed is developed or used in agriculture production and thus represent a deviation from natural lands uses. As such, this watershed is subject to impacts related to development.

4.0 Visual Assessment

A major component of this WPP is to accurately inventory the environmental resources of Sidney Brook and the associated watershed. This type of data now abounds thanks to a variety of sources including the excellent GIS mapping provided by NJDEP and the Highlands Council and water quality, biology, hydrology, and climate data supplied by NJDEP, USGS, NOAA, and a variety of other sources. Despite the high quality data, including maps, the resolution of this data is generally on a landscape scale and cannot replace in-the-field knowledge of the intricacies of the tributary network and riparian buffer and the ecological interactions. The effort to visually assess the entire tributary network seeks to improve knowledge of the stream and tributaries, identify problem areas and pollution sources, inventory outfalls, assess in-stream characteristics, evaluate land use, and confirm unmapped stream channels. Ultimately this data is used to address disparities in mapped resources, refine the knowledge of the workings of the stream, validate models, integrate landscape mapping and in-stream monitoring, and use the resultant data to target specific locations that require mitigation or conservation efforts in order to improve the ecology and water quality of the stream. The following sections summarize the findings of the earlier report *Stream Visual Assessment for the Sidney Brook Watershed* (June 2008).

4.1 Visual Assessment Methodology

Princeton Hydro and volunteers utilized the Stream Visual Assessment Protocol Plan (VAPP, August 2007) developed by the former NJDEP Division of Watershed Management to perform a comprehensive assessment of stream conditions. The field work was conducted from late February through March 2008 by Princeton Hydro staff with assistance from the AmeriCorps Watershed Ambassadors program hosted by the NJDEP. It was necessary to complete the visual assessments in the early spring in order to avoid dense vegetative growth and to utilize the data towards the proposed stream sampling efforts scheduled to be initiated in 2008.

The five data sheets for the NJDEP VAPP were developed from the Department's original Water Watch RATS (River Assessment Teams) volunteer monitoring programs, the Natural Resource Conservation Service's Stream Visual Assessment Protocol (SVAP), and the USEPA's Rapid Bioassessment Protocol (RBP) and Volunteer Monitoring Manual. Information for Sidney Brook collected utilizing the NJDEP VAPP data sheets is incorporated in the Visual Assessment Summary Tables in Appendix II.

The NJDEP Stream VAPP was used to qualitatively assess each stream reach based on several indicators including:

1. The Stream General Sheet is used to identify the stream and watershed area, GPS coordinates, field team, weather conditions and a site sketch.

2. The Stream Monitoring Sheet evaluates: stream width, depth, flow, velocity, sinuosity, pool and riffle variability, substrate type, substrate embeddedness, bank stability, vegetative cover, aquatic vegetation, channel alteration, water color and odor.
3. The Streamside Assessment evaluates land use within 50 feet and ¼ mile of the stream including: residential, commercial, industrial, institutional, roadway, agricultural, and recreational uses, as well as preserved forest and wetland land use.
4. The Drainage and Outfall Inventory was used to locate and evaluate the condition of drainage features and drainage infrastructure throughout the watershed. This information on drainage ditches, culverts or outfalls can also be incorporated into the state mandated Stormwater Plans required pursuant to N.J.A.C. 7:8 for each municipality and county.
5. The Invasive Plant Survey will identify where invasive species may dominate the riparian corridor.

It should be noted that because the Sidney Brook field work occurred in the late winter, it was difficult to accurately assess aquatic vegetation. This time frame is also not optimal for the documentation of wetland habitats. However, these specific conditions will be re-evaluated during the spring, summer and fall when stream sampling is conducted.

The Sidney Brook watershed was divided into eleven stream reaches approximately one mile in length, labeled from A to K, as depicted on Appendix I Figure 15. Each stream reach in turn was divided into stream segments, each approximately ¼ mile in length dependent upon field conditions, such as the confluence of tributaries, road crossings, varying land uses, stream conditions, riparian corridor health and stream access. The headwater tributaries that were assessed are also identified on the maps and included a "T" code to indicate tributary, e.g. BT1. To facilitate the data review, the Sidney Brook watershed has been divided into four quadrants.

An integral part of the stream assessment protocol was gaining access to walk the streams, headwaters, wetlands, and riparian corridors that include privately owned lands. To obtain this access, the NJWSA mailed letters in January and February 2008 to approximately 250 property owners, along with a postcard that upon return would grant the requisite access. The NJWSA worked in concert with members of the Union Township EC and Franklin Township EC to track property owners and obtain the access permissions. Initially approximately 30% of the requested access was granted. Several critical property owners were subsequently personally notified. In addition, UTEC mailed a newsletter to all town residents explaining the watershed project, and a public meeting was held by the UTEC on March 11, 2008 to explain the upcoming field work and respond to any questions. Appendix I Figure 16 identifies the parcels where access was granted. Access was not obtained on portions of stream segments A, B, C, E, J, H and K. The draft access letters and UTEC newsletter are enclosed as Appendix II.

4.2 Headwater Stream Mapping

Headwater and intermittent streams are an important component of the aquatic and terrestrial ecosystems of Sidney Brook and inventorying these resources is a critical component of the Visual Assessment effort. Headwater streams may include first and second order streams that provide important sources of nutrients and energy for higher order streams, and are often associated with wetland complexes and riparian areas that are important ecological features of the landscape, harboring plants, aquatic species, and terrestrial wildlife that are unique to the ephemeral or intermittent flow characteristics of these waterbodies. In general, headwater or intermittent streams are often not identified on USGS maps or state and local GIS maps because of their intermittent nature, remote location, canopy cover causing obstruction in aerial photographs, or too coarse resolution in maps. However, these streams are sometimes identified on the county soil survey maps produced by the SCS/NRCS.

This basic lack of mapping and documentation contributes to a lack of protection and the continuing degradation or disturbance of these vital headwater streams. Similar to wetlands, the value of headwater streams was not historically recognized, and previous regulations allowed these streams to be altered, ditched, filled, developed, diverted to storm sewers, or replaced by highly engineered stormwater basins. By formally mapping these waterways, the applicable New Jersey regulations for regulated water resources (e.g., Surface Water Quality Standards (N.J.A.C. 7:9B) and the Flood Hazard Area Control Rules (N.J.A.C. 7:13)) can be appropriately and legally applied to the newly mapped and verified headwater streams. This is especially important considering that headwater tributaries have a direct impact on the water quality of higher order waterbodies downstream.

For the purpose of the Sidney Brook Headwater Visual Assessment, the following criteria were relied upon to define and map headwater streams in accordance with the definitions provided by the NJDEP in the Flood Hazard Control Rules (N.J.A.C. 7:13), the NJDEP Model Ordinance to protect *Riparian Buffer Conservation Zones,* March 2005, and definitions provided by the US Geological Service (USGS).

The Sidney Brook Visual Assessment defines Headwater Streams as:

- An intermittent or ephemeral surface water body which flows seasonally, or when it receives water from precipitation, melting snow, or groundwater springs.
- Intermittent streams shown as a dashed line on either the USGS topographic quadrangle maps or the USDA-NRCS (nee SCS) County Soil Survey Maps.
- A surface water segment that has a discernible channel with definitive bed and banks in which there may not be a permanent flow of water. A channel depth equal or greater than 6 inches was used for this assessment.

Princeton Hydro initially created a GIS base map of the streams including the existing USGS Blue Line streams and digitized NRCS stream data. The resulting maps were initially analyzed with respect to topography and soils as well as the most recent available digital land use and land cover data to ascertain the basic validity of the newly identified stream segments. This step is necessary as much of the NRCS stream data is dated and subject to alteration by more recent land development activities.

Field verification of the newly mapped headwater streams was preformed to confirm whether these waterway features were viable headwaters, with defined channels, bed and bank. GIS maps were then revised as necessary based on the criteria listed above. Initially, the NJDEP GIS 2002 database had included 10.43 miles of the Sidney Brook stream network. Based on the methodologies outlined in this report, 11.84 miles of previously unidentified or unmapped headwater stream segments were added to the Sidney Brook stream maps, more than doubling the known stream length to 22.27 miles. These headwater streams are depicted in Appendix I Figure 17. These newly identified tributaries existed both as fully formed tributaries discharging to a mapped tributary or extensions at the head of mapped of features. These SCS streams were also fairly evenly distributed throughout the watershed. A limited number of these intermittent streams are located on lands that were not accessible, and therefore channel depth and location were not confirmed despite positive indications of their presence. All of the newly mapped intermittent streams that were accessible and assessed have a discernible streambank height greater than one foot. Most of these waterways had stream flow at the time of the field verification. The presence of a defined bank and the existence of flow fully validate the classification of these waterways as regulated streams.

The newly mapped streams should therefore be recognized as regulated features subject to the applicable C1 riparian corridor protections or Special Water Resource Protection Areas (SWRPA) of 300 feet for forested areas and 150 feet for farmed lands. Franklin and Union Township should consider officially adopting this headwater information and mapping as Appendices to their Township Environmental Resource Inventories to ensure the application of state and local ordinances.

4.3 Southwest Quadrant, Reaches I, H, G

Reach I

The land use for Reach I is primarily forest and hayfields and the immediate riparian corridor is forested (Appendix I Figure 18). The stream has a 4-8 foot width, a clear fast, shallow flow, frequent riffles and shallow pools, and a stable, cobble substrate. There are five large farm ponds on this segment of Sidney Brook: two small ponds approximately 1 acre and three larger ponds greater than 2 acres. In each situation the streambanks are eroded downstream of the pond outfalls with defined scour pools, possibly due to the high storm flows from the outfalls, steep slopes, and erodible soils. High runoff volumes and velocities are the likely cause of the observed eroded banks and turbid pond conditions. After a storm event the three downstream ponds were observed to be turbid. Generally the streambanks were eroded at a height of 2-3 feet throughout Reach I, even though the stream riparian corridor is intact forest. Geese were observed at each pond.

Reach H

The land use for Reach H is primarily forest with large lot residential development (8 acre lots). Much of the 300 foot riparian corridor is generally intact forest habitat. Access was not permitted for a portion of the main stem of reach H, but headwater tributaries were assessed. The stream has a 4-8 foot width, a clear, fast, shallow flow, frequent riffles and shallow pools, and a stable, cobble substrate. Significant erosion (4 feet) is evident on the tributary HT2 at High View Court and Cooks Cross Road, which in turn causes sediment deposition within the Sanctuary pond.

The **Sanctuary Development** of 12 homes built on 8 acre lots was constructed after 2003, and the 300 foot buffer for this segment and its tributaries was preserved. This development is not depicted on the project aerials, however an aerial was obtained via Google Earth and Union Township provided a copy of the development Lot and Blocks. A small headwater tributary and wetland area (HT1) runs parallel to the entrance roadway of the development, Asher Smith Road. At Stirling Place the wetlands and tributary (HT1) were dammed to create a wetland stormwater basin. A small 3-inch orifice allows continuous flow under the roadway, and during storm events the outfall structure restricts and detains runoff within the wetland basin south of Stirling Place. North of Stirling Place there is a 48 inch culvert which drains to wetlands. Thick Multiflora Rose (*Rosa multiflora*) prevents access to this area. Eventually the HT1 tributary drains to the main stem of Segment H which runs behind the homes, where access was also prohibited. Runoff from five lots is captured by the wetland basin and detained before it drains to Segment H.

The Sanctuary Pond receives runoff without detention from five lots within the Sanctuary development as well as five additional home lots on Cooks Cross Road and Perryville Road. The pond dam is reinforced with gabion structures and the emergency spillway refurbished with gabions. The property owner reports that it becomes very turbid after storm events. Sediment deposition was observed at the mouth of pond and within the pond. The pond owner estimates that a foot of sediment may have been deposited in the pond in the last five years. Severe erosion (4 feet) was evident from the pond emergency spillway which frequently overtops. Runoff from homes on Asher Smith Road drains without detention to a grassed drainage easement that bypasses the Sanctuary Pond. This runoff is not detained and connects with the discharge from the Sanctuary Pond, which has flooded a downstream property. A lengthy private driveway may also be restricting some stormwater runoff that exacerbates the flooding on this parcel.

Severe bank undercutting (4 feet for approximately 200 feet) is evident at the stormwater outfall at Cooks Cross Road and High View Court, which is the likely source of high flows and sediment deposition to the Sanctuary Pond. This outfall receives runoff from at least seven inlets on Cooks Cross Road, as well as 9 homes on Woodsedge Court and 7 homes on High View Court. The stormwater is conveyed via 2 foot wide storm sewer pipelines. There are no stormwater basins in these older developments.

Reach G

The land use for Reach G is primarily farmland and a large mature red cedar forest, and the majority of the 300 foot riparian corridor is generally intact forest habitat. Flow to the headwater tributaries begins in a farm field where a constructed berm directs runoff to the tributary via a 12 inch PVC outfall. The tributary GT1 has a 5 foot width, clear, fast, shallow flow, and a stable clay loam soil substrate. Downstream at the confluence of Reach G and the GT1 tributary there are eroded streambanks of approximately 2-3 feet in height. The GTI tributary may be protected from development under a conservation easement.

The Crestview Homes located on Hill and Dale Road was constructed on very steep slopes, but the vegetated detention basin, seems to function well. The stream appears in good health here with a 25 foot width, a clear, fast, shallow flow, frequent riffles and shallow pools, and a stable cobble substrate. No erosion was noted, even at the 48-inch stormwater outfall on the south side of Hill and Dale Road; rip rap was present at this outfall. A deep pool was observed south of the bridge crossing. In addition, a deck has been washed into Sidney Brook just upstream of the Hill and Dale Road on the right side of the development entrance, possibly during a severe flooding event.

Other concerns for Reach G include the frequent flooding of Perryville Road from uncontrolled stormwater runoff from Finn Park, which has eroded the drainage swales (1.5 feet) along the road. Limited stormwater swales exist at the park, but no stormwater detention/retention facilities are present.

4.4 Northwest Quadrant, Reaches K, J, F

Reach K

The land use for Reach K is currently hayfields and forest, and the immediate riparian corridor for Reach K is forested (Appendix I Figure 19). Reach K as it crosses Finn Road appears healthy, approximately 6 feet wide with clear, fast, shallow flow, and stable cobble substrate. No erosion was observed at the Finn Road crossing.

A small tributary, KT1, runs parallel to Finn Road within a forested wetland area and thick Multiflora Rose. No erosion was noted at this bridge crossing. A second tributary, KT2, runs from the Kenneth Place cul de sac and crosses Finn Road via a 48-inch culvert. A large scour hole has formed at this crossing, and approximately 100 feet downstream the streambanks are eroded (3-4 feet erosion) on both sides of stream. Also an old landfill area was observed within the woods on right side of stream.

At the Kenneth Place cul-de-sac a small stormwater basin, with one foot of accumulated leaf litter, and private pond discharge to the KT2 tributary. Erosion (1-2 feet) was noted at the pond inlet channel and downstream of an 8-inch PVC outfall from the pond to the KT2 tributary the streambank is eroded 2-3 feet for about 150 feet. Tussock sedge hummocks were identified beyond mowed lawn at Kenneth Place residences. The lawn area is mowed to the woods, but it is very wet and may be within the wetland transition area.

Reach J

The construction of new Union Township Elementary School was recently completed on Perryville Road. The campus is served by large stormwater basin that discharges to a large forested wetland area and tributary behind the Crop Production Center. The stormwater drainage from the school leads to an area that is tentatively identified as a vernal pool. The vernal pool, wetlands, and intermittent tributaries found in this area are not noted on state GIS coverages.

The land use for Reach J near Main Street is primarily single family homes, and the immediate riparian corridor is lawn with a thin forest canopy of around 25 foot height. The stream is approximately 6-8 feet in width, with clear, fast, shallow flow, and stable cobble substrate. A dark brown alga was prevalent on the substrate throughout this segment.

A 48 inch stormwater culvert crosses under Wolf Farm Road, and slight erosion of the downstream tributary was noted. Stormwater for the development is directed via street storm sewers to a wetland stormwater basin at the corner of Stonebridge Road. Significant maintenance to remove vegetation from the outfalls of the basin is needed. Downstream of this outfall the streambanks were eroded by 2-4 feet on both sides, just upstream of the Main Street crossing. Evidence of high flows, flooding, erosion, and downed trees were noted downstream of Main Street. Slight erosion (2 feet) was observed downstream from the crossing with Perryville Road. Significant brown algae growth was noted in the stream Reach J up and downstream from Main Street. PVC pipes apparently originating at homes in this section were observed discharging to the stream.

Reach F

Reach F begins at the confluence of Reach G and J, where observations confirmed a healthy stream and floodplain and an intact forested riparian corridor. However, some erosion along Reach J and downstream of the confluence is occurring and could be a source of sediment loading to Jutland Lake. Jutland Lake is owned and maintained by the newly formed Lakeside Estates Homeowners Association. The lake is located along Race Street and access is available only to the private Association residents. The riparian corridor for Jutland Lake is primarily single family homes, lawns, and limited forest. Reach F, as it enters Jutland Lake, is approximately 20 feet in width, with clear, fast, shallow flow and cobble substrate. The lake is approximately 10 acres in size, over 10 feet deep, the spillway is approximately 75 feet wide and the berm is approximately 500 feet wide. After a 1.5 inch rain event in March 2008, the lake was very turbid, which is reportedly a frequent occurrence. Residents also report algal blooms in the late summer months. Below the dam and spillway a deep pool exists but there is no evidence of erosion downstream.

A small tributary (FT1), receives significant runoff from the Midvale Road housing development and flows to Jutland Lake. This development includes approximately 40 homes constructed on steep slopes (>20%) which are vegetated with only lawn and a few thin saplings. The steep slopes cause flashy runoff to occur. A retention basin with a 3inch orifice on the outlet structure discharges to the FT1 tributary and wetland, and some erosion (1-2 feet) was noted on the streambanks downstream of the outfall. A second outfall at Race Street is nearly completely clogged with sediment.

Runoff from the Midvale development flows downstream under the Race Street Bridge, where significant erosion has occurred within a small ravine. A downed tree appears to cause the stream to fork which is causing oxbow formation and 3-4 foot eroded banks along Race Street. This erosion may also be a secondary source of sediment loading to Jutland Lake. Some rip rap has been added along the Race Street slope to reduce the erosion.

4.5 Northeast Quadrant, Reaches E, C, B

Reach E

Much of Reach E runs parallel with Race Street and is privately owned and access was not permitted (Appendix I Figure 20). A headwater tributary was noted on the NRCS soil survey maps but a defined streambank was not observed from the road. Limited access to Sidney Brook was provided from the entrance road and bridge to the Cozzi Brothers junkyard. Because full access was not provided a complete assessment was not conducted. However, the land use and immediate riparian corridor for Reach E is primarily forest and wetlands. From the bridge to the auto salvage yard, the stream was noted as approximately 20 feet in width, with a clear, fast, shallow flow, and stable cobble substrate; no erosion was observed at this location. A tributary to Sidney Brook is noted on the aerials but the salvage yard operator stated that this tributary was not present. Wetlands appear to extend further than shown in the NJDEP data layer and a potential large vernal pool was photographed near the access road to the salvage yard.

Full access was granted to assess the ET1 tributary, which receives flow from a quarry pond north of Race Street. The land use and immediate riparian corridor for Reach ET1 is primarily forest and wetlands. The quarry pond was turbid, but discharge to the stream was clear during our field assessment and the stream appears to function normally. Below the quarry pond the stream width is only 3 feet, with a clear, slow, shallow flow, and stable cobble substrate. Further downstream the ET1 tributary widens to 15 feet then to a 40 foot wide wetland. The tributary then flows into an old farm pond before it crosses under Race Street. The wetland area is located where a former bridge crossing had been removed and the area regraded. This area is also crossed by a gas pipeline and includes a mowed meadow. The bridge previously provided access to a former rifle range.

Reach C

Reach C includes a wide floodplain that runs parallel along Race Street, and the land use and immediate riparian corridor for Reach C is primarily forest and wetland floodplain. The forested areas have a high density of Multiflora Rose and the wetland meadow includes a combination of shrub/scrub and grass. Reach C appears healthy with a width of 15 feet, and a clear, fast, shallow flow with stable cobble substrate. The stream mapping noted that a tributary may cross under the train trestle running perpendicular to Reach C, but this area had limited access and it was not observed, however a small tributary was found flowing from a ravine east of the Cozzi salvage yard which contained a fair amount of debris including tires. This tributary flows parallel to the rail line and the confluence was forked and not perpendicular as mapped. The confluence of this tributary and the main stem of Sidney Brook is surrounded by a cattail wetland with an area of approximately 1 acre. A small patch of hummock topology was noted within the wetland. This wetlands and floodplain appear to be fully functional and connected to the stream.

Further downstream, as Sidney Brook crosses under Race Street, the land use consists of a wet meadow floodplain. Race Street is not significantly elevated (possibly 2 feet) above Sidney Brook at this crossing, and the stream often over-tops the road, causing its closure. Rip rap has been added near the Race Street crossing to reduce erosion in this area. Frequent flooding has also caused streambank erosion of 2-3 feet, damaged the historic bridge (1867) at Hill Top Road, and impacts the farm and properties east of the Race Street crossing.

Reach B

The Hunterdon County Development Center and the Edna Mahan Correctional Facility for Woman are located in the headwater area of this reach, and access for these areas was not granted. The aerials show a stormwater pond for each facility, but no other obvious stormwater controls were observed in the aerial maps. Segment B flows from these ponds and is joined by a tributary (BT1) that runs through Milligan Farm, which is being acquired by Union Township for open space preservation.

Reach B includes a wide wetland meadow floodplain that runs parallel with Race Street, and flows under the Route 513 Bridge. Land use in the immediate riparian corridor for Reach B is an open, wetland meadow floodplain with some forested areas. The forest area has a high density of rose, and the wetland meadow includes a combination of shrub/scrub and grass. Reach B has a 5 foot width, and a clear, fast, shallow flow, and a stable, cobble substrate. Overall the stream and tributaries appeared clear and healthy.

Tributary BT1 flows south through Milligan Farm, and a forested riparian corridor of at least 25 feet exists along the entire length. Beyond the narrow riparian corridor, the site is farmed. In some places the corridor extended to 50 feet and included unmowed meadow grasses and woody vegetation, which is predominately Multiflora Rose. Streambanks in this reach were stable. The NRCS soil maps indicate that tributary BT1 extends the entire north-south property length of the farm, however a defined bed and bank was not apparent in the northern half of the farm. A stormwater pond servicing the prison discharges to a wetland in the northern portion of the Milligan Farm site, but a continuous tributary was not found. The area can be described as a scrub/shrub wetland/meadow but a discernible channel was not observed. The headwaters for tributary BT1 were found in a second wetland area of tussock sedge hummocks. North of this wetland the tributary was indiscernible.

The main stem of Reach B of the Sidney Brook flows through an open wetland meadow floodplain, described as shrub/scrub and grass. The stream was running clear and flow was elevated with snow melt. The stream has good sinuosity and riffle frequency throughout this reach. The stream is also well connected to the floodplain. The confluence of segments B and C is stable and erosion was not noted.

A ponded wetland area was observed in a southern field on the Milligan Farm and an old 24 inch steel pipe had been positioned to drain this area into reach B. Some streambank erosion (about 2 feet) was noted on this northern segment of reach B, possible caused by steep slopes in the yards of the Patrick Drive homes, and possibly from high runoff flows from the Development Center located further upstream.

4.6 Southeast Quadrant, Reaches D and A

Reach D

Three large farm ponds are located within this segment, and each of the ponds was fairly turbid during the assessment (Appendix I Figure 21). In general, reach D includes a wide floodplain that runs parallel to Route 513, and this tributary joins the Sidney Brook main stem at the historic Hilltop Road Bridge, at Race Street. The land use and immediate riparian corridor for Reach D includes primarily wetland scrub/shrub floodplain, farmed lands, and some forested areas. The floodplain area has a high density of invasives and is inaccessible in several sections. The wetland meadow includes a combination of shrub/scrub and grass. Generally Reach D varies in width from 5-10 feet wide, and has a clear, fast, shallow flow, and stable cobble substrate.

Runoff to reach D originates along Cooks Cross Road. A stormwater detention basin that serves approximately 16 homes in the Wood Hollow Road development discharges directly to the Cooks Cross Road drainage system, and high storm flows overwhelm the road drainage swales. While the Woods Hollow basin is well maintained, the discharge directly to the roadway is a poor design. The discharge from the basin's 24 inch outfall floods Cooks Cross Road and causes erosion and flooding downstream. An upstream road swale also accepts street flow. Additional drainage from homes and the roadway is intercepted by the road drainage swales and street sewer systems, adding to the downstream flooding.

The Sotres Farm is an active horse farm, with stables, riding and paddock areas, and gently sloping pastures. Runoff from these grassed meadows and hillsides can add turbidity and nutrient loading to the farm pond and stream, and can add flow to the eroding streambanks. A historic spring house exists on property and its foundation has been severely damaged and undermined by uncontrolled runoff from Cooks Cross Road. A natural spring and drainage swales were present near the spring house. At the time of the assessment on February 12th there was significant flow in the outfall at Cooks Cross Road. The Township had recently regraded the road swale which has helped, but stormwater runoff problems remain.

A second outfall flows under a historic stone bridge on Cooks Cross Road onto the Sotres Farm and adds to the flooding and erosion of the Reach D. This flow originates from only few homes and fields, but they are located on fairly steep slopes south of Cooks Cross Road, causing the high flows. A small portion of Reach D as it exits the Sotres Farm has severely eroded and incised streambanks with a height of 4 feet.

Nearly 50% of the Peaceful Valley Farm remains forested, but the majority of the riparian corridor along this segment of Reach D flows through an open scrub/shrub wetland and floodplain. The farm itself has moderate slopes. Reach D is approximately 3-4 feet wide through Peaceful Farm. Sediment deposition was evident in the adjacent floodplain indicating good connectivity. Sediment deposition and turbidity affect the farm pond. Downstream of the farm pond, the steam widens to a 15 foot, stable, cobble stream bed, where erosion and flooding was not evident.

An old stone culvert exists under Route 513 that conveys stormwater runoff under the road and into a wetland area; this outfall is in disrepair.

Reach D flows through a forested riparian corridor into a large pond down gradient from the Care Center facility. During the assessment large septic system drain field was being reconstructed. Downstream from the pond the riparian corridor returned to a shrub/scrub floodplain, and the stream flow in reach D was clear. The floodplain both upstream and downstream of the pond included dense invasive vegetation which prevented access.

Reach D flows under a 20 foot wide train trestle before flowing under the historic Hilltop Road bridge at Race Street. Debris, including tires and drums, is strewn on the hillside north and south of the train tracks. In the section just upstream of the Hilltop Road Bridge there is an area of highly eroded banks. The historic bridge appears to be in need of repair and restoration.

Reach A – Franklin Township

The land use for Reach A is primarily forest, with residential houses on 1-2 acre lots, and much of the 300 foot riparian corridor is generally intact forest. The stream is approximately 20 feet wide with clear, fast, shallow flow, frequent riffles, shallow pools, and stable cobble substrate. Franklin Township acquired 55 acres of forested floodplain land through which the main stem of Sidney Brook flows. Access to Sidney Brook is available from Pittstown Road (Route 513) and Sidney Road (Route 617), but the stream flows were high during the scheduled field visits and were not entirely walked. Access to the lower segment of Sidney Brook downstream of Route 617 was not obtained due to private property restrictions, and the assessment was performed primarily from the Sidney Road bridge crossing.

The main stem of Sidney Brook flows under the Route 513 Bridge, and just downstream a large, deep pool has formed which offers good fishing opportunities and is frequented by fisherman. The area is stocked with trout each April by the NJDEP Division of Fish and Wildlife. Thick multiflora rose inhibits easy access to this segment of the stream. Fishermen also access the stream from the Sidney Road bridge, but private homes are adjacent to this area, no trespassing signs are posted, and public access is limited.

The housing development at Matthews Court is serviced by a grassed stormwater detention basin, in good maintained condition. Two intermittent streams cross under Grandin Road and minor erosion at the outfalls have been addressed with rip rap.

Sidney Brook flows east into the South Branch of the Raritan River. Access to this confluence is on a private farm and was not granted. The South Branch at the Hampton Road Bridge has evidence of sediment deposition and eroded streambanks. The streambanks are also severely eroded near the intersection of Hamden Road and Lower Lansdown Road undermining the road and exposing a 2 foot stormwater outfall with little to no support.

5.0 Water Quality Monitoring

Water quality monitoring was a major component of the characterization of the Sidney Brook and its watershed and is used to directly measure environmental function and impairment in the stream network. This data can and will be utilized in several capacities: to document and assess the water quality of Sidney Brook, to determine if the creek satisfies SWQS and other rules regarding quality, and to calibrate and confirm pollutant load and hydrology models. The water quality monitoring program used in this study was a systematic and comprehensive assessment of water quality and focused on characterizing eleven stations in the stream under both baseflow and stormflow conditions. Water quality metrics focused on in-situ (real time onsite) monitoring, discrete parameters analyzed at an aqueous chemistry laboratory, and bacteriological sampling. Regarding the visual assessment, the sampling program was conducted under a QAPP approved by the NJDEP. Additional work conducted included stream macroinvertebrate sampling, a fishery survey, toxic pollutant screening of both the water and stream sediments (PP+40), and discharge monitoring (discussed in the hydrology section).

5.1 In-Situ Temperature Monitoring

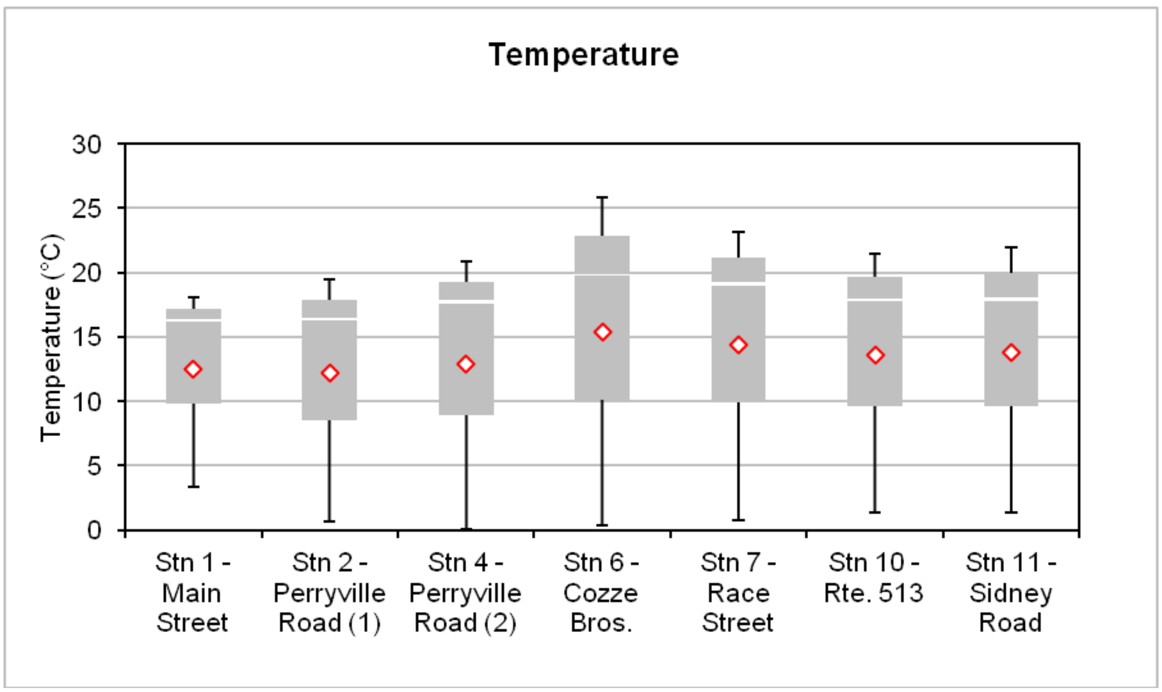
Probably the most important in-situ parameter measured in Sidney Brook is water temperature. Water temperature is an important parameter because it controls a wide variety of chemical and biological reactions, is a primary factor in regulating dissolved oxygen concentrations, may be used as an indicator of watershed disturbance such as buffer impairments, thermally elevated discharges, and impoundments, and largely structures aquatic communities, particularly the fishery. Since Sidney Brook is classified both as a TM (trout maintenance) and an NT (nontrout) waterbody (respectively the Union Township and Franklin Township portions) there are two different sets of water quality criteria, with stricter standards set for the TM portions in order to protect the coldwater biota. It should be noted that the NJDEP recently readopted the SWQS (November 2009) and amended some of the standards. The most important alteration to this project was the change in temperature criteria. The old standard relied merely on a summer seasonal average differentiated by TP (Trout Production), TM, and NT waters. The new standard relies on a rolling seven-day average as well as an absolute maximum. While the numerical data appear to be somewhat relaxed, they are actually more reflective of in-stream conditions and may in fact be more functionally restrictive and thus perform better at protecting the temperature regime. The standards are provided below:

- TM - Temperature shall not exceed a daily maximum of 25°C (77°F) or rolling seven-day average of the daily maximum of 23°C (73.4°F)

- NT - Temperature shall not exceed a daily maximum of 31°C (87.8°F) or rolling seven-day average of the daily maximum of 28°C (82.4°F), unless due to natural conditions

The station with the greatest temperature impairment is Station 6, located approximately 1200’ downstream of Jutland Lake, the major online impoundment of Sidney Brook (Figure 1). Not surprisingly, this station had the highest mean temperature (15.4°C) as well as the highest measured maximum temperature (25.8°C) recorded in the in-situ measurements. The elevated temperature at this station is caused by the impoundment where solar exposure and long hydraulic retention periods contribute to stream warming. However, despite this warming the stream also shows the ability to recover and Station 7, located approximately 2700’ downstream of Station 6, had a lower average temperature and a peak recorded temperature 2.7°C lower than Station 6 as the stream begins to run through intact riparian buffers and gain groundwater. Station 10 also showed a recovery (lowering) of temperatures and Station 11 only a very small increase. The data clearly show a divergence in stream temperatures upstream and downstream of Lake Jutland; those stations located upstream of Jutland Lake had lower mean and peak temperatures. In fact Station 1 had a peak temperature of 18.1°C, nearly 7.8°C lower than Station 6. While the limited number of sampling points limits statistical significance, it is evident that Sidney Brook is subject to temperature impairments, particularly the section downstream of Station 6.

Figure 1: *In-situ* Water Temperature



5.2 Continuous Temperature Monitoring

Continuous summer temperature monitoring was an important component of the characterization of the brook since the designation of Sidney Brook as Trout Maintenance (TM) water carries more restrictive temperature criteria to support a cold water fishery. This was accomplished by deploying temperature data loggers set to record at 10 minute intervals throughout the deployment period. Temperature was monitored at seven stations including four stations where the entire battery of in-situ sampling was conducted.

A review of the continuous temperature data is perhaps of higher value in assessing temperature impairments in the stream. While the temperature loggers were installed after summer temperature peaks it is clear that the stream is subject to temperature impairments. Once again Station 6 was shown to routinely violate temperature standards (Figures 2 and 3). In a 40 day period beginning on August 12 the seven-day rolling average of daily maximum was exceeded at Station 6 24 times; interestingly in the same period the daily maximum value was exceeded only 3 times. Station 3 showed a similar proclivity and violated the seven-day average 38 times and the daily maximum 14 times. Station 3, like Station 6, is located immediately downstream of an impoundment on one of the tributaries and therefore experiences the same type of warming effects. While none of the other stations showed any violations in the monitored period it seems likely that other stations would show mid-summer temperature exceedances at regular intervals and is most likely to occur at Station 7 and potentially Station 9. It should be noted that Station 11 is subject to the NT criteria.

Figure 2: Continuous Water Temperature Daily Maximum

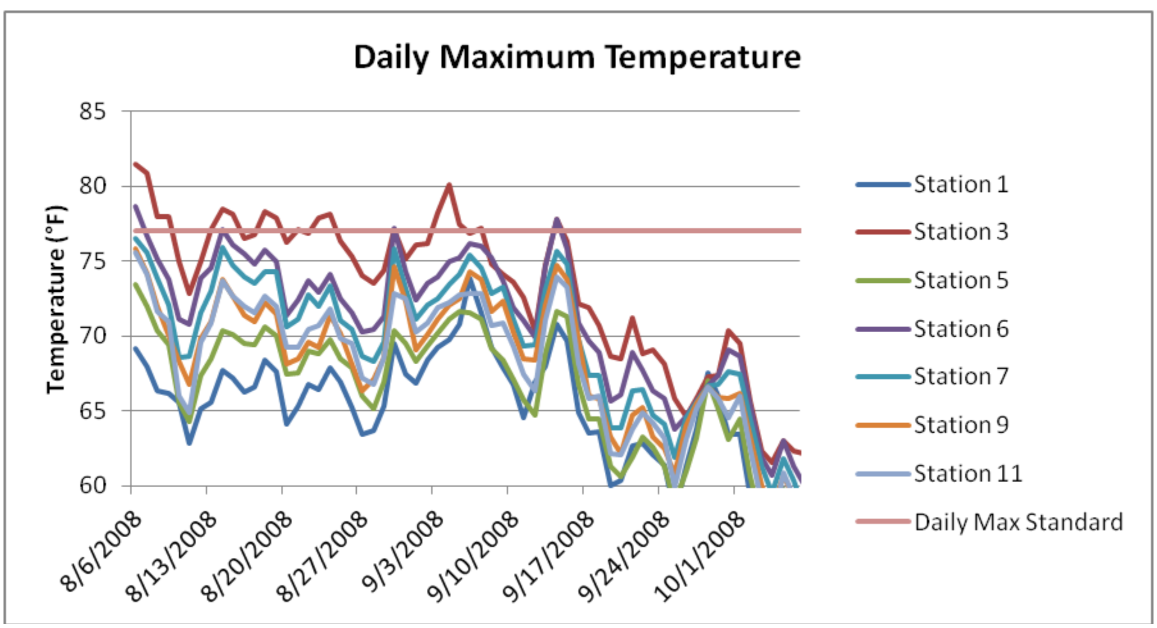
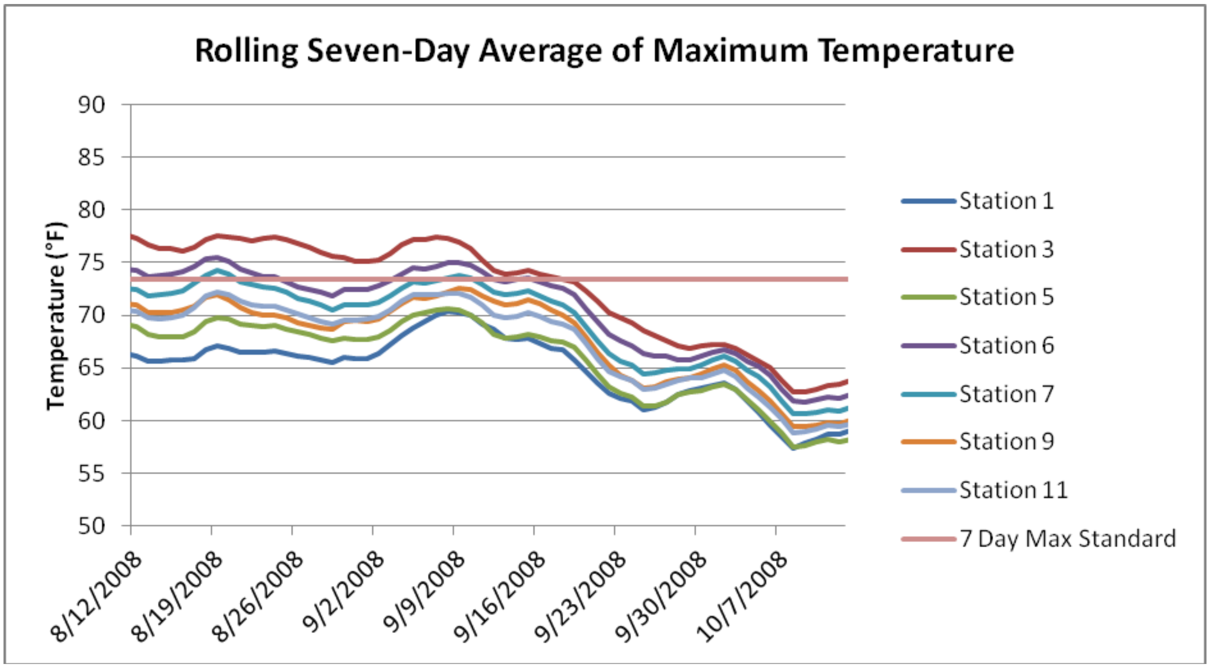


Figure 3: Continuous Water Temperature Rolling Seven-Day Average



5.3 Dissolved Oxygen

Dissolved oxygen (DO) is another important in-situ parameter in stream systems. Coldwater biota, including trout, have a high biological oxygen demand and therefore require higher DO concentrations than warmwater fish and other aquatic organisms. In stream systems DO concentration is primarily controlled by two abiotic factors, temperature and flow velocity. Oxygen solubility has an inverse relationship with temperature such that DO concentrations will decrease with warming temperatures. Flow velocity, and more specifically turbulent flow, is also a controlling factor and the more turbulent the flow the more oxygen is introduced into the system. Generally, higher gradient streams have more turbulent flow and higher DO concentrations; these stream types are typically thought of as classic trout streams. In waterways subject to eutrophication and nutrient enrichment stream DO concentrations can be altered by periphyton growth, macrophytes, phytoplankton, and microbes. The effect is two-tailed, that is DO levels can be increased to supersaturated levels by excessive photosynthetic production by the plants and algae during daylight hours and subsequently exhausted at night due to the respiration of microbes, plants, and algae.

As with water temperature, Sidney Brook is subject to different DO criteria in the TM and NT sections. In an effort to ensure meet habitat requirements for coldwater biota TM designations carry higher DO standards:

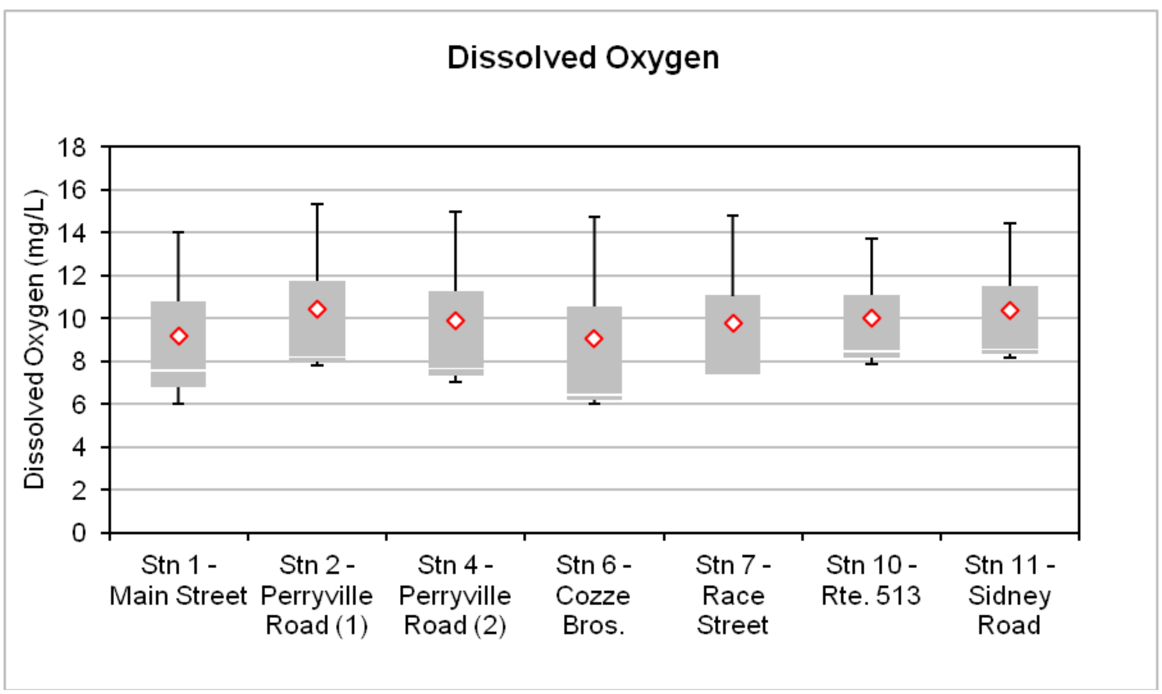
- TM - 24 hour average not less than 6.0 mg/L, not less than 5.0 mg/L at any time

- NT - 24 hour average not less than 5.0 mg/L, not less than 4.0 mg/L at any time

DO was measured at seven of the stations during each baseflow monitoring event with the use of a calibrated water quality meter. In this study DO was measured in two ways: the primary method was a direct measurement of concentration while the second method was a derivation of concentration accounting for temperature and percent saturation. Percent saturation is useful in determining DO trends over time since it normalizes the effects of temperature and therefore allows comparisons on a seasonal basis. It also allows for a more thorough understanding of biological processes which can contribute to supersaturated conditions (DO > 100% saturation) in eutrophic waterbodies.

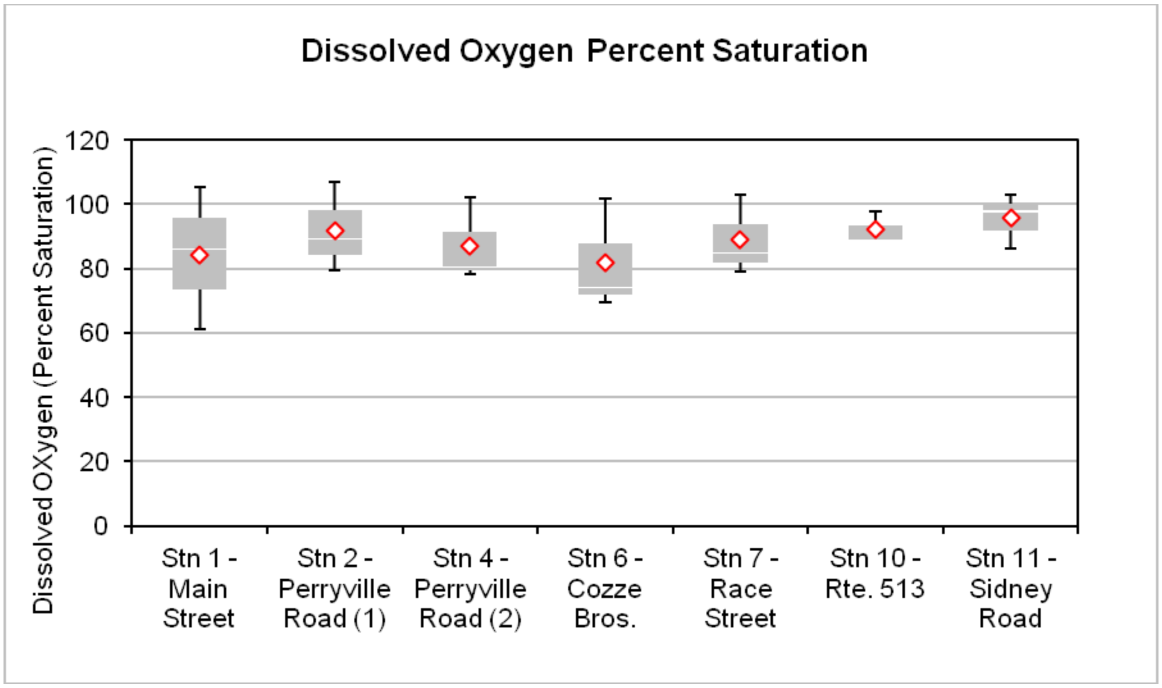
DO concentrations tended to be quite good across all stations (Figure 4). At no point were the SWQS criteria violated at any of the monitored stations. However, the data still yields some results that are useful in differentiating the stations. Station 6 had the lowest mean DO when expressed as both a concentration and percent saturation probably as a result of increased stream temperature, reduced turbulent flow, and increased organic material fluxes all related to the impoundment. Despite these issues DO levels were still adequate at this station. Station 1 also had slightly reduced DO concentrations relative to the other stations, and was also the site of the lowest DO concentration (5.98 mg/L) measured during the sampling. The cause of this is uncertain, but there are indications in other data, notably temperature and conductance, that the flow of Station 1 is strongly controlled by groundwater which may lead to somewhat reduced DO concentrations.

Figure 4: Dissolved Oxygen



It is also useful to look at percent saturation more broadly. All stations, with the exception of Station 10, experienced supersaturated conditions at some point (Figure 5). Supersaturated DO concentrations indicate elevated primary production, as oxygen is a by-product of photosynthesis. For the most part the supersaturation of DO was moderate, but indicates at the least some low level eutrophication of the stream throughout the watershed. It should be noted that Station 11 had the most consistent and highest mean DO percent saturation. While this may be attributed in part to the increased size of the stream at this end of the watershed and expected increases in primary productivity DO percent saturation is certainly aided in part by the number of unimpeded riffles upstream of this section which help oxygenate the water.

Figure 5: Dissolved Oxygen Percent Saturation

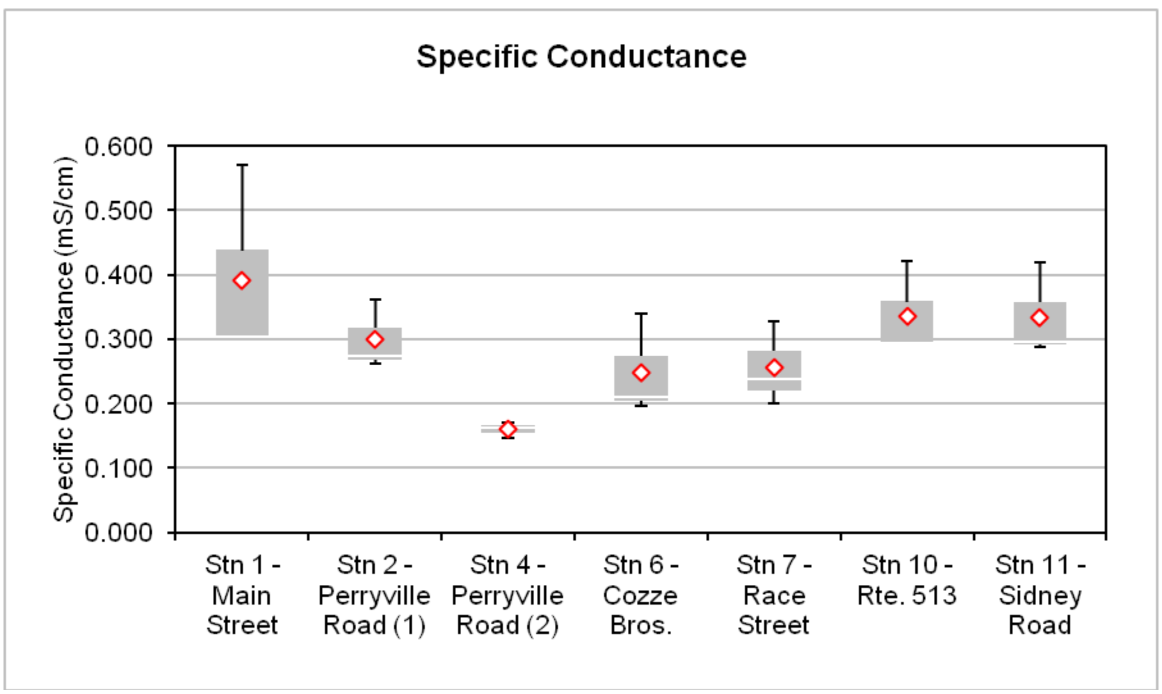


5.4 Specific Conductance

Specific conductance is a measure of the ability of water to conduct an electrical current and may be utilized as a proxy measure of solutes in water normalized for temperature. As with many other parameters, geology and soils are a strong influence in setting specific conductivity, however specific conductance can also be strongly affected by various pollutants derived from both point and nonpoint sources. These values may also yield clues about the hydrology of a system as groundwater may have higher conductance values than comparable surface waters. Specific conductance is not specifically regulated under the SWQS.

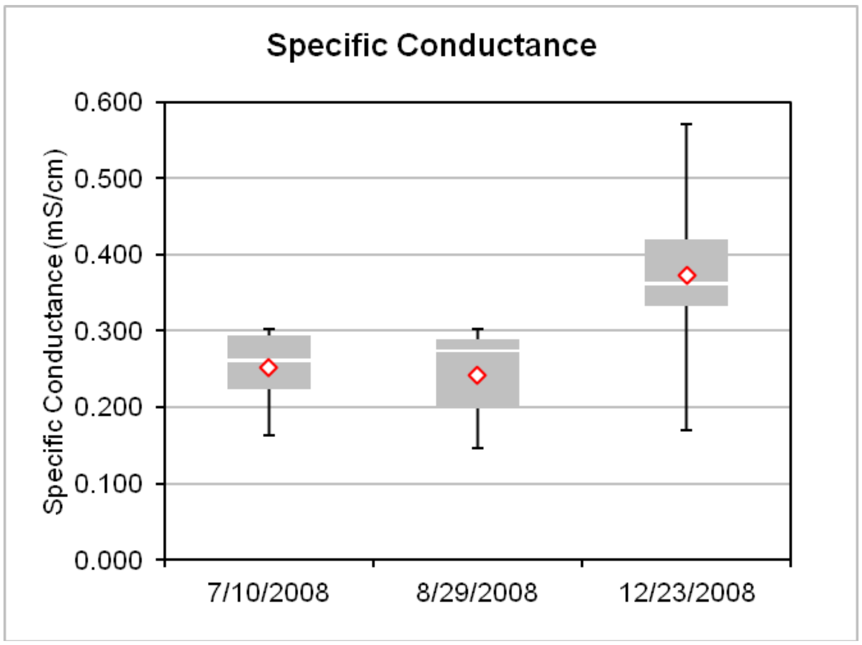
Specific conductance varied pretty widely between stations and over time. Station 1, located within Jutland, had the highest mean concentration and the highest discrete specific conductance value (Figure 6). While the mean value was high (0.392 mS/cm) it is not significantly greater than regional mean values, however the peak value of 0.571 mS/cm does represent a high value at baseflows. As mentioned previously, there are indications, including this data, that Station 1 may be more strongly linked to groundwater than other stations and thus be subject to higher base conductance levels, however it is worth noting that the subwatershed for this site is probably the most heavily developed in the watershed and thus subject to anthropogenic loading. The remainder of the stations had measured conductance values centered around 0.300 mS/cm. Also of particular note is Station 4 which was remarkably consistent over time and had a very low mean value of 0.167 mS/cm. The most obvious difference with this station is that catchment drains a different geology than the other stations, which are largely comprised of geologic formations consisting of carbonate rocks which are soluble and can increase conductance values. Areas upstream of Station 4 are also somewhat less developed and thus less apt to be influenced by anthropogenic source loading.

Figure 6: Specific Conductance



Another factor to consider in the conductance analysis is seasonal influences. While the first two events were relatively similar the final event conducted in December showed an increase of mean conductance of over 50% relative to the other events (Figure 7). All stations were measured at their respective peak values during this sampling event, highlighted by Station 1 which nearly doubled the previously measures values at this station. Several factors can be identified in the increase during this time period including the use of road salts or brines and increased groundwater contributions. While most of the stations are within acceptable limits the high values consistently measured at Station 1 are cause for concern and show elevated loading of dissolved solids that might be linked to septic effluent contributions and runoff from denser impervious coverage.

Figure 7: Specific Conductance by Date

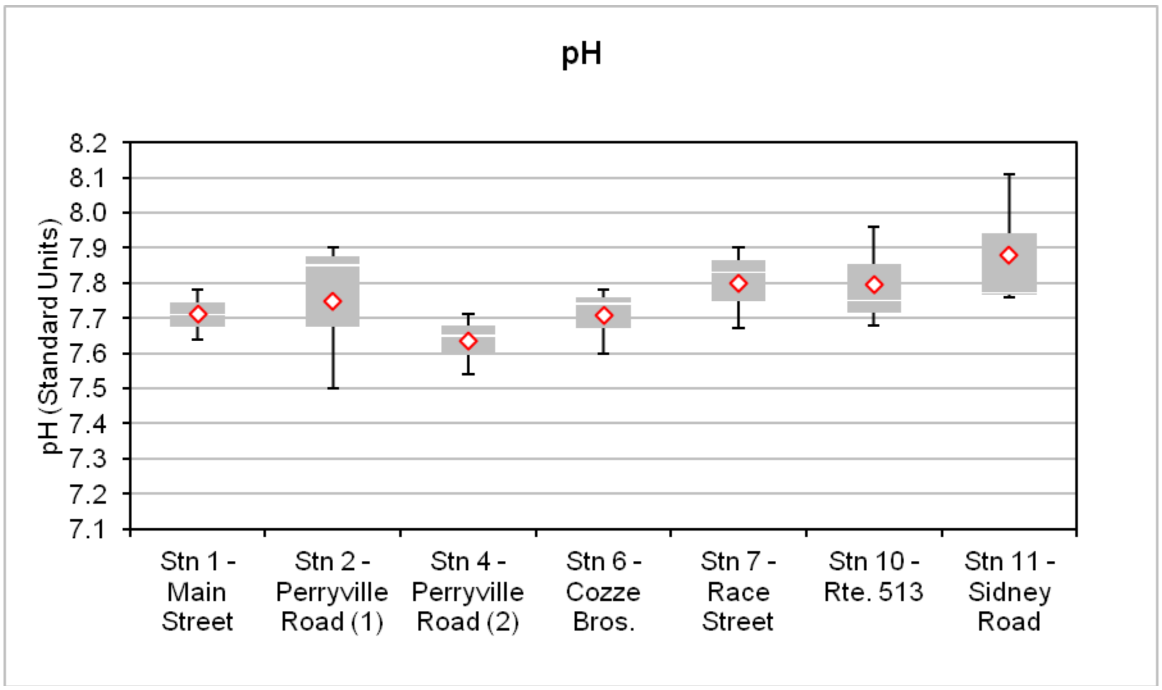


5.5 pH

pH is a unitless measure that describes the concentration of hydrogen ions in water, or more basically is a measurement of the acidity (<7.0) or basicity (>7.0) of water. As with conductance, pH can be largely influenced by the soils and geology of the watershed, but in addition can be affected by biological processes and pollution. From a biological perspective, primary production (photosynthesis) or respiratory processes will respectively cause pH to increase (become more basic) or decrease (become more acidic). Most aquatic organisms have a fairly narrow tolerance range of pH and most organisms in the Sidney Brook are adapted to neutral to basic pH values. SWQS for FW2 waterbodies state that pH is not to deviate from a range between 6.5 and 8.5.

pH was remarkably stable in the watershed and there was little variation between stations or within individual stations over time. The mean pH values varied between 7.6 and 7.9 which may show a slight elevation and perhaps low level eutrophication, but no measured value approached the applicable criterion (Figure 8). It should be noted that pH tended to increase slightly moving down through the watershed. This is consistent with the increased influence of the drainage of carbonate lithology in the lower portions of the watershed as well as suspected increases in primary production. In turn this is consistent with the slightly lower values measured at Station 4 which does not drain carbonate formations. Overall, pH values measured in Sidney Brook are ideal for supporting an array of freshwater aquatic biota.

Figure 8: pH



5.6 Discrete Parameters

A variety of discrete parameters were collected at the same stations where in-situ monitoring was collected. Discrete water sampling refers to the collection of water quality samples which are then analyzed at an aqueous chemistry laboratory. Discrete water quality parameters sampled for this project included a battery focused on substances of limnological interest:

- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)
- Total Phosphorus (TP)
- Soluble Reactive Phosphorus (SRP)
- Nitrate (NO3-N)

These analytes represent the parameters most commonly associated with degraded water quality and may be reliable indicators of eutrophication, erosion and sedimentation, and general water quality impairments. As with the in-situ parameters several of the discrete parameters are regulated by the SWQS. Unlike the in-situ parameters discrete sampling was conducted under both baseflow and stormflow conditions because of the wide divergence in concentrations under varying hydrologic conditions. Discrete grab samples were collected at seven of the stations during each baseflow monitoring event and composite samples were collected during each stormflow monitoring event.

The following table (8) lists the applicable SWQS parsed by TM and NT criteria. SRP is not specifically regulated as a stand-alone metric, but as a species of phosphorus would be effectively managed within and by the TP criterion.

Table 8: SWQS for TM and NT Waters

SWQS for Discrete Parameters		
Parameter	**Trout Maintenance**	**Nontrout**
Total Suspended Solids (Non-Filterable Residue)	25 mg/L	40 mg/L
Total Dissolved Solids (Filterable Residue)	No increase in background which would interfere with the designated or existing uses, or 500 mg/L, whichever is more stringent	Same
Total Phosphorus	Streams: Phosphorus as Total P shall not exceed 0.1 mg/L in any stream, unless it can be proven that Total P is not a limiting nutrient and will not otherwise render the waters unsuitable for designated uses	Same
Nitrate	10 mg/L (Human Health Standard)	Same

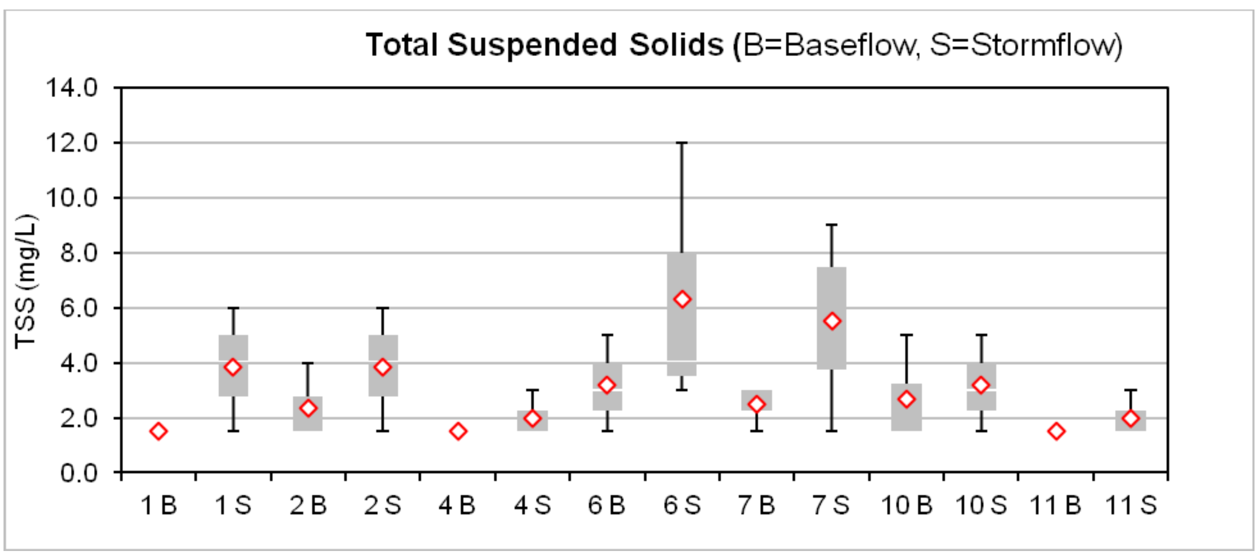
5.7 Total Suspended Solids (TSS)

Total suspended solids measures the concentration of both organic and inorganic particulates in the water and may be characterized alternatively as non-filterable residue. In streams TSS is usually associated with particulate matter eroded from the watershed or under increased hydraulic loading from within the stream channel. Poor management practices and increased imperviousness of the watershed leads to increased solids loading. Increased solids loading in streams is detrimental to many aquatic organisms that lead to a loss of habitat and smothering as well as changes in the hydrogeomorphology of the system. In TM waters suspended solids concentration is not to exceed 25 mg/L, while NT waters are not to exceed 40 mg/L.

Total suspended solids (TSS) concentrations in Sidney Brook tended to be quite low throughout the sampling period both at baseflow and stormflow conditions. At no time, including both baseflow and stormflow conditions, did TSS concentration exceed SWQS for TSS in either the TM or NT stream sections with respective concentrations of 25 mg/L and 40 mg/L (Figure 9). Under baseflow conditions TSS concentrations for three stations, Stations 1, 4, and 11, were always below minimum detection limits, and the remaining stations were all measured below MDL at least once. In the upper portions of the watershed only Station 2 exhibited concentrations above the MDL. The highest mean baseflow concentration was measured at Station 6. The exact reason for the localized increase is unclear, but it seems likely that algal cells or other suspended organic particles discharged from Jutland Lake are the source of this increase. Again, it should be emphasized that TSS concentrations at baseflow are quite low throughout the sampled stations.

Stormflows produced higher mean concentrations at each station relative to baseflow. Stations 6 and 7 had the highest mean concentrations and the greatest variation between baseflow and stormflow conditions. The peak stormflow concentration was recorded once again at Station 6 at 12 mg/L, which is still a relatively modest concentration. On a temporal basis concentrations were lower in the winter relative to summer and fall sampling again pointing to the contribution of algae particles as the source of some of the loading. TSS concentrations appear to be acceptable in Sidney Brook despite the reports of erosion and other stormwater issues in the watershed. The low solids loading also seems to be confirmed in the Visual Assessment data in which cobble was reported as the dominant stream channel substrate.

Figure 9: Total Suspended Solids

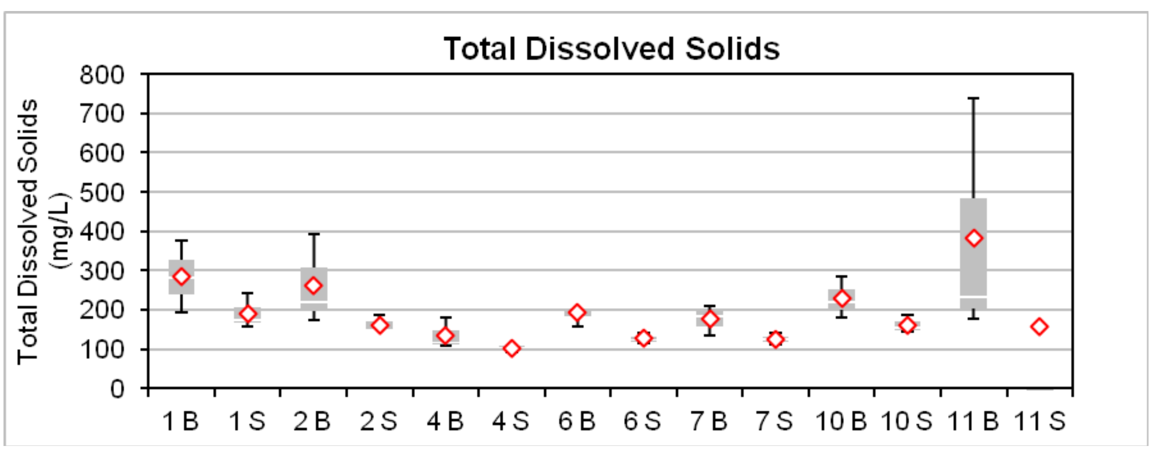


5.8 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) is another measure of solids that accounts for dissolved organic and inorganic substances of micro-granular materials; this parameter may also be called filterable residue. TDS is in essence a direct measure of the ionic constituents that affect the conductance of water. Again, the source is related to soils and geology in the watershed, groundwater inputs, and surface runoff. High values may be an indication of pollution in the watershed. SWQS for FW2 waterbodies for TDS have a limit of 500 mg/L or no increase above background levels that would interfere with designated uses, whichever is more stringent.

TDS concentrations were generally moderate in Sidney Brook but did show distinct differences based on flow status and station location (Figure 9). The SWQS for FW2 streams for TDS is set at 500 mg/L; only one exceedance was recorded at baseflow conditions at Station 11. Mean concentrations fell during storm events at all stations as a function of dilution. The highest mean concentrations were observed in the headwaters at Stations 1 and 2 and at the bottom of the watershed at Station 11. Temporal patterns are not well defined, but baseflow concentrations tended to be slightly higher under higher baseflows in the fall and winter probably as a result of increased groundwater contributions or road salts, while stormflow TDS values were highest in the summer indicating stormwater enrichment of solutes. While the concentrations generally met water quality standards the elevated concentrations at the stations near Jutland indicate increased loading in this area. Similarly, the very high concentration measured at Station 11 in August 2008 is some cause for concern. Interestingly, while TDS was elevated at this date there was no significant increase in specific conductance indicating that the TDS constituent was likely non-ionic and may have been colloidal or some other source. The increase at this station is also noteworthy because Station 10, located approximately 2800’ upstream of Station 11, did not show a similar response indicating that the loading originated between these two sites.

Figure 9: Total Dissolved Solids

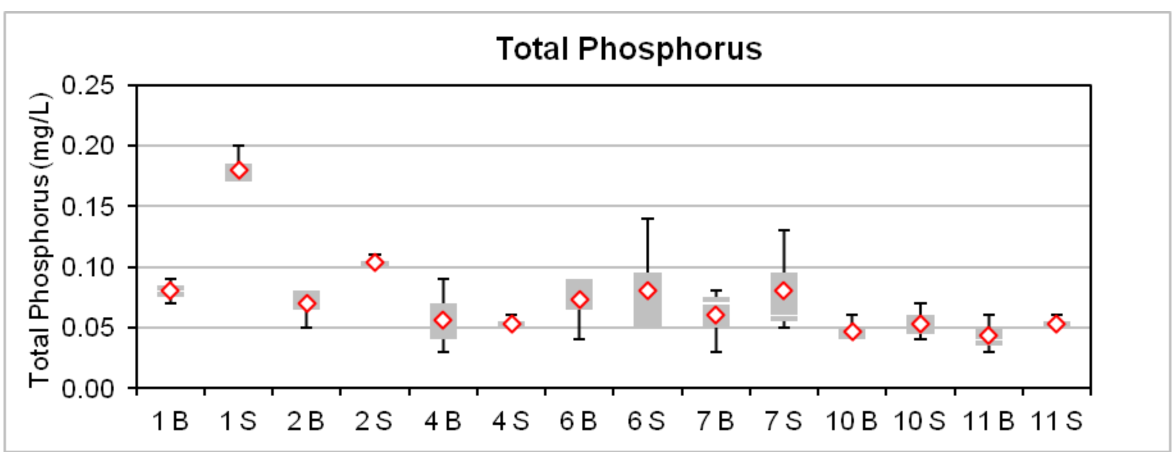


5.9 Total Phosphorus (TP)

Total Phosphorus (TP) is probably the nutrient that has garnered the most attention in relation to the eutrophication of waterbodies. This is because TP is generally the limiting nutrient in most freshwater ecosystems and thus directly controls the growth rates of plants and algae. While not as critical in streams as in lakes, TP nonetheless can contribute to excessive primary production in flowing systems. The major source of TP in most streams is particulates like inorganic sediments and organic detritus. Soluble forms of phosphorus are generally found in much lower concentrations because it is rapidly assimilated, but excessive concentrations can indicate pollution. Excessive loading is related to stormwater inputs, sediment, channel erosion, fertilizers, septic sources, and animal loading. The SWQS for TP in streams sets an upper bound of 0.10 mg/L unless TP is proven not to be the limiting nutrient.

TP concentrations tended to vary widely between stations and at some stations displayed considerable variation between baseflow and stormflow events (Figure 10). During stormflows TP concentrations exceeded the 0.10 mg/L SWQS for FW2 streams at four stations: 1, 2, 6, and 7, although Station 1 was the only site to exceed the standard more than once. In general TP concentrations tended to decrease moving downstream and Stations 4, 10, and 11 had the lowest mean TP concentration during both baseflow and stormflow conditions. Slightly elevated concentrations at Stations 6 and 7 were correlated to higher TSS loads at these sites, which have an increased proportion of organic particles. A seasonal trend was also observed in the data in which concentrations decreased throughout the sampling period with the lowest values measured in winter. For the most part the TP criterion is satisfied, particularly under baseflow conditions, however, a number of stations periodically or habitually exceed the standard during stormflows. This, as with other parameters, indicates that Sidney Brook is subject to eutrophication. The consistently high stormflow concentrations measured at Station 1 is definite cause for concern and seemingly is correlated with higher development density in the catchment draining to this station.

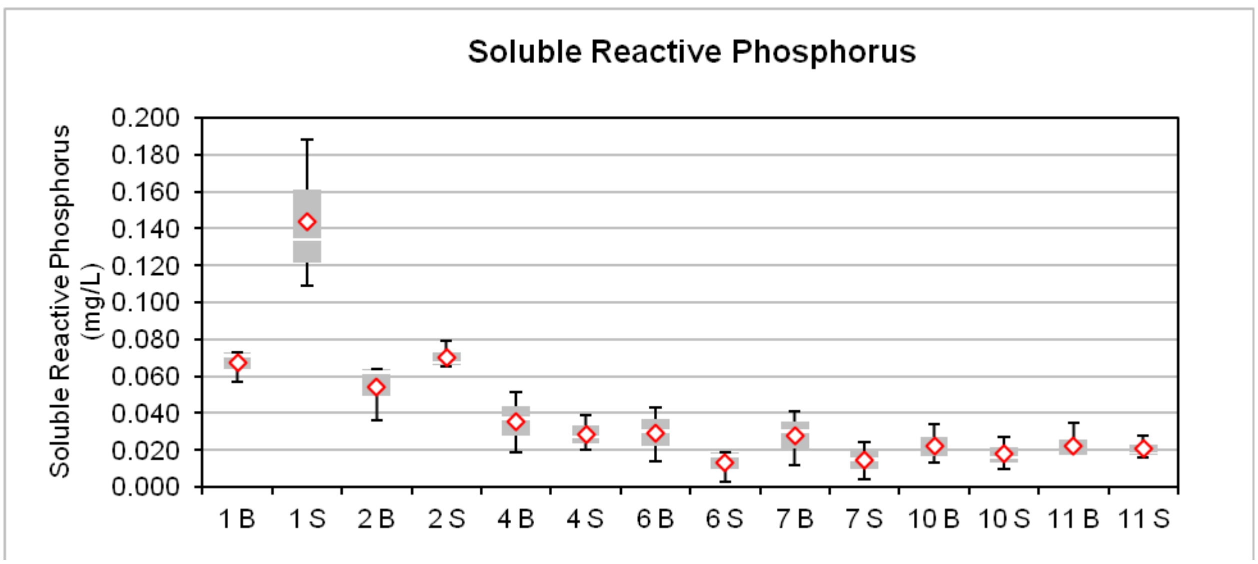
Figure 10: Total Phosphorus



5.10 Soluble Reactive Phosphorus (SRP)

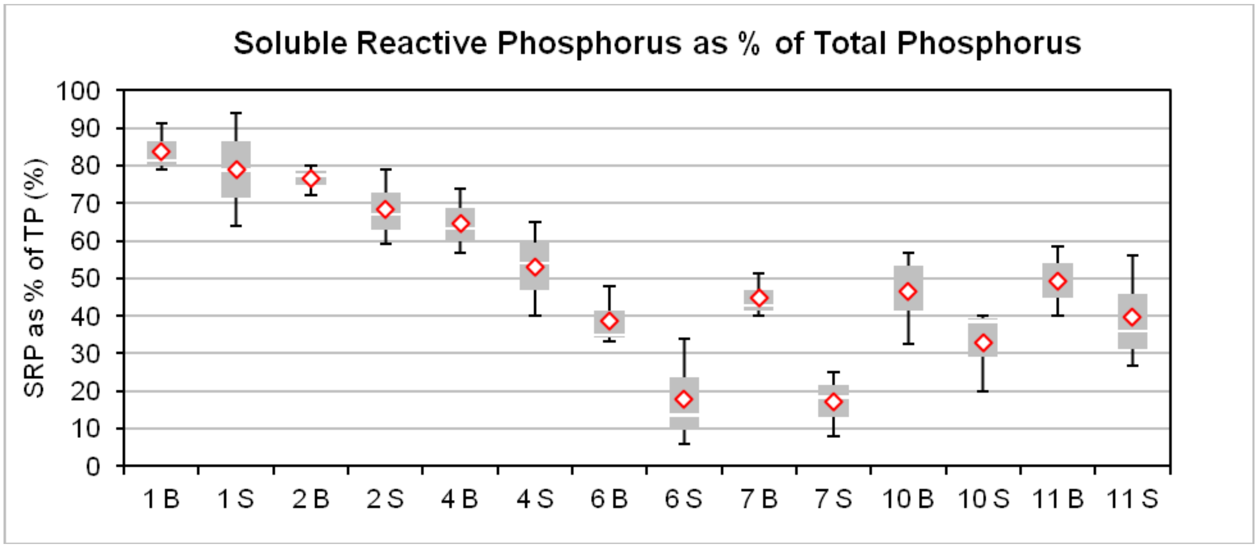
Soluble Reactive Phosphorus (SRP) is not specifically regulated in the SWQS as a nutrient pollutant other than its inclusion as a component of TP, but as the species of phosphorus that is most biologically reactive and associated with anthropogenic sources can be a valuable forensic tool in identifying excessive loading. For the most part SRP values were moderate and not indicative of excessive loading, and most stations were marked by a decrease in concentration during stormflow events due to the normal effects of dilution (Figure 11). Stations 1 and 2 displayed a different pattern marked by much higher concentrations during stormflow relative to baseflow and higher concentrations in general compared to the other stations. In fact, all measured stormflow SRP concentrations exceeded TP standards at Station 1. This pattern is indicative of excessive SRP loading. Normally SRP concentrations decrease during elevated stream flows due to dilution, but an increase indicates that some sort of loading is occurring which may be due to mobilization and dissolution of fertilizers in surface runoff or loading related to failing septic systems via runoff or increased groundwater interflow. SRP concentrations decreased throughout the course of the year.

Figure 11: Soluble Reactive Phosphorus



An additional analysis was performed to more fully contextualize SRP as part of TP which was accomplished by expressing SRP as a percentage of TP. One of the most important trends observed was that all stations below Jutland Lake, Stations 6 through 11, had much lower mean percentage of SRP as TP and that stormflow percentages were lower than baseflow (Figure 12). The lower concentrations at these stations are a result of biological uptake in Jutland Lake and the decreased prevalence of groundwater contributions in the main stem. At the stations upstream of the impoundment, mean percentage of SRP as TP was much higher and the difference between stormflow and baseflow was minimal. At Stations 1 and 2 SRP accounted for between 68 to 84% of TP on average, which is very high and consistent with excessive anthropogenic loading.

Figure 12: Soluble Reactive Phosphorus as Percent of Total Phosphorus



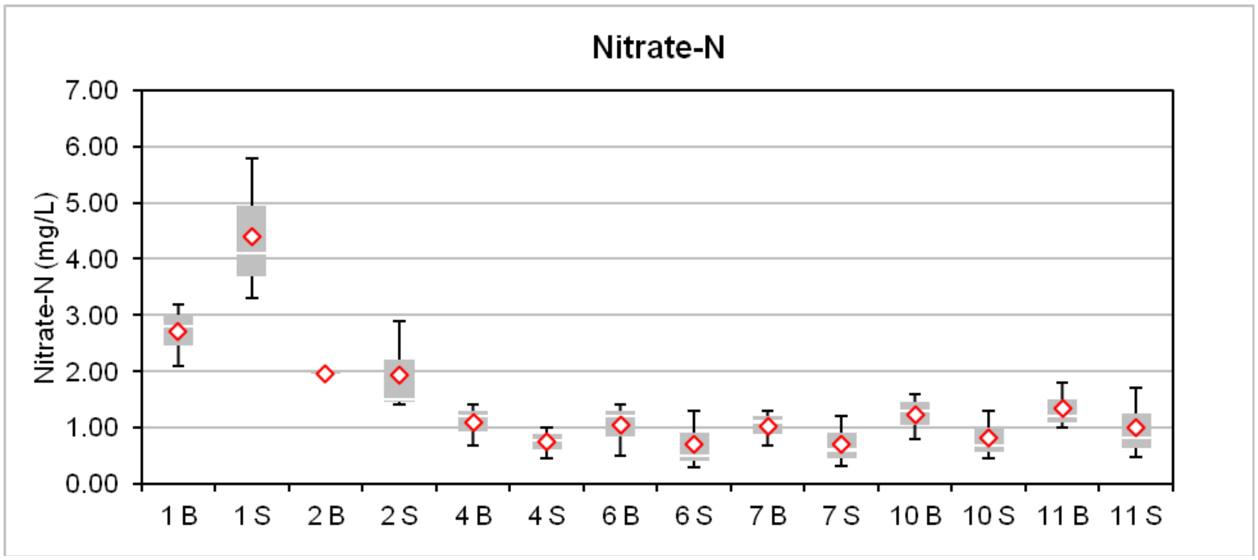
5.11 Nitrate (NO_3)

Nitrate (NO_3) is usually the most important nitrogen species simply because it is the most widely available and typically most other available species undergo nitrification by various nitrogen bacteria and are converted to nitrate. Nitrate is a primary growth nutrient utilized by macrophytes and algae. This parameter tends to be extremely variable seasonally, spatially, and hydraulically. This is due to its variety of sources including groundwater, stormwater runoff, wastewater, biological fixing, excretion, and decomposition of organics; sinks include biological assimilation. Additionally, nitrate is extremely soluble and thus highly mobile in water, including groundwater. Nitrate is primarily regulated under drinking water and human standards and is not to exceed 10 mg/L. This standard therefore is not based on ecological values as the other examined SWQS criteria are and 10 mg/L would represent a very high value in surface waters.

For the most part NO_3 concentrations are moderate in Sidney Brook, but as with other analytes Stations 1 and 2 exhibited much higher mean concentrations than the other locations (Figure 13). While NO_3 never exceeded the standards the measured elevated concentrations are consistent with loading related to development in the watershed. NO_3

concentrations at Stations 1 and 2 also tended to be higher at stormflow than baseflow indicating additional loading in surface runoff; all other stations showed the opposite pattern as the result of dilution. On a seasonal basis NO_3 baseflow concentrations increased through the year as a result of increased groundwater loading and decreased biological assimilation. The high concentrations in the headwaters of Sidney Brook are cause for concern, especially the increased concentration during stormflows. Higher population density in this catchment is highly correlated with this loading, and in conjunction with other data, may indicate loading related to septic systems.

Figure 13: Nitrate



5.12 *E. coli*

The NJDEP has developed criteria for *E. coli*, a fecal coliform bacterium, to protect designated stream uses such as primary contact recreation and potable water supply. While *E.coli* is a normal gut bacterium of endotherms (warm-blooded animals including mammals and birds) this metric is used as an indicator of pathogen contamination usually associated with fecal coliform loading. Currently, the SWQS for *E. coli* is: *E. coli* levels shall not exceed a geometric mean of 126 cfu/100mL or a single sample maximum of 235 cfu/100mL. *E. coli* was sampled at the same seven stations discussed above and was sampled under both baseflow and stormflow conditions. Following normal state protocol five samples were also collected within a 30-day window under varying flow regimes to calculate a summer geometric mean. *E. coli* loading in waterbodies is related to a variety of sources transported both in surface runoff and groundwater including:

- Livestock
- Failing Onsite Septic Systems

- Failing Sewage Conveyance Systems
- Domestic Pets
- Wildlife
- Waterfowl

E. coli loading in Sidney Brook was determined to be a serious issue. Regardless of analysis almost all samples and metrics violated a portion of the standards. Of the individual samples collected only 18 of the 77 samples satisfied the single sample maximum of 235 cfu/100mL, with the remaining 59 samples exceeding the standard. All stations exceeded the maximum standard on at least half of the sampling events, while Station 2 never conformed to the single sample maximum. While the stations in the upper portion of the watershed had worse geometric mean scores, Station 11 had the highest measured *E. coli* count at 88,000 cfu/100mL, an extraordinarily high number and one that was four times higher than Station 10 directly above. This difference may indicate that the source of the loading is the adjacent farm fields.

The 30 day summer geometric mean was violated by all stations; Station 6 scored the lowest concentration at 395 cfu/100mL, while Station 2 was the highest at 3094 cfu/100mL (Table 9). An interesting pattern in this data, and one repeated in the other analyses based on *E. coli*, is that Station 6 and the remainder of the stations downstream of Jutland Lake had lower mean values than those upstream. This indicates that Jutland Lake is acting as a regional sink for bacteria particles and thus reducing in-stream concentrations downstream.

Table 9: 30-Day Summer Geometric Mean of *E. coli*

Station ID	7/22/2008	7/24/2008	8/11/2008	8/21/2008	9/9/2008	Summer 2008 Geomean
Stn 1 - Main Street	1,600	4,600	4,400	240	25,000	2,869
Stn 2 - Perryville Road (1)	2,000	5,900	1,400	490	35,000	3,094
Stn 4 - Perryville Road (2)	410	3,200	470	470	34,000	1,580
Stn 6 - Cozze Bros.	270	400	320	70	4,000	395
Stn 7 - Race Street	360	510	360	250	3,800	575
Stn 10 - Rte. 513	300	1,700	460	360	21,000	1,121
Stn 11 - Sidney Road	280	2,400	430	4,400	88,000	2,569
Samples less than single maximum value of 235 CFU 100ml						
Geomean less than 126 CFU 100ml						

The *E. coli* results were also evaluated for geometric means for both baseflow and stormflow over the course of the sampling as a comparative metric. Again, all stations routinely violated the geometric standard during both baseflow and stormflow. The only exception to this is Station 6 which barely met the geometric mean standard during baseflow conditions only. The ubiquity of high values seen across all stations under both baseflow and stormflow conditions is a major cause for concern and indicates major coliform loading throughout the watershed. It is important to mention that the *E. coli* standard is one that is often violated throughout New Jersey even in very rural watersheds where the major source of loading is likely to be wildlife, however the scope of standards violations in Sidney Brook needs to be addressed and become a management priority as pathogen concentrations in Sidney Brook represent not only a contravention of designated use, but potentially a human health concern.

5.13 Macroinvertebrates

A benthic macroinvertebrate (steam insects and other aquatic invertebrates) component was included in this study to integrate biological data with an evaluation of water quality and general ecological function of the stream system. The use of biological indicators has been gaining traction in recent years as a valuable data source and a tool to evaluate stream function. Historically, NJDEP utilized the AMNET (Ambient Biomonitoring Network) New Jersey Impairment Score (NJIS) to evaluate macroinvertebrates that was based on family level taxonomy and yielded three ratings categories (non-impaired, moderately impaired, and severely impaired). AMNET scoring is based on the sum of several metric scores focused on diversity, tolerance and other categories. Recently, the NJDEP has replaced the NJIS with High Gradient Macroinvertebrate Index (HGMI) in the high gradient portions of the state (outside of the Coastal Plain) which uses refined taxonomy to genus and some different community metrics. This document and the approved QAPP utilized NJIS scoring. The last AMNET sampling of Sidney Brook occurred in 2004 and the HGMI score was 75.95 and rated as excellent. The raw data from this event however was back-calculated to yield an NJIS score of 30 (the maximum number) and is rated non-impaired.

Sampling was conducted at eight sampling stations in Sidney Brook. In total, the stations NJIS scores ranged from 21 to 30 with seven of the stations rated as non-impaired, while Station 11 was rated as impaired (Table 10). For the most part many of the metrics were quite good throughout the stations. The poorest scoring metric on average was the EPT index which is family richness of some of the most sensitive insect taxa including Mayflies (Ephemeroptera), Stoneflies (Plecoptera) and Caddisflies (Trichoptera). While this number is somewhat low, percent EPT, a score of the total abundance of these taxa expressed as a percentage of the whole sample was generally fairly high. The MFBI (Modified Family Biotic Index), which uses family tolerance values based on tolerance to organic pollution, was also robust indicating that many sensitive or intolerant species inhabit the stream which in turn indicates high water quality. Of most concern was the moderate impairment score for Station 11 which was characterized by somewhat more tolerant taxa, particularly the Chironomid midges which accounted for a very large fraction of the sample. The shift in community composition at this station may indicate eutrophication of this stream reach as well as sedimentation.

Table 10: Benthic Macroinvertebrate NJIS Scoring

Sidney Brook Benthic Macroinvertebrate NJIS Scoring									
	Station Identification								
Metric	**2**	**3**	**4**	**6**	**8**	**9**	**10**	**11**	**AMNET**
Taxa Richness	12	16	18	13	12	13	21	18	19
EPT Index	3	4	6	5	5	6	9	7	10
Percent Dominance	35.76	38.89	45.22	34.75	29.91	38.71	25.66	51.69	22.00
Percent EPT	63.58	35.71	73.91	51.69	32.48	63.71	45.13	34.75	52.00
FBI	3.01	4.25	4.19	4.37	4.36	3.96	4.42	5.26	3.73
	Scoring Criteria								
Taxa Richness	6	6	6	6	6	6	6	6	6
EPT Index	3	3	6	3	3	6	6	6	6
Percent Dominance	6	6	3	6	6	6	6	3	6
Percent EPT	6	6	6	6	3	6	6	3	6
FBI	6	6	6	6	6	6	6	3	6
SUM	**27**	**27**	**27**	**27**	**24**	**30**	**30**	**21**	**30**
NJIS Category	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Moderately Impaired	Non-Impaired

5.14 Fishery

The basic metric used in New Jersey to evaluate fisheries is the Fish Index of Biotic Integrity or FIBI. The FIBI uses ten different metrics and applicable scoring criteria for each to develop the final score and determine the condition category; it is important to note that four of these metrics vary according to stream or watershed size. The last FIBI survey conducted by the state was performed in 2001, at a site equivalent to Station 11, when the stream scored a 46 and was designated excellent. Since then the FIBI scoring has been modified to more accurately reflect the conditions and species composition in New Jersey. To reflect these changes in methodology the original data from the 2001 survey was used to recalculate the FIBI to ensure a direct comparison with newly collected data, however there was no change to the final score. It should be pointed out that part of the reason that Sidney Brook was upgraded to a TM waterbody was the capture of a juvenile brown trout (*Salmo trutta*) by Princeton Hydro in 2003 and subsequent captures by the NJDEP, which is an illustration of the utility and importance in incorporating fisheries data in this WPP (Figure 14).

Figure 14: Juvenile Brown Trout

The fishery survey was conducted in August 2009 at four stations indicated on the sampling map (Appendix I Figure 22). A relatively large number of species was captured in the 2009 effort, including the smallmouth bass (*Micropterus dolemieu*) and yellow perch (*Perca flavescens*) which had not been previously recorded, however no trout were captured in this survey (Table 11). It must be noted though that trout had been observed numerous times during other sampling efforts between Stations 9 and 11. As stated previously, a historic FIBI score for a site analogous to Station 11 was 46 or Excellent. In the current effort all stations were rated as Good with scores ranging from 38 to 44 (Table 12). Overall, it seems that the quality of the fishery may have deteriorated slightly since the 2001 survey. Two areas are of particular concern. First, intolerant richness was relatively low in the stream indicating stressors in water quality that may prohibit these sensitive species from inhabiting the stream. Second, the capture of even one additional intolerant species would have significantly boosted the scoring on this low order stream. The proportion of individuals as trout or piscivores (excluding eels) is also relatively low as the predominant piscivore in the stream is the American eel (*Anguilla rostrata*). While the fishery is good it could be improved and the predominance of tolerant species again indicates problems with eutrophication. An alternative explanation and probably complementary explanation for low intolerant richness is temperature which was shown to frequently exceed SWQS during the monitoring period. It is also worth noting that total abundance is rated as moderate in this stream, which was also indicated in the 2001 effort and while water quality issues may be a driver in this phenomenon the visual assessments note a real lack of coarse woody debris that serves as vital habitat for many of these small stream dwelling species.

Table 11: Fishery Species List

Sidney Brook Fishery					
Species		Station Identification			
		5	7	9	11
American Eel	*Anguilla rostrata*	0	17	6	8
Blacknose Dace	*Rhinichthys atratulus*	560	15	23	35
Bluegill	*Lepomis macrochirus*	0	2	8	4
Common Shiner	*Luxilus cornutus*	0	7	12	2
Creek Chub	*Semotilus atromaculatus*	22	7	9	3
Fallfish	*Semotilus corporalis*	0	44	17	0
Green Sunfish	*Lepomis cyanellus*	2	0	0	0
Largemouth Bass	*Micropterus salmoides*	0	2	5	4
Longnose Dace	*Rhinichthys cataractae*	0	20	25	22
Margined Madtom	*Noturus insignis*	0	2	6	0
Pumpkinseed	*Lepomis gibbosus*	1	0	11	5
Redbreat Sunfish	*Lepomis auritus*	0	1	2	0
Smallmouth Bass	*Micropterus dolomieu*	0	0	0	1
Tesselated Darter	*Etheostoma olmstedi*	2	6	13	25
White Sucker	*Catostomus commersoni*	106	0	37	18
Yellow Perch	*Perca flavescens*	0	1	1	1
	Totals	**698**	**131**	**184**	**139**

Table 12: Fish Index of Biotic Integrity Scoring

Sidney Brook FIBI								
Scoring Metrics	Scoring Criteria			Station Identification				
	5	3	1	11	9	7	5	NJDEP
Total Richness	Varies with Stream Size			5	5	5	1	5
Benthic Insectivorous Richness (excluding White Suckers and bullheads)	Varies with Stream Size			5	5	5	5	5
Trout and Sunfish Richness (excluding Green Sunfish and Bluegill)	Varies with Stream Size			5	3	5	5	5
Intolerant Richness	Varies with Stream Size			1	3	3	1	5
Proportion of Tolerant Individuals	<20%	20-45%	>45%	3	3	5	5	3
Proportion of Generalist Individuals	<20%	20-45%	>45%	3	3	5	5	5
Proportion of Insectivorous Cyprinid Individuals	>45%	20-45%	<20%	5	5	5	5	5
Proportion of Individuals as Trout or Individuals as Piscivores (excluding Am. Eel, whichever metric yields greater	>5%	1-5%	<1%	3	3	3	1	3
Number of Individuals (not including Tolerant Species)	>250	75-250	<75	3	3	3	5	5
Proportion of Individuals with disease and anomolies (excluding blackspot)	<2%	2-5%	>5%	5	5	5	5	5
	Total			38	38	44	38	46
	Condition Category			Good	Good	Good	Good	Excellent

5.15 Water Quality and Sediment Screening for Priority Pollutants + 40

A final quantitative analysis of the water quality of Sidney Brook consisted of a Priority Pollutant + 40 (PP+40) screening of aqueous and sediment matrices of Sidney Brook at three locations. PP+40 is a wide sweep of various pollutants of different classes classified as priority pollutants by the USEPA per the Clean Water Act, as well as an additional 40 organics. More specifically, in total this scan includes 126 compounds, consisting of volatile organics, semi-volatile organics, metals, polychlorinated biphenyls (PCBs), pesticides, cyanides and phenols. These chemicals represent a distinct class of pollutants relative to the discrete parameters discussed above which are typical limnological parameters that are used to assess eutrophication, biological activity and watershed loading. While the investigated discrete parameters are indicators of pollution they are generally not toxic, which is in contrast to the PP+40 compounds which are largely toxics. As toxins these compounds are regulated somewhat differently under a variety of standards usually based around human health or environmental biotic response related to acute and chronic toxicity. Sediments are regulated as soils and specified under the Soil Remediation Standards (SRS, N.J.A.C. 7:26D), which are then further broken down into Residential Direct Contact Soil Remediation Standards, Non-Residential Direct Contact Soil Remediation Standards, Inhalation Health Based Criteria, and Ingestion-Dermal Health Based Criteria; Impacts to Groundwater are assessed on a site specific basis as is the regulation of Chromium. PP+40 compounds in the aqueous matrix are regulated by the Surface Water Standards, which includes Human Health Criteria as well as Acute and Chronic Criteria for aquatic organisms. In general, the Residential Direct Contact Soil Remediation Standard for sediments and Human Health Standard for water are the applicable criteria for this exercise. Overall, the PP+40 scan was performed to evaluate whether toxic pollutants may be impacting aquatic communities and human health in the Sidney Brook. Accompanying the PP+40 analysis was an evaluation of Total Organic Carbon and Grain Size distribution for the sediment samples.

Water and sediment samples were collected under baseflow conditions at three stations in Sidney Brook including Stations 6, 7, and 10. Stations 6 and 7 were bracketed around the junkyard, which is a potential vector for various organics and metals related to the storage of scrapped automobiles, while Station 10 evaluates effects further downstream. Overall, the PP+40 scan showed that very few of the scanned analytes were detected in either the water or sediment. In the sediment matrix none of the following classes were found above laboratory detection limits: volatile organics, PCBs, pesticides, cyanides or phenols. Several of the semi-volatile compounds were detected (8 of 71 investigated analytes), but were only evident at Station 10, and all were well below applicable criteria. Semi-volatile organics tends to be much more persistent in the environment and thus are usually identified at a greater frequency. These chemicals are generally positively correlated with Total Organic Carbon (TOC) in lake and stream sediments, most of which is typically derived from organic detritus such as leaves, macrophytes, and algae, which was very low at all stations with organic carbon accounting for less than 0.5% of the total sediment matrix. Thus, the physical composition of the stream sediments in Sidney Brook is limiting for the accumulation of these toxics. The grain size distribution, or particle size analysis, largely confirms the findings, and fine sands and silt and clay accounted for less 3.4% of the total sediment matrix at all stations. Station 7 had the coarsest sediment, with gravel accounting for nearly 72% of total sediment, which is consistent with the marginally steeper slopes in this area and reduced streambank erosion. A variety of metals were found at all stations in the sediment, but many metals are naturally widespread in the environment due to geology and soils; all metals were well below applicable standards, although concentrations tended to be slightly higher at Stations 6 and 7. Overall, toxic pollutants in the sediment are virtually non-existent and are deemed to have no impact to aquatic communities or human health in the watershed.

Screening data for water are very similar to the sediment analysis and indicate very low concentrations of the investigated analytes. There was no detection of volatiles, semi-volatiles, PCBs, pesticides, cyanides, or phenols. In fact the only chemicals that were detected above minimum detection limits were Nickel and Zinc, which were identified at all three stations. The acute and chronic criteria for all metals are based on toxicity levels at varying hardness concentrations; even assuming a modest hardness value of 100 mg/L in this watershed, which is likely lower than actual hardness based on TDS concentrations and geological composition, all concentrations were considerably lower than the applicable chronic criteria which is the strictest standard. With sediment, concentrations of PP+40 toxins in the water are expected to have no impact to aquatic organisms, including fish and benthic macroinvertebrates, or human health.

6.0 Pollutant Loading

A pollutant loading analysis was conducted for this study utilizing the Unit Areal Loading (UAL) model[1] which integrates GIS data for LU/LC. The original scope of work also stated that AnnAGNPS would be evaluated in addition to or in place of the UAL model. While this more sophisticated model is appropriate for agricultural lands, it lacks the ability to integrate all land use types in the watershed in a single model and also utilizes archaic architecture. Thus UAL proved to be more robust and appropriate for this type of modeling. Loading coefficients came from a variety of sources including Uttormark et al., Reckhow (1980), USEPA (1980), and Schueler (1986) which were further refined based on watershed soils, vegetation and land cover conditions. The pollutant modeling focused on several of the pollutants most commonly implicated in stream eutrophication and sedimentation including Total Phosphorus, Total Nitrogen and Total Suspended Solids. Several iterations of the model were run to identify and assess various trends in pollutant loading. One analyses focused on examining the differences between historical or baseline conditions, prior to European colonization, and current development. A second analysis assessed pollutant loads from developed portions of the watershed relative to undeveloped areas. All of these analyses were conducted on a subwatershed scale delineated in house based on hydrography, topography and land use. The following sections represent a summary of the pollutant loading in the Sidney Brook watershed.

6.1 Current Pollutant Loading

The modeled loads for each of the examined pollutants parsed by subwatershed is provided below (Table 13) and mapped in Appendix I Figure 23. It is immediately obvious that several of the watersheds are major contributors, specifically subwatersheds 2, 5, and 3. Some of these loads though are an artifact of subwatershed size, such as 3, which despite large loads is the least developed of the subwatersheds. For this reason it is also important to compare percent area with percent load to better understand loading dynamics. Subwatersheds with percent loads in excess of percent area are those with elevated loading relative to the remainder of the watershed.

[1] Uttormark, P.D., J.D. Chapin, and K.M. Green. 1974. Estimating Nutrient Loadings of Lakes from Nonpoint Sources. U.S. EPA. EPA 660/3-74-020. 112pp.

Table 13: Pollutant Loading

Sidney Brook Pollutant Loading									
	Area			Load (lb/yr)			Load (%)		
Subwatershed	Hectares	Acres	%	Nitrogen	Phosphorus	Solids	Nitrogen	Phosphorus	Solids
1	256.87	634.73	18.02	2,929.0	173.1	339,270	36.5	34.0	35.5
2	349.77	864.30	24.54	4,281.3	235.1	482,660	53.4	46.3	50.6
3	302.01	746.29	21.19	3,997.2	232.3	418,787	49.8	45.7	43.9
4	138.67	342.66	9.73	1,348.4	71.9	148,015	16.8	14.1	15.5
5	266.29	658.01	18.68	3,842.4	312.2	478,986	47.9	61.4	50.2
6	52.38	129.43	3.67	680.5	48.5	137,032	8.5	9.5	14.4
7	59.47	146.96	4.17	607.9	47.5	99,669	7.6	9.3	10.4
Total	1,425.45	3,522.37	100.00	17,686.9	1,120.7	2,104,418	220.5	220.5	220.5

In order to better illustrate disparity in loading versus land area, specific loads were also calculated for each of the subwatersheds (Table 14). These specific loads basically mimic the form of the loading coefficients and represent load normalized for area. Again, this is a better indication of the magnitude of loading on a per unit basis. While total loading from subwatershed 3 is fairly high the specific loading is modest. In this analysis, subwatersheds 6 and 7 are also seen to be relatively large sources on a per unit basis, but subwatershed 5 continues to have very high specific loads.

Table 14: Specific Loading

Sidney Brook Specific Loads					
	Area		Specific Load (lb/ac/yr)		
Subshed	Hectares	Acres	Nitrogen	Phosphorus	Solids
1	256.87	634.73	4.61	0.27	534.51
2	349.77	864.30	4.95	0.27	558.44
3	302.01	746.29	5.36	0.31	561.16
4	138.67	342.66	3.94	0.21	431.96
5	266.29	658.01	5.84	0.47	727.93
6	52.38	129.43	5.26	0.38	1,058.73
7	59.47	146.96	4.14	0.32	678.21
Total	**1,425.45**	**3,522.37**	**5.02**	**0.32**	**597.44**

To reconcile these differences a ranking matrix was developed to identify targeted actions to specific subwatersheds. This ranking matrix utilizes a simple ranking structure based on both gross loads and specific loads equally weighted. Each of these ranks also utilizes an area metric as well. Gross load ranking uses normal area while specific load rank utilizes percent developed. Each subwatershed is then ranked by each load and area metric and summed. The ranks are assigned values 1 to 7, with rank 1 representing the lowest load, so that higher numbers represent higher loading potential and indicate subwatersheds that should be targeted to affect water quality improvements. The combined ranked sums are also ranked to provide overall rank which integrates all specified components (Table 15).

Table 15: Pollutant Load Ranks

Gross Load Rank					
		Load			
Subwatershed	Area	TN	TP	TSS	Rank Sum
1	4	4	4	4	16
2	7	7	6	7	27
3	6	6	5	5	22
4	3	3	3	3	12
5	5	5	7	6	23
6	1	2	2	2	7
7	2	1	1	1	5

Specific Load Rank					
		Load			
Subwatershed	% Developed	TN	TP	TSS	Rank Sum
1	6	3	3	2	14
2	2	4	2	3	11
3	1	6	4	4	15
4	3	1	1	1	6
5	7	7	7	6	27
6	5	5	6	7	23
7	4	2	5	5	16

Combined Load Rank		
Subwatershed	Total Rank Sum	Overall Rank
1	30	3
2	38	6
3	37	5
4	18	1
5	50	7
6	30	4
7	21	2

The overall rank shows that subwatershed 5 is the greatest contributor both in absolute and specific terms. Subwatersheds 2 and 3 also deserve attention in the implementation of NPS management solutions. Despite this ranking there are other considerations that this type of analysis does not explicitly address. One is development level, which will be discussed further in the following section. A related concern is this pollutant loading analysis did not account for other pollutants such as bacteria that are extremely difficult to model and furthermore difficult to peg to an exact source related to anthropogenic activities unless costly and complicated techniques such as microbial source tracking (MST) methods are adopted. In any case, this type of ranking matrix is valuable in providing a foundation from which to identify NPS pollution loading and develop pollution mitigation solutions, and to be used in conjunction with other data streams including the Visual Assessment. Overall, the Sidney Brook watershed is approximately 3,522 acres, or 5.5 square miles and generates approximately 17,700 pounds of nitrogen, 1,120 pounds of phosphorus, and 2.1 million pounds of sediment annually under current land use conditions, which means that controlling pollutant loading is a key factor in improving and mitigating measured water quality and stream function impairments.

6.2 Current Developed and Undeveloped Pollutant Loading

This analysis is a refinement of the current pollutant budget that examines the impacts of developed lands versus undeveloped lands. Developed land is defined in this analysis as any developed land use, including traditional designations such as residential or commercial uses, as well as land uses such as agriculture; in effect, this classification represents any deviation in LU/LC from natural uses. The undeveloped lands therefore are the natural uses such as forests, wetlands, and waterbodies (Table 16). Besides identifying the effects of landscape alteration this analysis can also be used to estimate that portion of the load that may be termed manageable which is equivalent to the developed load. This is the load that can be presumed to be mitigated or managed in some fashion, especially through the use of BMP's, to reduce pollutant levels. It is also assumed that the undeveloped load cannot be reduced significantly below the existing loading. Efforts in the undeveloped areas should therefore focus on preservation, conservation, and restoration as opposed to the interception and treatment of runoff.

Table 16: Land Cover and Development Level

	Land Cover Type (%, subwatershed)						
Subwatershed	**Agriculture***	**Barren Land***	**Forest**	**Urban***	**Water**	**Wetlands**	**% Developed**
1	29.2	0.4	27.0	36.2	0.2	7.1	65.7
2	34.1	0.2	38.2	18.2	0.7	8.8	52.4
3	34.2	2.0	44.3	12.7	1.5	5.3	48.9
4	24.7	0.0	32.8	28.5	0.0	14.0	53.1
5	42.5	0.0	14.1	29.7	0.1	13.6	72.2
6	17.1	14.7	38.3	26.9	1.0	2.0	58.7
7	9.6	0.0	35.6	45.8	2.7	6.2	55.4
Total	32.2	1.1	32.3	24.9	0.7	8.8	58.2

* = developed lands

The results of this analysis, which are presented as percentages in the table below (Table 17), show clearly the effect of development on loading in the Sidney Brook watershed. While developed lands account for over half of the watershed area (58.2%) the pollutant load originating from these areas accounts for 76% of TN, 85% of TP, and 84% of TSS loading. In contrast, the undeveloped portions of the watershed contribute only 24% of TN, 15% of TP, and 16% of TSS loading. This is a great disparity and is a good example of the relative effects of development on pollutant loading even in moderately developed watersheds. It also shows that much of the load is derived in areas that can be actively managed to reduce overall loading. Subwatersheds of concern in this analysis include most prominently Subwatersheds 1 and 5.

Table 17: Developed versus Undeveloped Pollutant Loading

Subwatershed	Land Use	Area Acres	Area %	Nitrogen lb/yr	Nitrogen %	Phosphorus lb/yr	Phosphorus %	Solids lb/yr	Solids %
1	Developed	417.3	65.7	2,440.7	83.3	150.6	87.0	299,162.4	88.2
	Undeveloped	217.4	34.3	488.3	16.7	22.5	13.0	40,107.2	11.8
2	Developed	453.1	52.4	2,948.0	68.9	186.0	79.1	380,965.2	78.9
	Undeveloped	411.2	47.6	1,333.3	31.1	49.1	20.9	101,694.7	21.1
3	Developed	364.8	48.9	2,722.7	68.1	175.8	75.7	314,099.4	75.0
	Undeveloped	381.5	51.1	1,274.6	31.9	56.5	24.3	104,687.2	25.0
4	Developed	182.1	53.1	1,032.0	76.5	60.7	84.5	123,917.1	83.7
	Undeveloped	160.6	46.9	316.4	23.5	11.2	15.5	24,097.9	16.3
5	Developed	474.8	72.2	3,383.4	88.1	304.3	97.5	442,700.0	92.4
	Undeveloped	183.2	27.8	458.9	11.9	8.0	2.5	36,285.7	7.6
6	Developed	76.0	58.7	519.3	76.3	39.4	81.2	121,034.3	88.3
	Undeveloped	53.4	41.3	161.2	23.7	9.1	18.8	15,997.5	11.7
7	Developed	81.4	55.4	457.6	75.3	39.1	82.4	85,049.7	85.3
	Undeveloped	65.5	44.6	150.4	24.7	8.4	17.6	14,619.0	14.7
Total	Total/%	2,049.6	58.2	13,503.7	76.3	956.0	85.3	1,766,928.2	84.0

A significant pattern evident in the review of the pollutant loading data is that more intensely developed subwatersheds generate higher per-unit area pollutant loads than less developed areas. While an obvious conclusion, it is based on specific conditions in the watershed that contribute to increased loading. Highly developed areas have more impervious cover, increased soil compaction, soil disturbances, and increased stormwater volume all of which decrease infiltration. Similarly agricultural areas are subject to soil compaction, soil disturbances, and the generation of nutrient pollutants. The increased impervious cover or altered vegetation also increases runoff velocities which more effectively mobilize and transport many pollutants and contribute to stream channel scouring. Similarly, disturbed or barren sites contribute increased pollutant loading. Therefore, mitigation must focus on targeted measures to control and reduce pollutant loads from developed (including agricultural) areas. This requires a two-pronged approach of source control: limiting initial generation of pollution and mitigation of developed area loads.

6.3 Historic and Current Pollutant Loading

This analysis compares pre-European settlement of the area to current pollutant loads. The baseline or historic load is calculated by assuming that only three land uses were present historically: forest, wetland and water. All areas identified as wetland or water in the 2002 LU/LC dataset were assumed to be historically wetland or water, while all other classes were considered forest. Loads are presented in absolute terms as well as a percentage: historic land uses are recorded as percent of current load while current loads are presented as percent of historic loads.

As with other analyses this iteration shows that current development patterns in the watershed have greatly increased pollutant loads relative to natural or baseline conditions prior to settlement (Table 18). TSS in particular has shown a very large increase over time, and the current load is 322% of the base load, while TN and TP are respectively 249% and 227% of baseline loading. The increase in the loading of TSS is reflected in the field observations that point to sedimentation of the stream and erosion within the channel and the watershed at large as major issues in the watershed. Subwatersheds 5, 6, and 7 in particular show the greatest deviation from historic loading highlighted especially in the generation of solids.

Table 18: Historic and Current Pollutant Load

		Area	Nitrogen		Phosphorus		Solids	
Subwatershed	**Land Use**	**Acres**	**lb/yr**	**%**	**lb/yr**	**%**	**lb/yr**	**%**
1	Historic	634.7	1,313.1	44.8	94.8	54.8	123,101.2	36.3
	Current		2,929.0	223.1	173.1	182.6	339,269.6	275.6
2	Historic	864.3	1,746.4	40.8	121.6	51.7	160,138.3	33.2
	Current		4,281.3	245.1	235.1	193.4	482,659.9	301.4
3	Historic	746.3	1,551.7	38.8	112.8	48.6	146,135.2	34.9
	Current		3,997.2	257.6	232.3	205.9	418,786.6	286.6
4	Historic	342.7	656.9	48.7	41.8	58.1	57,099.8	38.6
	Current		1,348.4	205.3	71.9	172.0	148,015.0	259.2
5	Historic	658.0	1,265.6	32.9	81.0	26.0	110,402.4	23.0
	Current		3,842.4	303.6	312.2	385.2	478,985.8	433.9
6	Historic	129.4	280.1	41.2	21.6	44.4	27,327.1	19.9
	Current		680.5	242.9	48.5	225.2	137,031.8	501.4
7	Historic	147.0	298.4	49.1	20.9	44.1	27,496.6	27.6
	Current		607.9	203.7	47.5	226.8	99,668.8	362.5
Total	Historic	3,522.4	7,112.3	40.2	494.6	44.1	651,700.7	31.0
	Current		17,686.9	248.7	1,120.7	226.6	2,104,417.5	322.9

7.0 Hydrology

The hydrologic component of a stream study is yet another crucial area of the characterization of any watershed because the hydrology of a stream system impacts all stream functions at a fundamental level and because it integrates a wide variety of watershed and climate factors. The investigation of hydrology in the Sidney Brook watershed focused on evaluating precipitation, evapotranspiration (the combined effects of temperature driven evaporation and transpiration of surface and groundwater by vegetation), overland runoff, groundwater interflow and tributary flow. The characterization of the Sidney Brook watershed hydrology was based on combining empirical field data collection and modeling various components of the hydrology.

7.1 Volumetric Stream Discharge

Volumetric discharge was measured directly in the field to quantify stream discharge during the course of the study. Of fundamental interest to this study is examining the hydraulic relationships between the three studied stations and differences in the contributing watershed that may alter local hydrology. Other goals of this exercise were to better document seasonal variability, to identify trends in the effect of precipitation on stream discharge, and to evaluate the hydrology models. Sidney Brook is ungaged (USGS terminology) and therefore there are no reliable instantaneous or long-term records of stream discharge for this watershed. For this reason paired staff gages and datalogging pressure transducers were installed at Stations 4, 6, and 10. Stage-discharge ratings curve were developed for each of the monitored stations in order to transform continuous stage (water level) records into stream discharge or flow.

Ratings curves are developed using a series of discharge measurements collected at each of the locations using standard wadable river discharge measurement methodology compared to staff gage data. Discharge measurements were conducted using Price AA horizontal axis flow meter connected to a top-setting wading rod that measures flow velocity at the six-tenths depth which approximates average flow velocity of a vertical column in a stream integrated with width measurements. The ratings curve is then calculated by performing a regression analysis comparing paired stage and discharge measurements. The USGS methodology recommends utilizing a natural logarithm transformation on these datasets prior to calculating the linear regression. This method was explored in Sidney Brook, but a much stronger relationship was identified using untransformed data or straight stage and discharge measurements. In particular the untransformed datasets yielded a much better estimate of stormflows which were grossly exaggerated using the log-log regression. These estimates were validated using regional stream hydrographs during specific storm events when specific discharge (discharge normalized for area expressed in this report as cubic feet per second per square mile) matched closely. It should be noted that ratings curves are most accurate within the sampled stage for which they are developed and are subject to increasing error at high and low flows outside the sampled stages. To further refine the ratings curves compound curves were utilized to more accurately express low flows. The following table (Table 19) expresses stage and discharge relationships at each of the monitored discharge stations within a typically encountered range of flows and stream stage.

Table 19: Stage-Discharge Ratings Curves

Station 4 - Perryville Road (2)		Station 6 - Cozze Brothers		Station 10 - Route 513	
Staff Gage Height feet	Discharge cfs	Staff Gage Height feet	Discharge cfs	Staff Gage Height feet	Discharge cfs
0.70	0.06	0.80	0.20	1.00	0.64
0.80	0.12	0.90	0.31	1.20	0.96
0.90	0.58	1.00	0.41	1.40	4.51
1.00	2.03	1.10	0.52	1.60	10.70
1.20	4.93	1.20	0.62	1.80	16.89
1.40	7.82	1.40	3.67	2.00	23.08
1.60	10.72	1.60	8.21	2.40	35.46
1.80	13.61	1.80	12.76	2.80	47.84
2.00	16.51	2.00	17.31	3.20	60.23
2.20	19.41	2.40	26.40	3.60	72.61
2.40	22.30	2.80	35.49	4.00	84.99
2.60	25.20	3.20	44.59	4.40	97.37
2.80	28.10	3.60	53.68	4.80	109.75
3.00	30.99	4.00	62.77	5.20	122.13
		4.40	71.87	6.00	146.89
		4.80	80.96		
		5.20	90.05		

The following figures (15 to 17) exhibit the stage and discharge hydrographs at each of the stream stations using the real time stage data collected with the pressure transducers and the transformed discharge data using the stage-discharge ratings curves. Several patterns are immediately evident in these figures. While Station 10 had a somewhat longer deployment period than the other dataloggers, it is evident that the hydrographs of all three stations are very similar. Figure 18 shows a combined view of all three stations' stage hydrographs as well as the precipitation record. The overlapping stage records for Stations 6 and 10 are largely coincidental, although the response to precipitation is not. Discharge responses at Station 4 are relatively muted relative to the other stations. Also of interest is the timing of stage which shows a very slight lag moving downstream in the watershed.

Figure 15: Station 4 Hydrograph

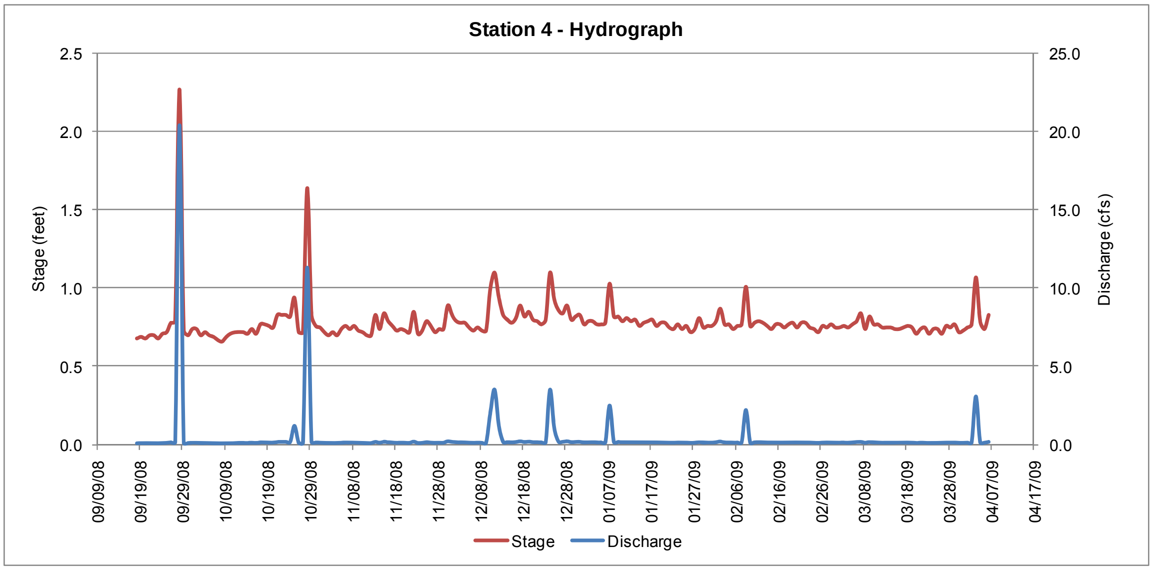


Figure 16: Station 6 Hydrograph

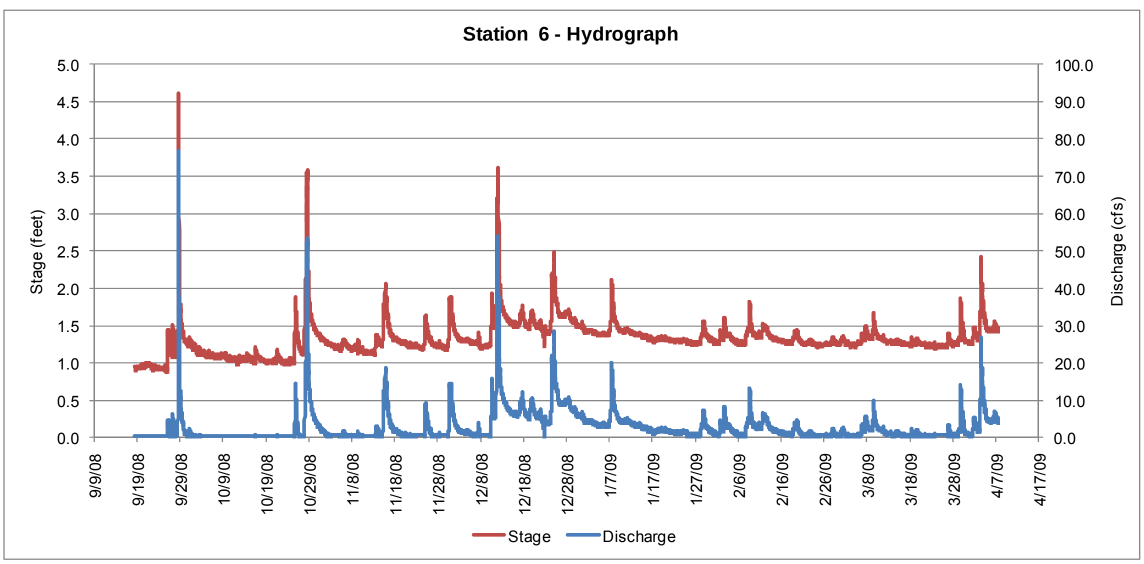


Figure 17: Station 10 Hydrograph

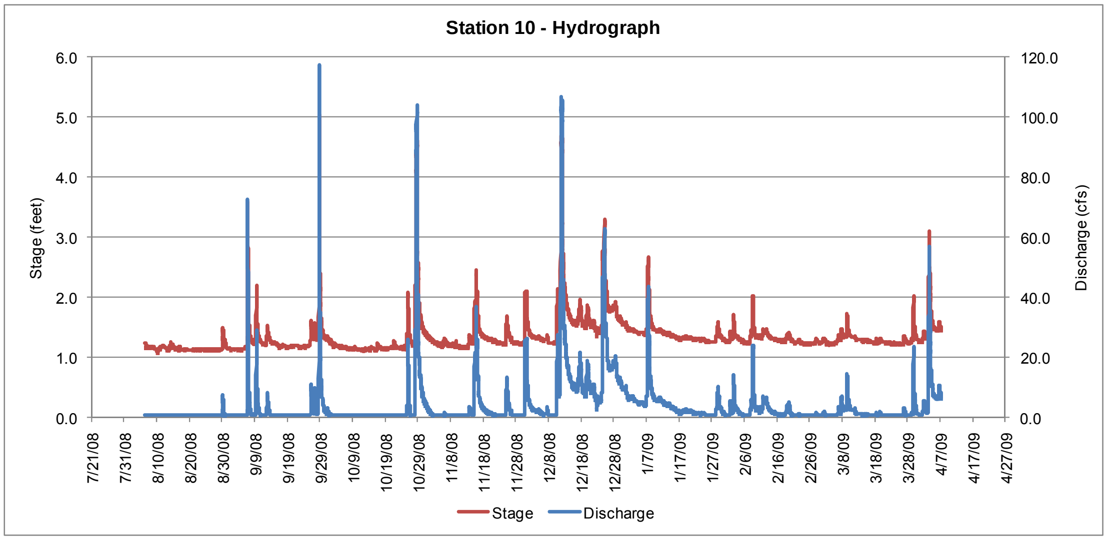
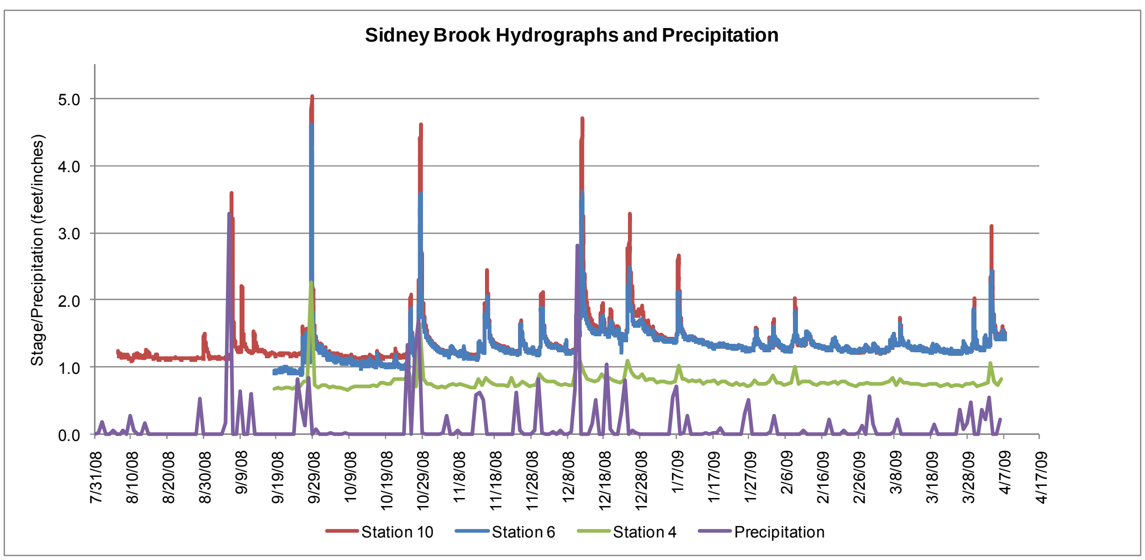


Figure 18: Hydrographs and Daily Precipitation



Of greater utility in comparing the hydrographs and the flows of each of the stations is the summary table (20) provided below. This table provides relevant flow and contributing watershed characteristics for each of the monitored stations. Since Station 10 had a longer record, statistics were calculated for both the entire record as well as the comparable record beginning on September 18 to provide a more direct comparison to the other stations. The most important feature of this table was the analysis of the data expressed as a percentage of the post 9/18 record of Station 10. Significant deviation from percent contributing area of each delineated watershed should indicate significant differences in hydrology between the two stations. While the hydrology study period did not last a full year flows were reduced relative to modeled results, which is consistent with other regional streams and the relatively dry conditions experienced during this period.

Table 20: Measured Hydrology Summary

Station	Watershed Area		Median		Average		Maximum	
	Acres	%*	cfs	%*	cfs	%*	cfs	%*
10 (All)	3064.1	100.0	1.08	97.2	4.34	89.4	117.18	100.0
10 (Post 9/18)	3064.1	100.0	1.12	100.0	4.85	100.0	117.18	100.0
6	1836.8	59.9	1.16	104.4	3.02	62.3	76.87	65.6
4	670.5	21.9	0.09	8.5	0.35	7.2	20.42	17.4

* = relative to Station 10 (Post 9/18)

Median flow is probably the most useful streamflow statistic in general because it moderates the effect of large storm events causing a positive skew in average flow data, and is the metric most closely associated with baseflow. Interestingly, median reported flows at Station 6, immediately downstream of Jutland Lake, closely matched those values observed at Station 10. While discharge calculations at low stages are subject to error, and an error that was likely encountered during the dry summer of 2008, median values at this station were nearly 40% greater than percent contributing area. This indicates more steady flow at this station which is certainly a result of the somewhat moderated discharge from Jutland Lake. On the opposite end of the spectrum is Station 4 which exhibited very low median flows relative to area and the other stations. This is likely related to differences in LU/LC and geology in this watershed. Geology in this area is somewhat different with almost no carbonate lithology, although groundwater recharge seems to be favorable relative to the other watersheds. LU/LC has a higher percentage of agriculture and less urban uses than the other the other watersheds which may indicate perhaps greater consumptive use of groundwater in this area. It should also be noted that there are several impoundments in this contributing watershed, particularly in the far headwaters, which may retard flow in this section.

Average flows showed a pattern closer to percent contributing area. Station 6 had mean flows only slightly higher than contributing area, which is probably a result of somewhat greater impervious area in the adjacent upstream reaches. At Station 4 mean flow was significantly below contributing area, which is consistent with median flow, and again seems to indicate that due watershed characteristics, less water seems to move through this stream than the other contributing watersheds. In a sense this was confirmed in the field during the discharge measurements when flows were typically very low and frequently were at the lower measurable limits of the equipment.

Maximum flows, which are probably the best measure of runoff generation and response to storm events, again show Station 6 to be in excess of the contributing area which shows that the generation of runoff in the contributing area of this watershed, which includes most of the larger developments as well as the village of Jutland, is excessive and problematic. Station 4 maximum flows continue to be less than the contributing area and show that the generation of excessive runoff is not as large a problem in this area as other portions of the watershed. It is also worth noting that relative to median and mean flows, maximum flows were significantly higher at this station which may show an imbalance between groundwater infiltration in this area and runoff.

While the hydrology study period did not last a full year, flows were reduced relative to modeled results, which is consistent with other regional streams and the relatively dry conditions experienced during this period. It is also worth noting the seasonal affects on hydrology in the hydrographs; all stations showed increased stream stage and baseflow discharge during the winter and spring.

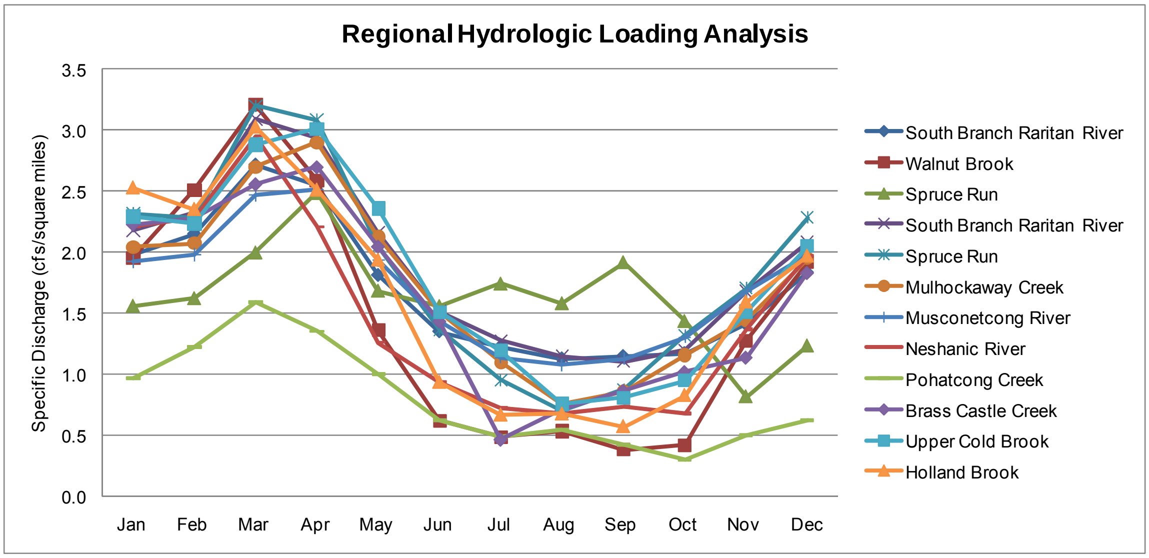
7.2 Regional Hydrologic Loading Analysis

The first analysis conducted was a version of the Regional Hydrologic Loading Analysis developed by Princeton Hydro. This analysis is used to compare the similarity of regional streams when normalized for area yielding what is termed specific discharge with units of cfs (cubic feet per second)/square mile; specific discharge is generally used to calibrate other models and to verify the results. The base data used for this analysis is taken from USGS gaged streams with monthly discharge statistics. Overall, most of the regional streams were similar both in terms of overall curve shape and magnitude (Figure 19).

Utilizing the data discussed above an average monthly specific discharge value was calculated. The computed monthly mean was calculated utilizing twelve regional streams. The bulk of the streams had datasets of at least 30 years with a maximum of 105 years of collected data which enables an accurate prediction of long term hydrologic trends. While several of the records appear as outliers, they were ultimately included because they expand the range of model including unique hydrology and also represent the effects of impoundments on stream hydrology, which is a potentially important influence in Sidney Brook.

Mean annual specific discharge was calculated as 1.61 cfs/mi^2. The most important trends taken from this analysis is that stream discharge in regional creeks is highly seasonal and that specific discharge between regional streams is fairly similar. In August, the month with the lowest mean specific discharge, discharge is only 53% of the annual average. Looked at differently, August discharge is only 32% of that in March, the month with the highest mean discharge.

Figure 19: Specific Discharge of Regional Streams



7.3 Corrected Modified Rational Method

Next the Corrected Modified Rational Method was conducted. The Modified Rational Method is commonly used as a predictor of gross hydrologic loading to streams as based on precipitation, LU/LC (Land Use/Land Cover), and soil hydrologic groups. Specific runoff coefficients correlated to both LU/LC and soil hydrology for the Sidney Brook watershed were interpreted from the runoff curve numbers published in the NRCS Technical Release 55 (TR-55). Precipitation and temperature data was derived from the National Oceanic and Atmospheric Administration (NOAA) 30-year Climate Summaries for New Jersey as well as Northeast Regional Climate Center (NRCC) CLIMOD data.

The use of the Modified Rational Method for calculating gross discharge is widely accepted by both the US Environmental Protection Agency (USEPA) and the NJDEP, however this method grossly overestimates annual water loads because it was created for quantifying storm event surface runoff in microbasins. Princeton Hydro has therefore developed a correction for the Modified Rational Method to more accurately predict stream hydrology. The chief correction is the inclusion of an evapotranspiration and abstraction term, which is very important in growing season hydrology. Evapotranspiration is the combined loss of water to the atmosphere via evaporation and transpiration; transpiration is the biological cycling of water that is removed from groundwater through vegetative uptake and exhausted as water vapor through the leaves, while evaporation is solely based on physical principles. Generally, the Modified Rational is calculated by multiplying the area of a delineated watershed by the curve number and gross precipitation. In the corrected model precipitation is modified by subtracting PET (potential evapotranspiration) calculated using the Thornthwaite methodology. However, in summer months PET can be greater than precipitation, but instead of modeling a net loss from the system there is an assumption that a certain percentage of precipitation, regardless of PET, is always available as runoff/groundwater to contribute to stream discharge. The correction therefore may be stated as:

P = Precipitation
CP = Corrected Precipitation
PET = Potential Evapotranspiration
% = defined percentage always available as runoff
CP = P – PET, if CP > % P
if P – PET < % P, then CP = % P

As an example, assume that at least 50% of P always becomes stream flow. In May precipitation (P) may be 4 inches and PET may be 1.5 inches the corrected precipitation (CP) is 2.5 inches, or P – PET (4 -1.5 = 2.5) > 50% P (50% 4 = 2) = CP. In July, precipitation may be 4 inches but PET may be 5 inches. In this case since P – PET (4 – 5 = -1) < 50% P (50% 4 =2) then CP may be assumed as 50% P (2 inches).

A final assumption of this use of the Modified Rational is that in watershed scale studies the model predicts not only runoff but also accounts for groundwater discharges as well. This assumption is based upon the high level of correlation with stream flow that this model has shown when compared to Regional Hydrologic Loading Analysis which utilizes empirically measured data sources. To compare the results of the Corrected Modified Rational Method to the Regional Hydrologic Loading analysis raw volumetric output is converted to stream flow and specific discharge, as discussed above. Agreement between these two analyses is used to calibrate the Corrected Modified Rational Method.

Several iterations of the Corrected Modified Rational model were calculated and calibrated utilizing the data shown above. The best fit occurred utilizing 40% as the correction factor, meaning that the model assumed that at least 40% of precipitation on the watershed is converted to stream discharge even when precipitation minus potential evapotranspiration is less than 40% of precipitation.

Upon comparison of the modeled data to that of USGS gaged regional rivers several discrepancies were noted. Namely, the modeled data did not accurately represent the effects of winter snowpack, spring snowmelt, and groundwater recession and storage. Snowpack, groundwater recession, and groundwater storage are expressed as reduced discharge because of temporary storage or loss while snowmelt and excess groundwater loading serve to increase discharge. In effect both the addition and subtraction of these various terms shows a discrepancy in discharge relative to strict precipitation modeling. To correct for these discrepancies a residual adjustment factor derived from regional tributary specific discharge data was applied to that of the modeled data. Specifically, the absolute value of the difference between the modeled and measured specific discharge was calculated for each month and then averaged. This value was then applied to our modeled data to account for seasonal hydrologic variations such as the effects of snow pack during the period from November through January, snowmelt and groundwater loading in March through May, and groundwater recession or recharge from July through November. When these correction factors were applied the refinement of the model increased significantly and benefitted agreement between modeled and empirical data.

Upon model calibration the results were used to calculate monthly watershed discharge volumes by simply multiplying the corrected specific discharge values by watershed area. The strength of this model lies in the integration of all the important hydrologic components affecting a budget including precipitation, evapotranspiration, surface runoff, groundwater flux, tributary loading, and hydraulic storage. Results will be described in the following sections

7.4 Posten Method Groundwater Estimation

Groundwater inputs were modeled, but were treated as component of the hydrology described in the Corrected Modified Rational Method. In other words, the quantification of groundwater described above is representative of the suspected magnitude of groundwater contribution but is not an additive component of the budget. As mentioned previously, the Corrected Modified Rational Method describes runoff and groundwater as a single indistinguishable component of the net water budget or streamflow. The same principle applies to the runoff component which utilizes the straight Modified Rational Method and describes merely initial runoff and not ultimate fate of surface runoff which may be evaporated, infiltrate through the soils to be incorporated as groundwater, or discharged directly to the tributary network. As such, the runoff term is not additive but merely descriptive of the magnitude of initial runoff of precipitation. Groundwater was calculated using the Posten Method, which describes groundwater interflow in northern New Jersey fractured rock geologic areas. Generally, Posten results describe a relatively stable monthly groundwater flux, but reduced groundwater loading was modeled during the summer months and early fall when less net water is expected to be expressed as groundwater. During various times of the year groundwater flux was corrected using residual correction factors.

7.5 Hydrology Budget

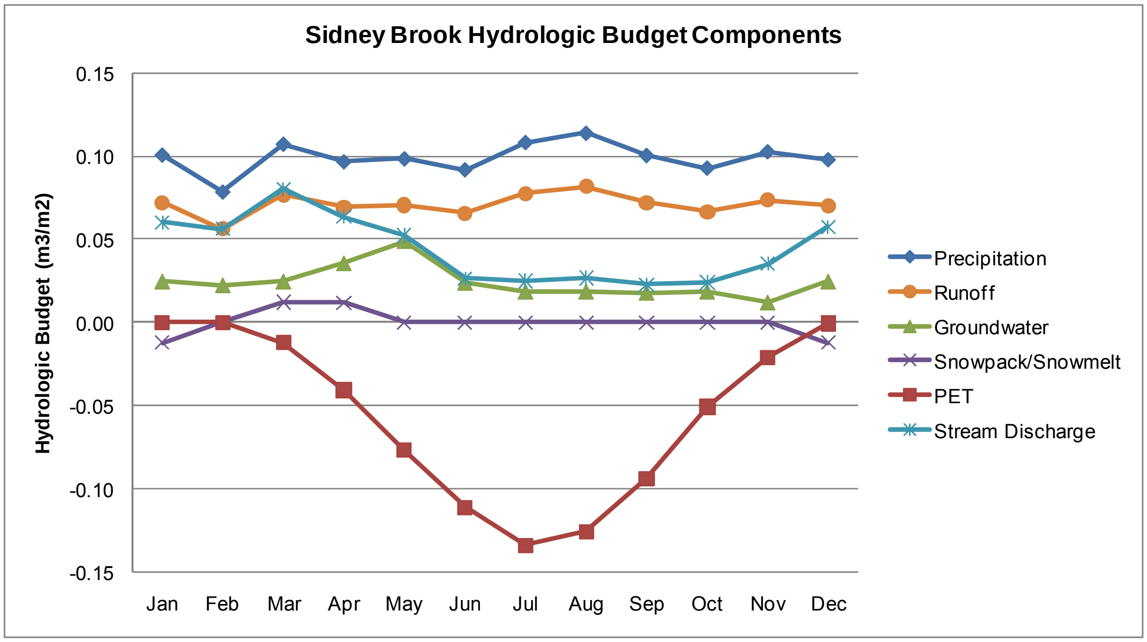
The hydrologic budget exhibited below in Table 21 and Figure 20 shows the most important hydraulic components modeled for this watershed. All values in the tables are expressed as volumes and converted to discharges, while the figure is expressed in the units of m^3/m^2 or m, which is a way to normalize volumes and discharge rates for the area of the watershed and is generally easier to grasp as it mirrors typical precipitation reporting units. This budget therefore expresses the components in a linear manner and is better at illustrating the fate of precipitation which is the origin of any hydrologic budget. It is important to express these budgets on a monthly timescale to accurately depict the changing hydrologic conditions through the year and to disabuse the notion of steady-state hydraulics in watersheds. Again, the net water budget term described shown in the figure is representative of the stream discharge for the watershed.

Table 21: Hydrology Budget

Sidney Brook Hydrologic Budget (m3)						
Month	Precipitation	Runoff	Groundwater	Snowpack/Snowmelt	PET	Stream Discharge
January	1,433,779	676,686	350,198	-172,354	0	854,548
February	1,115,161	479,556	319,132	0	0	798,691
March	1,527,916	744,108	350,198	172,354	-172,088	1,143,398
April	1,375,848	479,699	505,696	166,794	-581,303	902,622
May	1,401,193	308,641	694,906	0	-1,097,384	746,099
June	1,307,056	597,223	338,902	0	-1,586,243	374,451
July	1,542,398	840,658	264,022	0	-1,909,523	355,703
August	1,622,053	897,707	264,022	0	-1,791,837	378,523
September	1,430,158	768,787	255,505	0	-1,335,950	326,328
October	1,321,538	682,476	264,022	0	-722,678	342,741
November	1,462,744	875,522	172,108	0	-297,977	500,659
December	1,393,952	648,162	350,198	-172,354	-9,125	819,488
Annual	16,933,796	7,999,225	4,128,908	-5,560	-9,504,108	7,543,251

Sidney Brook Hydrologic Budget (cfs)						
Month	Precipitation	Runoff	Groundwater	Snowpack/Snowmelt	PET	Stream Discharge
January	18.90	8.92	4.62	-2.27	0.00	11.27
February	16.13	6.94	4.62	0.00	0.00	11.56
March	20.15	9.81	4.62	2.27	-2.27	15.08
April	18.75	6.54	6.89	2.27	-7.92	12.30
May	18.47	4.07	9.16	0.00	-14.47	9.84
June	17.81	8.14	4.62	0.00	-21.61	5.10
July	20.34	11.08	3.48	0.00	-25.18	4.69
August	21.39	11.84	3.48	0.00	-23.63	4.99
September	19.49	10.47	3.48	0.00	-18.20	4.45
October	17.42	9.00	3.48	0.00	-9.53	4.52
November	19.93	11.93	2.34	0.00	-4.06	6.82
December	18.38	8.55	4.62	-2.27	-0.12	10.80
Annual	18.95	8.95	4.62	-0.01	-10.64	8.44

Figure 20: Normalized Hydrology Budget



Modeled hydrology showed a significant decrease in discharge during the summer months. This decrease is related primarily to increased PET during this time period driven by peak biological function (transpiration) and peak temperatures (evaporation). Secondarily, the summer months may see decreased groundwater interflow despite slight increase in precipitation. Another striking trend is the very high discharge observed during March; mean discharge in March is approximately 179% of mean discharge and over 339% of mean September discharge. The surge is fed primarily by snowmelt which may mechanistically be reflected as increased groundwater discharge while the late summer sag is a result of cumulative summer groundwater recession and high PET.

8.0 Identified Impairments

This section reviews the results of the characterization of the Sidney Brook watershed provided above with intent to identify specific causes of impairment and pollutants that will be targeted by this Watershed Protection Plan (WPP). More specifically it references standards and regulations applicable to FW2-TM (C1) waterbodies and compares these to measured conditions and observations regarding stream water quality and watershed function to enforce compliance with protective measures in place. The end goal therefore is to prepare a list of known impairments and their causes and to mitigate, enhance, and improve these identified targets to ensure not only compliance with designated uses and water quality but to improve watershed ecosystem function in general.

This section also corresponds to the first of the nine elements listed by the EPA. The first element is described as follows:

> *Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).*

For the most part this section references the New Jersey Surface Water Quality Standards (N.J.A.C. 7:9B) to identify impairments against standards. In addition to the general water quality criteria this WPP considers regulatory language associated with Category One antidegradation policies which address the preservation of environmental function without specific numeric criteria. In total there are eight specific impairment types documented that need to be addressed in the WPP (listed in no particular order):

- Water Temperature
- Total Dissolved Solids and Specific Conductance
- Total Phosphorus
- *E. coli*
- Benthic Macroinvertebrates
- Erosion and Sedimentation
- Invasive Species
- Streambank Encroachment and Buffer Impairments

Each of these areas will be discussed in turn with reference to the standard or regulatory measure they violate, the effect on the stream or watershed ecosystem, the cause of the impairment, and a summary of its documented state in the Sidney Brook watershed.

8.1 Water Temperature

Water temperature in portions of Sidney Brook has been documented to contravene applicable water quality standards. The SWQS have been recently changed such that maximum and rolling seven-day averages are both considered, rather than, a simple seasonal average. Trout Maintenance waters, including the Union Township portions of Sidney Brook, should not exceed a seven-day rolling mean of 73.4°F (23°C) or single day maximum of 77°F (25°C). This standard exists to protect the coldwater fishery for trout, but also protects macroinvertebrate communities that require cool water. Trout are particularly sensitive to prolonged periods of high temperature because they are adapted to survive in coldwater streams and lakes which form their natural habitat. Secondarily, higher temperatures also decrease oxygen solubility and trout and other coldwater fishes have a high oxygen demand. The Non-Trout portions of Sidney Brook are subject to less restrictive standards such that temperatures should not exceed a seven-day rolling mean of 82.4°F (28°C) or single day maximum of 87.8°F (31°C). This standard is enforced to primarily protect warmwater biota.

Sidney Brook was shown to exceed the maximum temperature standard at Station 6, while the rolling average was violated at Stations 3 and 6. Stations that did meet the standards barely did so downstream of Jutland Lake and it is likely that Stations 7 and 9 routinely violate the standards during mid-summer. No temperature issues were detected in the Franklin Township portions of the stream in regard to NT temperature standards.

There are several causes contributing to the thermal pollution of Sidney Brook, but it seems clear those online impoundments, as well as other offline impoundments including stormwater basins, are chief among them. Impounding the stream contributes to thermal pollution through allowing increased irradiation due to a lack of canopy shading as well as increased hydraulic residence time. Degraded riparian buffers are also another contributor to stream warming in the watershed, which is confirmed both in the Visual Assessment results and the fact that nearly 45% of lands within the 300 foot stream buffer are comprised of developed or disturbed land uses. Degraded buffers and reduced canopy cover allow direct irradiation of the stream channel to increase temperatures. The last factor to be considered is that summer stream discharge was quite low during the 2008 summer and decreased flow velocities coupled with increased residence time and reduced groundwater flows likely contributed somewhat to increased temperatures.

8.2 Total Dissolved Solids and Specific Conductance

Overall, Total Dissolved Solids (TDS) and the related parameter Specific Conductance (SpC) is of relatively minor importance in Sidney Brook, but exceedance of SWQS was documented and thus bears mentioning. SpC has no specific standard, unlike TDS, which carries a standard of 500 mg/L. This standard, like most others, was developed to protect stream biota. These parameters may be especially important in assessing the impacts of wastewater effluent particularly NJPDES permitted surface discharges.

In Sidney Brook SpC was routinely elevated at Station 1, with a high of 0.571 mS/cm. While no standard applies to this measurement this is quite high and considerably higher on average than other monitored stations indicating excessive loading of some constituent that increases SpC. While TDS readings were somewhat elevated at Station 1, as well as Station 2, no exceedance was recorded. Stations 10 and 11 also had high average SpC measurements. TDS showed a single exceedance of the SWQS at Station 11 under baseflow conditions at a concentration of over 700 mg/L. What is particularly interesting is that Station 10, located in proximity upstream did not show the same elevation. Again, in a puzzling fashion, SpC did not show a similar increase suggesting that perhaps the dissolved solids were non-ionic and possibly colloidal.

Two primary sources are the most likely contributors to excessive dissolved solids loading and corresponding increases in SpC in Sidney Brook: septic system effluent and agricultural runoff. Other sources include other forms of residential and development runoff, including fertilizers and road salts. Septic system effluent, from either functional septic systems transported via groundwater or in failing systems via runoff, seem to be the primary driver in the headwaters of Sidney Brook, particularly around Jutland with high development density. The lower portions of the watershed, particularly Station 11, seem to be more affected by agricultural runoff.

8.3 Total Phosphorus

The Total Phosphorus (TP) standard for FW2 streams is 0.10 mg/L, unless it is determined to not be the limiting nutrient. TP is generally the limiting nutrient in most freshwaters in this region and is generally the nutrient most identified with eutrophication. In streams, excessive TP concentrations promote excessive growth of periphyton and is a proxy measure of pollutant loading in general. It may also be used to evaluate designated uses such as aquatic life.

In the course of this study discrete parameters were measured under both baseflow and stormflow conditions. Under baseflow conditions TP never exceeded the SWQS standard of 0.10 mg/L. During stormflows TP concentrations routinely exceeded the limits. In fact, the TP concentration was exceeded at four of the stations during at least one of the storm events. Even during baseflow events these same stations tended to be high despite compliance with the standard. In general TP concentrations tended to decrease moving down through the watershed. Station 1 in particular had very high concentrations and a great disparity between base and stormflows.

An additional analysis was conducted to evaluate the concentration of Soluble Reactive Phosphorus (SRP) as a percentage of TP loading in the watershed. In unimpaired systems SRP should generally account for a small fraction of TP as most phosphorus is bound in particulate matter or because the biological reactivity is so high that it is quickly bioassimilated. SRP concentrations expressed as a percentage of TP was very high in the headwaters of the watershed and decreased moving downstream, showing a much different pattern downstream of Jutland Lake. At Station 1 SRP accounted for, at times, in excess of 90% of TP, while SRP was in excess of 65% at Station 2, both of which are very high values. Even the standard concentration of SRP was excessive at these stations.

TP loading in the Sidney is related to a variety of factors. The most obvious manifestation of TP loading in the watershed is during storm events, squarely identifying nutrient enriched stormwater runoff as the primary source of phosphorus loading in the watershed. This implicates multiple areas as distinct sources of loading. Loading from various developed land uses, particularly residential and agricultural, are the primary loaders of both particulate and dissolved phosphorus which in turn are related to fertilizer use, household chemicals, septic effluent, and erosion. Septic effluent and lawn fertilizers in particular seem the primary sources of phosphorus loading particularly in the more densely developed areas around Jutland as supported by the SRP evidence. While erosion in the watershed at large and within the stream channel and the subsequent mobilization of particles with adsorbed phosphorus is another important source the relatively modest Total Suspended Solids loads may indicate this source is of secondary importance. Degraded riparian buffers related to streamside land uses are certainly implicated in promoting increased solids loading, but perhaps more importantly poor quality buffer lacks the ability to effectively capture particulates and dissolved substances in stormwater runoff, detain water, and stabilize creek banks, while increased coverage of impervious surfaces increases hydraulic loading and in-stream erosion. A lack of effective stormwater infrastructure is also to blame in the role of phosphorus in the stream.

8.4 *E. coli*

Bacterial counts, specifically *E. coli*, are regulated under the SWQS. For FW2 waterbodies there are two standards based respectively on an instantaneous value and an average value. *E. coli* is not to exceed a geometric mean of 126 cfu/100 mL, and no single sample is to exceed 235 cfu/100 mL. This standard is set to meet primary and secondary contact recreation uses in waterbodies and therefore is related to human health uses. Even then *E. coli*, the predominant gut bacterium of warm-blooded vertebrates, is treated as a potential vector and indicator of pathogens such as viruses and bacteria. In an environmental context it can be viewed in a similar manner, and is more useful as a proxy measure of nutrient loading, although direct effects of fecal loading can also impact aquatic and related terrestrial communities.

E. coli is a very serious issue in Sidney Brook and was shown to be problematic throughout the watershed during all seasons and all flow conditions, however the summer concentrations were the worst. During the 30-day sampling period in July and August of 35 collected samples only a single sample was analyzed below the maximum concentration standard and all seven stations exceeded the 30-day geomean. Expanded to include all sampling across seasons and flow regimes 59 of 77 collected samples contravened the single sample maximum criterion. Station 2 at no point satisfied the standards, and on one date the measured concentration at Station 11 was nearly 400 times in excess of the standard.

As with many of the noted impairments in this system the cause of elevated bacterial counts is multi-faceted. In the upper portions of the watershed, particularly around Jutland, the primary cause is almost certainly septic system effluent, which is particularly evident in the sustained high concentrations. These concentrations are also likely bolstered by pets and livestock. In other portions of the watershed livestock is probably the primary loader, which is especially apparent at Station 11. Waterfowl, such as Canada Goose (*Branta canadensis*) are certainly loaders as well and are linked to the various stormwater basins and impoundments in the tributary network, but it must be noted that these online impoundments do mitigate to some extent these loads. Indeed, the best sampled area in Sidney Brook was at Station 6 downstream of Jutland Lake, and while concentrations often exceeded applicable standards the *E. coli* concentrations at this locale were significantly lower than elsewhere in the watershed. Wildlife is also a potentially important source in a rural watershed.

8.5 Benthic Macroinvertebrate Community Composition

Benthic macroinvertebrates have shown some slight impairments in metric scores in Sidney Brook. While most of the stations were rated as Non-Impaired, under older style NJIS scoring, Station 11 was rated as moderately impaired. This station was characterized as having high percent dominance, high family tolerance value, moderate percent EPT, and a high proportion of Chironomid midges, all indications of excessive organics loading as well as poor substrate characterized by fine sediments. While there are no specific numerical standards under the SWQS associated with benthic macroinvertebrates there are protections granted by the designation of the stream. One of the primary designated uses of FW2 waterbodies is the “maintenance, migration, and propagation of the natural and established biota”, which certainly extends to the macroinvertebrate community. Similarly the Category One antidegradation standards provide “protection from measurable changes in water quality...and ecological integrity” (habitat, water quality and biological functions). While the majority of Sidney Brook stations were Non-Impaired, the scores were lower than previous AMNET efforts and may indicate a regression in macroinvertebrate quality in violation of Category One policies.

Benthic macroinvertebrates are perhaps the most important component of stream biota. Unlike other ecosystems, smaller stream systems are more reliant on detritus and allochthonous carbon (contributed from outside the stream) than autochthonous sources (from algae and plants). As such the typical role of primary producers such as periphyton is reduced and stream invertebrates serve as the base of the food chain. It is typically the benthic infauna that drives diversity and biomass in stream systems and serves as the forage source for fish and amphibian predators. Therefore, benthic macroinvertebrates are directly involved in carbon cycling and sustaining higher trophic levels and impairment of their communities represents not just a loss in water quality but a loss of ecologic function in general. Benthic macroinvertebrates also serve as a useful indicator of stream function because they integrate biological as well as chemical and physical factors.

Impairment in stream invertebrate communities is somewhat more complicated than the causes of other non-biological systems and is thus two-tiered. Declines in community quality or a shift to more pollution tolerant communities are caused by a variety of factors with the largest being increased pollutant loading. Pollutants can be direct acting toxics or other indirect effects associated with nutrient loading and eutrophication. Other causes of impairments include increasing temperature and loss of habitat through sedimentation. The second tier of impairments therefore is related to the reasons these factors have changed in the first place which is related to increased watershed pollutant loading. It is these factors touched upon in the temperature section above and in the following sections that contribute to a loss of benthic macroinvertebrate quality.

8.6 Stream Erosion and Sedimentation

The following sections discuss several important impairments documented in the course of this study through the Visual Assessment. These sections deal with the condition of the stream and streambanks as a function of watershed processes and to highlight the potential in the impairment of these functions to negatively influence water quality. This grouping of impairments, namely erosion, sedimentation, buffer impairments, and invasive species, therefore is not specifically recognized by name in the SWQS or other related rules, however certain language related to general surface water classification (FW2) and the Category One antidegradation policies do encompass these impairments. The primary designated use of FW2 is: Maintenance, migration, and propagation of the natural and established biota. These items therefore require not only adherence to water quality standards for specific measurable parameters but the maintenance of the aquatic ecosystem which must include substrate quality and composition, channel stability, riparian vegetation, channel morphology, and hydraulics, all of which contribute to biotic composition and utilization. The antidegradation policy for Category One streams encompasses these concerns in the following:

> *Purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d), for protection from measurable changes in water quality based on exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s) to protect their aesthetic value (color, clarity, scenic setting) and ecological integrity (habitat, water quality, and biological functions).*

This language specifically identifies the protection of ecological integrity including habitat and biological functions. From a mechanistic perspective the measurable change in water quality could relate to all of the parameters discussed above but would also refer to habitat integrity represented by channel and riparian buffer condition as critical components of the stream ecosystem.

The physical state of the stream and banks vary considerably throughout the watershed, but in many places erosion is severe and directly attributable to outfalls, failing stormwater management infrastructure and impervious areas. The converse of erosion is sedimentation, the deposition of solids derived both within the channel and from the watershed. The results of the Visual Assessment clearly exhibit these trends in the 45 surveyed stream reaches. Erosion considered moderately unstable or more severe, per survey protocols, was observed on the left bank of 15 surveyed stream reaches and 14 right bank reaches indicating fairly severe erosion or bank instability in roughly a third of the stream. Sedimentation was more widespread, and 22 of the surveyed reaches showed high embeddedness of coarse substrate, defined here as greater than 25% embedded. This represents the deposition of large quantities of fine materials as well as a substantial loss of interstitial spaces crucial to support quality macroinvertebrate colonization and preferred spawning sites for fish.

8.7 Invasive Species

The colonization of riparian corridors with invasive vegetation is a major problem throughout the eastern US and one that is also reflected in Sidney Brook. The presence of invasive vegetation on the banks represents a major loss of habitat integrity and displacement of native species including not only vegetation but also wildlife that is dependent on certain vegetation communities including insects, birds, and mammals among others. Besides the loss of habitat value invasive vegetation likely alters the pollutant removal capacity and soil and bank stabilization properties of native vegetation types. In turn, invasive species monocultures are also an indication of disturbed environments as these species typically have a competitive advantage in disturbed areas caused either through anthropogenic activities, land uses, and flooding (in turn a result of poor stormwater management and excessive impervious coverage).

In the Sidney Brook riparian corridors invasive species are ubiquitous. Invasive plant densities rated as medium or high were documented in 41 of the 45 listed reaches. Overwhelmingly, multiflora rose is the dominant invasive although other species such as common reed (*Phragmites australis*) and Japanese knotweed (*Polygonum cuspidatum*) are also locally present. Undoubtedly, much of the colonization of the streambanks by Multiflora rose is a legacy of former SCS efforts to propagate this plant as living hedge. This species is also colonizing formerly disturbed areas particularly abandoned agricultural areas and the edges of other maintained or formerly maintained spaces.

8.8 Streambank Encroachment and Buffer Impairments

Streambank encroachment and buffer impairments in the context of this section refer specifically to changes in land uses in the stream corridor. While more broadly buffer impairments can include other impairments, these have at least been discussed in part in the stream erosion and sedimentation section as well as the invasive species section. Thus, buffer encroachments in this section are specifically geared towards the land uses such as residential, agricultural, or commercial in variably defined buffers that represent a change from native wetlands and riparian forests and are in part characterized by impervious surfaces, non-native or altered vegetation community, soil disturbances, and structures. As with the other sections described above, buffer impairments, as defined by corridor encroachment, lead to a host of problems in stream function and lands within the riparian corridor including:

- Increased NPS loading
- Reduction of NPS reduction capacity
- Loss of habitat
- Increased solar irradiance and stream warming
- Decreased habitat value
- Increased flood hazard risk
- Increased impervious coverage
- Increased erosion and sedimentation
- Invasive species colonization

In the Sidney Brook bank encroachment is a widespread issue. Land use modeling indicates that approximately 42% of the watershed lies within 300 feet of the mapped tributary system and similarly that 45% of the area within the 300 foot buffer is developed. This section, however, is based primarily on the results of Visual Assessment, which consisted of 45 surveyed and listed segments. Near bank encroachments, extending from the top of the bank to a distance of 50 feet, which represent the most critical portion of the riparian buffer, were evident on 12 segments on the respective right banks and 12 segments on left banks. Typical impairments in this area included maintained lawn space. Encroachment percentage was more evident at greater distances, namely within the defined 300 foot stream buffers associated with C1 status. Encroachment was reported at 24 segments on the left bank of the surveyed segments in the 300 foot buffer, and 30 segments on the right bank. Encroachment at these distances tend to closely mirror land use data, and include agricultural areas, especially hayfields, residential areas including maintained lawn space, and other urban uses including transportation corridors. Category One antidegradation policies and Highlands Act policies will largely limit any further encroachment in these areas, but it will be critical, particularly in the areas immediately adjacent to the steam, to reduce the impacts of buffer encroachment to the greatest extent possible, and will be one of the primary vehicles of improving the overall quality and function of Sidney Brook and the Sidney Brook watershed.

9.0 Estimate of Load Reduction

This section will detail the scale and general type of reductions in impairments identified above. This section corresponds to the second of the nine elements listed by the USEPA.

An estimate of the load reductions expected from management measures.

The impairments identified in Sidney Brook, the characterization of the watershed, and the standards against which impairments are measured do not afford the ability to approach attainment of designated uses and water quality in this watershed in a simple load based approach. This is in part because impairments identified in the Sidney Brook and its attendant watershed transcends the simple water quality metrics used to evaluate NPS pollution impairments. For several of the examined water quality metrics seasonality and relative discharge rates showed a dichotomy in water quality in which baseflow conditions were acceptable while stormflows exceeded standards many times over. Additionally, certain impairments, such as water temperature, cannot be neatly quantified by loads. The following sections will therefore focus on describing the measures that will preserve and enhance water quality and ecosystem integrity in the system. As such, a practical and realistic approach to managing and correcting impairment will be maintained throughout the protection plan.

A central theme of this protection plan will be to address current water quality issues throughout the Sidney Brook watershed. For the most part many of the key protections that will maintain and protect water quality in the future are already in place. State protections include the Stormwater Management Rules (N.J.A.C. 7:8), Flood Hazard Area Control Act Rules Act (N.J.A.C. 7:13), the Highlands Act (N.J.S.A 13:20-1 et seq.), and of course the Surface Water Quality Standards (N.J.A.C. 7:9B), among others, work in concert to minimize impacts related to future development. The constituent watershed municipalities have also adopted as ordinance various protections for stream buffers, woodlands, floodplain, and other sensitive environmental features.

9.1 Temperature

Temperature is one of the parameters for which a simple load reduction does not adequately describe the measures that need to be taken to ensure use attainment. This is because temperature use attainment is not a product of load, but rather a complex set of factors including hydrology, hydraulics, meteorological variables, and land uses. To affect these temperature changes an evaluation of source impairment and management alternatives is necessary.

Impairments in stream temperature in Sidney Brook are driven primarily by online impoundments in both the main stem and the tributaries. As described above this is caused by increased hydraulic retention periods in impoundments, thermal retention, and increased irradiance. Secondary impacts are related to reduced riparian buffer quality and canopy cover in the stream. Most mitigation related to temperature impairments therefore focuses on maintaining vegetative cover, which provides shading, and maintaining flows and flow velocity which minimizes the timed exposure to solar irradiation. The actual mitigation activities typically focus on preserving natural buffers, streambank planting with shrubs and trees, the removal of impoundments, altering the flow regime of impoundments, and utilizing infiltration designs for stormwater management BMP's. Since the impoundments on the Sidney are privately held it is likely that riparian restoration activities will be the most effective in reducing temperatures by promoting increased shading of the stream and enabling increased cooling groundwater discharges.

The most useful assessment is to examine the relative distance of each of the stations to the nearest impoundment, which is also complicated by buffer integrity. The baseflow in-situ monitoring events confirmed much the same pattern as seen in the continuous temperature sampling, although at some different stations. Station 6, downstream of Jutland Lake, had very high temperatures in the growing season samples, over 5°C higher than any of the stations higher in the watershed. Station 7, the next station downstream, while having high temperature also showed a recovery in temperature with a 4 to 11% reduction in temperature. While buffer widths are somewhat reduced in this section, the immediate buffers consist primarily of native vegetation types and wetlands providing sustained cool groundwater flows and stream shading. The contrast between Station 6 and 10 is even starker with a reduction in temperature ranging between 10 and 17%. Once again, the buffer widths are not ideal, but the stream tends to be relatively well shaded in this stretch or abutted by wet areas that moderate temperature in all but a relatively short section. Tributary influx also provided temperature moderation in this reach. This overall reduction in temperature with increasing distance from the impoundment is a good indication of the temperature recovery potential. It must also be noted that Station 4 showed some elevated temperatures relative to the other upper watershed stations. While the buffers are generally fairly good in the areas upstream of this station there are several breaks in canopy that contribute to warming, but the series of at least 6 impoundments on this tributary limb certainly increase temperature in this section. For the most part, it seems evident that the buffer quality almost certainly modulates the influence of all these impoundments. Indeed, Station 3, which was monitored with the continuous temperature probe and is located immediately downstream of the impoundment on Finn Road and is part of the tributary upstream of Station 4, had the highest maximum and average temperatures which were considerably higher than those measured at Station 4.

The same patterns were evident in the continuous temperature data. As mentioned above, Station 3, located within 100 feet of the impoundment on Finn Road had the highest sustained temperatures throughout the study period and trend mirrored in Station 6 which is also strongly associated with an impoundment, Jutland Lake. Downstream of Station 6 the relevant continuous temperature stations, 7 and 9, showed a steady decline in temperature commensurate with the patterns in the in-situ data and strongly correlated with buffer quality and distance from the impoundment.

The total mapped network of Sidney Brook and all tributaries derived from USGS Blue Line streams and SCS streams GIS data is calculated to contain approximately 22.3 stream miles. A review of the Visual Assessment data shows that approximately 26.6% of assessed stream segments buffers (accounting for both banks) were characterized as having impaired buffers, often the result of various development encroachments, roughly equal to approximately 6 miles of impaired stream buffers. The designation of degraded buffer in regards to providing shade is based on buffer width, buffer continuity, vegetation height and coverage, and land use as determined during the stream walks. In any case, this analysis does imply that a significant percentage of the stream is inadequately shaded which leads to increased mean daily, mean daily maximum, and maximum temperatures.

For the reason discussed above not only water temperature, but poorly shaded stream miles, should factor in the calculus for improving stream temperatures. At a minimum the goal should be to achieve compliance with SWQS temperature criteria. This means that temperature reductions at some stations will likely need to exceed 2.5°C for both maximum and seven-day average temperatures. To mitigate some of the thermal pollution riparian buffer conditions and stream canopy cover must be improved. Currently, roughly 6.0 miles of the stream network are shown to have inadequate buffers although much of this tends to be in short stream reaches which pass through better shaded areas downstream. A realistic and achievable goal then should be the enhancement of approximately 4 stream miles with adequate buffers with a strong focus on the main stem and major tributaries with permanently wetted channels. This target of 4 miles is set therefore to account for areas that are not accessible, areas that cannot be changed without major restructuring of land use and significant economic loss, and in buffers in which land owners are simply not cooperative. The most important area to focus on however may be the impoundments themselves with a special focus on providing shade with large trees. The nature of growing large trees will necessarily take an extended period and early efforts should therefore focus on fast growing species such as eastern cottonwoods (*Populus deltoides*). These efforts will be discussed in greater detail below but much of the work could rely on natural vegetation succession and colonization in these areas fostered by a cessation of mowing or other frequent disturbances. The suggestions above offer the most realistic solutions for managing temperatures in Sidney Brook, but the removal of online impoundments should be strongly considered, as this would offer the best chance of lowering summer stream temperature. While the impoundments appear to be privately owned, this option should not be overlooked.

9.2 Solids

The inclusion of solids as a parameter for load reduction functions as a catch all for a variety of solids related impairments in the watershed and will incorporate suspended solids, settleable solids, and dissolved solids. In Sidney Brook several problems associated with various solids were documented including contravention of Total

Dissolved Solids on occasion, erosion of streambanks, and deposition of soft sediment including embedded substrates. Curiously, Total Suspended Solids criteria were never contravened. This may be related to several causes, one being that the sampled storms in the exceedingly dry period were not significantly large enough to mobilize large quantities of TSS, however it must also be considered that much of turbidity and solids loading in the stream during storm events was attributed both to large particles originating directly in the stream unlikely to be captured as TSS and very fine particles or colloids reflected partially in the TDS numbers. As such, hydrology and hydraulics may be more important in solids generation and loading in this watershed rather than more traditional watershed sources. For this reason, and others, a simple load determination is not appropriate and more reliance must be placed on recognizing the limitations of the system, identifying the characteristics of the creek and the watershed that contribute to this pattern of solids loading, and the ability to manage these loads.

A primary issue in limiting solids loading is the fact that nearly the entire watershed consists of highly erodible or potentially highly erodible soils. The erosion prone nature of the majority of the region's soils limits to some extent the level at which erosion and sediment loading can be controlled in the watershed. The erodibility also indicates that the stream itself may be more prone to erosion than similar streams. Furthermore, nearly 42% of the watershed is undeveloped and unfarmed and there is no practical method or reason for managing loads developed in these undisturbed areas. For these reasons efforts must focus on limiting solids loading from developed or otherwise utilized portions of the watershed and in-stream erosion. More specifically, this will involve reducing source generation in the watershed, capture of solids in stormwater, and perhaps most importantly reducing stream erosion through minimizing stormwater volumetric discharge. On a different tack, TDS loading in portions of the upper watershed, particularly around Jutland, will require septic management; these concepts are discussed more fully in *E. coli* control sections.

As discussed above a simple load calculation is not sufficient to set a targeted reduction. Baseflow and low intensity precipitation events pose little risk of either erosion or sediment delivery to the system as confirmed by in-stream sampling and as such solids standards (TSS) are satisfied. One typical approach to identify targets is to calculate an average annual concentration by dividing total load by total stream hydrologic load. This approach yields a value of 126 mg/L of TSS which would require an 80% reduction to meet the standard, however when the same exercise is performed utilizing the baseline or pre-development load average TSS concentration is still 39 mg/L which would require a 36% reduction under completely forested conditions to achieve the 25 mg/L standard which illustrates that the standard is not realistic for this watershed. That is why many other regulatory authorities utilize a multi-tiered standard that is based on exceedance distribution to account for variable storm intensity and acute versus chronic effects.

A better approach to quantifying load reductions would describe stormwater management measures and associated efficiency in reducing overall stormwater volumes and peak stormwater flows and increasing solids removal capacity. This approach therefore describes realistic and implementable strategies rather than setting an arbitrary target, but meets overriding environmental conservation and enhancement goals by reducing nonpoint source loading and stormwater quantity. Some of the general strategies to reduce solids and stormwater loading in this watershed include: preservation, enhancement, and creation of streamside riparian buffers; streambed and bank stabilization; implementation of cultural BMP's to reduce loading from developed and agricultural lands; retrofitting existing stormwater infrastructure to improve removal performance; and construction of structural BMP's such as infiltration basins at critical areas.

Since TSS loading in the watershed is so diffuse most effort should focus on the repair of riparian buffers; over 26% of the buffers in the watershed appear to be highly degraded. Besides the benefits in reducing solids loading and in-stream erosion the maintenance and enhancement of buffers also treats other NPS loading problems and creates valuable habitat. Indigenous forested buffer offers perhaps the best solids removal efficiency of any non-intensive restoration technique, reported at 70%, and implementation may be as simple as planting appropriate vegetation. If there is an assumption that overall solids loading is distributed equally along the tributary network restoration of buffers in the targeted 4 mile reach discussed in temperature reduction section above at 70% removal efficiency could decrease solids loading to the streams in a best case scenario by approximately 12.5% or 119,853 kilograms annually. Similarly, a conversion to forested riparian buffer yields decreased stormwater runoff and the modeled change from lawn to forest could decrease peak discharges approximately 15 to 20% in the converted area which decreases the potential for bank and bed erosion. Vegetated filter strips are somewhat more intensive to implement as they depend on creating a uniform grade, but in the end consist of introducing plant communities to filter and settle solids and minimize erosion. Removal rates vary from 60% to 80% dependent on the plant communities.

Agricultural BMP's are important in the source control of solids loading in the watershed. This would focus on utilizing conservation tillage practices. Given the efforts by USDA and NRCS as well as local Soil Conservation Districts and other advocates for agriculture it can be assumed that many farmers already actively practice many sound BMP's including conservation tillage practices, crop rotation, and cover crop planting in an effort to conserve valuable top soil, improve yields, and protect waterways.

Another means by which solids loading and stream erosion can be reduced would be to retrofit and upgrade any existing stormwater basins or related BMP's. To date, there are a number of these types of basins within the watershed. Initial inspection of these basins suggests that their performance, in terms of stormwater recharge, pollutant attenuation, and overall volume control, could be greatly improved by implementing some basic, simple retrofits. This would include the removal of the concrete low flow channels and the revegetation of the basins with a native, wet meadow/meadow plant mix.

The New Jersey Stormwater Best Management Practices Manual (NJDEP, 2004) lists a variety of other strategies to reduce solids loading that offer high removal efficiency but are intensive due to permitting, engineering, construction, and materials which substantially increases cost. These types of projects may also have a substantial footprint which could be prohibitive in siting the design. The following lists some of the applicable management alternatives and removal efficiency that may be appropriate for use in the Sidney Brook watershed: bioretention system, 90%; stormwater wetland, 90%; infiltration basin, 80%; and pervious pavement, flow reduction. Manufactured treatment devices or MTDs should also be considered particularly as retrofits of existing systems or in areas with limited space. A number of these systems have been approved in New Jersey and removal rates vary between 50% to 80%.

9.3 Total Phosphorus

Under baseflow conditions TP concentrations never exceeded the SWQS criterion, but four stations exceeded the standard at least once during storm events and concentrations tended to be higher during higher intensity storm events. As with solids, this pattern defies a simple load based reduction as an appropriate means of improving ecological function of the stream and use attainment, and thus a description of removal efficiencies for management alternatives will be more useful.

TP is generally highly correlated with solids loading in streams without large point sources and the most effective control methods generally focus on controlling solids loading. However, TP loading in the Sidney Brook, at least in the upper stations is also driven in part by dissolved phosphorus loading (specifically SRP), which must also garner attention. Since TP is highly correlated with solids many of the same limitations that exist for solids loading in this watershed are applicable to TP. Solids and phosphorus loading is prone to be excessive in the watershed due to the erodible soils of the watershed, but under baseflow conditions SWQS are attained. As such, the enhancement and creation of vegetated riparian buffers will be among the most useful for controlling TP loading in the Sidney. Management should therefore focus primarily on reducing peak concentrations during higher intensity storm events, limiting additional loading to the system, and maintaining low baseflow concentrations. Since many of the management measures discussed for solids control are effective in managing TP the same solutions will be evaluated for TP control. The management of SRP will also be associated with septic management options, agricultural BMP's and cultural practices for homeowners.

Using some of the same analyses that were employed for solids shows some of the same issues in trying to calculate a realistic load reduction. Utilizing the concentration standard strictly based on stormflow exceedance could require a reduction of 50% to reduce the measured high of 0.20 mg/L to attainment of 0.10 mg/L. Conversely, calculating an annual average by dividing total calculated TP load by annual hydrologic load yields a mean TP concentration of 0.07 mg/L, below the SWQS for TP. These conflicting accounts highlight the difficulty in determining an appropriate load reduction. The following section discusses the phosphorus removal rates associated with the various strategies employed for solids.

The enhancement or creation of indigenous forest buffer and other vegetative filters offer phosphorus removal rates of approximately 30%. Utilizing the same reasoning as with solids loading that TP loading to the tributary network from nonpoint sources is generally equitable on a landscape scale the restoration of 4 stream miles to an indigenous forest buffer would reduce TP loading to the Sidney by 27.4 kg or 5.4% of the total phosphorus load. While the magnitude is less than that described for the removal of solids this can still be an important reduction in phosphorus rates, especially if weighted towards storm loading. Additionally, the benefit of reduced stormwater loading will further decrease TP loading related to the erosion of the stream channel.

Other management alternatives tend to offer higher removal rates and when used in targeted areas can offer larger load reductions although at increased costs. Bioretention basins offer removal rates of approximately 60% and constructed stormwater wetlands can remove up to 50% of TP loads. These systems benefit through dual removal mechanisms including the physical filtering and settling of solids as well as bioassimilation or uptake by plants. Infiltration basins and pervious pavement can also remove approximately 60% of influent TP loads. Manufactured treatment devices also offer TP removal capabilities, but removal rates are poorly described in the literature simply because they tend not to be evaluated for TP removal. However, some common types, such as baffle boxes and vortex units, seem to offer removal rates of approximately 20% to 40%.

Cultural and agricultural BMP's can be very important in controlling phosphorus loading in rural watersheds because of the diffuse nature of the loading. Cultural BMP's generally focus on actions related to property maintenance. In regards to phosphorus this would include maintenance and repair of onsite septic systems and reducing loading related to lawn fertilizer applications and erosion. Use of phosphorus-free lawn fertilizers was shown in a pilot study to reduce TP loading by between 12% and 16% in residential areas. In the Sidney Brook watershed maintained lawn space from various LU/LC classifications accounts for approximately 21.0% of the land area and a 16% reduction from these areas could reduce TP loading by 18.5 kg or 3.6% of the total. Regular septic system maintenance may also be important in reducing TP loading to the Sidney. Septic systems generally retain at least 48% of all phosphorus passing through the system (Pell and Nyberg, 1989). Regular maintenance of these systems consisting of pumping the septic tank can remove this substantial portion and be especially beneficial in failing or overflowing systems in which solids and effluent pool at the surface, although the reduction in effluent concentrations in properly functioning systems would be considerably less.

Manure management will be an important consideration in this watershed. At a minimum the NJDA Animal Waste Management Rules should be enforced that require that manure piles be located at least 100' from any State water. One dairy cow produces approximately 4 pounds of phosphorus per year and managing manure away from the tributary network is critical in reducing phosphorus loading particularly during storm events where leachate and particulate forms are easily transported to streams. Utilizing conservation tillage practices can decrease TP loading by up to 30% on agricultural lands.

9.4 *E. coli*

High *E. coli* concentrations are endemic throughout the Sidney Brook watershed and are observed throughout the year, although summer counts were higher due to microbial growth directly within the stream and decreased flow or dilution factor during this period. *E. coli* represents a major problem in the watershed and does not meet contact use designations. Control of *E. coli* is going to be difficult because no point source, such as a wastewater treatment facility, is readily identifiable, wildlife is likely to be the major loader, and septic effluent from residential lands is probably only locally important. As such, much of the coliform loading in this watershed may be characterized as unmanageable. An additional complicating factor related to coliform loading is that only minor portions of the load are related to particulates bigger than individual cells so the mobilization of bacteria mimics dissolved substances or colloids. Management of *E. coli* will have to focus strongly on manure management techniques, buffer repairs, and septic system management where applicable.

Traditional BMP's used for stormwater management tend to offer relatively low removal efficiency for reducing fecal loads. A recent study in the journal *Stormwater*[2] based on paired influent and effluent concentrations show that vegetated swales and detention basins are not effective in reducing bacteria and have been shown in many cases to actually increase concentrations. Retention ponds and media filters including bioretention cells show the most benefit, but all evaluated BMP's showed a high degree of variability and even the better performing types may at times show increased concentrations post-treatment and that none of the measures are able to reduce concentrations below contact standards. The ability of retention basins or other similar features to reduce concentrations is confirmed in field collected data from Station 6 which had the lowest measured concentrations as a result of the removal efficiency provided by the impoundment upstream of the sampling location. Overall, these systems may provide reductions in concentration up to 70%, but overall reductions are likely to be small as these reported reductions would apply only to the catchment area of an installed BMP.

Manure management techniques will likely be more important in reducing manageable coliform loads including *E. coli*. Studies indicate that storage prior to field applications is probably the most effective way of reducing bacterial concentrations and storage up to a month has the capacity to reduce concentrations by up to 99%, although storage solutions including stockpiling still require management. The use of vegetated buffers in agricultural applications may have somewhat higher percent removal but this may be a factor of higher initial concentrations in agricultural settings as opposed to more typical BMP catchments. The reported efficiency of agricultural BMP's for the control of microbes is very variable but seems to range between 50-70% for filter strips, vegetated

[2] Clary, J. et al. 2008. *Can Stormwater BMPs Remove Bacteria?* Stormwater. http://www.stormh20.com/may-2008/bacterial-research-bmps.aspx

swales, and riparian buffers. While this is probably not adequate to meet primary contact standards locally in stream segments adjacent to fields that receive manure applications it could represent a sizable decrease in total loading and at stations downstream.

It is very difficult to estimate the *E. coli* loading attributable to septic systems in the Sidney, but various tests including bacterial counts and SRP data indicates this to be a significant source near Jutland. Ideally, functioning septic systems should contribute little in the way of coliform loading to the stream, but malfunctioning systems probably represent the vector in this watershed. Malfunctions can be caused by poor initial siting near streams or in hydric soils and poor maintenance characterized by infrequent pump-outs or by flushing solvents and fats that clog leach fields. The Visual Assessment showed these are issues in the watershed and systems were identified in the riparian corridor and some showed the classic symptoms of poor function including vibrant grass growth and wet areas in the leachfield. Regular maintenance and perhaps replacement of these systems, especially of conventional designs with sand mounds or other alternative systems may be necessary to limit loading and correct these issues.

9.5 Stormwater Runoff

Considerations for stormwater management typically focus on reducing runoff related to new development or redevelopment with the main consideration for management being reducing peak discharge rates. More recently stormwater management has focused on a paradigm of managing stormwater quality to reduce contaminant concentrations. This focus has been fostered in part by the nature of the technical regulations. However, since stormwater volume has led to increased erosion in this watershed as well as other impacts it will also be useful to think of runoff as a pollutant load. Reducing runoff volume will be challenging as is management for other loads because this type of loading is diffuse across the watershed. Reducing volume instead of just rates will depend on displacing runoff primarily through increasing infiltration processes or potentially by increasing potential evapotranspiration. The benefits of these actions besides an overall reduction in runoff volume is increased groundwater to sustain higher baseflow, reduced erosion, reduced contaminant loading, and potentially reduced stream temperatures.

As with many of the management measures discussed above a simple load reduction calculation is impractical. Most BMP’s that offer infiltration or groundwater recharge capabilities such as infiltration basins are highly correlated with site specific conditions, particularly the infiltration rates of native soils as well as soil compaction, however an achievable target for most infiltration systems is 100% recharge of the catchment area for the water quality design storm, typically the 1-year storm (1-year average return frequency). Another design standard for these systems is that they infiltrate at a minimum 0.5 inches/hour. Stormwater wetlands and bioretention systems also offer some volume reduction with reported values between 20% to 60% due to ET losses. Retrofitting existing stormwater systems can also reduce runoff volumes but the lack of stormwater infrastructure in the watershed minimizes any practical benefit for this approach. The use of pervious pavement systems functions similarly to dry wells with a minimum design standard of 0.5 inches/hour of infiltration.

The use of less intensive BMP's is likely to be of greater benefit to the Sidney Brook watershed overall and should concentrate on land uses such as rural residential development and agriculture because these areas offer the best opportunities to successfully manage runoff volume. Managing roof runoff from houses and outbuildings including barns and sheds is probably one of the easiest ways to reduce runoff volumes and peak discharge rates. While the total area of roofs in this relatively rural watershed is small they contribute disproportionately to stormwater volume. Both rain barrels and dry wells can completely recharge all stormwater generated from roof runoff and rain barrels add a beneficial reuse component as this water can be used to irrigate lawns and gardens. Dry wells are usually designed to handle storm intensities up to the 1-year storm event which in an average year will account for a majority of all precipitation falling on roofs.

In addition to reducing runoff volume traditional rate reduction solutions should be considered as well. In the Sidney watershed the enhancement of buffer habitats will offer some benefit both in reducing runoff rates by detaining sheet flow through increased roughness attributable to vegetation and through simple infiltration of the detained water. The use of runoff curve numbers may be the most reliable method of describing anticipated reductions in the generation of stormwater. The curve number for forested lands in good condition in soils classified as hydrologic group B is 55, indicating that roughly 55% of precipitation on the site will result in runoff with the remainder being infiltrated by the soils or lost to the atmosphere via evapotranspiration. Pastures in fair condition in hydrologic soil group B have a curve number of 69, farmsteads with lanes and buildings and associated land uses have a curve number of 74, and 1-acre lots corresponding to rural residential development in the watershed have a curve number of 68. Conversion of pasture, farmstead, and rural residential to a forested riparian buffer could conceivably reduce the generation of stormwater respectively by 20%, 26%, and 19% in these areas. Besides affecting a reduction in total volume runoff loading rates would be reduced with a longer time of concentration, the time at which peak stream discharge is reached upon the commencement of a storm event. Reducing stormwater in the areas adjacent to the tributary network of the Sidney Brook will have a greater affect in reducing erosive forces than more generalized measures throughout the watershed.

9.6 Invasive Species

Invasive species management is generally not regulated in a quantifiable fashion such that a certain percent colonization of an invasive triggers a removal action. Despite this, invasive vegetation is widespread and needs to be controlled in the watershed. There are several negative effects associated with invasive vegetation the most prominent being the competitive exclusion of native plants with a resultant impairment of ecological function and habitat value in the riparian corridor. Invasive vegetation may also be an indicator of disturbance as many invasive plants are pioneer species and within riparian systems can be indicative of frequent or excessive erosional or depositional process that are favorable for colonization. The most problematic species in the riparian corridor of Sidney Brook is multiflora rose.

Treatment methods for invasive vegetation will vary but would likely consist of both herbicide application and mechanical removal in concert. Addressing the root causes of invasive plant colonization, primarily the disturbance of riparian buffers and secondarily the intentional introduction of invasives (i.e. multiflora rose and bamboo), require both an educational aspect and of course a restoration of riparian buffers throughout the watershed. The goal to achieve a reduction of invasive species in the watershed will therefore focus on implementing the general plan of riparian buffer restoration in the watershed with a stated goal of 4 miles of restoration. It is therefore important to establish thresholds at which increased action is devoted to the removal of invasives during restoration. In areas where virtual monocultures of invasive plants have been identified in otherwise undisturbed riparian corridors, treatment or removal should be triggered when 100' linear feet of monoculture (defined for this report as plant community percent composition of 75% of invasive species) or a stand in excess of 1000 square feet. This ensures that at a minimum large stands are adequately treated in more naturalized areas where continued rapid expansion is unlikely due to a lack of disturbed soils. In disturbed portions of restoration areas especially where bare soils are present treatment intensity should be increased such that stands exceeding 25' or 250' square feet are treated. In areas where intensive replanting of native shrubs and other vegetation is attempted, particularly where there is a conversion of lawns, agricultural areas, or other developed land covers, all invasives should be removed prior to planting. This should be followed by additional removal post-planting as necessary during a critical phase before full coverage of natives is achieved when invasives often exhibit the most vigorous growth.

10.0 Description of Nonpoint Source Management Measures

This section is the heart of the watershed protection plan and discusses in detail the management measures to be implemented in the watershed to assure protection of Sidney Brook. This section corresponds to the third of the USEPA nine elements.

> *A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in the second* [*element*]*, and a description of the critical areas in which those measures will be needed to implement this plan.*

Up to this point in the Watershed Protection Plan the impairments observed and documented in the creek and the watershed have been fully characterized and identified and a general estimation and quantification of the changes necessary to protect the ecological state established. Additionally, some discussion has been made in a general sense of the measures to be implemented to protect the ecological integrity of the stream upon which this section will expand.

Clearly the problems that have impacted and will continue to impact Sidney Brook are linked directly to widespread watershed development (including agricultural development) and nonpoint source loading. Due to the ubiquitous nature of these impacts the entire stream system has been negatively affected to some capacity. In some cases, the impacts are eutrophication related, caused by runoff from both farmed and residential areas. In other cases, the impacts can be linked to pathogen impairments arising from septic loading or livestock runoff. Additionally, there are a number of stream segments where the impacts are directly attributable to physical damages (erosion, undercutting, sedimentation, etc.) caused by too much runoff, runoff discharged to the stream at too high a rate, storm flows that continue for too long a period of time, or lack of a functioning floodplain or riparian buffer. Again, these impacts are caused by watershed wide problems; many of which at the individual level are too small in scale to be managed, but on a cumulative scale have led to the observed impacts.

Through the combination of the analyses of Princeton Hydro and the New Jersey Water Supply Authority, a number of project sites were identified and ranked. The New Jersey Water Supply Authority also indentified, mapped and ranked critical stream segments. Overall, through these analyses and field assessments, 25 project sites have been identified. Each project site is important in itself. There is also ample opportunity to instigate a number of very small projects as cost and effort allow, or as development requirements dictate, and the widespread implementation of simple solutions like no-mow zones is encouraged throughout the watershed.

The characterization and assessment of this watershed contained within this document show that while the overall water quality of Sidney Brook is fairly good a number of impairments affect the ecologic integrity of the watershed and the general water quality of the stream. Therefore, the overarching goal of this protection plan is to identify and implement those measures deemed appropriate to address those specific impairments and protect the water quality and integrity of the watershed to improve these functions. An important caveat of protecting and increasing water quality is that all efforts must be conducted in manner that is realistic and achievable with commensurate attention and resources. Since this watershed is primarily rural the impairments in the stream and watershed and the base causes are diffuse. This therefore will require full public buy-in to affect positive changes in water quality especially in light of the limited holdings of public lands where improvement projects could be implemented by the constituent municipalities.

In review, there are six NPS pollutants including traditional and non-traditional loads that have been identified as the source of most major use impairments throughout the Sidney Brook watershed. These include:

- Temperature or Thermal Load
- Solids
- Total Phosphorus
- *E. coli*
- Stormwater Runoff
- Invasive Species

Increased loading of these pollutants as well as the root causes of their generation have been discussed in detail in the sections above, but a brief summary is found below in Table 22, along with a description of the generalized major management measurements that need to be enacted to ensure the protection and improvement of the water quality and ecological function of Sidney Brook. Many of the proffered management measures for the protection of the Sidney Brook watershed are low intensity solutions that require a minimum of engineering, materials, construction, and funding, all of which is reflective of the diffuse yet extensive NPS loading identified in the watershed and appropriate for meeting protection goals. Because these measures are low intensity this increases the potential for widespread implementation to affect meaningful protection and improvements, but which will, as mentioned above, be strongly reliant on public education and community participation to enact.

Table 22: NPS Management Measures

NPS Management Measures				
NPS Load	**Source**	**Management Measures**		
		Primary	**Secondary**	**Tertiary**
Temperature	Impoundment, Reduced Riparian Canopy	Buffer Enhancement	Impoundment Removal	Structural BMPs
Solids	Channel Erosion, Soil Erosion, Runoff	Buffer Enhancement	Bank Stabilization	Agricultural BMPs
Total Phosphorus	Soil Erosion, Fertilizer Use, Septic Effluent	Buffer Enhancement	Septic Management	Cultural BMPs
E. coli	Septic Effluent, Livestock, Wildlife	Septic Management	Manure Management	Buffer Enhancement
Stormwater Runoff	Impervious Surfaces, Lack of Infrastructure	Structural BMPs	Cultural BMPs	Buffer Enhancement
Invasive Species	Floodplain Encroachment, Erosion	Invasive Species Management	Buffer Enhancement	Open Space Preservation

A scoring matrix was subsequently used to rank and prioritize the various generalized load reduction methods listed above. The scoring system awarded 3 points to each of the primary measures, 2 points to secondary measures, 1 point to the tertiary methods, and then tallied. This matrix is included in Table 23 below. Not surprisingly, riparian buffer enhancement was chosen as the most important NPS load reduction strategy for the watershed because of the inherent benefits associated with buffer enhancement including bank stability, nutrient uptake, decreased runoff, and improved wildlife habitat, and because degraded riparian buffers have been characterized as one of the more common and important impairments in the watershed. Riparian buffer enhancement and all of the management measures shown above as well as a variety of auxiliary management measures will be discussed in turn in this section of the document. These discussions will focus on a variety of components as necessary including structural BMP's, cultural BMP's, and agricultural BMP's. General conceptual solutions to be utilized as templates and specific implementation sites will also be provided. A review of regulatory protections is discussed first to better explain the regulatory framework including protection goals and standards.

Table 23: NPS Management Measures Matrix

NPS Management Measures Scoring Matrix				
	Primary	Secondary	Tertiary	Total Score
Buffer Enhancement	3	1	2	13
Structural BMPs	1	0	1	4
Septic Management	1	1	0	4
Cultural BMPs	0	1	1	3
Invasive Species Management	1	0	0	3
Impoundment Removal	0	1	0	2
Bank Stabilization	0	1	0	2
Manure Management	0	1	0	2
Agricultural BMPs	0	0	1	1
Open Space Preservation	0	0	1	1

10.1 Existing Regulations

A variety of ordinances, rules, and regulations currently exist to protect water quality in waterbodies throughout New Jersey originating from local municipalities to the federal government. In fact, it is these rules on the books that will ensure the water quality of Sidney Brook remains high moving forward and that simple enforcement and implementation of these rules is going to be among the strongest tools in protecting the watershed in the future. Most of the existing regulatory framework regarding stream protection is focused on mitigating impacts related to planned future development and changes in land use, particularly the Highlands Act. While potential future impairments are well addressed the pollutant loading and impairments related to current development and land use patterns, especially within defined stream buffers up to 300' from the channel, is not defined as fully pointing to the need for a watershed protection plan. This document therefore must address mitigating current impairments to improve water quality in the present in addition to implementing those regulations that protect water quality in the future. The following section is a review of some of the more important regulatory measures related to water quality and watershed protection for the Sidney. One of the most important regulatory tools, the Highlands Act, was discussed above in Section 3.0 of this document.

10.1.1 New Jersey Surface Water Quality Standards

The New Jersey Surface Water Quality Standards (N.J.A.C. 7:9B) have been discussed at great length in the sections above and really form the basis for much of this document. The SWQS define the designated use and general classification of the Sidney, provide a series of scientifically based water quality standards, and establish the antidegradation policies relative to water quality. From this perspective the SWQS regulate the current water quality of the stream, expressed as water quality metrics, and through antidegradation components regulating future uses.

The specific parameter-based water quality standards were discussed above in the characterization section of the document. While water quality in the creek is fairly high there were documented deficiencies to a varying degree at certain stations or sampling dates for water temperature, *E. coli*, total phosphorus, and total dissolved solids. In addition to the defined parameters list specified in the SWQS the antidegradation policies can also be interpreted in a more qualitative fashion particularly in regard to protecting aesthetic value and ecological integrity of Category One streams as outlined in the SWQS. In particular, maintaining habitat quality and biological functions is an important concept of the antidegradation policy and thus includes assessing stream functions that are not as easily measured as contaminant concentrations, annualized loads, or other similar parameters. These additional stream functions would include descriptions of biological communities including benthic macroinvertebrates, fish, periphyton, and riparian vegetation as well as stream habitat related to substrate, sediment aggradation/degradation, and erosion and bank stability among others.

10.1.2 Stormwater Management Rules

The Stormwater Management Rules (N.J.A.C. 7:8) dictate a broad set of goals related to managing stormwater at a variety of governmental levels including municipalities, counties, regional and interstate commissions, and various state agencies. The basic goals of these rules are to: reduce flood damage, minimize increases in stormwater runoff, reduce soil erosion, maintain groundwater recharge, maintain stream channel integrity, reduce pollutant loading, and ensure proper design, performance, and maintenance of stormwater BMP's. It also encourages and provides guidance for the formulation of regional and municipal stormwater management plans and stormwater control ordinances. This set of rules and the production of stormwater management plans is primarily focused on stormwater management associated with major development, but may include stormwater management focused on upgrades and retrofits for existing land uses.

The Stormwater Management Rules provide special protection for C1 waters and mapped tributaries in the same HUC14 watersheds, such as Sidney Brook, through the establishment of Special Water Resource Protection Areas (SWRPA). The SWRPA is a 300' buffer on both banks measured perpendicular to the top of bank or from the centerline of a stream with poorly defined banks applied to C1 waters. From a regulatory perspective and functionally, SWRPA's act as regional BMP's. The purpose of the SWRPA is to limit encroachment in this buffer to preserve important ecological functions and any encroachment in the SWRPA shall be limited to areas of previous development or disturbance. Even when encroachment is allowed within the SWRPA the buffer shall not be reduced below 150'. This extends to the discharge of stormwater and no outfalls can be located within 150' of the stream. In some senses, the strict prohibition of disturbance in the buffers can be limiting for restoration activities or managing stormwater for existing land uses, but the protection of riparian buffers is a powerful tool for maintaining water quality and effectively addresses the one of the most important causes of impaired water quality in the Sidney, namely buffer degradation.

Any encroachment in the SWRPA on C1 streams and tributaries is based on satisfying two criteria: that the site is developed or disturbed and the proposed activities do not degrade the functional value of the SWRPA. The second criterion is satisfied through conducting a Functional Value Assessment, which consists of four components. Habitat function is evaluated based on its potential suitability for threatened and endangered species and general vegetative character. Nonpoint source pollutant loading is also considered for the SWRPA, but the pollutant removal effects related to structural BMP constructions are discounted since any removal is only related to the post-construction footprint which could generate additional pollutants. Temperature moderation is considered as one of the key functional values of SWRPA and must be protected, and is especially important in the Sidney watershed in trying to reduce stream temperatures to satisfy the TM stream temperature criterion. Besides referring to canopy and vegetative coverage, BMP's that impound water could affect the temperature regime if inadequately shaded and discharging overland to the stream. Channel integrity is also evaluated and is assessed through the volume and rate of stormwater runoff as well as recharge potential within the SWRPA.

10.1.3 Flood Hazard Area Rules

The Flood Hazard Area Rules (N.J.A.C. 7:13) are an expansive set of rules related to land uses, development, and other activities related to or located within flood hazard areas and riparian zones of regulated waters. The general intent of the rules is to minimize damage to life and property associated with flooding caused by development in flood hazard areas, preserve water quality, and protect wildlife and vegetation. The rules include a number of methodologies for determining flood hazard area and riparian zone and define regulated waters and regulated activities. Six methods are described for determining flood hazard area and in non-tidal waters; this is usually based on some derivation of the 100-year flood elevation with appropriate constraints. Riparian zones are also determined in various ways, but a 300' wide riparian zone from each bank is designated for all C1 waterbodies including Sidney Brook. The 300' riparian zone distance coincides with the SWRPA, but each references separate rules and from a regulatory perspective are separate entities although functionally they both exist to protect and preserve existing buffers. Besides defining the limits of the flood hazard zones and regulated waters it also defines regulated activities which range from in-stream activities to encroachment in the floodplain. A thorough understanding of regulated activities is important in assessing permitting requirements and the level of effort and detail needed to implement management alternatives for the watershed protection plan; it must be stressed however that additional permits may be required to undertake regulated activities such as freshwater wetlands permits. Regulated activities are classified in four groups: permit-by-rule, general permit, individual permit and emergency permit.

Permit-by-rule is the least intensive class and requires no prior approval from the State, only a notification prior to initiating work. These activities are generally anticipated to have little to no impact to the riparian zone or increased chance of flooding when undertaken in compliance with the technical regulations by following specific instructions for each activity. Many of the proposed management activities that will be discussed elsewhere in the document are likely to be considered as permit-by-rule including activities such as constructing an aquatic habitat enhancement device, conducting normal property maintenance, implementing soil conservation practices outside a floodway, and planting native vegetation.

General permits are required for the next class of activities. These types of activities are generally more intensive and may involve the use of heavy machinery or operating within the stream channel, and carry a higher burden of detail as well as prior approval from the State upon review. At a minimum these permits require submitting engineering or surveying plans sealed by the responsible party. These permits may also require obtaining additional permits and abiding by various other rules including the Standards for Soil Erosion and Sediment Control (N.J.A.C. 2:90). These activities include, but are not limited to, channel cleaning, constructing agricultural roadways and fords, wetlands restoration, outfall installation and maintenance, and repairing or relocating flood damaged structures. Each of the general permits is accompanied by a specific set of limitations to protect both the floodplain and the regulated activity.

Individual permits are issued for larger and more complex projects set within a regulated area or those that fall outside the purview of general permits. These activities include non-agricultural crossings, bank stabilization, stormwater discharges, construction activities, and utilities crossings. Permit submissions are also more complex and must include full engineering drawing sets, hydrology and hydraulic assessments, flood hazard area identification methodology, existing and final grading plans, construction methodology, and identifying and addressing potential impacts as well as many other requirements. Individual permits must satisfy not only all requirements related directly to the Flood Hazard Rules, but also satisfy Water Quality Management Planning Rules (N.J.A.C. 7:15). Individual permits will be required for in-stream restoration activities including bed and bank stabilization activities requiring grading or importing new materials or any activity related to disturbance of the channel or the riparian zone. Individual permits are enforced to protect flood storage capacity and other natural and constructed resources and functions, water supply, ecological functions, drainage, and navigation associated with waterbodies and flood hazard areas.

Emergency permits are issued to undertake regulated activities when immediate action is required to protect the environment and public safety, health, or welfare. Two basic conditions are linked to approval and the permit shall only be approved if severe environmental damage will occur or there is an immediate and high risk to public health and safety and there is a high probability that the impacts to the environment or public welfare will occur before a general or individual permit could be reasonably obtained. Again, these permits are related only to emergency activities and barring a catastrophic flood event in the Sidney watershed will likely not be utilized for any restoration activities.

10.1.4 Freshwater Wetlands Protection Act Rules

The Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A) are based in part on satisfying the Federal Water Pollution Control Act (Clean Water Act) regulations. In scope and function they are similar to the Flood Hazard Area rules and define identification methodology, regulated activities and permits. The end goal of these rules is to protect the integrity of freshwater wetland systems including habitat and hydrologic functions which are critical components of stream systems and watersheds. Some of the benefits associated with wetland systems include their habitat value to plant and wildlife communities, flood storage, mitigation of contaminated stormwater, stormwater storage (distinct from flood storage), and providing a buffer for streams in both the headwaters and lower in the basin.

Identification of freshwater wetlands is performed under the three-parameter approach that focuses on hydrology, soils, and plant communities. Wetland determination is subject to review by NJDEP and the findings published as a Letter of Interpretation (LOI) which defines presence or absence and the delineation of the wetland boundary. Wetlands are further defined as one of several classes, including Ordinary Resource Value, Intermediate Resource Value, and Exceptional Resource Value, which carry different regulatory weight with increasing protection for higher value resources. One of the variable protections associated with the different classes is the Transition Area width which increases with higher resource value wetlands to provide refuge and buffer the wetland.

Regulated activities associated with wetlands are similar to those defined for flood hazard areas and include disturbance from excavation, fill, dredge operations, drainage or disturbance of water stage or groundwater table, dumping, construction, or destruction of vegetation. These activities may be performed under several permit classes including general permits encompassing freshwater wetlands permits, open water fill, or transition area waivers, individual permits and emergency permits. There are a large number of general permits, nearly 30, that cover a variety of activities including maintenance of existing structures, utilities, channel cleaning, additions to existing structures, habitat creation and enhancement, trails, and bank stabilization amongst others. Individual permits may be granted for projects in which a combination of general permits is insufficient or have additional permit conditions that would not be sufficient to ensure compliance with the act. Emergency permits are granted on an emergency basis where there is an unacceptable threat to the environment, public safety, or property, and that there is not a reasonable expectation of receiving a general or individual permit before the anticipated threat.

The enforcement of the wetlands rule is certainly important in protecting the resources of the watershed. In terms of implementing restoration strategies these rules are likely to play a part. Bank stabilization, in-channel habitat restoration, channel cleaning, and the removal of all invasive vegetation are all activities regulated under general permits within certain restrictions including disturbance area or linear distance of the activities. However, other activities, such as planting native vegetation by hand, are unregulated and may be performed freely with the conditions outlined in the rules.

10.1.5 New Jersey Pollution Discharge Elimination System Rules

The New Jersey Pollution Discharge Elimination System Rules (NJPDES, N.J.A.C. 7:14A) is similar to the federal National Pollution Discharge Elimination System, and is charged to protect potable water sources, the chemical, physical, and biological integrity of waterbodies, health and human safety, and ecological integrity from the discharge of pollutants. Regulated activities under the NJPDES rules include discharge to ground or surface waters, indirect discharge, land application of wastewater, animal feed operations, stormwater and storm sewers, site remediation, and wastewater treatment plants as well as other activities. Much of the enactment of the NJPDES rules is related to water quality based effluent limitations listed within the rules and related to other statutory vehicles such as the Surface Water Quality Standards. The effluent standards target a variety of pollutants and physicochemical parameters including nutrients, solids, floatables, petroleum hydrocarbons, microbes, temperature, and a large suite of additional parameters.

In addition to the broad categorization above all municipalities and other agencies in the state are required to file for Municipal Separate Storm Sewer (MS4) permits related to storm sewers draining roadways and public complexes. MS4 permits are granted on condition of satisfying the Statewide Basic Requirements (SBR) including public involvement and participation, reduction of pollutants, long-term operation and maintenance of BMP's, controlling solids and floatables, and implementing Municipal Stormwater Management Plans which are enacted through local ordinance, policy, or inclusion in the Master Plan. The constituent municipalities in the Sidney Brook watershed have completed and are in compliance with MS4 permits and are designated as Tier B communities.

The NJPDES rules are important for protecting both surface and groundwater resources from point and nonpoint source pollution. In the Sidney Brook watershed nonpoint source pollution is a much larger contributor to pollutant loading than point sources and the SBRs for the MS4 permits ensure that nonpoint sources related to roadways and other infrastructure are addressed. However, as with many of these statutes, the NJPDES rules are directed mostly towards new development or redevelopment activities and therefore have a reduced efficacy in treating and managing stormwater discharge from existing development.

10.1.6 Constituent Municipality Ordinance

As discussed above, the constituent municipalities of the Sidney Brook watershed have been proactive in establishing local ordinances to protect sensitive ecosystems and natural resources, as included in Table 24 shown below, which provides a summary of some the more important regulations found in the respective township Master Plans or adopted as ordinance. Most of these regulations are based on the identification and preservation of critical habitats or natural resource features protected by limiting disturbance or development or offsetting such activities through the use of buffers and other performance standards. In practical application many of these ordinances are similar to the state regulations discussed above, but often offer a stronger degree of protection based on more stringently applied restrictions or increased buffer widths. These types of environmental regulations fall in several categories including zoning, flood plains, stormwater management, various environmental performance standards, and stream corridor protection.

Table 24: Regulatory Review of Watershed Municipalities

Regulatory Measure	Municipal Measure
Zoning	Union - Establishment of Districts with varying land use goals and requirements to protect environmental and economic interests, includes Conservation Management and Agricultural Preservation
	Franklin - General Zone Regulation subject to varying use requirements to sustain characteristics regulated through building and zoning permits
Flood Plains	Union - Flood Damage Prevention controls alteration of natural floodplains through a number of regulated activities establishes areas of Special Flood Hazard
	Franklin - Floodplain Regulations state there shall be no building, fill, storage, or other regulated activities in defined flood hazard areas
Stormwater Management	Union - 300' buffers in Special Resource Waters as designated by NJDEP Stormwater Management Rules
	Franklin - Creation of Stormwater Management and Grading Plan with disturbance greater than 1 acre or impervious surfaces greater than 0.25
Environmental Performance	Union - Resource Restrictions and Resource Protection Lands including Floodplains, Floodplain Soils, Steep Slopes, Wildlife Habitats (Critical Wildlife Habitat), Natural Resources, etc.
	Franklin - Natural Resource Conservation Calculations regarding Freshwater Wetlands, Floodplains, Forests and Woodlands, Stream Corridor, Soil Classification with Septic Limitations, etc.
Stream Corridor	Union - 150' buffer
	Franklin - 100 year floodplain or 300' buffer for C1 waters

10.2 Riparian Buffer Enhancements

The enhancement, preservation, and protection of riparian buffers are the most important measure for protecting water quality in the Sidney Brook watershed. As mentioned above, riparian buffers serve a great variety of ecological functions and their observed degradation throughout the watershed is the primary cause of most of the water quality impairments and other observed ecological damage. Enhancing and protecting riparian buffers therefore is the most important management measure to be implemented. One of the reasons that riparian buffer enhancement is so important is that the benefits are multi-lateral. For instance, the enhancement of a degraded buffer, one that is characterized by lack of native vegetation including shrubs and trees, soil disturbances, and impervious surfaces among other problems, offers improved canopy coverage and stream shading which reduces stream temperature thereby improving benthic macroinvertebrate and fisheries habitat with resultant improvements in community structure, as well as decreased biological productivity related to periphyton growth thus leading to improvements both in excessive DO and pH. The following list exhibits some of the benefits of riparian buffer enhancement:

- Increased shading and maintenance of lower temperatures
- Decreased algal productivity
- Nutrient removal through vegetative uptake
- Vegetative trapping of solids and other pollutants
- Reduced runoff velocity and increased infiltration and evapotranspiration
- Increased bank stability and decreased erosion and sedimentation
- Functional wildlife habitat and protection of rare species
- Barrier to Canada Goose access and decreased coliform loading
- Reduced flood damage
- Improved carbon cycling and allochthonous material deposition
- Reduced invasive vegetation colonization

As such, it is evident that buffer enhancement will provide a variety of benefits in reducing a number of specific NPS pollutant loads.

10.2.1 No-Mow Zones

The establishment of no-mow zones is probably the most easily implemented BMP that can significantly improve stream function in the Sidney watershed. The mowing of riparian buffers or the establishment of maintained lawn space was reported in a number of surveyed stream segments in the visual assessment and mowing was often continued to the very top of the streambank within feet of the wetted channel (Figure 21). Foremost this has led to severe bank instability often characterized by mass wasting and severe undercutting. Besides the erosion and subsequent sediment deposition of the unstable banks much of the function associated with vegetated buffers, including shading, nutrient uptake, and wildlife habitat, among others, is lost.

Figure 21: Lawn Encroachment to Bank

The ideal solution is to simply establish no-mow zones in at least a 50' buffer extending from the top of both banks where vegetation is allowed to simply grow unimpeded. In some senses this type of buffer is already stipulated in various technical regulations and municipal stream buffer and stream corridor ordinances, but existing lawns and "routine" maintenance is often granted exemption. While the establishment of no-mow zones seems simple there will certainly be some resistance to comply, especially with a 50' buffer that may comprise a large portion of maintained lawns or smaller residential lots. A compromise would be to establish as an absolute minimum a 10' riparian no-mow zone to at least establish the vegetation necessary to maintain bank integrity, decrease erosion, and provide at least some shading and other associated functions. While this should probably be adopted as ordinance and applied to existing maintained lawns, with obvious enhanced protections already in place for new development, education will probably be the strongest tool in promoting this practice and effectively conveying the benefits listed above will be crucial in this conversion.

The establishment of no-mow zones is also hastened by the lack of adjunct requirements. Establishing no-mow zones is free, and in fact is less costly and requires less labor than continual seasonal mowing, requires no permits, is consistent with wetlands and flood hazard regulations, and can be implemented immediately without consulting or engineering. Another benefit is limited maintenance of no-mow zones. Maintenance of these zones consists primarily of the removal of invasives species which can be accomplished through chemical treatment or mechanical removal which is recommended for most residential settings. Overall, this approach should be strongly promoted to protect and enhance water quality.

10.2.2 Riparian Buffer Planting

The next step in riparian buffer enhancement is a more thorough approach focused on the restoration of native vegetation. Crucial to this scheme is the replication of natural riparian vegetation communities which integrate multiple vegetation types including herbaceous plants, shrubs, and trees, and may be structured to match different communities including riparian forests and herbaceous and scrub/shrub wetlands. In addition, these planting plans can be tailored as necessary to provide enhancement of existing but degraded buffers or the complete mitigation of severely degraded or non-existent buffers such as in maintained lawns. The design philosophy of riparian buffer planting is to restore the natural pollutant removal capabilities and stabilizing properties of fully functioning riparian buffers by adapting to site specific conditions such as soil moisture and incorporating those considerations into a three-dimensional plan that prominently features vertical design elements, such as trees, to produce a self-sustaining plant community.

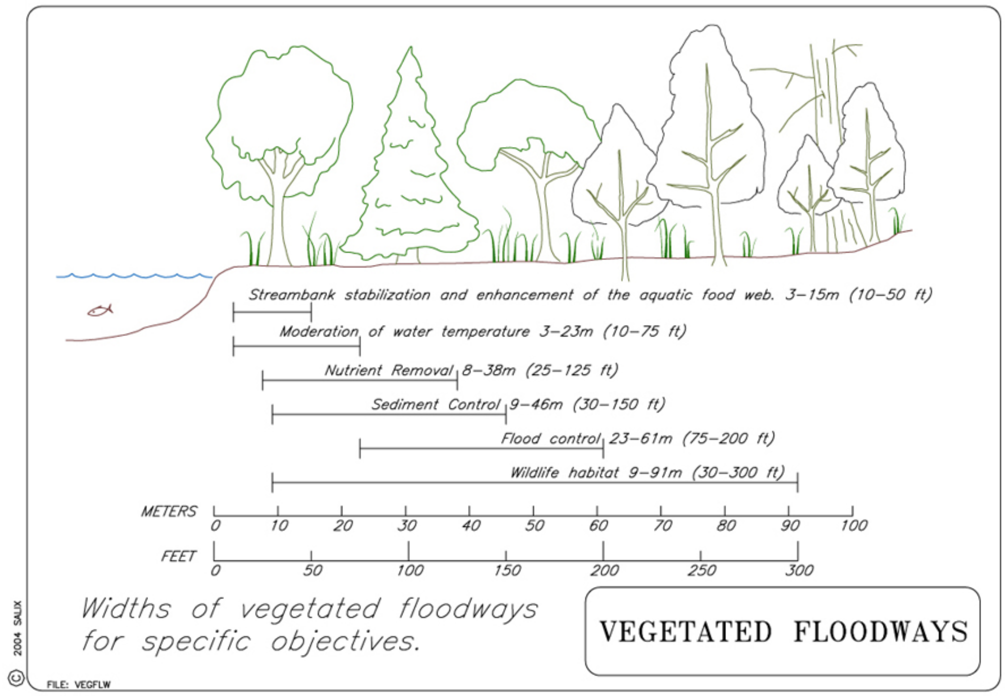
The intensity of this buffer restoration is somewhat higher than simple no-mow zones, but most of the effort and cost is upfront with relatively low maintenance requirements. Degraded riparian buffers can be recognized by maintained lawn space, a lack of herbaceous, shrub, or tree components, exposed soils and erosion, the predominance of invasive plants, impervious surfaces, structures, and other encroachment, as seen below (Figure 22).

The planting and enhancement of riparian buffers should target establishing buffers with a width of at least 50’. Even at limited width forested buffers show amazing capacity to remove pollutants; Figure 23 below shows that many of the stated benefits of riparian buffer enhancement can be achieved in as little as 50’. While 50’ is a reasonable goal it will not always be achievable due to various site restraints including landowner placed restraints. As with the no-mowing zone as little as 10’ of enhanced buffer can be valuable. In such a circumstance many of the benefits associated with planting will be reduced, but will not be eliminated. In particular, focusing on near-bank planting of woody vegetation can serve the roles of bank stabilization and shading almost without diminishment. Even in an area where a full 50’ has been selected as a candidate site for enhancement through planting the focus needs to remain on the near-bank areas to affect the greatest change. Additionally, the scope of the planting does not have to be all encompassing. As mentioned above the loss of any component of the riparian buffer, either herbaceous, shrub, or tree, signals a degradation of the buffer, but the missing component can also serve as the focal point of restoration activities. For example, many buffers, particularly in lawns, obviously lack the shrub layer yet the large trees adapted to floodplains are still in place and the herbaceous layer still exists although in a maintained state. In such a case discontinuing mowing and augmenting the existing community with planted shrubs is probably sufficient to set the conditions to allow the regeneration of the buffer.

Figure 22: Lack of Riparian Buffer

Prior to initiating planting site preparation may be necessary to remove debris and invasive plants. The planting or re-planting of riparian buffer proposed here is designed to restore functionality and work within the confines of a selected site with minimal earthmoving. More intensive streambank stabilization projects requiring extensive engineering, excavation, and grading that incorporate planting will be discussed elsewhere in this document. For the most part buffer planting should be relatively low intensity and require primarily hand tools to dig holes to insert plants. Coir fiber mats may be installed in areas where there is extensive soil disturbance to help herbaceous vegetation become established, but other materials, like coir fiber logs that are typically installed along the toe of the bank, are not consistently effective in riparian settings and may not persist after bank full discharge events. The relatively low key planting and removal of vegetation can, for the most part, be conducted without securing permits although consultants and sponsors collaborating on the design and installation need to be cognizant of potential restrictions.

Figure 23: Forested Buffer Functions Relative to Width



As mentioned above several different plant types are to be utilized in the planting plan. While all plant types should be incorporated together the composition will change when moving away from top of bank such that wetland indicator species or those adapted for periodic inundation will be placed closer to the channel with a gradient shift towards upland species with increasing distance from stream. As such, the idealized planting plan would consist of three zones corresponding roughly to the bank, the floodplain, and the terrace (although different sources adopt widely varying naming schemes) with each zone incorporating the three plant types as seen below (Figure 24).

The herbaceous layer is planted to prevent surface erosion and provide much of the stormwater filtering capacity as well as reducing runoff velocity. There are a wide variety of herbaceous plants, particularly grasses that are used in enhancing riparian buffers. The table shown below (Table 25), taken from the NJ Stormwater BMP Manual, lists a variety of these plants as well as some pertinent information regarding natural history and life cycle as well as a variety of seed mixtures suited for different conditions. Paradoxically, some of the species listed are introduced and should probably be avoided in order to create a more natural species composition. Seeding rates vary considerably between mixes from 3 to 35 pounds per acre, but most mixtures require about 15 pounds per acre; in a 50' buffer this is equal to almost 900 linear feet parallel to the channel. It may also be desirable, especially where aesthetics are an important component of the restoration goal, to add wildflower mixes and other herbaceous plants as well as the grasses and groundcovers. Many of these herbaceous plants may be purchased and planted as plugs.

The shrub and small tree component begins to provide much of the bank stability with increased root zone depth, as well as providing shading and wildlife habitat. Finally, the large trees are responsible for creating canopy cover, transpiring water, and contributing to mass soil stability. Spacing guidelines vary, but the PA Stormwater BMP Manual recommends a mature tree density of approximately 320 trees per acre. Because the goal is the enhancement of natural systems it is important to plant in a fluid fashion with clustering and other natural features maintained to the exclusion of straight lines and other ordered designs.

As with no-mow zones public outreach and education are paramount in encouraging buffer planting projects. While planting plans may require professional guidance, particularly in choosing the correct species or matching the existing vegetation in adjacent undisturbed buffers, replanting buffers is a relatively simple operation. Material needs are largely limited to the actual plants which are available from a number of nurseries in New Jersey and Pennsylvania specializing in native plants and supplying materials for streambank restoration projects. Funding will likely be a limiting factor for much of this work, despite relatively low costs, especially compared to most other BMP's. This is where the municipalities need to develop a cost-sharing program with landowners to provide materials or alternatively offer some other financial incentive. Funding should be available from a variety of sources as long as there is a coherent plan to implement its distribution and completion. It should also be noted that this work may be conducted in a modular fashion so that plants are added to the site or multiple sites over time focusing on the particular site needs and working from the bank outward. Maintenance should be relatively modest for most planting projects after the initial planting and watering period and consist mostly of replacement of failed plants that are detected during spring or summer survey events. There may be several causes for failure including herbivory by deer and mice, compromised nursery stock, or selecting the wrong plant for a site, which is likely a function of soil moisture. Herbivory can be easily controlled by utilizing vinyl tree guards or wraps and repellant sprays while plant selection errors can be corrected with the consultation of an environmental professional.

Figure 24: Riparian Planting Zones

Figure 5. Sample Planting Recommendations According to Moisture Conditions

TREES

- Silver Maple
- Box Elder
- Persimmon →
- Black Ash
- Red Ash
- Pawpaw →
- Sweet-bay Magnolia
- Sycamore →
- Cottonwood
- Swamp White Oak
- Oak,Willow →
- Willow, Sandbar & Black

SMALL TREES/SHRUBS

- River Birch
- Smooth Alder
- Chokeberry, Red
- Chokeberry, Black →
- Groundselbush
- Dogwood, Red Osier & Silky
- Summersweet →
- Winterberry →
- Inkberry →
- Swamp Rose
- Swamp Azalea
- Meadowsweet →
- Highbush Blueberry →
- Witherod →
- N. Arrowwood

TREES

- ← Maple, Red →
- Bitternut Hickory →
- ← Redbud →
- Hackberry →
- American Beech →
- ← Ash, White →
- ← Honey Locust →
- Kentucky Coffee Tree →
- ← Sweet-gum
- Tuliptree →
- Black-gum →
- ← Large-toothed Aspen →
- ← Oak, Pin →

SMALL TREES/SHRUBS

- ← Black/Sweet Birch →
- Mountain Laurel →
- ← Hornbeam →
- Yellow Birch →
- ← Shadbush (A.arborea & canadensis) →
- ← Dogwood, Gray & Flowering →
- Fringe Tree →
- American Hazelnut →
- ← Black Huckleberry
- ← Common Spicebush →
- ← Rosebay Rhododendron
- ← Southern Arrowwood
- ← Ninebark
- ← American Elder →
- Bayberry →
- ← Highbush Cranberry →
- Red Elm

TREES

- White Pine
- Black Cherry
- Sassafras
- Canada Hemlock
- Oak, White
- ← Oak, Red
- Oak, Chestnut
- Hickory, Shagbark
- Maple, Sugar
- Black Walnut

SMALL TREES/ SHRUBS

- Hop-hornbeam
- Witchhazel
- Staghorn Sumac
- Nannyberry
- Blackhaw

Arrows denote that certain species can tolerate either a wetter or drier environment.

Table 25: Herbaceous Plants

Species	Common Name	Remarks
Agrostis gigantea	Redtop	SP,I,CG
Agrostis palustris	Creeping bentgrass	P,I,CG
Calamagrostis candensis	Canada bluejoint	P,N,CG
Cinna arundinacea	Wood reedgrass	P,N,CG
Dicanthelium clandestinum	Deertongue	P,N,WG
Elymus virginicus VA./riparius	Riparian wildrye	P,N,CG
Lolium multiflorum	Annual ryegrass	A,I,CG
Panicum virgatum	Switchgrass	P,N,WG
Poa trivialis	Rough bluegrass	P,I,CG
Poa palustris	Fowl bluegrass	P,N,CG
Puccinellia distans	Alkali saltgrass	P,N,CG
Tripsacum dactyloides	Eastern gamagrass	P,N,WG

Legend:
P = perennial CG = cool-season grass
A = annual WG = warm-season grass
I = introduced CL = cool-season legume
N = native SP = short-lived perennial

10.3 Structural BMP's

Structural BMP's have also been determined to be a potentially important component of NPS load reduction strategies in the Sidney Brook watershed. The utility of widespread implementation of structural BMP's throughout the watershed is limited because of the general lack of the development density or development types that are usually associated with most traditional structural BMP's. Additionally, the lack of public holdings, especially developed lands, will also limit implementation in the watershed. However, the construction or installation of structural BMP's will be useful in targeting specific problem areas in the watershed where lower intensity solutions such as cultural BMP's or riparian buffer enhancement do not offer the level of treatment or mitigation necessary to achieve water quality protection goals. The construction of structural BMP's is of course integral to new development designs and required by a variety of regulatory vehicles from municipal ordinance to State law and technical regulations. The following section represents a review of a variety these structures and their potential use in the watershed. Table 26 below reviews a wide variety of structural BMP's in relation to hydrologic and pollutant treatment capabilities. Discussions of their applicability and efficacy will be reviewed below. It should be noted that site conditions will often be the primary determinant in the success or failure of a given BMP. Additionally, it is possible to link a number of BMP's together to function in concert, thus creating a pollutant removal "train" that achieves a greater cumulative improvement in water quality, management of peak flow, and reduction in total runoff than could be achieved with a single BMP.

Table 26: NPS Management Measures

Best Management Practice Screening Matrix (EPA 2005).

Structural Management Practice	Hydrologic Factor				Pollutant Factor				
	Interception	Infiltration	Evaporation	Reduced Peak Flow	Total Suspended Solids	Nutrients	Fecal Coliform Bacteria	Metals	Temperature
Bioretention	●	ɵ	ɵ	ɵ	●	●	●	●	●
Conventional dry detention	○	○	ɵ	●	○	○	●	ɵ	ɵ
Extended dry detention	○	○	ɵ	●	ɵ	ɵ	●	ɵ	○
Grass swale	ɵ	ɵ	○	○	ɵ	○	○	●	ɵ
Green roof	●	○	●	ɵ	○	○	○	○	●
Infiltration trench	○	●	○	ɵ	●	●	●	●	●
Parking lot underground storage	ɵ	ɵ	○	●	●	●	ɵ	●	●
Permeable pavement	ɵ	ɵ	ɵ	ɵ	ɵ	○	ɵ	○	ɵ
Sand filter	○	○	○	○	●	●	ɵ	●	●
Stormwater wetland	●	○	ɵ	●	●	●	●	●	ɵ
Water quality swale	ɵ	ɵ	ɵ	ɵ	●	●	○	●	●
Wet pond	○	○	●	●	●	●	●	●	○

Table key: ○ Poor, Low or No Influence, ɵ Moderate Influence, ● Good, High Influence [3]

[3] The recommendations in Table 20 were based primarily on the following references: USEPA National Management Measures to Control Nonpoint Source Pollution from Urban Areas, NJDEP Stormwater BMP Manual, NYDEC Stormwater Manual on Structural BMPs, and the Connecticut Stormwater Manual.

10.3.1 Detention Basins and Wet Ponds

Conventional dry detention, extended detention, and wet ponds are relatively similar systems, differentiated mainly by hydraulic retention period and thereby offering different NPS load treatment efficiency. All of these systems are designed to capture runoff from developed areas and attenuate peak discharge volumes up to the design storm limit. Conventional dry detention systems typically discharge all intercepted runoff in less than 24 hours and provide insufficient solids removal typically below minimum State requirements. Extended detention basins have a similar function but detain water for a minimum of 24 hours and may offer solids removal rates of 40 to 60% dependent on design; treatment efficacy increases with hydraulic retention period. Wet ponds offer both stormwater detention and a limited amount of permanent storage and may offer 50 to 90% solids removal capabilities.

These systems, while attenuating peak flows, offer very little volume reduction with no infiltration capacity and limited evaporation. Other components of the design also limit other aspects of NPS control. Conventional and extended detention basins continue to be constructed with concrete low flow channels, as illustrated in this detention basin located in the watershed in Figure 25, which do a poor job of treating first-flush stormwater runoff, which typically contains the highest levels of solids, nutrients, metals, and other pollutants. Extended detention and wet ponds also raise water temperatures contributing to summer stream warming.

Figure 25: Detention Basin

This type of structural BMP still has utility, especially in larger catchments, but is reflective of an older design philosophy less concerned with treatment and volume reduction and primarily focused on peak flow attenuation. For new development it is recommended that these systems be replaced with other structural BMP's such as bioretention systems, stormwater wetlands, and infiltration designs that utilize wetland vegetation and other components to increase evapotranspiration, improve filtering and solids removal capacity, and reduce volumes. These newer systems also offer increased aesthetic and habitat value as well as less maintenance demand related to mowing after initial planting. For existing detention basins and wet ponds several retrofits options should be considered. The first option is to retrofit outlets and control structures to add detention time, particularly during the first-flush, thus effectively converting conventional detention basins to extended detention basins or further to wet ponds; this type of retrofit will be discussed further in this section. The second option is to convert existing systems to infiltration systems where soils allow or stormwater wetlands and bioretention features otherwise; the benefits and design standards of these systems including conversions will be discussed in the following section.

Figure 26: Outlet Modification

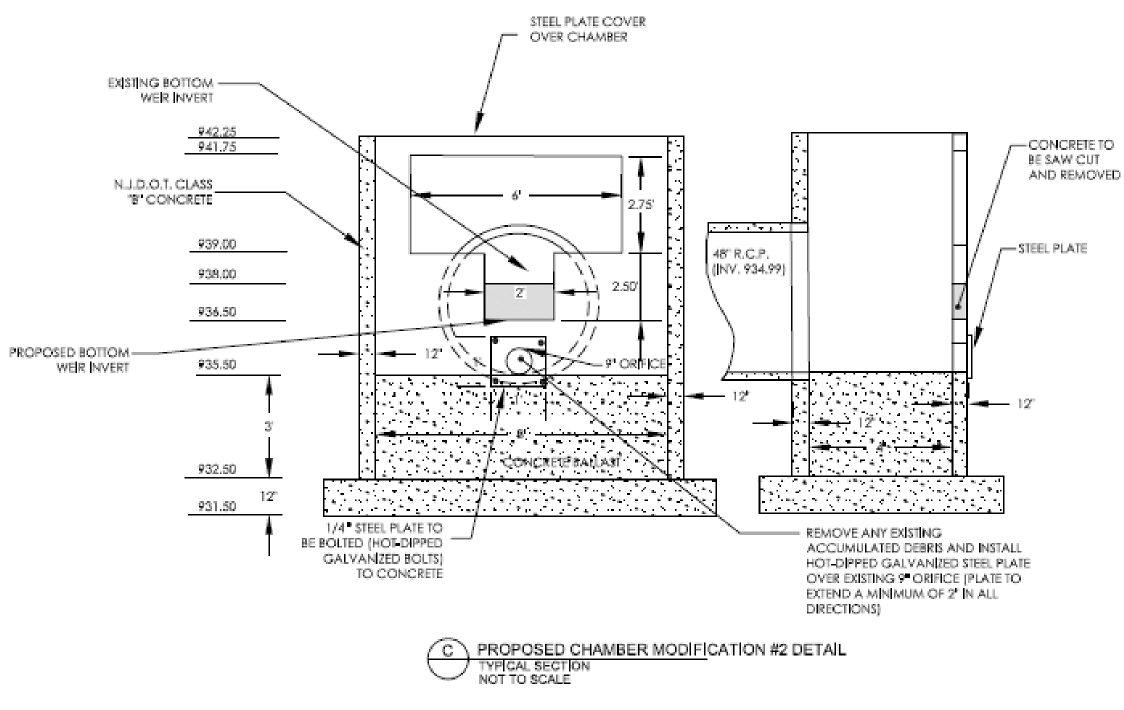


Figure 26 shown above is a conceptual detail for retrofitting a detention basin outlet structure. This type of retrofit proposes two simple modifications entailing the blockage of the low flow orifice and raising the weir invert. This accomplishes two important functions: first, by blocking the low flow outlet the first-flush and runoff from low intensity storm events is allowed to be treated by increasing detention period and retaining directed runoff instead of simply discharging through the structure; second, the raising of the weir invert increases detention during moderate and large storm events allowing increased capture of stormwater pollutants. This is all accomplished without serious engineering or installation effort and furthermore does not impact the ability of the basin to handle design storm volumes or increase the risk of overtopping.

10.3.2 Bioretention Systems

There are a variety of bioretention systems designs that go by numerous names including bioretention basin, constructed wetland, stormwater wetland, shallow marsh, and newer systems such as rain gardens and green roofs. In all cases these systems rely heavily on plant material, specifically wetlands plants and plants adapted to alternating inundation and dry cycles. Specific benefits of utilizing plants, especially native species, in stormwater management designs include:

- Runoff volume reduction related to increased plant evapotranspiration
- Potential increases in infiltration due to increased permeability related to root growth
- Bioassimilation of nutrients and other pollutants in plant tissue
- Decreased erosion within the BMP due to adequate groundcover
- Increased trapping of solids and bacteria related to mechanical filtering of the vegetation
- Decreased warming due to additional shading

Secondary benefits include:

- Decreased maintenance related to mowing
- Improved aesthetic value, especially with the use of wildflowers
- Enhanced wildlife habitat
- High vegetation should limit site utilization by geese

The effort to construct new bioretention BMP's can vary relative to traditional designs. Larger complex projects that would replace traditional retention or detention basins would be expected to have some increased cost due to the purchase of plant materials although overall permitting, engineering, and construction may be virtually the same. Smaller projects, such as the installation of rain gardens or various retrofits, may be exempt from much of the permitting and thus experience large cost savings. It is clear that the NPS management benefits are significantly increased as many bioretention systems are capable of removing 80 to 90% of solids. The increased pollutant capture capability may reduce the overall complexity and cost of these systems as pre-treatment or linking BMP's may not be necessary to meet stormwater management rules. The retrofitting of existing systems to be upgraded to bioretention systems may be considerably easier and consist of little more than selecting appropriate vegetation and planting. This is ably demonstrated when comparing the following figures (27 and 28).

Figure 27: Extended Detention Basin

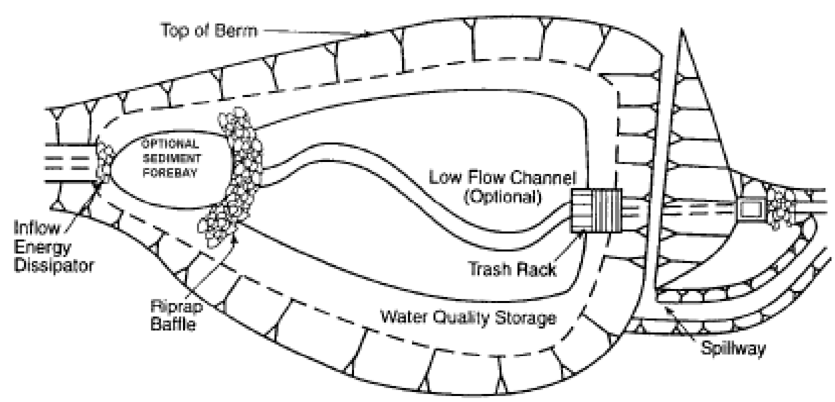
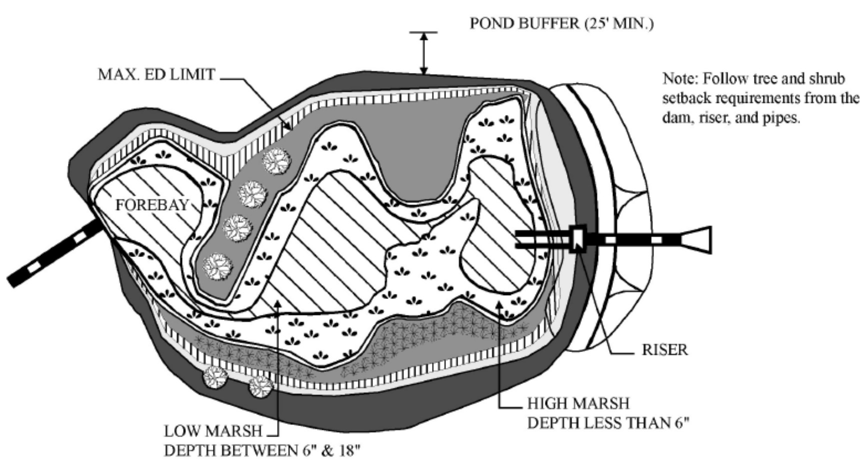


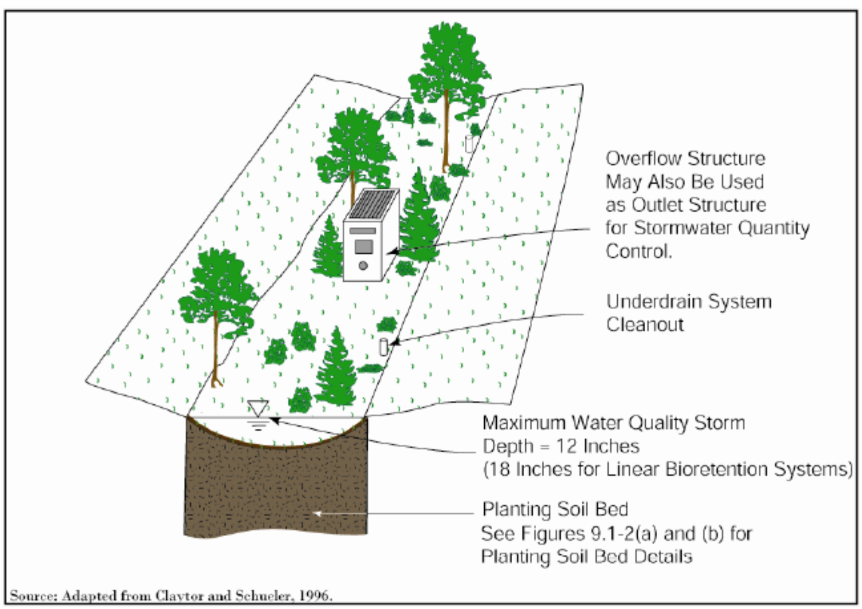
Figure 28: Constructed Stormwater Wetland



For the most part these systems share many of the same components including engineered berms, control structures, sediment forebays, general basin morphometry, and storage capacity. The primary difference lies in the utilization of plant materials, and secondarily in extending the linear flow path or increasing sinuosity. The extended detention basin has no specific vegetative component other than a non-native groundcover requiring mowing, while the stormwater wetland has high and low marsh communities composed of wetland plants as well as trees. The small difference, as mentioned above, provides a great array of benefits to a standard design. The image provided below is an example of a retrofitted detention basin, which is nearly indistinguishable from a natural wetland (Figure 29).

Figure 29: Constructed Stormwater Wetland

Figure 30: Constructed Stormwater Wetland Schematic



Typical bioretention systems may be relatively complex systems requiring extensive engineering design and construction as shown above (Figure 30). The efficacy of many systems depends strongly on the design of the planting bed. The planting bed material is a specific composition of soils components, largely sands, and amended as necessary with organic material. This overlays additional permeable layers consisting of sand, gravel underdrains, and in some designs may include geotextiles and other drainage features. These types of designs and retrofits should be strongly considered for any new development and encouraged from the initial design.

On smaller scale settings additional bioretention systems should be considered. In most residential settings or commercial properties with a "campus" layout rain gardens should be considered. Their function is almost identical to larger systems and differs chiefly in scale. Water directed towards rain gardens may be derived from roof runoff or small parking lots. A schematic design is shown in the figure below (Figure 31) taken from the Portland BMP manual, as well as an image from a rain garden installed at the DRBC campus in Trenton, New Jersey (Figure 32).

Figure 31: Rain Garden Schematic

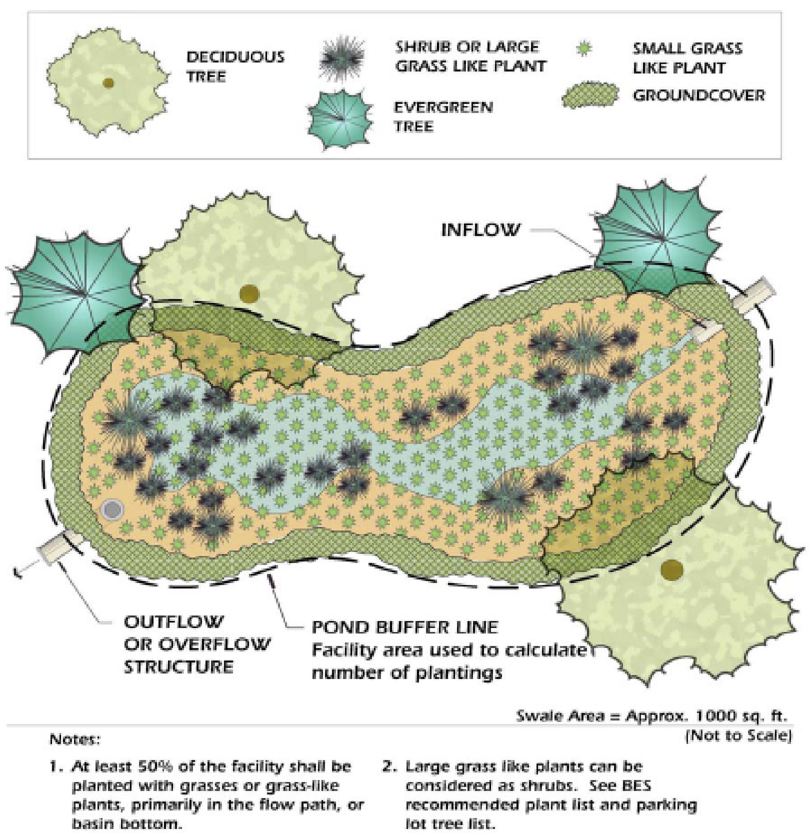


Figure 32: DRBC Rain Garden

10.3.3 Infiltration Systems

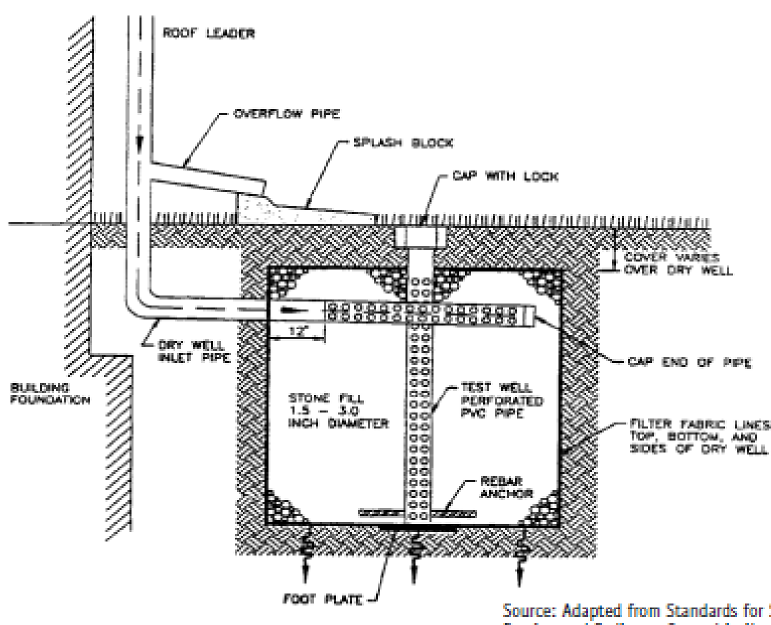
Infiltration BMP's should also be considered for use in the Sidney watershed. Infiltration BMP's, including infiltration basins, infiltration trenches, permeable pavement, dry wells, and sand filter, offer a variety of benefits:

- High treatment efficacy for the removal of solids and other NPS pollutants
- Reduction of stormwater volume quantity and discharge rate
- Groundwater recharge
- Reduced stream warming

The reduction of stormwater quantity is especially attractive in the Sidney because stormwater loading is a major problem contributing to excessive erosion, sedimentation, and bank instability throughout the watershed. Additionally, the C1 status of the stream limits the discharge of stormwater to the stream and the ability to infiltrate through the soil limits, the need for direct surficial discharge. However, the utility and practicality of implementing larger infiltration BMP's may be limited in the watershed. Siting limitations are a major concern as infiltration basins cannot receive water with potentially hazardous components such petroleum hydrocarbons, metals, pesticides, or where the potential for the release or spill of any toxic materials may occur, which largely rules them out for use in industrial or commercial settings. Similarly, care must be taken near potable water supplies or where a potential exists for the flooding of basements or other structures. Caution must also be exercised in karst or carbonate formations which can be easily polluted. Design standards state that infiltration systems must be constructed at least two feet above seasonal high water tables or above bedrock to ensure proper drainage. Identifying these types of sites may be difficult in the watershed because of the prevalence of relatively shallow soils or wetlands. For this reason adoption of infiltration technologies will be strictly limited by site conditions which need to be fully evaluated during early planning stages. However, lower intensity infiltration technologies, such as dry wells and permeable pavement that treat discrete areas, may find wider applicability and should be encouraged in residential settings and for new development.

Dry wells are bound by the same site restrictions as other infiltration BMP's but generally treat clean water from roofs where the major concern is controlling volume. The NJ Stormwater BMP manual recommends complete infiltration of the design storm in a 72 hour period and a maximum catchment of 1 acre. Dry wells are an environmentally friendly BMP that should be encouraged for residential uses in the watershed, particularly in some of the denser housing developments that may provide stormwater treatment, but no reduction of volume (Figure 33).

Figure 33: Dry Well Detail

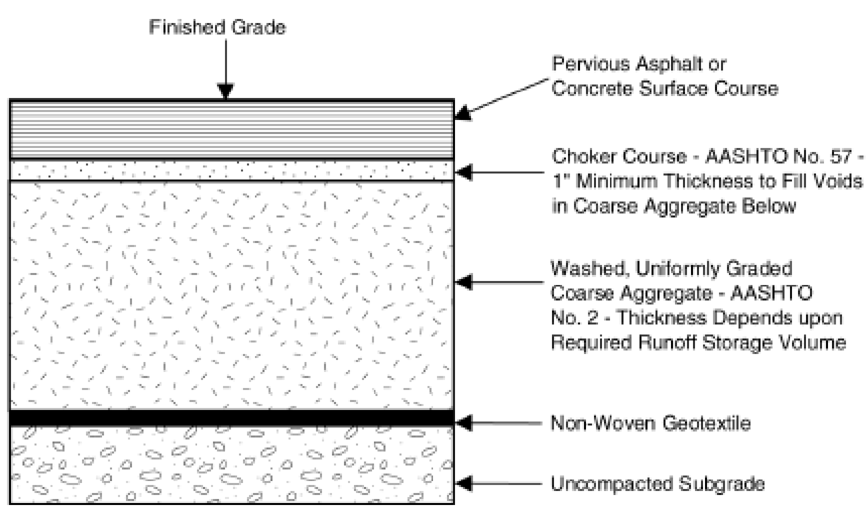


Source: Adapted from Standards for Soil Erosion and Sediment Control in New Jersey

Permeable pavement or pervious paving systems are BMP's primarily designed to reduce the quantity of runoff generated from traditionally paved areas such as roadways and parking lots, but may also be applied on a smaller scale to areas such as patios or walkways. The primary mechanism of these systems relies on infiltrating captured water, but systems with storage beds also have the capability to capture solids with an adopted

TSS removal rate of 80%. There are generally three types of systems: porous pavement, permeable pavers with storage beds, and permeable pavers without storage beds. Porous pavement describes porous asphalt and pervious concrete over a storage bed. Permeable pavers describes different individual, usually pervious pavers that can be concrete, brick, cobble, crushed aggregate, natural stone, or unit pavers that infiltrate through the void spaces or at the joints of the pavers. These systems may or may not have subsurface storage, but those without have a reduced capability to infiltrate larger storm events and may still generate runoff though at a reduced rate. Pavers can also be turf block designs that incorporate load bearing surfaces and permeable soil plant with grasses to provide additional infiltration, solids removal, and evapotranspiration. The images below show details for permeable pavement and installed turf blocks (Figures 34 and 35).

Figure 34: Permeable Pavement Detail



Maintenance requirements vary between the systems, but can be relatively intense. Permeable pavement in particular requires routine maintenance with seasonal sweeping and high pressure washing to remove captured solids and maintain open pore spaces. In paver systems the burden is reduced but those with integrated vegetation require care of the plant materials. Snowplowing, which is a concern in New Jersey, must be conducted with care in paver systems to avoid displacement of the pavers. As with other infiltration devices site soil conditions can be a primary determinant of their applicability and they cannot be located where there is a chance of hazardous materials release that could contaminate the groundwater.

Figure 35: Turf Blocks

Traditional infiltration basins may also be considered for the Sidney. Besides the capacity to treat stormwater runoff and pollutant loads infiltration basins are valuable for their ability to limit stream warming by directly discharging to shallow groundwater through soil media and preventing the discharge of warm, impounded stormwater to the tributary network. For the most part, the design of large infiltration basins are similar to dry detention basins with the exception of the basin bottom which is a permeable sand layer that allows the infiltration of stormwater directed to the basin.

The sand filter incorporates some of the design elements of the other infiltration systems and relies primarily on the percolation of directed stormwater through a large sand bed to filter out a variety of pollutants including solids, nutrients, coliform bacteria, but ultimately differ by the subsequent discharge of at least a portion of the filtered runoff inflow through an underdrain. These systems are designed to receive runoff from highly impervious areas with a high degree pollutant loading. Because the sand bed must maintain high percolation rates to properly function these systems are typically built with forebays to effectively capture much of the large debris and solids prior to discharging to the sand bed. As a consequence maintenance demands can be relatively high based on the frequent clearing of the forebay. This system probably has limited utility in the watershed.

10.3.4 Water Quality Swales

Water quality swales come in a variety of designs and configurations and may be called by a variety of names including grass swale, vegetated swale, vegetated filter, dry swale, wet swale and water quality swale. These designs, like the bioretention BMP's, utilize vegetation adapted for frequent inundation to provide a variety of pollutant removal services as well as to reduce runoff velocities. One of the primary differences is that these systems are designed for the conveyance of water and detention period and storage volume is generally limited.

The simplest design is the grassed swale, which is simply a grass lined swale constructed in maintained lawn space. Because the grass is typically mowed in this design, the amount of treatment in this system is quite limited and is generally valuable only for pre-treatment to other BMP's and in limiting erosion. A vegetated swale, sometimes referred to as a dry swale, has a similar channel morphometry, generally trapezoidal with modest slopes, but is planted with a variety of native plants including trees to provide mechanical filtration and maintain channel stability. These systems may also incorporate very small check dams within the channel to reduce velocities and provide short term detention. Figure 36 illustrates a conceptual design of a vegetated swale and a location within the watershed where such a design may be implemented (Figure 37). Wet swales are similar to dry swales but also incorporate small permanent pools and function more closely to a series of linked wetland cells.

Figure 36: Vegetated Swale Detail

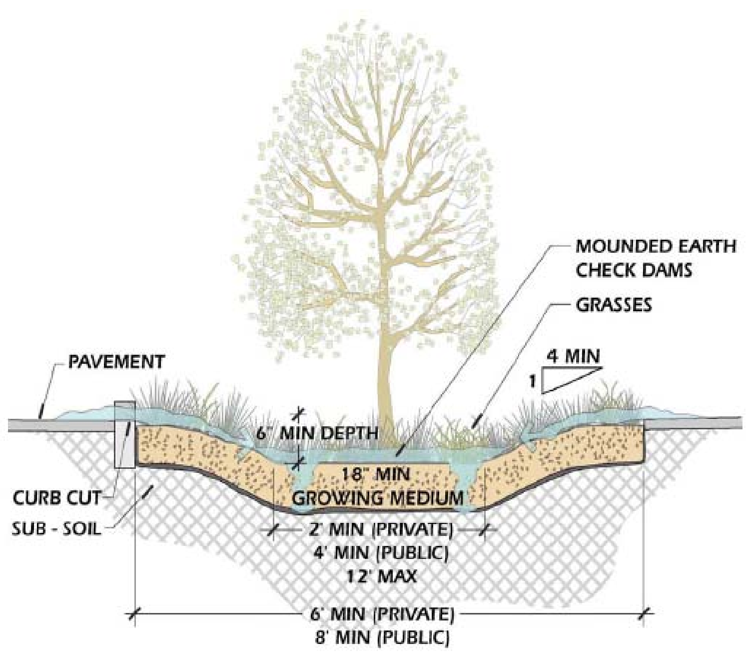


Figure 37: Vegetated Swale Candidate Site

Vegetative filters are related to swale features but are designed to treat sheet flow and not concentrated flow in a channel. As such they are oriented perpendicular to the flow path and parallel to elevation contours on a slope, and are generally sited on grades of less than 5%. In some senses vegetative filters mimic the function of riparian buffers and native forests. The figure below (Figure 38) illustrates the schematic of a vegetative filter while Figure 39 shows a candidate site.

Incorporating these design elements is important for minimizing erosional processes in new developments. Additionally, they can be used to treat drainage issues on developed lands or in agricultural settings, particularly pastures and other areas that are infrequently tilled or otherwise disturbed.

Figure 38: Vegetative Filter Schematic

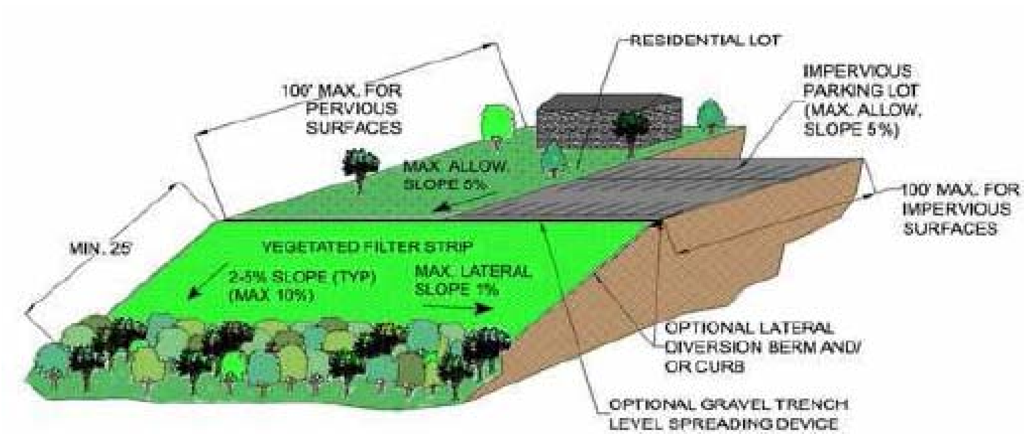


Figure 39: Vegetative Filter Candidate Site

10.3.5 Manufactured Treatment Devices

Manufactured treatment devices (MTDs) are pre-fabricated structural BMP's designed to mitigate stormwater pollutant loading with most offering solids and nutrient capture; some are also effective for the removal of metals, bacteria, debris, and hydrocarbons. These devices are generally used to treat small catchments that are usually highly impervious and may contribute disproportionately to pollutant loading or are installed where there is limited space to site traditional BMP's and where other site limitations, such as soil permeability, may exist. MTDs utilize a variety of methods to achieve pollutant removal including:

- Filtration Chambers
- Filtration or Adsorptive Media
- Vortex Flows
- Vegetative Components
- Settling Chambers

In New Jersey these types of systems are certified by the New Jersey Corporation for Advanced Technology (NJCAT) for solids removal rates, although other pollutants may also be certified concurrently. Currently, only two devices have final certification, while all others have an interim certification subject to continued performance reviews (Table 27). Adopted removal rates are certified at either 50% or 80%, although many offer higher performance than indicated. These certifications may be important in meeting stormwater management quality rules.

MTDs may have limited use in the Sidney watershed due mostly to the lack of road and other stormwater management infrastructure. However, MTDs may be useful along some of the roadways where catch basins and other storm sewer components discharge to the tributary network, and thus would be used mostly in a retrofit capacity to add improved treatment capability to existing systems. Maintenance is vital to these systems, particularly those that utilize filter media or where excessive road grit and other solids may be captured. The maintenance of these types of systems would certainly be classified as cultural BMP, as discussed above, and could consist of, dependent on design, replacing cartridges or vacuuming.

It should also be noted that there are a number of additional, highly effective MTDs that do not have NJCAT certification that should not be discounted for use in the Sidney Brook watershed. Some of these structures, for example the Suntree Technologies Baffle Box and Modular Wetlands are very effective and can be used in both a retrofit and stand-alone capacity. The importance of using NJCAT certified technologies has more to do with NJDEP permit compliance or qualification for NJDEP funding as opposed to treatment efficiency. As such, NJCAT certification alone should not be used to evaluate the applicability of an MTD.

Table 27: NJCAT MTDs

Stormwater MTD	Manufacturer	NJDEP Adopted TSS Removal Rate (%)
AquaFilter Filtration Chamber	AquaShield, Inc.	80
Aqua-Swirl Concentrator	Aqua-Shield. Inc.	50
Bayfilter	BaySaver Technologies, Inc.	80
BaySeparator	BaySaver Technologies, Inc.	50
Downstream Defender	Hydro International, Inc.	50
FloGard Dual-Vortex Hydrodynamic Separator	CONTECH Stormwater Solutions, Inc.	50
High Efficiency Continuous Deflective Separator (CDS) Unit	CONTECH Stormwater Solutions, Inc.	50
Jellyfish Filter	Imbrium Systems Corporation	80
Media Filtration Systems	CONTECH Stormwater Solutions, Inc.	80
Stormceptor OSR	Imbrium Systems Corporation	50
Stormceptor STC	Imbrium Systems Corporation	50
StormVault*	CONTECH Stormwater Solutions, Inc.	80
Stormwater Management StormFilter*	CONTECH Stormwater Solutions, Inc.	80
TerreKleen Stormwater Device	Terre Hill Concrete Products	50
V2B1	Environment 21, LLC	50
High Efficiency Continuous Deflective Separator (CDS) Unit	CONTECH Stormwater Solutions, Inc	50
VortFilter System	CONTECH Stormwater Solutions, Inc.	80
VortSentry System	CONTECH Stormwater Solutions, Inc.	50

* - Final Certification

10.4 Cultural BMP’s

Cultural BMP’s include those actions taken to reduce point and nonpoint source pollutant loading that do not rely primarily on the installation of complex structural or engineered solutions. In the context of this WPP, cultural BMP’s include those practices primarily adopted by homeowners, but also commercial, municipal, and other similar parties to limit pollutant loading from a site. In general, these types of activities are often simple, easy to implement and low cost. With widespread adoption within the community these techniques can be very effective and yield large improvements in water quality at low cost. Cultural BMP’s were also ranked as the third priority for NPS management measures and incorporate other management measures called out in greater detail such as BMP maintenance and Septic Management which will be discussed in further detail in their respective sections.

Cultural BMP's are identified as important management measures for the management of stormwater and TP loading and are also important auxiliary measures for *E. coli*, solids (both particulate and dissolved), and invasive species. The institution of cultural BMP's in this watershed is important because they reflect small changes in behavior that are relatively easy to implement and for the most part require awareness of the benefit of adopting these practices. The following section describes a variety of cultural BMP's that should be adopted in the Sidney Brook watershed.

10.4.1 Fertilizer Use

Fertilizer use within residential areas is common given the propensity to develop manicured lawns and flowerbeds; the same is true of other landscape uses including parks, athletic fields, cemeteries, and other spaces with maintained lawn space. In addition to being unnecessary in many cases due to sufficient soil nutrient concentrations, the application of fertilizer is often conducted during those periods when rainfall is the heaviest (April through June and September through October). The phosphate and nitrogen salts present in commercial fertilizers are easily transported in runoff during storm events and are easily assimilated by aquatic macrophytes and algae contributing to stream eutrophication and potential nuisance growth.

This reinforces the need for the implementation of integrated pest management (IPM) techniques in upland areas within 300' of the tributary network. IPM is the commonsense approach to the use of fertilizers and pesticides that incorporates technical considerations, and can be easily used at the individual home level to limit the transport of fertilizers and pesticides within the watershed. Unfortunately, a considerable amount of over-application of pesticides and fertilizers occurs during the routine care of residential lawns and other lawn areas. Homeowners often operate under the assumption that if "a little is good, more is better". This leads to the over-application of products and an increased potential for the offsite transport of pesticides and fertilizers. A key element of community IPM entails the limited use of fertilizers and the use of specific types of fertilizers. Specifically, it is highly recommended, given the potential for increasing eutrophication, that the community only use non-phosphorus and slow-release nitrogen lawn fertilizers.

Residents should also be educated about conducting soil pH and nutrient testing before applying fertilizers to their lawn. Fertilizer uptake and retention is promoted by proper soil pH. Although soil pH can have a significant bearing on the ability of soils to retain nutrients, such testing is not commonly conducted by homeowners. A detailed survey of homeowners in Virginia commissioned as part of the Chesapeake Bay initiatives, found that less than 20% actually tested their soils to determine whether fertilization was actually necessary (Watershed Protection, 1994). Thus, the simple application of lime can improve phosphorus uptake and retention and decrease the need for repeated applications. Fertilizer applications must also be properly timed in anticipation of rainfall events. Rain induced fertilizer losses are greatest immediately following an application because the material has neither become adsorbed by the soil nor taken up by the plants.

Fertilizer applications must also account for seasonal lawn needs. For example, nutrients are most needed by lawns in the spring and fall, not throughout the summer. Therefore much, if not all of the fertilizers applied to a lawn in the summer go unassimilated.

Residents should also be informed about the benefits of aeration and thatch control, both of which promote a healthy lawn without the need for fertilizers. However, de-thatching and aeration are rarely conducted as part of routine lawn maintenance (Watershed Protection, 1994). Soil aeration is especially important as lawns can become compacted over time and function almost no differently in respect to the generation of runoff than impervious surfaces (Schueler, 1995). Aerating lawns helps promote better infiltration and reduces the generation of runoff and the off-site transport of nutrients and pesticides. An additional means by which to decrease fertilizer and pesticide use and the subsequent transport of these pollutants is through the use of alternative lawn cover. Where appropriate, the use of native plants or plants that have lower irrigation needs than typical suburban lawns needs to be promoted. As part of the ongoing strategy to reduce the influx of lawn related pollutants into Chesapeake Bay, the National Park Service has started to use native ground covers to reduce the need for fertilization and irrigation (NPS News-Notes, 1996).

10.4.2 Yard and Pet Waste

Another localized source of nutrients that is relatively easily controlled is that of pet wastes. In addition to providing an excessive source of phosphorus these wastes are unsightly and may cause health concerns due to high fecal coliform bacteria concentrations in runoff coming into contact with waste sources. Reduction of nutrient and pathogen loading may be obtained through the implementation of municipal ordinances and education requiring the retrieval of pet wastes and proper disposal with the residential garbage service. Yard wastes, including grass clippings and leaves, should also be properly managed. Indiscriminate dumping into waterways leads to excessive solids and nutrients loading. Yard waste can be composted onsite to provide eco-friendly mulches, disposed at municipal organic recycling centers, or disposed in trash collection systems subject to provider policy. The beneficial reuse of yard wastes can also reduce the need for chemical fertilizers.

10.4.3 Waterfowl Control

Wastes associated with nuisance waterfowl, primarily Canada Goose, can be a significant nutrient source. Studies have shown a single goose may contribute approximately 0.5 lbs of phosphorus per year to waterbodies. In addition to being a source of nutrient pollution geese are also a potentially significant source of bacterial loading in the Sidney which is amplified by direct defecation into waterways or the adjacent reaches, particularly the many impoundments in the tributary network. While a comprehensive assessment of goose populations throughout the watershed was not conducted, reports from the visual assessment indicate that geese and ducks may congregate in nuisance densities at the impoundments. Many of these waterfowl may be so-called residents that have a weak migratory instinct and will stay in place as long as there is ice-free water and available food.

In order to prevent excessive goose populations several approaches may be implemented. One of the most effective approaches, especially in stream settings where aerial access to stream corridors is negated by canopy, is to establish shoreline buffers that inhibit access. These buffers may be as simple as establishing a no-mow zone at the top of bank which also has the added benefits of nutrient removal and bank stabilization. There are also several commercially available deterrent products including Flight Control™ that are non-toxic and effective in applications such as golf courses. Intentional or directed feeding should be strictly inhibited. Finally, there are other techniques including harassment by dogs, which can be effective in a short term capacity or for longer periods if a high frequency is employed. Other control methods such as the use of predator silhouettes including dogs and coyotes seem to have very limited utility.

10.4.4 Road Salt Application

The most commonly used and effective means of maintaining winter road safety involves the application of road salts, particularly sodium chloride (NaCl). This deicing agent is readily available and inexpensive. However, road salt is released into the environment as it runs off impervious surfaces into adjacent soils and nearby waterbodies or percolates into the groundwater. There is no natural removal mechanism for NaCl accumulations in fresh surface waters other than flushing. Additionally, numerous studies have documented that over time residual road salt accumulates in the soils of drainage ditches or in the discharge swales of stormwater catch basins. These salts in turn may leach out into the groundwater over time or during periods of heavy rains. Salt is also released into the environment from other sources the most notable being salt storage piles, salt loading areas, car and truck washing areas, and sites where large amounts of snow is stock piled over the winter. Studies completed by various groups including New York State Department of Transportation, USEPA, Environment Canada, and Minnesota have shown that chloride containing compounds negatively impact soils, vegetation, aquatic biota, water quality (both surface and groundwater), and drinking water supplies in addition to causing corrosion to vehicles, bridges, and other infrastructure.

Though NaCl is inexpensive and efficient in melting and preventing ice and snow accumulation on roads, its impacts to the environment and infrastructure (through corrosion) can be significant. There are alternatives to traditional road salt, however the alternatives tend to be more expensive and would cause municipalities to cover additional costs to address modified storage, handling, equipment, and spreading operations. Some alternatives appear to be viable options; however a greater understanding of the extent of the environmental and infrastructure impacts of NaCl alternatives still needs to be investigated.

The primary determinant of environmental impact related to road deicing in streams is elevated conductance values. While measured conductance was generally within acceptable limits an elevation of winter concentrations of TDS and SpC levels was documented. As population levels continue to rise coupled with increased traffic it is likely that there will be increased demand to apply deicing agents in the future and this issue needs to be addressed to minimize potential impacts to natural resource. Watershed municipalities should adhere to the SBRs or de-icing material storage and develop a plan that incorporates the following elements:

1. Right Material- will depend on the conditions being treated; when pavement temperature is very cold, materials with low working temperature or mixtures of materials may be more appropriate.
2. Right Amount- of materials also depends on conditions, such as the amount of residual chemical on the pavement surface, the expected pavement temperature, and the amount of precipitation expected.
3. Right Place- placement of materials is important increasing efficiency and minimizing waste. This requires the right equipment and trained operators.
4. Right Time- timing is important to minimize waste and maximize effectiveness. If pavement temperature is above freezing salt may be ineffective.

The incorporation of salt brines within the deicing protocols is recommended in various sources, and has been recommended in workshops sponsored by the NJWSA and implemented by local communities, such as Princeton Township. Studies indicate that less salt is used in the brine format than if municipalities rely on solid forms of salt. Several other items should be noted in deicing application, some examples include: (1) the use of proper equipment like a pavement temperature sensor; (2) an instrument that controls the rate of salt application; (3) storm and weather tracking to provide guidance and assist in making snow and ice control decisions by officials and operators; and (4) taking special precautions near systems such as wetlands and streams, which are sensitive to salt.

10.4.5 Water Conservation

Water conservation practices offer several benefits including the protection of groundwater resources, decreased operational stress on septic systems and other wastewater treatment systems, and decreased potential to generate runoff. Many strategies exist to conserve water. In residential settings the following practices are generally advocated:

- High efficiency plumbing fixtures
- Low flush toilets
- Plumbing maintenance
- Maximizing load size for washing machines, dish washers, and similar appliances
- Utilizing native or drought resistant landscaping
- Altering irrigation practices

- Irrigating with captured water from rain barrels

Changing irrigation practices can yield substantial benefits to reducing water consumption, especially in a rural watershed. Several common sense practices can lead to considerably less consumption:

- Avoid irrigating impervious surfaces
- Limit irrigation to early or late in the day to minimize evaporation
- Assess soil moisture before irrigating, factoring in recent and forthcoming precipitation events
- Utilize drip irrigation systems where applicable
- Utilize low pressure sprinkler systems

These recommendations can be extended beyond residential settings and are useful for institutional holdings such as schools, parks, and municipal buildings, and in agricultural settings as well.

10.4.6 Septic Management

The wastewater management needs within the Sidney watershed are almost exclusively met by means of on-lot wastewater treatment systems (septic systems). Data shows that even recently constructed, code-consistent septic systems located within 300' of a lake or stream generate both nitrogen and phosphorus that can potentially enter the waterbody via shallow groundwater flow paths. This includes all septic systems regardless of age or design that are functioning satisfactorily and show no evidence of failure. As such, all septic systems represent a source of nutrient loading to the stream. Septic system effluent has also been identified as a potentially important vector for dissolved phosphorus and *E. coli* loading in the watershed and garners extra attention. The following provides recommendations concerning how existing and future septic related nutrient loads to Sidney Brook can be best minimized and managed by implementing cultural BMP's.

The proper management and maintenance of septic systems is the most feasible and achievable means of minimizing septic-related nutrient loading of existing septic systems and protecting the watershed against future septic failures. Successful septic management involves the integration of public education, product modification, septic system inspection and maintenance, and water conservation practices. Managing the performance of septic systems to decrease nitrogen, phosphorus, and bacterial loading is consistent with the overall source control objectives needed for long-term resource protection. Regardless of their distance from the tributary network, residents should be educated about the use of various products and practices that they can implemented on an individual scale to reduce nutrient loading and improve septic system performance.

Product modification entails the use of non-phosphorus or low phosphorus wash products that minimize septic-related phosphorus loading to the environment. Today, most wash products contain little if any phosphorus, so the selection of environmentally-friendly dishwashing liquid, dishwasher soap, laundry detergent, and hand and body soaps is easy. Product modification also applies to the education of homeowners regarding the disposal of paint, solvents, fats and oils, or leftover household chemicals and cleaning products in septic systems. Improperly disposed household chemicals and degreasing agents can cause serious upsets to the biological treatment processes that occur in the septic tank itself and in the soils of the disposal field. Equally important, these products can result in serious groundwater pollution and the contamination of drinking water wells. There are no specific regulations in place pertaining to the discharge of such materials. As such, this needs to be accomplished through public education. Fortunately there are numerous fliers and brochures readily available through the USEPA and other sources including a number of fact sheets available through the National Environmental Services Center (NESC) Small Flows Clearinghouse[4], which specializes in the dissemination of information on the correct maintenance and operation of septic systems. Therefore it is recommended that all residents of the watershed be provided with educational materials dealing with the problems caused by improper discharge of household wastes into their septic systems.

Similarly the community needs to be educated concerning the lack of any benefit associated with enzymes, bacterial inoculants, or other products advertised as septic tank supplements. As demonstrated by the USEPA these products do very little to enhance septic system operation. They also give a false sense of maintenance to the property owner and may actually dissuade them from regularly pumping or inspecting their system. Again, the NESC Small Flows Clearinghouse is a very good source of information on this matter.

Also, residents should be cautioned about the use of garbage disposal units. Excessive or improper use of these devices can increase organic loading and further stress the operation of a septic system by adding to both the sludge and grease layers. Furthermore, once ground up, the disposed solids may exist as fine particulate material that resist settling. This can decrease the operational efficiency of a septic system and accelerate the clogging of the leach field.

Inspections and routine maintenance are usually the two controversial elements of most septic management programs. There is an innate resistance by homeowners to allow periodic inspections or to comply with mandatory pump out schedules. The prevailing thought among most homeowners is, “if it flushes, it’s OK”. However, as demonstrated in studies conducted as part of nationwide septic management studies, routine inspections help decrease the occurrence of large scale failures by identifying and correcting septic tank and leach field problems before they become serious or magnified. Similarly, routine pump outs decrease the build-up of sludge and grease in the septic tank itself, both of which can be transported into the leach field and create clogging problems. In general, routine inspection and pump out should be viewed as an insurance policy for the long-term proper operation of a septic system and not an imposition on the property rights of a homeowner.

4 http://www.nesc.wvu.edu/wastewater.cfm

In extreme cases the complete replacement of a septic system may be necessary to ensure proper function as decided by specific criteria and determined by qualified municipal, county, or state authorities. Septic system failures are the type of environmental problem that typically go unreported and are only discovered upon normal inspection. The primary issue with many older conventional systems is that they were improperly sited, often in hydric soils in lots adjacent to streams or in wetlands, and simply cannot function properly to infiltrate septic effluent. Primary signs of these malfunctions include the pooling of water at the surface or the lush growth of vegetation. Improper siting in turn represents a failure in older regulations, or even a complete lack of regulations, to properly address septic system function and identify risks associated with nutrients and fecal bacteria to both human health and stream water quality.

Water conservation is another tool that can be used along with routine pump out and inspection to help protect and increase the operational longevity of septic systems. These measures are intended to reduce hydrologic loading to the leach field. Included in this category are the use of low flush toilets, flow reduction fixtures, and other similar devices designed to reduce water usage. It can also encompass lifestyle habits such as spreading out laundry wash loads over a number of days, shorter showers, and other similar cooperative techniques.

10.4.7 BMP Maintenance

Maintenance of existing stormwater infrastructure is another extremely important cultural BMP and one that is frequently overlooked. Almost all structural BMP’s including the various basin types and storm sewer systems require periodic maintenance that is crucial to ensure the continued proper functioning of these systems. Routine maintenance activities are generally not costly, but may be somewhat labor intensive which leads to a lapse in the upkeep of these systems despite regulatory and ordinance requirements as identified in the MS4s and Municipal Stormwater Management Plans.

Maintenance of structural BMP’s usually consists of the following seven basic activities:

Visual Inspection – can be the most efficient method of determining whether a structure or system is functioning as designed and can be used to direct further maintenance or repair as required. Inspectors should be qualified professionals trained in recognizing structural or functional inadequacies of a wide variety of systems. Most BMP’s should be inspected annually. BMP’s that utilize vegetation as an integral component of their function should be inspected during the growing season.

Vegetation Management – These practices vary according to BMP type and the specification of design and vegetation composition. Many BMP types, such as dry retention basins, recommend periodic mowing, although efforts should be made to maintain grasses at lengths of at least 6” to increase the efficacy of the system. If bare spots develop in groundcover they should be quickly reseeded or have new sod installed to prevent erosion and maintain high transpiration. BMP's that have native landscaping features should try to maintain viable vegetation which may require periodic replanting of diseased or dead vegetation, especially in the first several growing seasons. Invasive species should always be removed upon identification to limit colonization of the site through mechanical or chemical means. While woody vegetation may feature in some BMP designs it is generally discouraged on engineered berms particularly near the spillway or weir and should be removed, as specified in the design, to prevent instability caused by roots.

Debris and Litter Removal – The accumulation of foreign objects in many BMP's may cause impairments by impeding design flows, clogging outlets, damaging vegetation, and impacting aesthetics. In particular the blockage of outlet structures may lead to serious failures including overtopping and bank instability. Removal of this debris may typically be performed manually, but may require construction machinery.

Mechanical Components – Some of the more complex BMP's may consist of pumps, gates, valves, pipes, access ports, and supporting infrastructure such as fences and locks that need to be periodically inspected and maintained to ensure proper function. Performance is generally maintained through periodic operation, removal of debris and lubrication. More modern stormwater BMP's may include the use of filters, filter fabrics, or other media that require periodic replacement as stated in manufacturer specifications.

Biological Control – A variety of organisms can impair the function of BMP's. As mentioned above waterfowl can prove problematic causing nutrient removal BMP's such as basins to act as sources rather than sinks when densities become high, and animals such as muskrats (*Ondatra zibethicus*) may damage berms. These animals are frequently dealt with by disturbance or trapping. Other biological factors affecting BMP performance are related to unwanted vegetation. Invasives species, as discussed above, are removed mechanically or through the use of herbicides and proactively managed by limiting erosion or depositional features that are easily colonized. Algae blooms are common in many retention basins due to a variety of conditions including enriched nutrient concentrations, shallow depths, and high water temperatures which may foster filamentous algae mats and blue-green algae blooms, which produce cyanotoxins that may be dangerous to wildlife or livestock utilizing the source water. Algae are frequently controlled by the application copper-based algaecides or a variety of Integrated Pest Management (IPM) solutions, which are encouraged in New Jersey, including aeration and destratification systems. Mosquitoes may also be problematic in less naturalized BMP systems and may be controlled through the use of insectivorous fishes, circulation, or chemical and organic larvacides.

Sediment Removal – This type of maintenance tends to be expensive, necessary to maintaining design function, logistically complicated, and overlooked. Besides the cost of removing sediment, permitting can be a barrier to the disposal of captured sediment. On large basins the frequency of sediment removal varies but is generally 5 to 15 years, and this time frame may contribute to foregoing necessary sediment removal activities. Nonetheless, removal is important and needs to be done to ensure design efficiency and to provide necessary storage capacity for both solids and stormwater. Removal of sediment in retention and detention basins, as well as treatment forebays and swales, requires the use of heavy equipment, on-site dewatering facilities, and a final disposal site.

The problem is even more severe in storm sewer systems. Catch basins in roadways and adjacent to impervious areas generally offer minimal storage capacity that fills quickly with road grit and other materials. At a minimum most catch basins and even larger manufactured treatment devices (MTD) should be inspected on a six to twelve month schedule and cleaned as necessary. The cost, labor, and disposal requirements are typically much lower and most of this sediment removal activity can be accomplished with a vacuum truck. Removal of sediment in this type of system is perhaps more crucial to maintaining function and will improve the capture of solids and increase hydraulic efficiency thereby lowering the instance of roadway flooding.

Street Sweeping – Street sweeping can be an important practice in preventing the in-filling of roadside ditches, catchment basins, and other such infrastructure leading to a loss of hydraulic and treatment efficiency. In particular this practice is valuable at construction or redevelopment sites and may also be used to good effect near agricultural access points or near the intersection of paved and unpaved roads.

Many of the issues discussed above are addressed in technical regulations, ordinance, easements, and memoranda of understanding that outline fiduciary responsibilities including budgeting and labor. The MS4 requirements neatly handle the identification of responsible parties for maintaining storm sewers on public roadways and public spaces. However, these types of requirements are not universal, especially when related to new private development or older complexes. In fact instituting the practice of identifying responsible parties for the required maintenance of structural BMP's is itself a BMP and one that must be followed diligently to maintain functionality of BMP's and to limit nonpoint source pollutant loading to the Sidney.

10.4.8 Rain Barrels

Impervious coverage in the Sidney watershed is relatively limited but still contributes to increased hydraulic loading of the tributary network. During storm events the runoff produced is generally of a higher velocity, increased volume, and shorter duration than what would be observed in a forested setting. This allows greater erosion of surrounding soils and therefore higher nutrient and sediment loading. One management option that would help mitigate the negative effects of increased impervious areas is the use of rain barrels.

The installation of rain barrels that intercept rainfall from roof surfaces via the downspouts reduces the overall higher flows that result from increased runoff velocities from these impervious surfaces. Essentially, these barrels capture rainfall that would otherwise serve as a transport vector for nutrients and sediments (Figure 40). In addition, the water contained within rain barrels serves as a water source for uses such as residential irrigation of gardens and lawns helping to conserve water resources. Costs for rain barrels are entirely based on initial material expenditure with little in the way of upkeep. Rain barrels may be converted from recycled food barrels or purchased from many environmental retailers, in many different styles which match a home's exterior, and pre-fitted with spouts.

Figure 40: Rain Barrels

10.5 Invasive Species Management

Invasive species have been shown to be a major problem in the Sidney, as they are throughout the Mid-Atlantic region and much of the country. Some of this is the result misguided efforts to combat soil erosion promoted by the then Soil Conservation Service to plant invasive species such as multiflora rose. Others species are escapees from landscaping projects and others uses and many continue to be sold at commercial nurseries. *Phragmites*, one of the most common invaders of riparian and wetland habitats, is believed to be hybridized cultivar of a native plant. In any case, the riparian corridors throughout the watershed are infested with invasive plants. The main problems associated with invasive species is that they crowd out native plants and provide far fewer ecological services and as such provide poor habitat, poor forage, alter natural carbon cycling, and nutrient uptake (Figure 41).

Figure 41: Multiflora Rose

There are many methods for managing invasive plant species, but few are as effective as chemical treatments, especially in large monocultures. This is in part related to the growth form and life cycle of many of these plants as well as the lack of natural herbivores or plant pests and the high effort required for mechanical removal. There are several major concerns with the use of pesticides in natural settings namely toxicity to non-target organisms and contamination of ground and surface waters and soils. While these are valid concerns public perception likely exceeds the actual risks. The most common chemicals used to treat most problematic species in wetland settings, such as *Phragmites*, purple loosestrife, bamboo, lesser celandine, and even multiflora rose, are glyphosate and secondarily imazapyr. These two chemicals specifically target metabolic processes unique to plants and thus have very low toxicity to non-target organisms such as fish and mammals, tend to bond to soil particles thus reducing groundwater contamination, and generally breakdown in the environment quickly when exposed to sunlight and other conditions. Additionally, regulatory controls at the Federal and State level on the purchase and application of these chemicals are rigorous.

The use of glyphosate, sold under the brand names Rodeo™ and AquaPro™, is probably the most appropriate product for use in this watershed to control most of the common invasives colonizing the riparian corridor. Dependent on proximity to open water and whether an area is deemed a wetland an Aquatic Pesticide Permit will need to be issued by the NJDEP Pesticide Control Program prior to treatment and the application made by a licensed pesticide applicator with the appropriate certifications. Landowners can also make limited applications with commercially available products as long as the restrictions printed on the container label are followed. Treatments can be highly targeted and range from broadcast sprays to backpack spraying and even hand wiping to limit non-target mortality. The highly targeted treatment methods can be especially effective in limiting recolonization of planted sites as part of routine maintenance.

Once large scale monocultures have been chemically treated mechanical removal becomes much more tenable. Mechanical control techniques include physical removal, girdling, tilling and excavation, and repeated mowing. These methods, once again, may be important in maintaining sites after buffer enhancement planting or other site transformation. The important component of maintaining sites is maintaining control to prevent vegetative colonization through the spread of rhizomes or seeding.

10.10 Impoundment Removal

The removal of impoundments is usually a contentious issue for a variety of reasons, but both online and offline impoundments contribute significantly to stream warming and are barriers to fish passage. They may also contribute to downstream erosion if improperly engineered, change sediment transport dynamics, and present a danger to downstream users upon failure. Safety issues are important considerations because many dams are inadequately maintained once their active use is discontinued. However, many impoundments continue to serve useful purposes and may provide irrigation water, function as regional detention basins that capture solids, and provide recreational opportunities. The number of impoundments in the Sidney watershed is fairly high, however most if not all are located on private property. While homeowners or associations may be encouraged to remove functioning impoundments, the major thrust of impoundment removal in the Sidney should focus on the removal of dam, culverts, or other obstructions that serve no purpose, are failing, or have been breached and abandoned. It is important to note that trees and other natural “obstructions” should be left in place and are a natural component of stream channels and channel shaping processes. It should also be noted that normal roadway and rail crossings are beyond the scope of impoundment removal as small bridges and culverts are a vital part of the transportation infrastructure. Unless there are specific problems such as road flooding or structural failure these bridges and pipes should be left alone. In the event of flooding, new design strategies should be employed to maintain the deck at a higher elevation, limit sediment deposition by resisting the impulse to over-widen the channel, or simply enlarge the span.

Besides the problems discussed above failed dams and other structures may cause significant erosional problems. As these obstructions fail they are breached or otherwise bypassed typically resulting in severe bank erosion. Additionally, debris is left which may pose a danger. When these structures fail captured sediment is then resuspended and deposited elsewhere downstream leading to increased sediment embeddedness and reduced macroinvertebrate habitat. If the deposition is severe enough it can also cause localized flooding.

The image shown below (Figure 42) is an example of an old dam located in the watershed that no longer serves any useful purpose, is in a state of disrepair, and is partially breached along the right bank. Additionally, this dam serves as barrier to fish passage, acts as a hydraulic obstruction contributing to localized flooding, and contributes to decreased flow velocity in the section behind the impoundment. Removal of this type of structure is relatively simple and could be easily accomplished with a small excavator. This is the type of structure that should be targeted first; one that is relatively inexpensive to remove and can provide significant localized benefits to stream function. Post-removal rehabilitation of this site would likely require the installation of a grade control structure to prevent headcutting and some minor bank stabilization likely provided by planting alone.

Impoundment removal can be a complicated process requiring engineering consultation and a rigorous permitting process. However, the state recognizes the need to remove these small impoundments and looks favorably on restoration processes. From an implementation standpoint the physical removal can be relatively simple, and may be accomplished with a trackhoe or other excavation equipment; removal may also require the excavation of captured sediments impounded behind the obstruction.

The challenging part of dam removal may be the restoration process. Typically, after the removal of the obstruction bed and bank stabilization measures are implemented, as discussed in the following bed and bank stabilization section. This may include flow deflection devices, toe protection and bank armoring, and grade control. Grade control, provided by a cross vane or an engineered rock riffle is usually a crucial component and is installed to prevent the formation of headcuts and limit erosion. Bank plantings and riparian buffering are also encouraged to convert the riparian corridor to more natural function.

Figure 42: Small Mill Dam

10.7 Bed and Bank Stabilization

Bed and bank stabilization is the keystone of most current stream restoration projects. These projects usually revolve around the maintenance of bed and bank stability, prevention of erosion, limiting excessive or accelerated sedimentation, restoring floodplain connectivity, improving fish passage, maintaining natural hydraulic and hydrologic conditions, and protecting at-risk infrastructure. The opportunity to affect most of these changes is available in the Sidney Brook. Two caveats must be kept in mind when considering the implementation of bed and bank stabilization projects: first, the Sidney watershed is composed primarily of highly erodible soils and along steeper slopes the formation erosional features is natural; second, some of the erosion identified in the visual assessment occurred in forested areas where access to the stream channel is severely limited and efforts to improve the access for heavy equipment could offset the environmental benefit of accessing these areas. The focus of bed and bank stabilization implementation should therefore focus on areas where accessibility is relatively high and where erosion is a clear result of anthropogenic causes, such as the removal of all riparian vegetation or other buffer encroachments. The following section will discuss some of the varied streambank stabilization projects that are applicable in the watershed.

Table 28 below shows most of the major stabilization methods currently employed (utilizing commonly accepted terminology), as well as their primary function, best uses, and implementation complexity. These various methods will be discussed below as separate functional groups.

Table 28: Bed and Bank Stabilization Measures

Method	Primary Functions	Best Use	Implementation Complexity
Bank Grading	Floodplain Connection, Bank Stabilization	Long Runs, Bends	Moderate
Bendway Weir	Flow Deflection	Outer Bend	High
Boulder Placement	Flow Deflection	Habitat Creation	Low
Boulder Toe	Toe Protection	Outer Bend	Moderate
Brush Mattress	Bank Stabilization	Inner and Outer Bend, Habitat Creation	Low
Cross Vane	Grade Control, Flow Alignment	Prevent Head Cuts, Habitat Creation	High
Engineered Rock Riffle	Grade Control, Flow Alignment	Prevent Head Cuts, Habitat Creation	High
Gabion Baskets	Toe and Bank Protection	Limited Space	High
J-Hook Vane	Flow Deflection	Outer Bend, Habitat Creation	High
Live Fascines	Bank Stabilization	Inner and Outer Bend, Habitat Creation	Low
Longitudinal Peaked Stone Toe Protection	Toe Protection	Long Runs, Outer Bend	Moderate
Riprap	Toe and Bank Protection	Outer Bend, Long Runs	Moderate
Rock Vane	Flow Deflection	Outside Bend	High
Rootwad Revetment	Toe Protection	Outer Bend, Habitat Creation	Moderate
Step Pool	Grade Control, Flow Alignment	Prevent Head Cuts, Limited Space	High
Vegetation Planting	Bank Stabilization	Inner and Outer Bend, Habitat Creation	Low

10.7.1 Bank Stabilization

A variety of methods are used to stabilize streambanks ranging from fairly simple projects such as planting to more complex methods such as grading and eventually the placement of gabions and riprap (discussed under toe protection strategies). The choice of method depends on a variety of factors including site hydraulics, stream order, erosion severity, channel incision, floodplain connectivity, and proximity to structures.

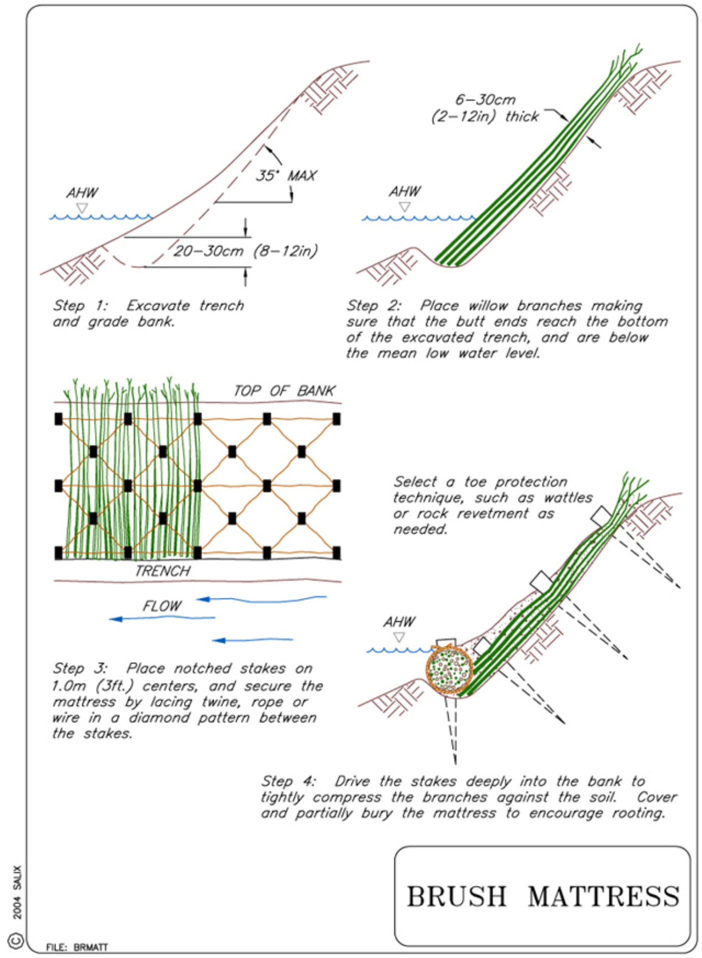
Most modern stream stabilization and restoration projects rely heavily on a vegetative component. As with riparian buffer enhancement vegetation serves a variety functions the most important of which is the stabilization of the bank through the rooting of both herbaceous and woody vegetation. While some projects may begin and end with bank plantings where hydraulics permit and erosion is relatively mild almost all other projects, especially those involving grading and excavation, utilize bank plantings as the final component of the project. A more complete accounting of bank planting is specified in Section 10.2, but trees that feature prominently in local bank plantings include black willow (*Salix nigra*), box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), and river birch (*Betula nigra*). Candidate sites for simple planting as a stand-alone measure would include those with mild erosion and a lack of riparian vegetation (Figure 43).

Figure 43: Planting Candidate Site

There are also more highly engineered approaches to vegetative planting, including the use of brush mattresses and live fascines as well as vegetated riprap designs. Brush mattresses, live fascines, and vegetated riprap solutions usually follow more extensive work, particularly bank grading, but take advantage of willows and red-osier dogwood (*Cornus sericea*) to stabilize banks and to reduce velocity and bank shear stress. Brush mattresses are simply willow or dogwood cuttings placed perpendicular to the channel lining the bank and anchored in place with stakes and ropes. The roots are placed in a trench below the normal water line and the toe protected with wattles or riprap (Figure 44).

Live fascines serve a similar purpose but are bundles of willow cuttings 6 to 12 inches in diameter stacked parallel up the face of the bank. They also promote the growth of willows along the banks but may serve an additional purpose as bank armoring materials until normal growth and colonization occurs. Riprap may also be placed over fascines with a reorientation of the bundles or live stakes may be inserted in the voids in the riprap. Gabions can be treated similarly but generally use a larger tree as opposed to the cuttings described above.

Figure 44: Brush Mattress Detail



Bank grading is also useful for stabilizing banks especially when paired with plantings and toe protections, and is often seen on outside bends or along long eroded runs. More complex bank grading, including major excavation in channels that are extremely incised, may be performed to create a new floodplain. More generally though, bank grading is used to reduce the hydraulic angle of incidence thus decreasing erosive forces along the outside bend, allowing excessive flows to reach the floodplain, and providing stable substrate for planting using brush mattresses and fascines, or armoring with riprap which significantly increases the roughness coefficient. The slope of the grade varies with the desired outcome, but a 3:1 slope is often desired for most planting exercises or other bioengineering. A grading or slope flattening detail is provided below (Figure 45) and would be the preferred stabilization method for the site depicted in Figure 46.

Figure 45: Bank Grading Detail

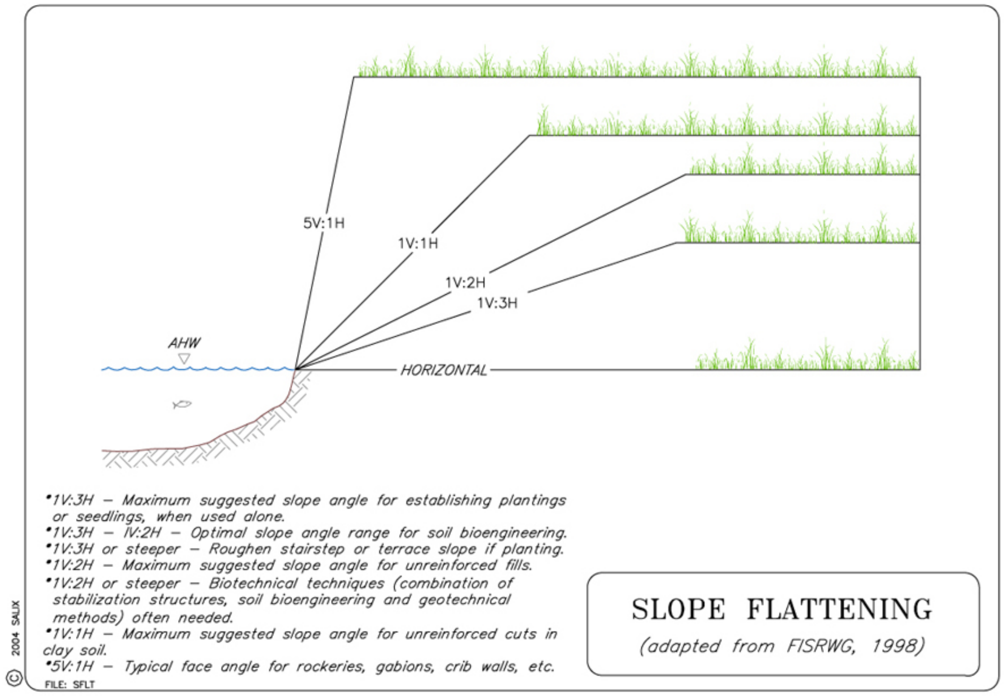


Figure 46: Bank Grading Candidate Site

The practical implementation of these types of bank stabilization measures is generally low to moderate. Flood Hazard Area Rules may require at least general permits for some of these activities, and engineering consultation will probably be required for at least grading activities.

10.7.2 Toe Protection

Toe protection measures serve a slightly different purpose than the bank stabilization measures discussed above and are designed primarily to absorb hydraulic forces and sheer stresses that cause excessive erosion, mass wasting, and endanger nearby infrastructure. More specifically, these measures involve the placement of heavy materials, usually stone, along the toe of the bank, sometimes extending up the bank, to limit erosive effects. These types of strategies may be considered bank armoring, a practice that is gradually losing favor in stabilization projects because these types of systems can be unattractive, may be subject to failure and "overkill" (excessively engineered), and are largely artificial. However, the limitations of many project sites, including the required protection of structures and roadways or a simple lack of space to implement preferred design elements means that these protective measures are still important for bank and bed stabilization projects. Indeed, the judicious use of toe protections is absolutely critical to the success of many projects.

One of the best toe protection measures involves the use rootwads or rootwad revetments (Figure 47). The rootwad describes the lower portion of a tree trunk with limbs removed but the major portion of the root ball retained. These are usually placed in the toe of the bank on an outside bend with the trunk angled slightly back and keyed in deeply to the bank so that the anterior section of the root ball is flush with the bank, seated on a footer log, and oriented perpendicular to the main flow vector. The rootwad is then able to absorb most of the hydraulic impact to decrease erosion, but unlike some of the other toe protection measures serves other functions in the stream. The roots themselves can significantly increase local roughness in the stream thus slowing flow velocities. These rootwads are also fantastic fishery habitat and offer refugia from predation and flow, provide ambush points for predators, and foster abundant forage as the organic roots become well colonized by benthic macroinvertebrates.

Rootwads have several additional benefits to consider. Availability of the raw material tends to be high as they can be collected from construction sites where large trees have been removed or even onsite at restoration projects as some trees may have fallen into the river due to excessive or erosion or are removed during grading processes. Additionally, larger materials are generally more efficacious and implementation is limited only by the size of rootwad available; it is interesting to note that there are anecdotes of redwoods being utilized in Pacific coast projects.

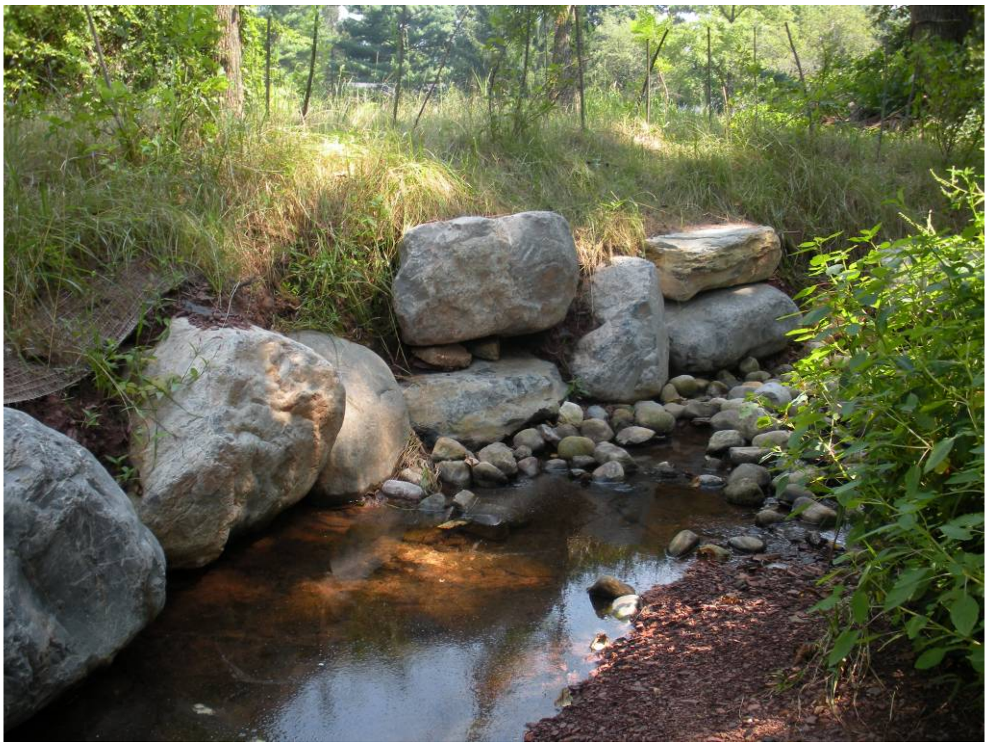
Figure 47: Rootwad Placement

Boulder toe protection designs function similarly to rootwad to provide bank stability and prevent erosion along outside bends utilizing large boulders instead of trees. In addition to protecting the toe of the bank the boulders may be stacked as necessary to provide additional armoring higher up the bank. Design specifications are generally mutable but the resistive boulders should be placed to achieve approximately 50% embedment. Bank grading and the placement of fill material behind the boulders are usually encouraged. The material behind the boulders is usually planted with woody vegetation. A boulder toe design is shown below (Figure 48).

The placement of riprap and gabion baskets is among the most familiar bank stabilization and bank protection measures. Riprap is coarse rock, relatively well graded (non-uniform or well distributed) and angular placed along outside bends or longer runs where erosion is observed. Most designs feature a trench or other retaining feature at the toe of the bank to help maintain the rock in place. Grading is usually extensive in these projects as a uniform surface and grade is required to maintain the rock in place with a final slope of 1:1 or 2:1. Geotextiles or other bedding materials may be necessary to ensure proper drainage and seating of the riprap, which must be carefully sized to handle hydraulic conditions during stormflow events to maintain bank stability. Newer designs may incorporate vegetation planted either in the void spaces between the riprap or planted in amended fill materials on the face of the riprap, the rock serving as an underlying layer.

This type of approach is now considered somewhat excessive and unnecessary unless there is a need to absolutely lock the channel and bank in place.

Figure 48: Boulder Toe Protection



Gabions are large wire cages filled with coarse rock, similar to the material used in riprap applications. Gabions have several advantages over riprap related to the cages which provide increased structural integrity and thus allow smaller rock to function as a single unit or be placed where larger rock would be required in a riprap placement. For this reason gabion baskets can be used in much steeper applications, and may be placed almost vertically without concern for the angle of repose (the angular limit at which loose materials can be stacked), which is an important consideration where space is a defining limitation. There are several other gabion designs including gabion mattresses, which are much shallower than baskets with a larger footprint and gabion sacks which is mesh sack filled with rock. Both of these designs must be placed on flatter slopes than baskets. Gabions are almost always filled in place which aids greatly in their installation. As mentioned above gabions may be vegetated as discussed above and shown in Figure 49 below. The successive image (Figure 50) identifies a location in the Sidney where gabion baskets may be required to withstand high shear forces eroding the bank in order to protect the road situated at the top of bank.

Figure 49: Vegetated Gabion Detail

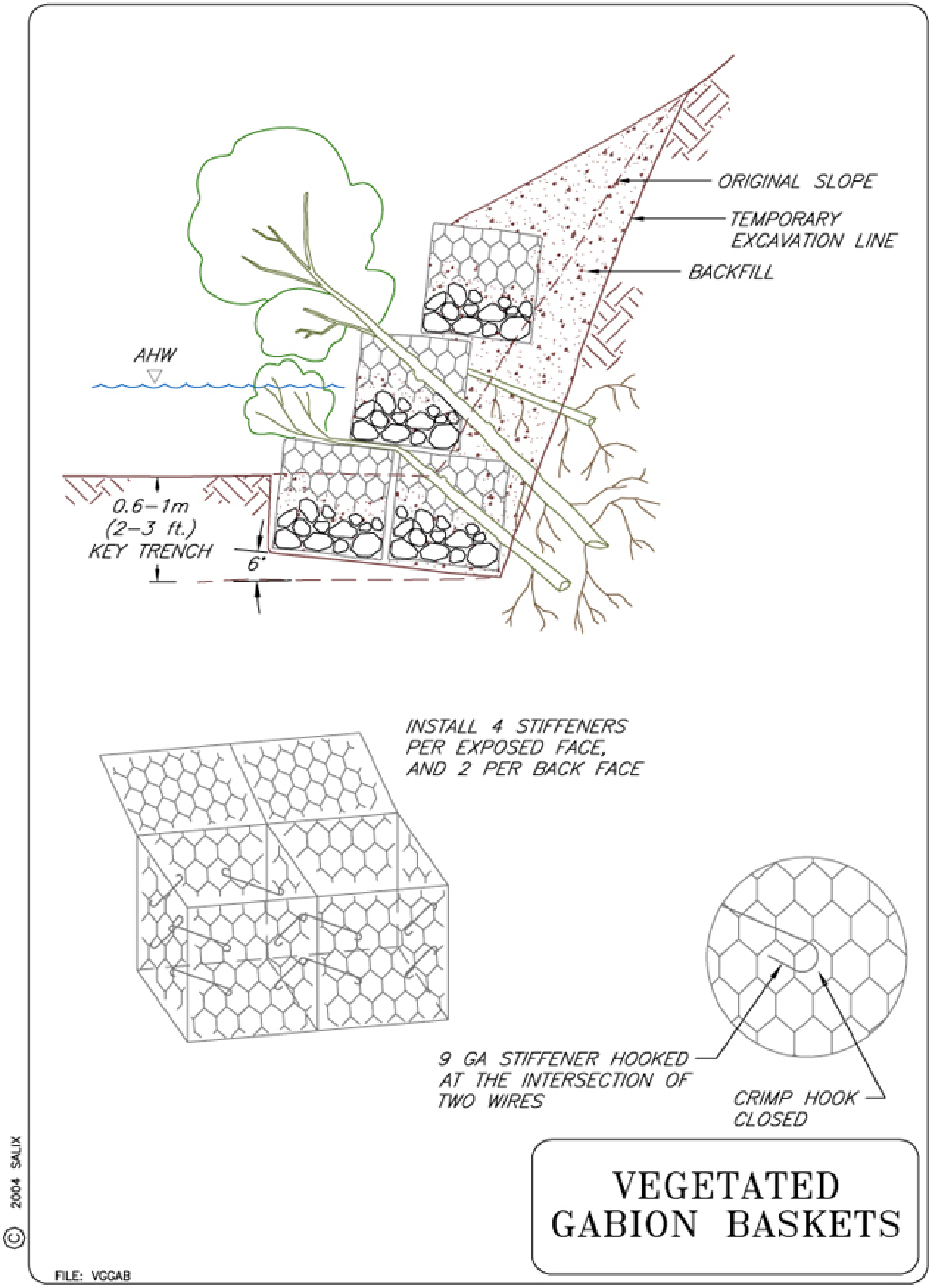


Figure 50: Potential Gabion Placement

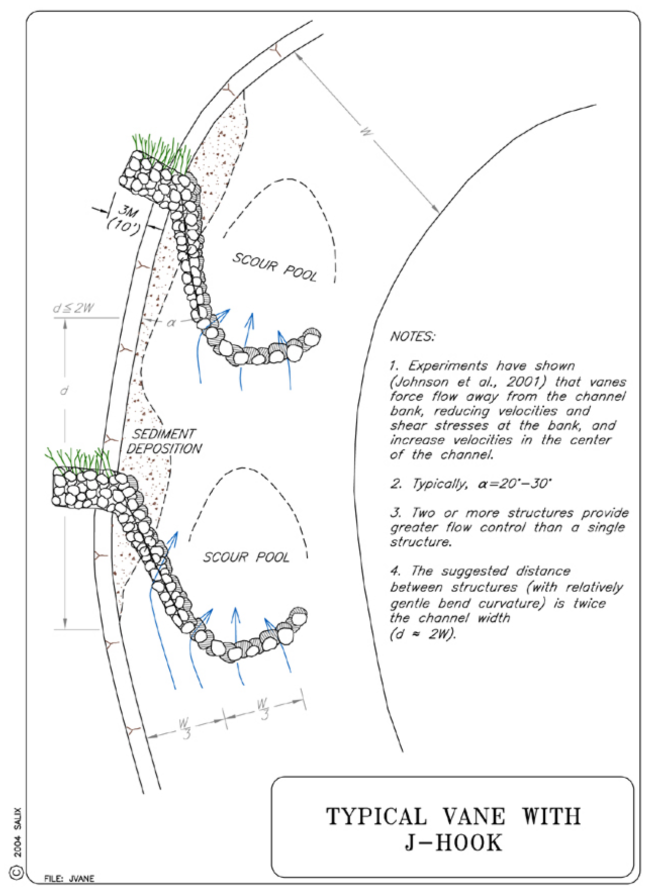
10.7.3 Flow Deflection

Another series of structural bank stabilization methods includes the use of flow deflection devices. Unlike toe and bank protection measures which are designed to absorb the impact of accelerated flows to prevent erosion, flow deflection devices alter the hydraulics of the system and divert the majority of the discharge away from the bank and towards the center of the channel. Another major difference of this type of device is that they extend into the channel from the bank. A variety of flow deflection devices are currently utilized including bendway weirs, J-hook vanes, rock vanes, and rock spurs, but most are simple variations on a similar design.

Rock spurs are the simplest flow deflection devices, but utilize the same design strategies to limit erosion. At their simplest, rock spurs are merely rock piles abutting the bank and extending into the channel. The primary function is to reduce near bank velocity, shift the thalweg towards the center of the channel and minimize the potential for erosion.

J-hooks and rock vanes or vane arms are more highly engineered designs that are longer linear features that extend from the bank upstream at approximately 20 to 30° off the streambank with a gentle slope down the face of the vane. The main difference between the designs is that the J-hook has a curve at the end contributing to a scour pool and habitat creation (Figure 51), a feature missing in normal vane arms. Placement is critical to these devices and a common design flaw is not locating the vane far enough upstream. This is exhibited in the detail below which should probably have shifted the placement slightly upstream to initiate flow realignment sooner. The second common mistake is that too few features are installed to adequately maintain the desired flow path including at the egress of the curve. Finally, the third error is a tendency to expand the angle such that the main arm is installed at a 45° angle or larger. This type of installation minimizes the velocity gradient across the face of the vane thus decreasing the potential to redirect flow. However, good designs are proven to be effective at limiting erosion and show even higher efficacy when paired with other bank stabilization methods. As with other complex designs, good engineering is the key to the success of these solutions.

Figure 51: J-Hook Detail



The image below (Figure 52) would likely be a good site in the Sidney watershed to implement a flow deflection solution. Such a design would deflect the heaviest flows away from the bank, and a J-hook design would provide scour to minimize sediment deposition and provide some larger and hydraulically more complex features in the stream bed which would promote better in-stream habitat for fish and macroinvertebrates.

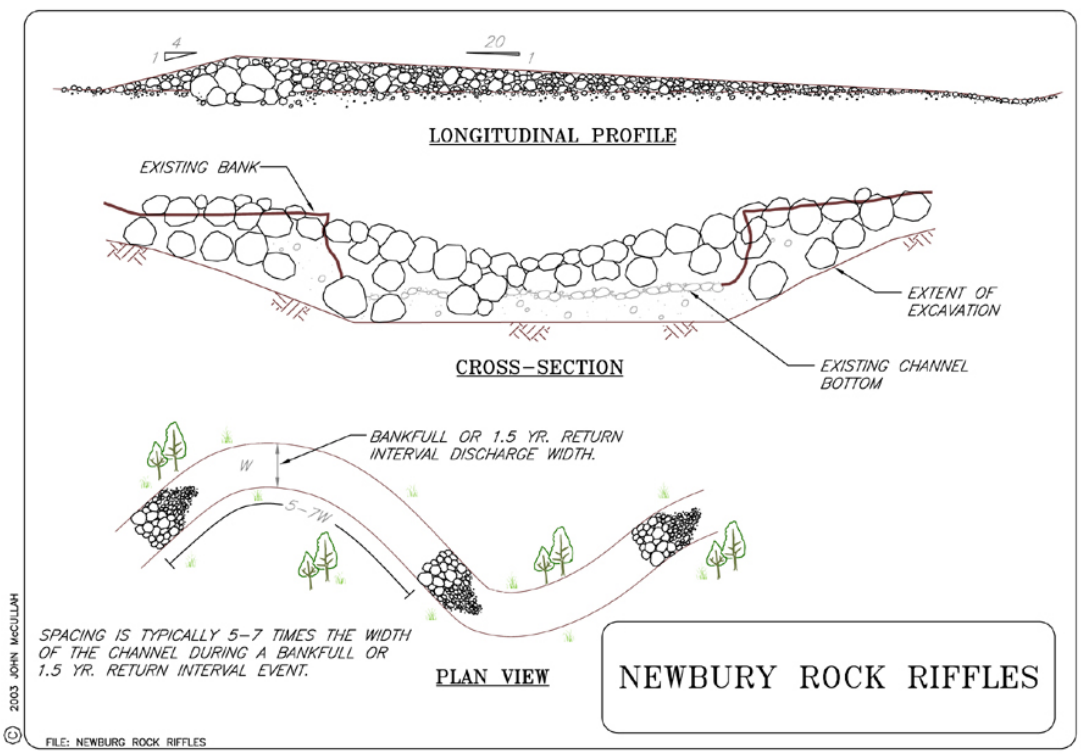
Figure 52: Flow Deflection Candidate Site

10.7.4 Grade Control

In-stream grade control is also another important component of bed and bank stabilization. While erosion is mostly thought of as a problem with the banks, channel incision includes both horizontal (bank) and vertical (bed) erosion. The erosion of bed materials results in entrenchment or a hydraulic disconnect of the channel with the floodplain. Since the stream no longer is able to flood the adjacent plain all the flow is forced through the incised channel resulting in even greater erosion. Under these conditions a typical type of erosional process that develops is the head cut, an erosional feature in the bed that migrates upstream. Grade controls therefore mitigate these processes and include several structures such as engineered rock riffles, step pools, and cross vanes or V-weirs. Other grade controls used historically such as dams will not be discussed here as they exacerbate erosion and sedimentation processes and represent other risks such as stream warming, altered hydraulics, and fish passage barriers. Grade control measures are also frequently used when stream channels have been extensively reshaped or when impoundments have been removed to prevent the formation of head cuts and to align flows in the center of the channel. Another use of grade control structures is to elevate the entire channel of severely incised streams to restore floodplain connectivity.

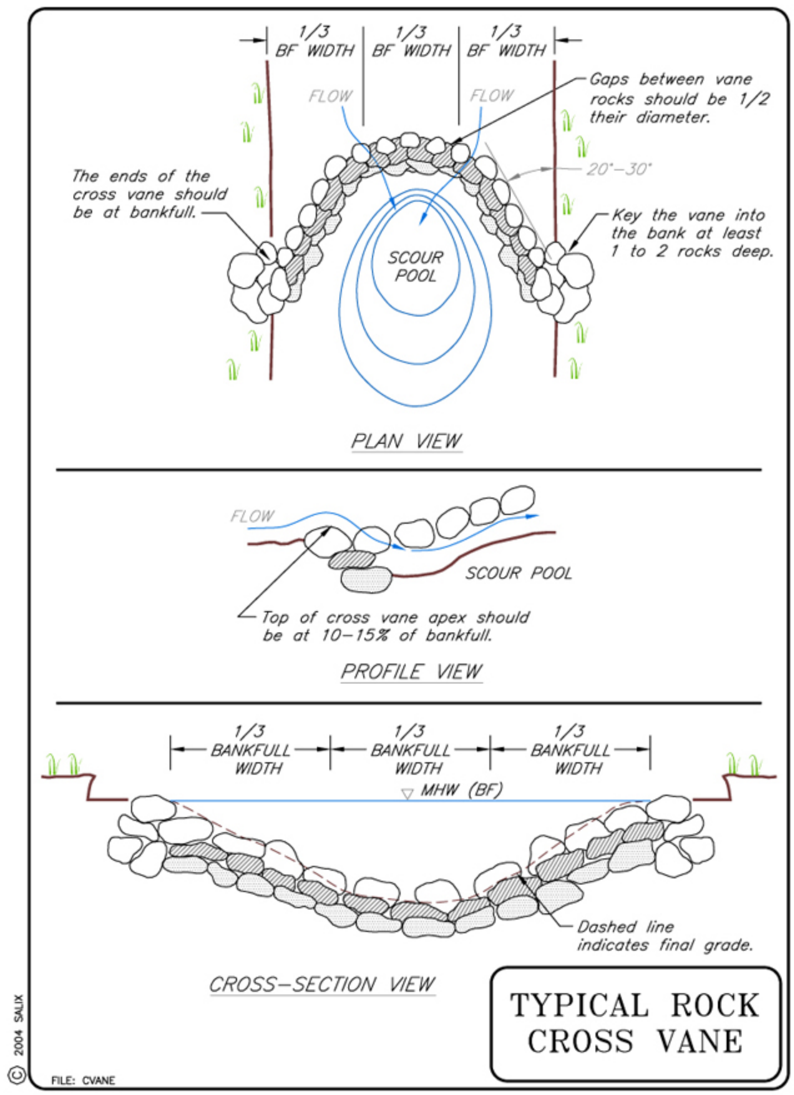
Engineered rock riffles replicate naturally occurring riffles in streams (Figure 53). Besides providing grade control and preventing erosion, rock riffles are also important habitat features. Riffles are generally characterized by high grades relative to other stream segments and coarser sediments or substrate. This combination of factors introduces turbulent streamflow through these areas which creates highly oxygenated water. High DO levels and coarse substrates are critical to maintaining healthy macroinvertebrate populations in streams, particularly the EPT taxa discussed above which are among the primary macroinvertebrate indicator groups of stream health.

Figure 53: Engineered Rock Riffle Detail



The cross vane or V-weir is similar to rock vane designs described in the previous section but extend completely across the stream and when seen in plan view look like a normal rock vane connected to a J-hook vane (Figure 54). Their primary function is grade control but also the alignment of flow in a channel. Like other vane designs they work by lowering flow velocity along the bank, but also structurally shape channel morphology. Cross vanes have the added benefit of limiting downstream sediment deposition and creating a scour feature at the toe of the vane. Combined these features can help improve DO concentrations, limit bed and bank erosion, and provide habitat complexity.

Figure 54: Cross Vane Detail



The obstruction shown below (Figure 55) is an interesting case and another example where grade control should be utilized. In this image a pipe is currently acting as a grade control device and is preventing a head cut from migrating upstream, but is also subject to failure itself; it is interesting to note that the configuration of this pipe also likely exacerbates the undercutting on the far bank. In this case a rock riffle or a cross vane would be placed immediately downstream of the pipe to protect the pipe, prevent headcut migration, limit bank undercutting, and reconnect the stream bed on either side of the hydraulic jump to improve fish passage.

Figure 55: Grade Control Candidate Site

A final grade control measure is the step pool. Step pools are similar to cross vanes, but are linked in series and utilized in higher gradient streams. While the angularity of the vane would be reduced other details remain essentially unchanged. An important consideration that must be accounted for in this type of design is the relative difference between pool elevations which must be maintained at an acceptable height to allow fish passage; this height would vary based on targeted species. Step pools may also be used to realign water in tight, steep bends where the use of flow deflection techniques such as J-hooks would be impractical because of space limitations.

10.8 Manure Management

Manure management may be rightly considered an agricultural BMP, but the elevation of fecal coliform in the Sidney and subsequent impact on contact recreational use of the stream and potential human health effects demands that this management measure be discussed more prominently. Manure management was identified as the primary management solution to control coliform bacteria loading in the lower portions of the watershed based on the results of the *E. coli* sampling and secondarily on the visual assessment which noted swales and other conveyances that drain active pastures discharging directly to the creek. The need to address proper manure management is an important initiative in terms of avoiding negative impacts on water quality due to the agricultural character of the community. Because the use of manure helps the farmer recycle animal waste and fertilize the soil, it is important that its management be outlined in an agreeable manner that does not jeopardize farm production or stream health.

Manure solids may be composted with materials such as leaves and grass clippings, to produce soil nutrient supplements high in organic content. Because manure contains both animal waste products and decaying vegetation, improper management can threaten water quality in terms of fecal and nutrient contamination. Proper manure management is important because it prevents these pollutants from migrating to surface and ground waters. Application of manure to the land at the proper time, using proper management techniques, and in proper amounts recycles the nutrients through the soil, reducing the expense of commercial inorganic fertilizers as well as the need to add organic matter. Proper application of manure can improve soil quality, fertility, and water-holding capacity.

Since large, commercial farms are regulated by Right to Farm, the manure management initiative proposed as part of this WPP would only affect small farms in the watershed. Because small farms are vital to preserving the agricultural character of the watershed and essential in providing services to the community, manure management is recommended as a voluntary measure so as not to financially burden these small scale operations. It is strongly recommended that small farms, that have the financial resources, comply with the NJ Dept of Agriculture (NJDA) Animal Waste Rules (draft). It is encouraged that farmers conform to additional measures that are not required but are highly recommended by NJDA, such as fencing along waterbodies. (http://www.state.nj.us/agriculture/divisions/anr/agriassist/animalwaste.html).

The five general requirements of the NJDA Animal Waste Rules are:

- No agricultural animal operation shall allow animals in confined areas to have uncontrolled access to waters of the State
- Manure storage areas shall be located at least 100 linear feet from waters of the State
- The land application of animal waste shall be performed in accordance with the principles of the NJDA BMP Manual
- No dead animals and related animal waste resulting from a reportable contagious disease or an act of bio-terrorism shall be disposed of without first contacting the State Veterinarian
- Any person entering a farm to conduct official business related to these rules shall follow bio-security protocol (NJDA 2009)

Various farming BMP practices to minimize discharges of pathogens, nutrients, and pesticides are highlighted in publications funded by the USDA-NRCS in fact sheets provided at the website: http://www.sera17.ext.vt.edu/SERA_17_Publications.htm. This supplementary information could be distributed to farmers as education and outreach materials and used as a resource for drafting farm conservation management plans.

Filter strips are one of the methods described in the NJ Agricultural BMP Manual as an effective, low cost manner to manage and reduce manure related water quality impacts. Vegetated filter strips were previously discussed in Section 10.3.4. These BMP's are recognized as one of the most effective methods of reducing excessive bacteria loading. In particular the use or construction of filter strips will probably be of greatest benefit in the control of *E. coli* with an agricultural vector in this watershed. The main mechanic in this system is the use of native vegetation to capture and filter contaminated runoff.

Manure storage through field stacking can be an important method for reducing loading when weather and antecedent soil conditions precludes routine handling. Indeed, some studies have shown that storage is probably the most effective method in controlling bacterial loading although this method may do little to control nutrient loading related to manure.

The strategies discussed above are relatively inexpensive to implement. Other manure management solutions, such as the construction of combined waste facilities, while offering high treatment efficacy are likely cost prohibitive and generally not consistent with the agricultural practices and layouts in this watershed. As with many other management measures, community outreach will be important in implementing these changes to affect positive water quality in the watershed. It should also be mentioned that while manure management guidance from the State and other sources tend to concentrate on cattle operations, horse farms and other livestock facilities, including non-commercial operations, also need to be strongly considered in the overall manure management goals in this plan, which is chiefly to reduce the bacterial loading and nutrient loading in the watershed.

10.9 Agricultural BMP's

Agricultural BMP's have a long history in this country and were originally implemented to promote soil conservation, increase yields, conserve water, and decrease fertilizer use, while newer strategies have focused more strongly on preserving natural resources, promoting wildlife, and mitigating NPS pollution impacts while maintaining the original design goals of increased farm yields. In the Sidney watershed agriculture is an important economic driver and one of the dominant land uses, yet most of the farms are relatively small and focus on the production of hay, horses, and cattle as well as row crops (corn, soy beans and grains), orchards and vegetables. As such, none of the problems associated with large industrial farms or confined feed lot operations are evident in the watershed and thus lower intensity solutions are recommended. For the most part, many of the recommendations for agricultural BMP's are already utilized in the watershed, but more uniform adoption is recommended. Many of the incentive programs listed above are tailor made for agricultural adoption and ample technical assistance from government agencies is available to implement these programs. The following recommendations are taken primarily from the *On-Farm Strategies to Protect Water Quality* document published by New Jersey Association of Conservation Districts, which is in essence a thorough agricultural BMP manual. While this document discusses many different agricultural BMP's this section will focus on those deemed of greatest utility in the Sidney watershed. Many of the recommended BMP's described in the manual have been discussed in the preceding sections of this document and may be found above including riparian buffer enhancement, filter strips, and manure management.

The table displayed below shows the pertinent agricultural BMP's for the Sidney watershed that have not been discussed elsewhere in this document (Table 29). For the most part these BMP's focus on the control of erosion and sedimentation although many also offer nutrient loading reduction benefits as well. Many of these strategies take advantage of a vegetative component to maintain ground cover and prevent soil erosion, but it should be noted that strategies focused on the control of erosion also reduce runoff volume and rates by decreasing runoff velocity, enhancing infiltration, and promoting evapotranspiration, and these reductions in runoff are a crucial component of maintaining channel integrity in the tributary network. It is also worth noting that many of these BMP's are procedural relying specifically on altering practices rather than installing structural solutions to minimize NPS loading. This table was developed utilizing data from the agricultural BMP manual.

Table 29: Agricultural BMP's

BMP	Erosion and Sedimentation	Nutrient	Pest and Pesticide	Barnyard, Manure, and Waste	Grazing
Conservation Cover	●	ɵ			
Conservation Crop Rotation	●	●	ɵ		
Contour Farming	●				
Contour Strip-cropping	●	ɵ			
Cover Cropping	●	●	ɵ		
Field Borders	●				
Grassed Waterways	●	ɵ			
Residue Management	●	ɵ	ɵ		
Nutrient Management Plans		●			
Green Manure Cropping	ɵ	●			
Livestock Fencing	ɵ				●
Pasture Management	ɵ	ɵ		ɵ	●
Stream Crossing	●				ɵ

● - primary
ɵ - secondary

Conservation cover, conservation crop rotation, cover cropping, and pasture management all rely on maintaining vegetative cover in agricultural areas. Conservation cover specifically refers to the establishment of permanent vegetation in areas retired from active production. Cover cropping on the other hand is the seasonal establishment of cover crops, such as winter wheat or winter rye, after the harvest of primary crops in the summer or fall to provide cover until the next planting. Crop rotation is the practice of rotating different crops through several fields to limit nutrient deprivation and may be used in conjunction with techniques such as green manure cropping to bolster soil nitrogen levels through the periodic planting of legumes.

Residue management is another important technique that sees use in the watershed and is based on maintaining plant residues at 30% or greater coverage to prevent erosion, and depending on site conditions can decrease erosion and sedimentation by as much as 90%. Residue management is based on the implementation of conservation tillage practices including no-till, mulch till, and ridge till.

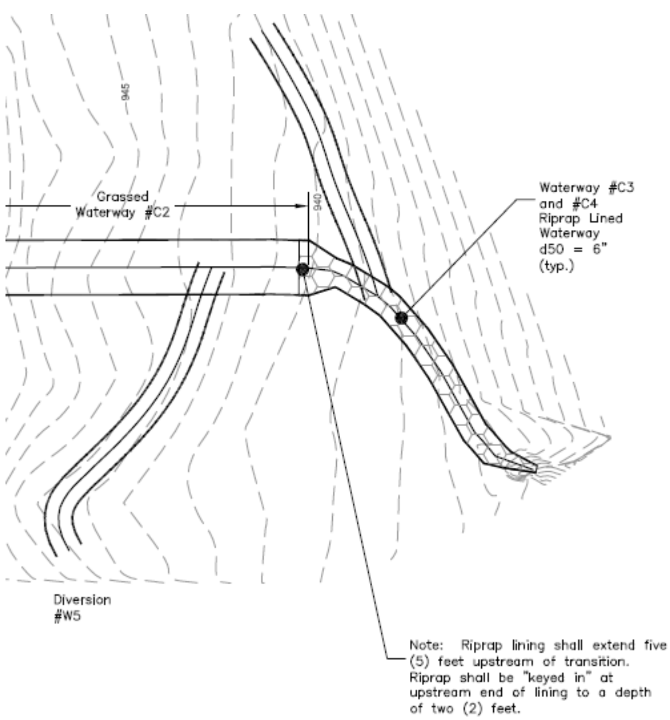
Contour farming and derivations such as contour strip-cropping and contour buffer strips is the simple practice of tilling, planting, cultivating, and harvesting across the slope of a field or parallel to the contours. This is done mainly to slow flow velocity and prevent the transport of sediment into adjacent waterways. This is a basic practice that has been promoted for a long time, but has not been uniformly adopted in the watershed. The widespread implementation of contour farming could provide substantial benefits in the watershed and prevent the loss of valuable topsoil in farmed fields. In fact the high erodibility of many soils in the watershed increases the importance of implementing BMP's that minimize erosion including contour farming, residue management, and cover solutions.

Grassed waterways and diversion methods should be strongly considered for implementation throughout the watershed. As a result of topography many of the fields in the watershed are sloping and are situated close to the tributary network. As such, management of runoff and water in general is a concern in these fields, and many drainage features discharge directly to adjacent tributaries. Because of the direct discharge field drainage features have an even greater potential to deliver eroded sediments directly to the stream. In the image provided below (Figure 56) a small swale located in the watershed is showing signs of erosion and thus serves as vector for both solids and nutrient loading to the stream.

The implementation of grassed waterways would be ideal for this situation. Like vegetated swales discussed in the structural BMP section above, the grassed waterway is merely an agricultural application of the same principles in residential and other settings. Namely, grassed waterways utilize a permanent groundcover to provide surface stability to prevent erosion and the vegetative filtering and removal of suspended sediments in directed runoff. The following detail, taken from a Princeton Hydro engineering plan shows a schematic view of a grassed waterway with tributary diversion situated on the contour (Figure 57). While additional diversions are not required, especially if there is adequate riparian vegetation at the toe of the field or a vegetated field border, grassed waterways should be considered for the Sidney.

Figure 56: Eroded Ditch

Figure 57: Grassed Waterway Detail



Nutrient management is a related series of BMP's designed primarily to reduce costs associated with fertilizing and improving yields, while limiting the NPS loading of nutrients to waterways. As such nutrient management plans must consider the handling of manure, crop rotation, cover cropping and fertilizer use. The use of fertilizers is probably the most important component of many nutrient management plans and simple practices such as soil testing, knowledge of crop requirements, and good application practices can significantly reduce fertilizer demand and nutrient loading.

Finally, stream fencing and crossing improvements should be considered to limit in-stream erosion, solids loading, and bank instability. While livestock access to tributaries in the watershed seems to be limited, agricultural crossings of water features including swales, marshes, and wet areas, may be relatively common as depicted below (Figure 58).

There are a variety of simple fixes, one of the most popular being the hog panel stream crossing with gravel driveways, and where livestock cross, fencing (Figure 59). These solutions can significantly reduced localized bed instabilities, which can result in the formation of migrating head cuts and erosion upstream, and solids loading to the stream.

Figure 58: Unimproved Agricultural Stream Crossing

Figure 59: Improved Agricultural Stream Crossing

10.10 Open Space Preservation

Open space preservation is an important component of this WPP and the continued thrust of watershed municipalities to preserve open spaces must be maintained to preserve natural resources, mitigate development related impacts to stream water quality, and improve the ecologic function of the watershed. Open space preservation works through several means to protect the integrity of the watershed. Primarily, it preserves natural features that have important ecologic and hydrologic functions, including species diversity, habitat, pollution mitigation, groundwater recharge and stream baseflow. Second, it limits further development which is intrinsically tied to water quality and other ecological impairments. Third, it benefits the public by providing recreational opportunities and preserving the rural character of the watershed.

Much of the open space preservation in the watershed is related to the Farmland Preservation program, conservation easements and other deed restrictions, and Green Acres holdings. Other preservation classes include municipal, county, and state holdings and utility easements. These types of holdings, particularly Farmland Preservation, Green Acres, and deed restrictions on private lands should continue to be pursued as codified by the respective municipalities. While a sizable portion of the watershed is currently preserved or has regulatory protections related to classification as wetlands, flood hazard zones, or as preserved open space much of the watershed may still be considered developable under existing zoning ordinances, although the propensity to develop continues to decrease with many of the Highland Act restrictions. Much of the potential development would likely consist of the conversion of agricultural lands to residential development. As mentioned above, many of the existing ordinances, township policies, and technical regulations provide a measure of protection, but a more explicit set of goals is useful to direct preservation activities. Continued open space preservation in the watershed should focus on:

- Open space acquisition through existing programs and models
- Low impact development
- Protection of natural resources
- Preservation of rare or at-risk plant communities, ecosystems, and wildlife
- Adoption and upgrade of BMP's during development and redevelopment
- Preservation of agricultural land elements
- Promotion of agriculture and landowner friendly initiatives
- Habitat connectivity through the implementation of greenways initiatives

Implementation of these types of programs is of course dependent on funding sources and public outreach to foster participation. Many programs, agencies, and policies have been created to aid in the preservation of open spaces including the following:

- NJ Department of Agriculture Farmland Preservation Program
- NJDEP Green Acres Program
- Hunterdon County Soil Conservation District
- Natural Resources Conservation Service (NRCS)
- Conservation Reserve Enhancement Program (CREP)
- Conservation Reserve Program (CRP)
- Environmental Quality Incentives Program (EQIP)
- Farm and Ranch Land Protection Program (FRPP)
- Grassland Reserve Program (GRP)
- Wetlands Reserve Program (WRP)
- Wildlife Habitat Incentives Program (WHIP)
- D&R Greenway Land Trust
- River Friendly Farms Certification Program (North Jersey RC&D)
- Union Township Open Space, Conservation, and Farmland Preservation Trust Fund

All of these programs and additional opportunities should be investigated to ensure additional protection of open spaces in the watershed.

10.11 Specific Candidate Restoration Sites and Project Ranking

The selection of various candidate restoration sites was a collaborative process between the project partners to develop several lists highlighting opportunities to employee many of the NPS management methods discussed above to affect improvements in the quality and function of Sidney Brook and its watershed. In particular the report of findings issued by the New Jersey Water Supply Authority was important in selecting a variety of candidate sites. This report used a unique approach in identifying potential candidate sites that was based primarily on GIS evaluations of candidate sites to objectively identify sites. The first component of the report was based on the delineation of riparian areas factoring in wetlands, wildlife corridors, floodplains, and other important features contributing to riparian buffer function. Next a Riparian Health Analysis was conducted. This analysis is conducted on a watershed basis and was used to define and compare riparian health of constituent watersheds throughout the Raritan River watershed. The Riparian Health Analysis consists of a landscape and riparian zone condition components which utilize land use, impervious cover, habitat quality, erosion potential, and other watershed properties to assign a score and rank. While the Sidney Brook watershed is one of the better scoring watersheds in the Raritan, riparian corridor conditions were also characterized as having specific impairments that negatively affect watershed quality. In particular, the density of impoundments, riparian land uses, and conversion of riparian forest are serious issues that negatively impact Sidney Brook.

Building on these analyses the Priority Riparian Buffer Restoration Analysis/CCPI Analysis was conducted to identify specific sites, at a parcel scale, along the tributary network that would benefit from riparian buffer restoration based on a number of specific risk factors that indicate high potential for erosion, stream warming, NPS pollutant generation, loss of habitat quality, and other impacts. Specifically, the model utilizes GIS modeling techniques to overlay soil erodibility based on soil K-factor, hydrologic sensitivity/topographic index based on the potential to generate runoff, wildlife habitat using Landscape Project species data, and impervious surface coverage. In total, using this analysis, 54 sites were identified as potential candidates. Field reconnaissance was then used to further characterize and prioritize the sites to produce a final list of five candidate sites which also accounts for ownership and other related issues affecting potential implementation. For each of these five a more thorough description of the site was produced which includes site characterization, maps, and an overview of recommended restoration measures including a detailed planting plan and projected cost. One of these five sites, the Milligan Farms site (site 3), was restored in 2011 with NJWSA as project lead as a demonstration project for the other four high priority sites and in general for the remainder of candidate sites. The complete report, including all supporting materials, is discussed and presented in detail in Section 11.0

In addition, Appendix IV was developed by Princeton Hydro and contains 20 specific candidate restoration sites within the Sidney Brook watershed to implement a variety of NPS reduction measures discussed above. These sites were selected based on the results of the visual assessment and various in-field monitoring efforts, as well as stakeholder input, to identify problematic areas that could be improved utilizing many of the management measures discussed above. For each of the selected sites a description of the problem or concern was provided including photographic documentation followed by a series of specific recommendations, and the projected benefit to function improvements. It is important to note that these two lists are complementary with NJWSA focused on GIS investigations while Princeton Hydro's list is based primarily on the visual assessment.

Implementation priority and rank are an important concept in this plan. Each site was assessed a priority determined by rank. While all these sites have merit and deserve attention, the priority rankings draw attention to those projects that should be considered in order. The semi-quantitative ranking matrix was based on six parameters described below. This ranking scheme is a slight modification of that approved and adopted for the Alexauken Creek Watershed Protection Plan by the NJDEP.

- Severity: More severe problems are ranked higher, especially in regard to their contribution of NPS pollutant. For instance, a site with 5 vertical feet of bank erosion would be ranked higher than one with 2 vertical feet of erosion.
- Extent: The greater the area affected or the greater the water quality impairment would receive higher ranking. An erosional feature 100 feet long would score higher than a 20 foot reach.
- Temporal Risk: Impairments or impacts that are likely to further degrade or degrade at an accelerated rate or cause problems in the immediate future are ranked higher.
- Source Identification: Impairments in which a causal action is linked to an observed impairment would receive a higher score. An erosional feature directly related to outfall discharge would score higher than a generalized erosion feature.
- Accessibility and Land Use Setting: Priority is given to those sites that are accessible or where impairments are noted in developed lands (residential, agricultural, commercial, industrial) rather than undeveloped lands. For example, channel instability in a reach running through maintained lawn space would receive higher ranking than a similar feature in a riparian forest. Accessibility refers to the ability to access the site with equipment. Again, forested areas will score lower than maintained spaces both because of physical access and potential collateral loss to functioning habitats.
- Benefit versus Cost: The benefit of a given mitigation strategy is weighed against financial cost, complexity, and overall effort and is related in part to both severity and extent. Projects that provide greater benefit to water quality and ecology are given higher priority.

Each of these categories was qualitatively evaluated relative to all identified sites and scored from 1 to 3, with 1 representing the lowest concern or importance with successive increases to high concern at score 3. These scores were then summed across all categories. The highest sum scores received the lowest numerical rank and highest priority. The Finn Park project, a comprehensive stormwater implementation project, received the highest summed score of 16, and was ranked 1 with highest priority. Conversely, Lakeshore Aquascaping projects, consisting of simple plantings on the margins of ponds only scored an 8, was ranked tied for eighth and was assessed a low priority. While these are still important projects with tangible benefits they are scored low because there is relatively little risk of further deterioration and they are of low severity initially. Many of the scores overlapped resulting in ties for rank. Ranks 1 through 3 are considered high priority, ranks 4 and 5 are medium priority, and ranks 6 through 8 are considered low priority.

The qualitative scoring of the categories is based largely on the project experience of Princeton Hydro in implementing these types of solutions in the field. This is especially true of cost estimates, which are explained in further detail in Section 12.0 Technical and Financial Assistance, and a general sense of the complexity of these works. This project experience, including engineering, the acquisition of permits, scientific field studies, funding, and designing within regulatory requirements, is also bolstered by various training classes in Rosgen restoration techniques as well as others promoted by the USACE and NJDEP, a variety of sources in the literature, and implementation throughout the Mid-Atlantic and New England states.

11.0 Project Site Selection and Demonstration Project

This section focuses on the technical evaluation of the Sidney Brook watershed, the selection and ranking of candidate restoration sites with respect to restoration of riparian areas and their environmental services, and finally the implementation of a demonstration project to serve as an initial implementation project and as a model for other projects. This work was conducted by the NJWSA for this project, but also dovetails with larger Raritan Basin efforts they spearhead and utilizes much of the established methodology. The specific tasks covered in this chapter include the following:

- Riparian Area Analyses: NJWSA and other Raritan Basin stakeholders have developed a series of analyses intended to support and facilitate stream and riparian buffer protection and restoration. These include delineation of riparian areas, analysis of riparian health, and prioritization of areas for restoration. NJWSA prepared maps and narrative detailing this information.
- Identification of Riparian Buffer Restoration Sites: Based on the riparian area analyses and field work, NJWSA identified potential locations for riparian buffer restoration. A rough cost estimate was provided for all of the sites, and planting plans were developed for five priority sites. The NJWSA also completed a demonstration project of one of the five priority sites, site 3 at Milligan Farms.
- Identification of Critical Parcels for Water Resources Protection: In 2001, the NJWSA and Raritan Project stakeholders developed a set of criteria to identify parcels for protection of water resources by groups throughout the Basin. Protection was defined as acquisition, easements, land management or protection through ordinances. In addition, the NJWSA developed another set of criteria to better guide their organization's acquisition program. Using these criteria, NJWSA identified critical parcels within the watershed based on the two sets of criteria.

11.1 Riparian Area Delineation

Defining riparian areas is a difficult task due to the large number of influencing factors that require consideration, including soil characteristics, hydrology, and landscape features. Riparian areas vary in width, shape, and character and do not stop at a uniform distance away from a stream or watercourse. For this reason, buffers defined as a standard width through various regulations, such as municipal stream corridor ordinances or NJDEP flood hazard area and stormwater regulations do not always delineate the area that is critical for water resource protection. As part of the Raritan Basin Watershed Management Plan (2002, www.raritanbasin.org), the NJWSA and Basin stakeholders proposed a definition of riparian areas using a GIS-based methodology. This approach provides a watershed-specific method using readily available environmental datasets that are generally agreed upon when discussing the ecological, hydrologic, and economic resources associated with surface waterbodies. This riparian area definition and GIS-mapping exercise applies the following parameters to define "riparian areas" within the Raritan Basin:

- Wetlands directly adjacent to stream channels including, wetlands larger than one acre and modified wetlands;
- Wetland transition areas for exceptional resource value and intermediate resource value wetlands;
- Wildlife passage corridors;
- Floodplains including the 100-year floodplain and other flood prone areas; and
- Hydric soils adjacent to surface waterbodies.

The Raritan Basin Riparian Methodology can be viewed at http://www.raritanbasin.org/Alliance/Publications/Methodologies/Riparian_Methodology.pdf.

In 2009, the NJWSA updated the original coverage with the most recent data for each parameter. It should be noted that the above characterization was performed using the 1995 NJDEP stream coverage. An updated stream coverage based on 2002 aerial photography was released in 2005; however, the data did not have any associated attribute data. The methodology identified 1043 acres of riparian areas in the Sidney Brook watershed as of 1995.

11.2 Riparian Area Conversion

Based on the above definition of riparian areas, the NJWSA characterized the loss of riparian areas due to development and other land management activities. Riparian area loss is discussed in the NJWSA report "Surface Waters and Riparian Areas of the Raritan River Basin" (http://www.raritanbasin.org/Alliance/surface_water_riparian.html, 2002). Figure 16 of that report illustrates the estimated degree of riparian area conversion for the North & South Branch Raritan Watershed Management Area (WMA) as defined by the parameters discussed above and based on 1995 land use conditions. That figure also indicates the degree of riparian area conversion for the WMA – 32% of the historical riparian area in the Upper Raritan WMA was converted to urban or agricultural uses by 1995.

Figure 19 of the 2002 report shows the degree of riparian area conversion for each of the subwatersheds (HUC-14s) in the Basin. The majority of the subwatersheds in the Raritan Basin experienced conversions between 20 and 40%. In the Sidney Brook watershed, slightly less than 500 acres of historical riparian area, or approximately 31%, was converted to agricultural or urban land uses by 1995. These data were updated using 2002 land use, and the Sidney Brook watershed did not show any significant change.

11.3 Riparian Health Analysis

The Raritan Basin Watershed Alliance (RBWA), a coalition of public, private, and non-profit interests, promotes the restoration and protection of the Raritan River Basin's 4,000 miles of streams as a critical part of regional water quality and water supply management.

The RBWA's Riparian and Stream Restoration Initiative (Riparian Initiative) directly addresses one of the six critical issues identified by the Raritan Basin Watershed Management Plan. Stream impacts from decades of poor land use and stormwater management can only be reversed through the restoration of impacted streams and protection of remaining natural riparian areas. The Riparian Initiative is coordinated by the RBWA and involves a wide variety of interests and projects.

RBWA Riparian Initiative members identified a list of 26 issues, including showing the scope of and need for restoration, identifying long-term funding and building capacity for project implementation that must be addressed for the Riparian Initiative to be successful. A subcommittee from the New Jersey Section of the American Water Resources Association (NJAWRA-SRC) formed a Technical Workgroup to provide assistance to the Initiative in addressing technical questions under four topics:

1. Inventory and Assessment;
2. Criteria for Site Selection and Setting Priorities;
3. Restoration Methods and Techniques; and
4. Indicators for Success – Monitoring and Evaluation.

The group reviewed many existing protocols for inventory and assessment. The protocols varied widely in terms of scale, need for training and level of detail. Several levels of detail were identified, two of which are addressed in this report:

- **Baseline**: The Raritan Project Riparian Methodology (NJWSA, 2000) was used as a baseline for identifying all riparian areas in the Raritan Basin.
- **Level I:** Level I is intended to provide a basin-wide baseline assessment using remote sensing, aerial photography and available geographic information system (GIS) data. The results of this evaluation focused on characterization of subbasins at the HUC-14 level and did not involve field data acquisition.

The Level I assessment approach involved collecting all readily available data and characterizing each subwatershed throughout the Raritan Basin to provide focus and direction for stakeholders when conducting additional investigations. This process consisted of reviewing and assessing existing information using digital mapping technologies to identify threats and impairments to waterways throughout the basin without the collection of costly field data.

Level I involved a characterization and classification of each HUC-14 as follows:

- *Target for protection and preservation*: Healthy ecosystem, performs all key ecological functions. Proper functioning condition - Stream channel morphology and function are appropriate to soil type, climate and land form. Desired species, including native, threatened, endangered and special status species, are maintained at a level appropriate for the site and the species involved.
- *Generally Good Quality/At Risk/Threatened*: Healthy, but with problems. Some ecological functions are impaired because of degradation, functions are at risk.
- *Impaired or Degraded, Target for Restoration:* Unhealthy. Stop and take action. Many riparian functions are lost or impaired. Not functioning.

The Level I analysis grouped HUC-14s into the above categories and provided a quick comparison of watersheds and a general understanding of riparian condition. From those categories, a HUC-14 can be chosen for additional analysis based on the goals of a particular organization or agency. For instance, an organization could select a HUC-14 classified as an Area of Concern to do an analysis to identify specific restoration sites. Alternatively, an organization could select a HUC-14 classified as Good for protection to do an assessment to support a water quality classification upgrade or to select areas appropriate for open space protection.

Table 30: Riparian Health Analysis – Summary of Parameters

Landscape Condition - all layers apply to the entire HUC-14						
	Parameter	Score 1 (bad)	Score 2	Score 3	Score 4	Score 5 (good)
1	Land Use	Urban	Barren	Agriculture		Forest, Wetland, Water
2	% impervious cover	>20%	15.0 – 19.99	10.00 – 14.99	5.00 – 9.99	0 – 4.99
3	Habitat quality (% of HUC containing habitat based on Landscape Project)	0-19.99	20.00 – 39.99	40.00 – 59.99	60.00 – 79.99	80.00 – 100.00
4	Population density (2000)	>3.0	2.0 – 2.99	1.01 – 1.99	0.5 – 1.00	0 – 0.49
5	Frequency of road crossings, total # crossings/total stream miles	3.00+	2.01 – 2.99	1.51 – 2.00	1.01 – 1.50	0.00 – 1.00
6	Dams - #/stream mile	0.360 – 0.669	0.178 – 0.359	0.098 – 0.177	0.036 – 0.097	0 – 0.035
7	Loss of forest 1986 - 2002	(-1027.57) – (-500.00)	(-499.99) - 0	0 – 99.99	100.00 – 199.99	100.00 – 469.76

Table 31: Riparian Health Analysis – Summary of Parameters

Riparian Zone Condition – all layers apply to the defined riparian area from Baseline						
	Parameter	Score 1 (bad)	Score 2	Score 3	Score 4	Score 5 (good)
1	Land Use	Urban, Barren	Agriculture, Modified Wetland, Agricultural Wetland			Forest, Water, Wetland
2	Water/wetland dependent species	0.00 – 25	26 - 40	41 - 55	56 - 70	71 - 100
3	Riparian Conversion (1986 – 2002)	>3	2.00 – 2.99	1.00 – 1.99	0.01-0.99	Gain or no loss
4	% Impervious cover	>8.00	6.01 – 7.99	4.01 – 5/99	2.00 – 3.99	0.00 – 1.99
5	Erosion potential	High and medium		Low		none

Scores were generated for Landscape Condition and Riparian Zone Condition for each HUC-14 then summed to generate a total score. The Sidney Brook HUC-14 received a Watershed Condition Score of 23.18 and a Riparian Condition Score of 21.68, with a summary score of 44.86. The individual parameter scores are shown in Table 32.

Table 32: Sidney Brook Score

Riparian Condition Parameters	
Land Use	3.76
Water/wetland dependent species	5
Riparian Conversion (1986 – 2002)	5
% Impervious cover	4
Erosion potential	3.9
Total (maximum 23)	21.68
Landscape Condition Parameters	
Land Use	3.18
% impervious cover	4
Habitat quality	4
Population density (2000)	4
Frequency of road crossings	4
Dams - #/stream mile	1
Loss of forest 1986 - 2002	3
Total (maximum 35)	23.18
Summary Score: 44.86 (maximum of 58)	

The riparian health analysis shows that the Sidney Brook HUC-14 falls within the top ranking watersheds in the Raritan Basin (28th out of 136). The Sidney Brook has a relatively high number of dams per stream mile, which reduced the score significantly. There are three known dams in the watershed. The other parameter that reduced the Sidney Brook score somewhat was the Loss of Forest parameter, although this is somewhat misleading. The Sidney Brook received a score of 3, which actually indicates a gain of approximately 52 acres of forest area. Overall, the Sidney Brook watershed scored very high in the riparian health analysis.

11.4 Priority Riparian Buffer Restoration Analysis/CCPI Analysis

In 2005, the North Jersey Resource Conservation & Development Council, the New Jersey Institute of Technology and NJWSA received a Cooperative Conservation Partnership Initiative (CCPI) Grant from the USDA-Natural Resources Conservation Service to develop a riparian restoration plan for agricultural lands in the Raritan Basin. The plan includes identification of agricultural lands in riparian areas, prioritization of lands for restoration projects, estimation of costs for restoration, identification and evaluation of available funding sources and institutional needs and methods for implementation of riparian projects, and creation of a comprehensive education and outreach plan. As part of the CCPI project, a model was developed to identify the highest priority lands for riparian restoration. Some of the model parameters are similar to those utilized in the RBWA Riparian Health Analysis; however this model was modified to focus on individual parcels. The model includes four components, which are detailed below.

1. Soil Erodibility: This index demonstrates the relationship among rainfall, runoff intensity, susceptibility of the soil to water erosion (soil K-factor), and the combined effects of slope length and steepness to estimate the potential for soil loss.
2. Hydrologic Sensitivity/Topographic Index: This measures the potential for generating runoff and is measured through a modified topographic index. This consists of upslope contributing area, surface slope, soil depth, and saturated hydraulic conductivity.
3. Wildlife Habitat: The layer uses NJDEP Nongame and Endangered Species Program's Landscape Project to determine areas of current and probable State endangered or threatened wildlife habitat. Three of the five habitat types listed in the Landscape Project were utilized: forest, forested wetlands and emergent wetland.
4. Impervious Surface: This layer displays the percent impervious cover within the grid, and was based on research which indicates habitat degradation at 10% impervious cover and severe degradation beyond 25% impervious cover.

The four component scores were combined for a final prioritization score. The scores were divided into three categories – high, medium and low priority for riparian buffer implementation. There are many areas along the main stem branches of the Sidney Brook that are considered medium and high priorities for restoration. This information was utilized in the identification of riparian buffer restoration locations. This information can be also useful when determining what the appropriate width of a riparian buffer should be, rather than relying on a standard buffer width throughout a watershed.

11.5 Identification of Riparian Buffer Restoration Sites

In 2007, NJWSA performed reconnaissance at all of the road/stream crossings in the Sidney Brook watershed using the Raritan Basin Watershed Alliance Road Crossing protocol. The protocol was developed to gather basic information about a watershed and to assist in identifying stream assessment and buffer restoration sites.

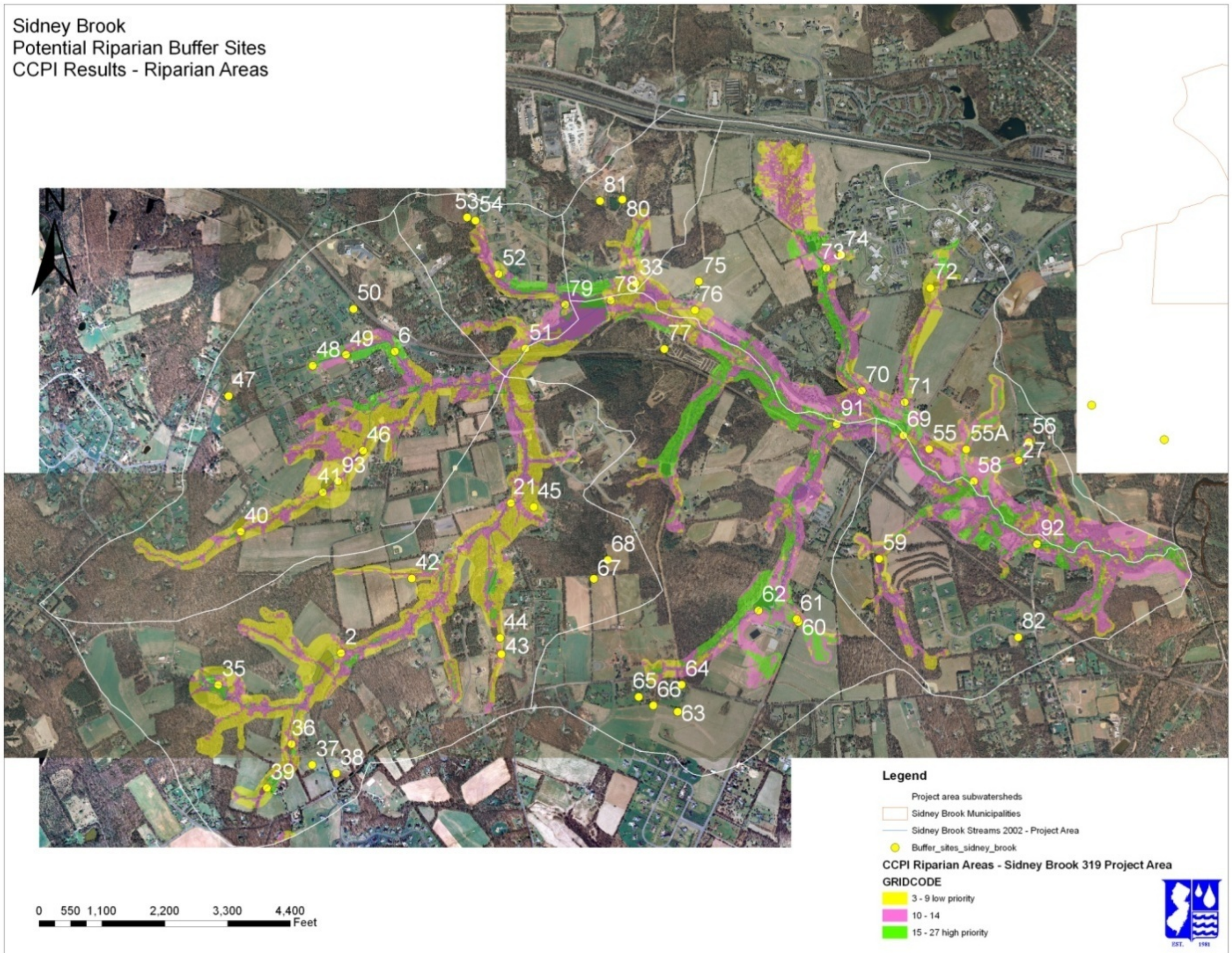
Basic field reconnaissance is performed for each road crossing, collecting data such as the type of crossing (e.g. bridge, culvert, ford), adequacy of riparian buffer, suitability of the location for visual assessments and adjacent land use. Photographs were taken looking upstream and downstream. Appendix V contains the road crossing protocol and information collected for the Sidney Brook, which contains 35 road crossings. An initial list of potential riparian buffer restoration sites was developed from this list.

NJWSA then reviewed the aerial photographs (2007, NJDEP) for the Sidney Brook watershed to further identify potential buffer restoration sites.

A total of 54 potential riparian buffer sites were identified based on the road crossing reconnaissance and the aerial photograph review (Figure 60). Appendix V contains the list of potential riparian buffer sites.

Additional field reconnaissance was performed at the potential buffer sites to determine the need and suitability for buffer restoration. Thirty-four sites were eliminated from the list based on the lack of a stream channel, lack of need for restoration, or other situations which made the location inappropriate for restoration. The remaining 20 sites were then prioritized based on access, the CCPI results, and general need for buffer restoration. Seven sites were prioritized as high, five were prioritized as medium, two were ranked as low/medium and seven were ranked as having a low priority. The seven high priority sites were then grouped into five locations based on common ownership. Planting plans were developed for these five sites. From the five plans, one demonstration project site was to be selected for implementation with funding from the Section 319(h) project.

Figure 60: Potential Riparian Buffer Restoration Sites with CCPI Results

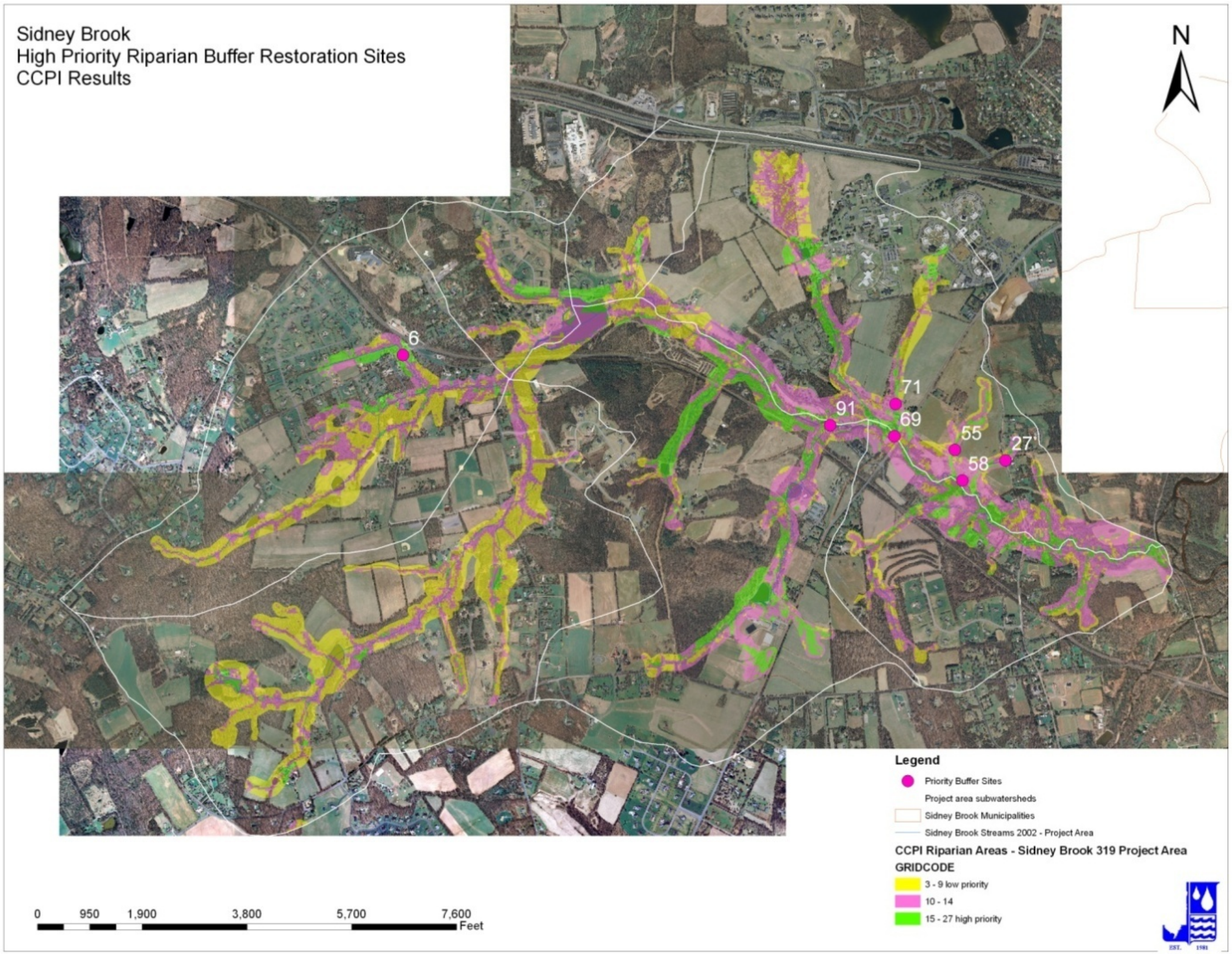


11.6 Priority Riparian Buffer Restoration Sites

Five priority riparian buffer restoration sites were identified (Figure 61):

- Restoration Site 1: Pittstown Road, Potential buffer sites 27, 58
- Restoration Site 2: Pittstown Road, Potential buffer site 55
- Restoration Site 3: Milligan Farms, Potential buffer sites 69, 71
- Restoration Site 4: Adjacent to historic municipal building, Potential buffer site 6
- Restoration Site 5: Race Street, Potential buffer site 91

Figure 61: Priority Riparian Buffer Restoration Sites with CCPI Results



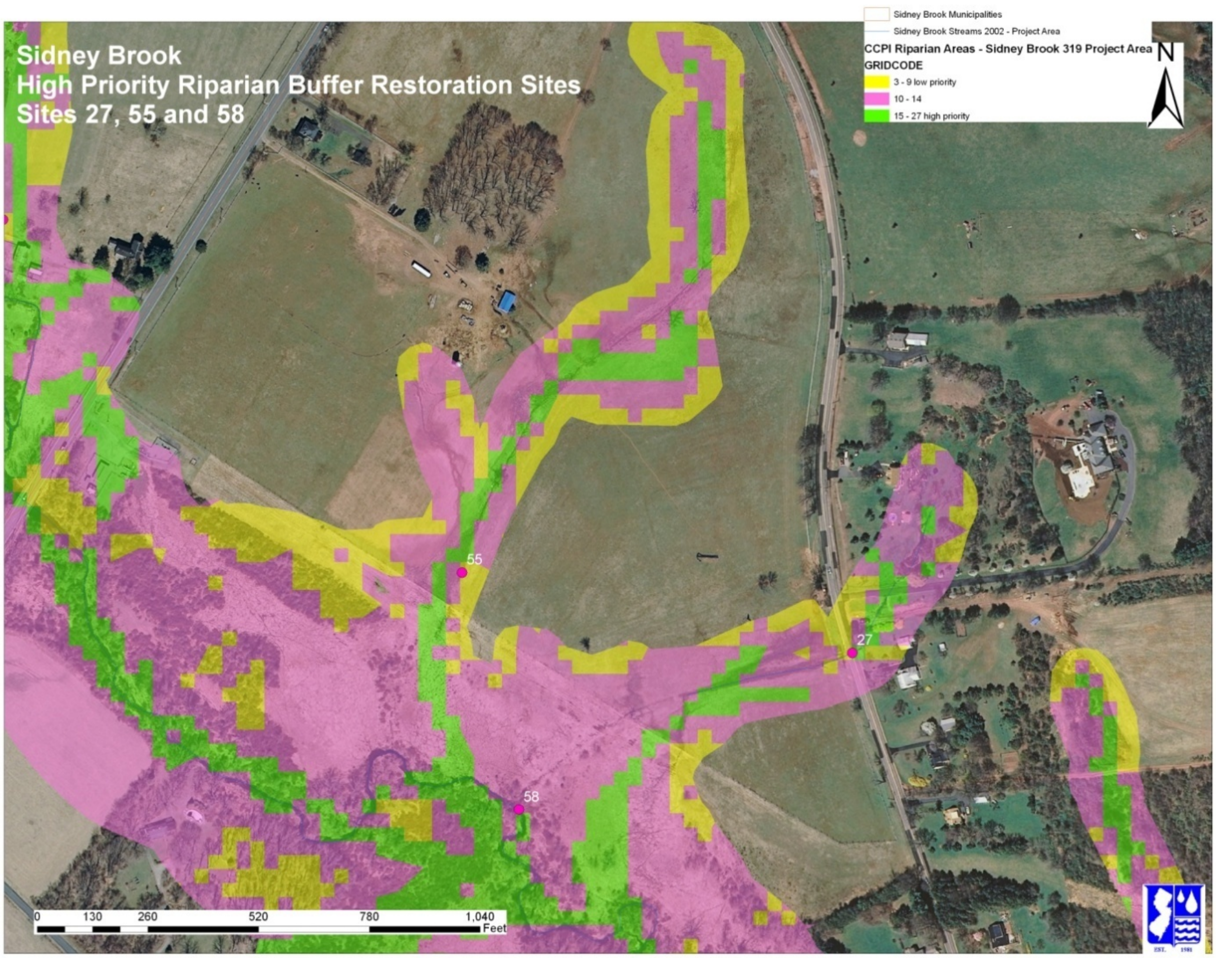
11.6.1 Restoration Site 1

Restoration Site 1 is comprised of potential buffer Sites 27 and 58 within a pasture area on a preserved farm in Franklin Township. The swale starts in the northeastern portion of the pasture by Sidney Road and travels through the pasture to the southwest, then splits into two branches approximately 2/3 of the way down the pasture. There is an unconnected fragment of mapped stream in the northern portion of the pasture, which appears to correlate to the existing swale. There is no mapped stream that correlates to the two branches of the swale. In addition, the RBWMP riparian area delineation correlates to the area of the swale. The northern portion of the swale is ranked as medium and high priority in the CCPI model. After the swale splits, the more northern branch is classified as medium priority in that model and the southern branch is classified as high priority.

The area around the swale is unvegetated, and the swale appears to be contributing sediment to the main stem of the stream. It is likely that nutrients and pathogens are also being contributed to the stream via this swale. Approximately 1,400 linear feet of swale would benefit from revegetation, approximately 25 feet on each side of the swale.

This project is estimated to cost $5,600 to complete. Figure 62 show the location of the site and the CCPI results. The site could be eligible for funding from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) or Farm Service Agency (FSA) through the Farm Bill for buffer restoration.

Figure 62: Priority Riparian Buffer Restoration Sites with CCPI Results



11.6.2 Restoration Site 2

Restoration Site 2 is comprised of potential buffer Site 55, and is located in the same pasture as potential Sites 27/58. This swale starts in the northern portion of the pasture and continues southwest to Grandin Road and the main stem of the stream. The NJDEP stream layer does not show a stream in this pasture; however, the riparian area delineation shows extensive areas expected to contain streams in this pasture. This swale is classified as high priority in the CCPI model.

The area around the swale is unvegetated, and the swale is contributing sediment to the main stem of the stream. It is likely that nutrients and pathogens are also being contributed to the stream via this swale. Approximately 1,200 linear feet of swale would benefit from revegetation, approximately 25 feet on each side of the swale. This project is estimated to cost $4,800 to complete. This site is located on a preserved farm in Franklin Township. The site could be eligible for NRCS or FSA funding through the Farm Bill for buffer restoration.

11.6.3 Restoration Site 3

Restoration Site 3 is comprised of potential buffer sites 69/71 within the Milligan Farms property, which was preserved by Union Township and NJWSA. Figure 19 shows a portion of the restoration site, and Figures 20 and 21 shows the location of the site and the CCPI results. There are two branches of stream that flow through the property before entering the main stem at Route 513. Both are mapped in the NJDEP GIS layer, and the NJWSA riparian area delineation shows extensive riparian areas on the Milligan Farms property. A significant portion of the stream channel is classified as high priority in the CCPI model.

Two segments of stream are recommended for buffer restoration. The first, associated with Site 69, is approximately 1,300 linear feet and is estimated to cost $2,600 to complete. The second segment, associated with Site 71, is approximately 700 linear feet, 25 feet wide on each side of the stream and is estimated to require $2,800 to complete. The stream near Site 71 is intermittent and surrounded by meadow-type vegetation, but could benefit from the addition of trees for canopy cover. This site was selected as the demonstration project and is described in detail in Section 11.11 below.

11.6.4 Restoration Site 4

Restoration Site 4 is comprised of potential buffer Site 6, adjacent to the historic municipal building on Main Street. Figure 63 shows a photograph of the site. This stream segment is mapped in the NJDEP GIS layer and is shown in the riparian area delineation. The CCPI model ranks this site as high and medium priority for restoration.

There is a large area of lawn next to the stream, which is incised and eroded. Stream stabilization could be considered to address the bank erosion issues at this location, which is addressed in the Princeton Hydro suggested projects, and in addition the culvert under Main Street needs mitigation. However, use of vegetation to replace the lawn area could help stabilize the banks to a certain extent. Approximately 100 feet of buffer area approximately 20 feet wide is recommended for the left bank of this reach. The estimated cost for this project is less than $200.

Figure 64: Restoration Site 4

11.6.5 Restoration Site 5

Restoration Site 5 is comprised of potential buffer Site 91, at the intersection of Race Street and Hilltop Lane. The stream is mapped in the NJDEP GIS layer, and also is shows in the riparian area delineation. The CCPI model ranks this segment of stream as high and medium priority. This location is the confluence of multiple tributaries to the Sidney Brook. The stream does not have adequate canopy cover in this location and would benefit from a riparian forested buffer. This project would require approximately $400 to complete.

11.7 Open Space Analysis

Open space preservation is a known and effective means of protecting water resources, however open spaces are rapidly disappearing due to the intense development pressure experienced in central New Jersey. Urbanization and suburbanization can and do impair water resources. The increase in impervious surfaces (roads, sidewalks, parking lots, and roofs) causes a variety of problems for water resources including the faster delivery of stormwater to streams causing erosion; delivery of warmer water to water bodies impairing biota; the deposition and wash-off of pollutants from vehicles causing pollution; the reduction of ground water infiltration causing well losses and reduced stream flows; and, the removal of vegetation (forest, meadows, wetlands) that can provide some treatment of stormwater before delivery to water bodies. Lawns, both corporate and homeowner, also adversely affect water resources if fertilizers are applied in excess and are washed into local water bodies by stormwater.

11.8 RBWMP/RBWA Water Resources Protection Open Space Criteria

Facing the continuing loss of open space from development pressure, NJWSA worked with Raritan Project stakeholders to develop a methodology titled "Water Resources Protection Open Space Criteria" (WRPOS, www.raritanbasin.org) as part of the Raritan Basin Watershed Management Plan. This methodology used GIS technology to identify critical areas for water resource protection. The project was finished in 2002 and covered the entire Raritan River Basin (WMA8, 9 and 10). Protection was defined as acquisition, easements, land management or protection through ordinances. The criteria can be used in ranking parcels for acquisition, easements, and stewardship by entities that preserve or protect open spaces as well as provide additional justification for purchases or other preservation techniques. In developing the criteria, the stakeholders wanted to provide land acquisition entities with a means to integrate water resources protection into their existing methodology for ranking or targeting parcels for acquisition or easements. The criteria can be used in concert with an entity's existing criteria, with their criteria if method does not already consider water resources protection, or can be used directly as a new focus for protection efforts.

The Raritan Project stakeholder group consolidated a set of 20 initial criteria into 4 GIS coverages that encompassed water resources protection criteria. In addition, the subcommittee recommended use of the land use and existing open space coverages to exclude developed and preserved areas. Table 33 outlines the GIS coverages and the criteria represented by each. An explanation of the six coverages is presented below. The NJWSA updated those data layers in 2009 with the most recently developed data.

<u>Wellhead Protection Areas</u>: Wellhead Protection Areas show the spatial extent from where ground water flows into a well for a specific time period. A Wellhead Protection Area is divided by multiple times of travel. Tier 1 and Tier 2 were used in this open space model to indicate the spatial extent in which ground water pollution, if it occurs, poses a significant threat to the water quality of the well. Of note, this GIS coverage, available from the NJDEP, only includes wellhead protection areas for public community supply wells. Individual home or property owner wells are excluded.

Table 33: RBWMP/RBWA Water Resources Open Space Criteria

RBWMP/RBWA Water Resources Open Space Criteria		
GIS Coverage	**Initial Criterion/Criteria Addressed by Coverage**	**Protection Area Includes**
1. Wellhead Protection Areas (WHPA)	Wellhead Protection Areas (A) Recharge Protection (B)	Undeveloped portions of Tiers 1 & 2
2. Ground Water Recharge (NJGS GSR-32 calculation)	Ground Water Recharge (B)	Open spaces within the undeveloped areas of highest recharge rate that comprise 25% of ground water recharge volume for each HUC-11 watershed
3. Riparian Areas (Raritan Project coverage)	Headwaters (D); Floodplains (H); Lakes and ponds (G); Wetlands (I); Proximity to Water Body (R); Trout Production Streams (O)	Use complete Raritan Project methodology (Riparian soils, wildlife corridor, 100-yr floodplain, wetlands) for existing riparian areas
4. Threatened and Endangered Wildlife Species Habitat	Threatened and Endangered Species (K); Mature Forests (J); Vegetative Cover (P); Wetlands (I)	Emergent wetlands and forested wetlands that protect various categories of T&E species, from NJDEP Landscape Project; plus dense forest area as defined by Spruce Run Initiative
5. Preserved Open Space	Preserved Open Space (Determines proximity and linkage of preservation targets to existing, dedicated open space)	All open space identified in Green Acres and NJ Conservation Foundation coverages, plus others as available
6. Land Use/Land Cover or Percent Impervious Cover	LU/LC (S); Percent Impervious (T); Vegetative Cover (P)	NJDEP 1995/97 Land Use/Land Cover

<u>Ground Water Recharge Rates:</u> Ground water recharge rates were calculated using NJGS Method GSR-32, which estimates ground water recharge below the plant root zone using municipality-based climatic, soil type, and land use/land cover information. For the Raritan Basin, ground water recharge rates were developed from the NJDEP's 1995/1997 land use/land cover data. Both the volume and the rate of recharge were used to develop this criterion. The goal of the criterion is to protect areas that contribute the largest amount of recharge in the shortest amount of time. The subcommittee determined that the area that contributes 25 percent of the recharge should be preserved. The analyses were performed by HUC 11 subwatershed to minimize the effects of local climatic and geologic conditions within the Raritan Basin and ensure that areas determined to be protective of groundwater recharge were not concentrated in one area or one WMA. To determine the area that preserves the top 25 percent of volume, the volumes for each land use polygon were ranked by recharge rate then cumulatively summed to equal 25 percent of the annual recharge volume. This ensures that properties desirable to be preserved recharge the quickest. In doing so, large slowly recharging areas will not be selected over quickly recharging areas based on volume alone.

<u>Riparian Areas:</u> The Riparian Area Methodology was discussed elsewhere in this report.

<u>Threatened and Endangered Wildlife Species Habitat:</u> Threatened and endangered wildlife species habitat information was derived from the New Jersey DEP Division of Fish and Wildlife's Landscape Project data. This data was included in the model to

represent high quality vegetated areas, which are beneficial to and protective of water resources. The subcommittee chose to concentrate on forested and emergent wetlands. In addition, a dense forest layer was incorporated into the wildlife species habitat coverage. The Spruce Run Initiative defined dense forests as woodlands in which core areas exist beyond a 400-foot buffer from the forest edges. By definition, all of the areas in the wildlife species habitat coverage are non-urban. The dense forest coverage was created using NJDEP 1995/97 land use land cover data.

Preserved Open Space: The preserved open space coverage was a compilation of all known open space and preserved areas including federal and state-owned lands, land trust properties, county and municipal open space properties, etc. This coverage will be used to exclude areas from the model since they are already preserved.

11.9 RBWMP/RBWA Water Resources Protection Open Space Criteria

In 2003, the NJWSA started an Open Space Acquisition Program to purchase critical lands for water resource protection based on the WRPOS critical area database. To date, about 2,534 acres of land have been preserved by NJWSA and their partners. In 2009, NJWSA recognized the need to refine the criteria to better represent source water protection needs.

The final criteria include seven major criterions (Table 34). Each criterion can be a single data layer or a composite database comprised of other several layers which require further data manipulation and analysis. The details of each criterion are discussed briefly in this report; the full documentation is available at www.raritanbasin.org. The criteria for NJWSA open space acquisition focus primarily on water resources and may not address all of another land conservation entity's or program's goals.

Table 34 RBWMP/RBWA Water Resources Open Space Criteria

	NJWSA Open Space Criteria
1	riparian area based on 2002 Raritan Project
2	highly erodible soil based on Omni Environmental work for WMA 3
3	critical habitats/threatened & endangered species (emergent wetlands, forested wetlands, wood turtle, bald eagle)
4	core/dense forested area based on 2002 NJWSA definition in Raritan Project
5	primary ground water recharge areas
6	primary aquifer recharge areas
7	isolated wetlands from streams & their associated buffers

1. Riparian Area - A riparian zone is defined as the areas adjacent to or hydrologically connected to the surface water network (e.g., streams, rivers, lakes or reservoirs). Riparian zones constitute the immediate upland buffers to surface water as well as areas that may be more physically distant but are hydrologically connected through groundwater flow (e.g., hydric soils or wetlands that are in close proximity to a stream).

2. Highly erodible soils - "Highly erodible soil" means a portion of land surface that is very susceptible to erosive forces and is characterized by steep or long slopes. The USDA-NRCS Soil Survey Geographic Data Base (SSURGO) GIS 2006 defines "highly erodible soil" based on slope and soil composition. Protection of erodible soils will help protect water quality and support wildlife activities.

3. Critical Habitat for Threatened and Endangered Species - Federal and state threatened and endangered species habitats were included to represent high quality vegetated areas, which are beneficial to and protective of water resources. Four types of habitat, including forested wetlands, emergent wetlands, wood turtle and bald eagle were used in the model. These habitats were delineated by the NJDEP Division of Fish and Wildlife's Landscape Project.

4. Dense Forested Area - The criterion for dense forested lands focused on the special ecological role that such forest areas serve for birds and other species that cannot tolerate invasive species. The criterion used to define dense forest is borrowed from the Spruce Run Initiative Project, which defined dense forests as woodlands in which core areas exist beyond a 400-foot buffer from the forest edges.

5. Primary Groundwater Recharge Areas - Ground water recharge rates were calculated using NJGS Method GSR-32, which estimates ground water recharge below the plant root zone using municipality-based climatic, soil type, and land use/land cover information. The NJWSA acquisition workgroup agreed to protect the areas with the highest infiltration rates.

6. Primary Aquifer Recharge Areas - The primary aquifer recharge information was a subset of the Potential Aquifer Recharge dataset developed by New Jersey Geological Survey (NJGS). Aquifer recharge potential was mapped by superimposing ground-water recharge maps over aquifer maps.

7. Isolated Wetlands and Buffers - The isolated wetlands are those that are not associated with the NJDEP 2002 stream network, they are extracted by geoprocessing steps by excluding the "riparian wetlands" from the entire NJDEP wetland data layer. The isolated wetland buffer is the same definition as the "riparian wetland" buffer, which is a 150 foot buffer on exceptional value wetlands, 50 foot buffer on intermediate value wetlands and 25 foot buffer on ordinary wetlands.

For more information on these criteria and how they were developed and selected, see "Preservation of Sensitive Water Resource Areas" (NJWSA, 2009, www.raritanbasin.org).

11.10 Prioritization of Parcels for Water Resource Protection

The first step in prioritizing parcels for protection in the Sidney Brook Watershed was to target the properties that contained at least one-quarter (0.25) acre of at least three overlapping critical area criteria within the parcel boundary. Acreage of critical areas was also examined for total size if they expanded over several parcels. If a parcel had at least four overlapping critical area criteria, it was included, regardless of acreage. The parcel data layer was then placed over the critical area layer. Additional open space layers were also added to examine the potential connectivity and opportunity to develop corridors, as well as to avoid targeting parcels that were already preserved. A spreadsheet was then developed that included block, lot, acreage and types, and number of critical areas found on that property.

From this priority list, potential methods of protection for these parcels could be developed. Potential methods of protection include, but are not limited to: local ordinances that protect water resources by protecting riparian corridors or limiting impervious surfaces, participation in land stewardship programs such as the River-Friendly Farm program, or targeting a parcel for purchase through an acquisition program.

Thirty-nine parcels in the study area of the Sidney Brook Watershed were targeted for protection of water resources. The land use is generally residential and agricultural, with farmland tax assessed properties totaling eighteen parcels. The spreadsheet that was developed as a result of this prioritization is attached in Appendix V.

11.10.1 Protection by Acquisition

Block 25 in Union Township is delineated by Race Street to the north, Route 513 to the east, Cooks Cross Road to the south and Perryville Road to the West. Several of the parcels in Block 25 in Union Township would be excellent prospects for acquisition by land preservation organizations for several reasons. Acquisition could be through direct purchase the property or purchase of development rights.

Based on the NJWSA Critical Area Criteria, several parcels have areas where four and five critical areas overlap. These lands have the ability to provide several water quality benefits if left in a more undeveloped state. Secondly, Block 25 is bordered by existing open space to the west by Union Township Recreation Areas as well as preserved farmland areas to the south. To the north and east of this block is more existing open space stretching from Milligan Farms, across Route 513 to a Franklin Township Open

Space parcel and Summit Manor parcel. These parcels would provide a large area of contiguous open space for water resource protection.

Specific parcels that could be pursued for acquisition for the purpose of water quality enhancement are listed below (Table 35).

Table 35: Potential Acquisition Targets

Potential Acquisition Targets			
Municipality	**Block & Lot**	**Street Address**	**Acreage**
Union Twp.	B25, L35	PITTSTOWN-CLINTON RD	149.77
Union Twp.	B28, L12	JUTLAND-MECHLIN CORNER RD	60.1
Union Twp.	B25, L18.06	HILLTOP LN	49.75
Union Twp.	B25, L21	47 RACE ST	47.1
Union Twp.	B25, L18.04	PITTSTOWN RD	36.29
Union Twp.	B25, L18.01	HILLTOP LN	30.98
Union Twp.	B25, L7	RACE ST	28.3
Union Twp.	B25, L 18.03	PITTSTOWN-CLINTON RD	12.9
Union Twp.	B25, L18	HILLTOP LN	12.1
Franklin Twp.	B5, L16	17 LOWER LANDSDOWN RD	105.82

11.10.2 Protection by Implementation of Best Management Practices

Some parcels in the Sidney Brook Watershed are not suitable candidates for land acquisition or the River-Friendly Farm program, but still can be encouraged to implement some best management practices. For example, the Conrail railroad system owns several parcels in the watershed that contain up to four overlapping layers of critical areas. Some of these parcels are adjacent to the stream and fall within the riparian area. These sensitive areas can be protected by the use of some best management practices along the railway such was proper disposal of waste and controlling erosion during repairs.

There are several best management practices for homeowners that can help protect waterways. Regular maintenance and pumping of a septic system will ensure that it is functioning properly. The installation of rain gardens and rain barrels slows down storm water and allows pollutants to be filtered out before reaching the stream. By participating in the voluntary River-Friendly Resident program, homeowners can learn about several ways to reduce their impact on the watershed.

Proper stewardship of existing open space and preserved farms will also benefit the watershed. Finn Road Park provides many opportunities to capture and slow down stormwater during rain events. Princeton Hydro has worked with Union Township to develop such opportunities. Stream buffer plantings on public lands provide an educational opportunity for communities to discuss stormwater pollution.

11.10.3 Protection by Ordinance

Municipal officials have the ability to institute laws or ordinances that can help protect water quality. There are model ordinances that have been developed to protect sensitive areas such as those identified in the NJWSA Open Space Critical Area database. An ordinance limiting the amount of impervious surface on a property will help to ensure that an area can continue to infiltrate stormwater into the groundwater, an essential environmental service for well dependent communities. Other critical areas found commonly in the Sidney Brook Watershed include habitat for threatened and endangered species as well as dense forests. These habitats are already protected by federal and state law, but can be strengthened through tree protection ordinances that limits clear cutting and other major habitat modifications. In some areas of the watershed, certain types of soil and steep slopes can contribute to large amounts of erosion, impacting the waterway. Local ordinances that limit development on steep slopes and the disturbance of soils will help to reduce erosion in the watershed.

Some of the more sensitive and ecologically important parts of a watershed are found in the wetlands and riparian areas. Protecting these areas not only helps in maintaining a healthy waterway, but also helps to reduce flooding. Municipal officials can enact a Riparian Corridor ordinance that limits development in the riparian area. A similar ordinance for wetlands can strengthen existing laws and protect sensitive habitat and areas for storing and filtering stormwater during heavy flows. These types of ordinances are already largely extent and described in more detail in Section 10.1.6.

Model ordinances from New Jersey Department of Environmental Protection's Division of Watershed Management can be found at the following link: http://www.state.nj.us/dep/watershedmgt/rules.htm#modord

11.10.4 River Friendly Farm

Based on our land use analysis using the critical area criteria, several properties were recommended for the River-Friendly Farm Program. This program is administered by the North Jersey Resource Conservation & Development Council (RC&D), the Raritan Watershed Agricultural Committee and the NJWSA. The program is currently implemented throughout much of Hunterdon County, although the target areas are the Mulhockaway Creek Watershed, Spruce Run Watershed, South Branch Raritan Watershed, and Neshanic River Watershed. An agricultural outreach specialist from North Jersey RC&D performs a review of the farm's management activities, in particular soil loss management, nutrient management, pest management, riparian buffer management, and irrigation water management. If the farm meets the criteria, it is certified River-Friendly. If the farm does not meet the criteria, the agricultural outreach specialist works with the farmer and with a conservation planner from NRCS to develop a conservation plan so that the farm can meet the River-Friendly criteria and to identify potential cost-share programs.

One of the biggest issues in the Sidney Brook Watershed is the high levels of bacteria found in the streams. Producers can utilize techniques that will help to minimize the impacts of livestock, erosion, and fertilization on the watershed. Agricultural areas that are not available for acquisition should be pursued for participation in the River-Friendly Farm program.

Table 36 lists parcels that should be targeted for River-Friendly Farm participation based on the critical area analysis. Note that some of these parcels are also included on the list of potential acquisition targets. The CCPI model can be used to identify priority areas for conservation practice implementation on these properties.

In addition, the CCPI model can be used to identify and prioritize additional parcels for the River-Friendly Farm program by intersecting the agricultural land use layer with the CCPI model results.

Table 36: Potential River Friendly Farm Locations

Potential River-Friendly Farm Locations – Critical Area Analysis			
Municipality	**Block & Lot**	**Street Address**	**Acreage**
Franklin Twp.	B10, L6	131 PITTSTOWN RD	38.85
Franklin Twp.	B10, L2	107 PITTSTOWN RD	18.72
Franklin Twp.	B5, L16	17 LOWER LANDSDOWN RD	105.82
Union Twp.	B28, L33	647 COUNTY RT 579	73.25
Union Twp.	B25, L35	PITTSTOWN-CLINTON RD	149.77
Union Twp.	B28, L12	JUTLAND-MECHLIN CORNER RD	60.1
Union Twp.	B25, L18.06	HILLTOP LN	49.75
Union Twp.	B25, L21	47 RACE ST	47.1
Union Twp.	B25, L18.04	PITTSTOWN RD	36.29
Union Twp.	B25, L18.01	HILLTOP LN	30.98
Union Twp.	B25, L7	RACE ST	28.3
Union Twp.	B25, L 18.03	PITTSTOWN-CLINTON RD	12.9
Union Twp.	B25, L18	HILLTOP LN	12.1

11.11 Milligan Farm Riparian Buffer Planting Demonstration

In January 2010, the New Jersey Water Supply Authority (NJWSA) staff began prioritizing potential buffer sites that were identified through Stream Visual Assessments as well as remote sensing. When the top five sites were selected, based on need for buffer enhancement, accessibility and feasibility of implementation, planting plans were developed. Plans included recommended species, number of plants, design, and cost estimates. Of the five sites with planting plans, one was to be selected for implementation. Due to the public ownership and lack of diverse vegetation, the Milligan Farm site on Pittstown-Clinton Road in Union Township was selected.

11.11.1 Milligan Farm Riparian Buffer Restoration

The project site is located at Milligan Farms on Pittstown-Clinton Road in Union Township, New Jersey. There are several land uses upstream from this site including residential, agricultural and open space. The parcel was preserved as open space by Union Township in partnership with the New Jersey Water Supply Authority in 2009. It was purchased with a combination of funds, including Green Acres and Environmental Infrastructure Trust funding.

The location, its public ownership, and lack of quality riparian vegetation made this site an excellent candidate for the demonstration riparian buffer enhancement. There is very little canopy cover above the stream at this site. The streambanks are vegetated with invasive grasses such as reed canarygrass (*Phalaris arundinacea*), which is beginning to encroach on the stream, and the shrub layer is dominated by invasive species like multiflora rose and autumn olive. Invasive species can reduce the effectiveness of riparian buffers by not allowing the establishment of larger, native trees that are better able to remove nutrients and stabilize soil. There is some fine material in the stream bed indicating some erosion and exposed banks in some areas.

11.11.2 Permitting

The NJWSA, Princeton Hydro and the Union Township Environmental Commission conducted site visits to the Milligan Farm to characterize site conditions. Based on visual observations and soil cores it was determined that the site qualified as wetlands and a freshwater wetlands permit would be needed in order to conduct the planting and the removal of invasive vegetation. The NJWSA prepared a Freshwater Wetlands General Permit 16 – Habitat Enhancement that was submitted by UTEC with the NJDEP as a co-applicant. The permit was received in May of 2011.

11.11.3 Planting

Upon receiving the permit, the NJWSA scheduled the planting for June 17th and 18th. The timing of the planting required a modification to the planting plan. The original planting plan recommended the installation of willow and dogwood stakes, which must be planted while they are dormant. As an alternative, rooted stock willows and dogwoods were planted.

The plants were ordered from Pinelands Nursery in Columbus, NJ. Approximately 270 trees were planted. Species planted included black willow (*Salix nigra*), red-osier dogwood (*Cornus sericea*), silver maple (*Acer saccharinum*), pin oak (*Quercus palustris*), swamp white oak (*Quercus bicolor*), Atlantic white cedar (*Chamaecyparis thyoides*), and river birch (*Betula nigra*). Five NJWSA staff, one AmeriCorps Watershed Ambassador, and four volunteers from the Union Township Environmental Commission and three unaffiliated volunteers participated in the planting. Photographs are included in Appendix V as are all other relevant project materials.

Although invasive species removal was included in the permit, which is valid for five years from date of issuance, no removal was conducted by NJWSA. UTEC may choose to perform invasive species removal at a later date. UTEC issued a press release following the planting (http://www.thehcnews.com/breaking/_article/00005699.htm).

11.11.4 Maintenance Plan

The UTEC must conduct ongoing maintenance to ensure plant survival and the effectiveness of the buffer. For the first several months after the planting, there should be routine examinations to make sure tree shelters and cages are in place. Watering will be necessary to assist the plants in establishing, especially during periods of low rainfall. Checks should also be made after any major rain event where water may cause damage to the plants or cages. Evidence of deer browse or rub should also be noted while conducting site visits. While the plants are being examined, opportunities for adaptive management should be considered. Over time, as the plants are established, the routine checks can be reduced in frequency.

12.0 Technical and Financial Assistance

This section discusses technical and financial assistance necessary to achieve the goals and objectives of the WPP. More specifically it discusses the implementation costs and needs associated with the listed NPS management measures and identifies responsible parties. This section corresponds to the fourth USEPA element.

> *Estimate of the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.*

This WPP has been designed primarily to focus on low intensity NPS management measures that are relatively low cost which require minimal technical assistance to implement thus enabling landowners and other interested parties to participate with minimal expenditure. These types of projects are ideal for this watershed in order to treat the diffuse nature of NPS loading utilizing management strategies that are environmentally friendly and mimicking natural processes, such as vegetative bank stabilization. However, many of the management measures discussed above, including specific implementation projects, are costly and require permitting and engineering studies that will likely require governmental sponsorship in some capacity. While the use of these more intensive designs is limited relative to the overall scope and intended use of the plan they are still important and proper planning considerations including funding must be secured in order to meet the protection goals.

At the basic level there are number of factors that affect implementation; one of the most basic is cost. Cost estimates should include materials, labor, monitoring (pre- and post-installation), engineering, permit acquisition, and maintenance. Funding project implementation, or securing the monies identified by cost estimates, is probably the most critical step in advancing work. Funding may be derived from a wide variety of sources including governmental and non-governmental organizations (NGO), private donations or other fundraisers, taxes or low-interest loans. Not to be overlooked are in-kind matches including landowner cost sharing and other similar initiatives. Securing funding also entails the identification of responsible parties to sponsor projects, which in the watershed will likely stem primarily from the municipalities, but will also rely heavily on landowners. Technical assistance, particularly for agricultural BMP's, will be provided by a number of government organizations, as outlined in Section 10.10. Many of the lower intensity solutions and agricultural BMP's will likely be provided to landowners by municipal and county authorities, but many of the structural projects will require assistance from scientists and engineers to thoroughly characterize the site, file necessary permits, design the solutions, oversee construction, and monitor the results. Another important component is the informational and educational component to provide the community outreach to educate and mobilize the citizens of the watershed.

The following section provides generalized estimates of technical and financial assistance needed to implement the NPS management measures discussed above and to meet the NPS reduction objectives throughout the watershed.

12.1 Riparian Buffer Enhancements

The implementation of riparian buffer enhancements has been identified as the primary NPS reduction measure recommended for implementation in the WPP. This is in large part due to the relative simplicity of these mitigation measures, their efficacy in treating and mitigating numerous NPS pollutant loads, and relatively low costs. Table 37 lists the specifics of riparian buffer enhancement implementation.

Table 37: Riparian Buffer Enhancements

	No-Mow Zones
Description	No-mow zones along stream banks to promote vegetation, bank stability, shading, and other functions.
Responsibility	Landowner, Municipality.
Technical Assistance	Limited, consultant for development of educational information.
Information and Education	Development of mailings and demonstration or workshops. May consider a $50 one-time voucher for program participation.
Funding Sources	Municipality.
Maintenance and Monitoring	Very limited. Removal of invasive vegetation.
Costs	$0 to landowner. $10,000 to municipalities with participation of 200 landowners, plus workshop and mailing costs, anticipated at less than $5,000.
	Riparian Buffer Planting
Description	Replanting of native riparian vegetation to provide a variety of NPS reduction functions.
Responsibility	Landowner, Municipality.
Technical Assistance	Again limited. A standard planting list should be provided for interested landowners. Some permitting may be required on more intensive projects, especially with the removal of invasive vegetation. Professional help may be desirable on larger projects or the use of volunteers. Implementation for a site can be protracted to ease labor and materials costs. County Conservation District, consultants, municipal Environmental Committees, and similar sources may provide technical assistance.
Information and Education	Development of mailings and demonstration or workshops. May consider a cost sharing program for the purchase of plant materials, tree shields, and repellants.
Funding Sources	319(h) grants for public holdings implementation, NRCS grants, NJ Environmental Infrastructure Financing Program, municipal funding, and private funding.
Maintenance and Monitoring	Periodic monitoring of site. Replacement of dead or browsed vegetation as necessary. Bank stabilization surveys to determine impacts. Larger stream monitoring efforts to assess cumulative effects on temperature and NPS loading.
Costs	Materials include plants, repellants, tree shields, and invasive species removal. On projects requiring permitting, design work, and planting plans consultant fees may range from $3,000 to $10,000. Projects requiring only supplemental planting of certain vegetation types such as herbaceous plants and shrubs costs should be less than $1,000 per acre (an area equal to a 50' wide buffer of approximately 900' in length). More intensive designs including complete restoration of vegetated materials may range from $5,000 to $10,000 an acre including labor, materials, and consultant fees. Expected total cost to implement up to 4 stream miles of riparian buffer enhancement along both banks at the upper bound cost of $10,000 per acre would total approximately $500,000.

For the most part implementation will hinge on community outreach to provide information concerning the benefits of riparian buffer enhancement and to develop the public will to implement these plans. Generally technical assistance need is fairly limited and a plant list as well as some general planting guidelines may be sufficient to initiate such projects. Some consulting may be required if buffer enhancements are specifically utilized to provide bank stability rather than general NPS reductions and habitat enhancement. Bank stability plantings may also require a land use permit. In any case ample funds should be available to implement these projects. Total cost for the restoration of up to 4 linear stream miles in the watershed is anticipated to cost around $500,000, a relatively low cost relative to other BMP's considering the scale of implementation or even when weighed against the cost of open space preservation.

12.2 Structural BMP's

Structural BMP's are much more technically difficult to implement and thus are considerably more costly than most of the other NPS pollution reduction measures discussed in the WPP. The simple lack of developed infrastructure in the watershed also limits their use, but new development will absolutely require these measures, as will identified problem areas that require engineered treatment solutions to meet water quality standards, performance goals, and general environmental stewardship. While the education of the public at large is not necessary, familiarity of regulators and policy makers is crucial especially as new designs are developed and implemented. Technical assistance needs are certainly high for these systems and will require consultant engineering assistance, but on public properties the design work may be sponsored by government engineering staffs or subcontracted. Ample opportunity exists to access public funds and grants, including 319(h) grants. Table 38 provides some of the technical considerations for structural BMP implementation.

Table 38: Structural BMP's

	Detention Basins and Wet Ponds
Description	A standard structural stormwater BMP to limit flooding by reducing rates and providing TSS and nutrient removal capacity.
Responsibility	Landowner, municipality in public settings, and sometimes the developer.
Technical Assistance	High, requires extensive engineering including surveying and geotechnical analysis.
Information and Education	Limited, but the promotion of systems offering greater NPS reduction efficiencies should be considered.
Funding Sources	Landowner, sometimes municipality. Modification and retrofits may be eligible for 319(h) grants and other stormwater infrastructure funding.
Maintenance and Monitoring	Routine inspections and mowing. Periodic dredging to remove captured sediments in the basin and the forebay. Influent and effluent monitoring to assess removal efficiency.
Costs	Costs estimated using EPA formula at around $40,000 for 1 acre-ft of storage with declining cost for storage with increased basin size, 10 acre-ft basin estimated at $250,000. Installation projected primarily for newly developed sites

Table 38 (continued): Structural BMP's

Bioretention BMPs	
Description	An advanced structural stormwater BMP to limit flooding by reducing rates and providing increased TSS and nutrient removal capacity utilizing vegetation as a key design element.
Responsibility	Landowner, municipality in public settings, and sometimes the developer.
Technical Assistance	High, requires extensive engineering including surveying and geotechnical analysis. Retrofits of detention basins to bioretention designs should be considered.
Information and Education	Limited, but the promotion of these systems relative to standard detention systems in relation to NPS reduction efficiencies should be considered.
Funding Sources	Landowner, sometimes municipality. Modification and retrofits may be eligible for 319(h) grants and other stormwater infrastructure funding.
Maintenance and Monitoring	Maintenance of vegetation to maintain healthy plant communities is recommended. Mowing and other routine maintenance is not necessary for these designs.
Costs	Costs estimated using EPA formula at around $60,000 for 1 acre-ft of storage with declining cost for storage with increased basin size, 10 acre-ft basin estimated at $290,000. Installation projected primarily for new sites. Retrofits of existing basin cost much less and would consist of appropriate scientific/engineering evaluation of the basin, modification of the existing outlet and low flow channels, design, plant materials and planting.
Infiltration BMPs	
Description	Structural BMP designed to infiltrate captured stormwater up to design storm or decrease the generated runoff volume.
Responsibility	Landowner, municipality in public settings, and sometimes the developer.
Technical Assistance	High, requires extensive engineering including surveying and geotechnical analysis. Retrofits of detention basins to infiltration designs may be considered. Utility in the watershed likely limited by soil percolation.
Information and Education	Limited, but the promotion of these systems relative to standard detention systems in reducing runoff volume should be considered.
Funding Sources	Landowner, sometimes municipality. Modification and retrofits may be eligible for 319(h) grants and other stormwater infrastructure funding.
Maintenance and Monitoring	Maintenance requirements are fairly high in this type of system due to the propensity of the sand layer pores to become blocked over time thus reducing infiltration capacity. Pervious pavement systems require frequent sweeping or power washing.
Costs	Costs estimated using EPA formula at around $20,000 for 1/4 acre-ft of treatment in infiltration basins. Infiltration trenches may cost $5 per ft^3 treated. Pervious pavement may run $90,000 to $130,000 an acre.
Water Quality Swales and Vegetative Filters	
Description	Structural BMP designed to capture and convey water while managing NPS loads.
Responsibility	Landowner, municipality in public settings, and sometimes the developer.
Technical Assistance	High, requires extensive engineering including surveying and geotechnical analysis. Retrofits of existing swales should be considered.
Information and Education	Limited, but the promotion of these systems relative to standard ditches and conveyances should be considered.
Funding Sources	Landowner, sometimes municipality. Modification and retrofits may be eligible for 319(h) grants and other stormwater infrastructure funding. Agricultural uses may be funded through a variety of NRCS sources.
Maintenance and Monitoring	Maintenance requirements should be fairly low, although plantings must be maintained. Periodic removal of solids may be required, especially with systems that use small check dams.
Costs	Costs estimated using EPA guidance at around $15,000 to $30,000 per acre utilizing sod placement, other designs likely cheaper. Vegetated swales, particularly simpler designs, are estimated to be less costly than curb and gutter designs.

Table 38 (continued): Structural BMP's

	Manufactured Treatment Devices
Description	Structural BMP manufactured offsite and inserted in-place. May be used to retrofit existing systems for NPS control.
Responsibility	Municipality, county, or state in public settings, and usually a developer or other party for private holdings.
Technical Assistance	Medium. Large systems may require extensive engineering and other studies. Smaller or simpler systems may be simple bolt-on designs. NJ Stormwater BMP Manual, NJCAT, and manufacturers recommendations and consultants to advise.
Information and Education	None.
Funding Sources	319(h) grants when related to public infrastructure.
Maintenance and Monitoring	Maintenance requirements are high in most of these systems. In particular sediment removal using excavators or vac-trucks can be costly, or the replacement of media filters and should likely be scheduled several times per year based on projected solids capture.
Costs	Vary widely according to size and treatment capacity and are set by the respective manufacturers. Larger designs may range from $5,000 to well over $150,000. Engineering and mentoring costs can be quite high ranging from $5,000 to $30,000 and potentially more. Installation costs may also be high. Costs are most closely linked with site specific conditions.

12.3 Cultural BMP's

Cultural BMP's are another measure that needs to be implemented throughout the watershed, which, like riparian buffer enhancement measures, will depend strongly on public outreach. Unlike other measures a simple change in procedure or practice is the impetus of most of these measures which means little expenditure or procurement of materials. Technical assistance on the implementation may be necessary, but should be limited; information is provided in Table 39.

Table 39: Cultural BMP's

	Fertilizer Use
Description	To promote the use of non-phosphorus and slow release nitrogen lawn fertilizers and to alter application practices to minimize runoff.
Responsibility	Landowner.
Technical Assistance	Limited. Confined to development of educational program.
Information and Education	Landowner education program development and mailing. Also, interface with local vendors to ensure availability of product.
Funding Sources	Municipal.
Maintenance and Monitoring	None.
Costs	Educational costs of $3000.

Table 39 (continued): Cultural BMP's

	Yard and Pet Waste
Description	To promote the responsible disposal of yard and pet waste to minimize bacterial and nutrient loading to the stream.
Responsibility	Landowner.
Technical Assistance	Limited. Confined to development of educational program.
Information and Education	Landowner education program development and mailing.
Funding Sources	Municipal.
Maintenance and	None.
Costs	Educational costs of $3000.
	Waterfowl Control
Description	To limit NPS loading, especially bacteria, related to Canada geese.
Responsibility	Landowner.
Technical Assistance	Limited, confined to development of educational program. May require professional to disturb resident birds, addle eggs, or apply repellants.
Information and Education	Landowner education program development and mailing.
Funding Sources	Municipal.
Maintenance and Monitoring	None.
Costs	Educational costs of $3,000. Site costs may range from $500 to $3,000.
	Road Salt Application
Description	To limit water quality impacts related to road salt application by changing application practices and maintaining acceptable yard and storage conditions.
Responsibility	NJDOT, County Road department, Municipal road department.
Technical Assistance	Limited to road crews.
Information and Education	Road deicing seminars are held periodically throughout the state.
Funding Sources	State, County, and municipal. NJDOT and USDOT grants may be available.
Maintenance and Monitoring	Monitoring would be part of a larger water quality monitoring effort with special attention paid to seasonal variation in conductance or TDS measures.
Costs	Cost should be limited to employee training programs. Storage facility upgrades are assessed on an individual basis. Product cost differentials are low.
	Water Conservation Practices
Description	The reduction of water consumption to protect groundwater sources and limit wastewater generation.
Responsibility	Landowner.
Technical Assistance	Limited, confined to development of educational materials.
Information and Education	Landowner education program development and mailing.
Funding Sources	Municipal.
Maintenance and Monitoring	None.
Costs	Educational costs of $3,000. High efficiency plumbing fixtures and appliances should be upgraded on a normal schedule.

Table 39 (continued): Cultural BMP's

	Septic Management Practices
Description	The maintenance of onsite septic systems to promote proper function and reduce bacterial and nutrient loading to surface and groundwater.
Responsibility	Landowner.
Technical Assistance	Limited, confined to development of educational program.
Information and Education	Landowner education program development and mailing. Many educational materials are available from the USEPA, ANJEC, and the Groundwater Foundation.
Funding Sources	Municipal.
Maintenance and Monitoring	Regular maintenance and monitoring as directed in the information and education materials.
Costs	Educational costs of $3,000. The offer of $25 vouchers to promote regular septic tank has been used with success elsewhere in the state. Watershed wide cost up to $25,000. Homeowner costs to pump septic tanks is usually around $300.
	BMP Maintenance
Description	The maintenance of BMPs to ensure continued efficacy per design standards.
Responsibility	Variable, including landowner, developer, municipality, county, MUAs, or responsible road crews. Identifying and assigning responsibility, as well as funding, is a goal in establishing normal BMP maintenance routines.
Technical Assistance	Design engineer and developed SOPs, NJ Stormwater BMP manual, NJDEP, and other similar agencies.
Information and Education	Relatively limited. Should be predicated on information obtained from design engineer and SOPs.
Funding Sources	Variable, see Responsibility.
Maintenance and Monitoring	Monitoring BMPs for efficacy is an important component of maintenance. Maintenance activities may include: visual inspections, vegetation management, debris and litter removal, mechanical components, biological controls, sediment removal, and street sweeping.
Costs	Cost vary widely depending on need. Projects requiring heavy equipment, such as sediment removal, may be substantial. Annual maintenance costs should be budgeted at 5-
	Rain Barrels
Description	Using rain barrels to minimize roof runoff, beneficial reuse of captured water, and limiting further withdrawals from groundwater.
Responsibility	Landowner.
Technical Assistance	The Rutgers Water Resources Program provides technical assistance and educational materials. http://water.rutgers.edu/Stormwater_Management/rainbarrels.html
Information and Education	An awareness campaign should be implemented that could be dovetailed with water conservation practices and other environmental news.
Funding Sources	Landowner.
Maintenance and Monitoring	Limited, periodic use of captured water.
Costs	$150 per install, less for clean, recycled barrels.

12.4 Invasive Species Management

The management of invasive species in the Sidney Brook watershed is crucial to restoring suitable wildlife habitat and maintaining high riparian buffer efficiency in the capture of NPS pollutants and other valuable ecological services. The control of invasive vegetation may be relatively simple, though labor intensive, and will likely require the use of a certified pesticide applicator when spraying adjacent to the tributary network and on large scale removal efforts. Education should be provided on the benefits of restoring native vegetation and removing invasive species which should be packaged with other educational efforts. It will also be important to educate the public about potential issues in the use of chemical herbicides and the safe handling of such material. Invasive species control is also one of the BMP maintenance items and will need to be considered in the maintenance plans of most other BMP's and be integrated in most riparian buffer enhancement and bank stabilization projects. The control of invasive species using professional services is estimated to run between $1,000 to $2,000 per acre for both chemical and mechanical removal activities. Table 40 provides more information.

Table 40: Invasive Species Management

	Invasive Species Management
Description	Chemical treatment and mechanical removal to limit the spread of invasive species. May be used in advance of riparian buffer enhancement and as a maintenance measure.
Responsibility	Landowner.
Technical Assistance	NRCS and NJDEP Pesticide Control Program. Certified applicators likely needed for larger projects.
Information and Education	Information and Education should be packaged with other programs.
Funding Sources	Landowner, NRCS grants, component of 319(h) grants.
Maintenance and Monitoring	An important maintenance technique for stream restoration projects. Simple invasives control may require follow up treatments to ensure complete removal and to limit new colonization.
Costs	Certified applicator costs will range from $1,000 to $1,500 per acre for chemical treatment and up to $2,000 per acre for mechanical removal. Landscapers and others may charge less for mechanical removal.

12.5 Impoundment Removal

Impoundment removal in the Sidney will help to restore normal stream hydraulics, reduce stream warming, and restore fish passage. Impoundment removals are highly technical projects and will require substantial H&H studies and engineering to both remove the impoundment and then restore bed and bank conditions. Impoundment removal will certainly require technical assistance, but much funding is being made available from a variety of sources including non-profit groups to affect widespread removals throughout the northeast. For the most part the impoundments in the Sidney watershed that are likely to be removed are quite small with most of the associated costs belonging to *in-situ* studies, permitting and regulatory compliance, and bank restoration activities. Smaller impoundment removals will probably cost approximately $10,000 to $20,000 (Table 41) and may be even less for unregulated or breached structures that function similarly to general obstructions rather than true impoundments. While the removal of larger impoundments would be of great value in the watershed, particularly for the reduction of temperature, which is one of the highest priority threats impacting the stream, the removal of these impoundments in the near future is unlikely given their land use setting, their function, and ownership. However, efforts should be made to encourage their removal where appropriate which would be initiated with educational efforts.

Table 41: Impoundment Removal

	Impoundment Removal
Description	The removal of impoundments, debris, and other obstructions that are barriers to fish passage, impound sediments, and cause changes in stream hydraulics.
Responsibility	Landowner.
Technical Assistance	Probably the most technically driven strategy discussed here, requires H&H studies, surveys, engineering, and construction expertise. Other technical assistance may be obtained from American Rivers, Dam Safety, Army Corps of Engineers, NRCS, US Fish and Wildlife Service, and others.
Information and Education	High value on the promotion of such techniques and continued promotion. Many of these techniques are standard procedures on agricultural lands in the watershed.
Funding Sources	Variety of sources including 319(h), Fish and Wildlife, NJDEP, American Rivers, stakeholders, private, and other.
Maintenance and Monitoring	Maintenance may include adaptive management solutions to ensure proper design function and should primarily focus on adjunct restoration features such as plantings.
Costs	Costs are variable. Actual removal, especially of small impoundments such as those identified in the Alexauken, are removed at minimal expense. Adjunct activities such as engineering, permitting, and restoration activities such as the installation of grade controls and plantings account for the bulk of the expense. Very small impoundments, such as those found on first-order tributaries, may be removed for as little as $10,000 - $15,000, with increasing costs thereafter.

12.6 Bed and Bank Stabilization

Bed and bank stabilization, along with structural BMP measures, are among the most complex measures recommended for the watershed and will require significant technical assistance for most projects. These measures involve a number of strategies including planting, various toe protection measures including riprap and boulder toes among others, flow deflection devices to redirect flow away from vulnerable banks, and grade control structures. Technical assistance can be found among a number of government agencies especially during the planning phases, but the implementation will require private consultation for surveys, hydraulics and hydrology (H&H) studies, engineering, and installation. Funding for these projects will also vary, but 319(h) grants may be a major funding source for these activities, especially with identification and inclusion of these designs in this document. Maintenance and monitoring requirements will again depend on assessing function in the field, particularly after the first several storm events and during floods. It is also necessary to consider that bed and bank stabilizations are targeted measures and that multiple management measures may be utilized in conjunction. For example, bank grading would almost certainly be followed by bank plantings and the establishment of a riparian buffer. Therefore costs for these activities vary widely. Material costs can be modest for most of these designs with the bulk of funding going towards the design and installation phases. Permitting for these designs is also a special consideration and the antidegradation protections afforded by the C1 status of the stream will increase the complexity of permitting in this watershed. Many of these jobs, on the scale likely to be seen in Sidney Brook, will start around $10,000 to $20,000 dollars, but more extensive measures, particularly where severe or long erosional features are being repaired, may easily run a range of $50,000 to $100,000, as indicated in Table 42.

Table 42: Bed and Bank Stabilization

	Bank Stabilization
Description	A variety of bank stabilization measures to limit erosion or lateral migration including planting, brush mattresses, live fascines, and bank grading.
Responsibility	Landowner, municipality or other government agency on public lands.
Technical Assistance	Will vary according to selected measure. Planting, brush mattresses, and fascines are easily installed but bank grading will require engineering assessment and H&H studies as well as excavators.
Information and Education	Limited. The use of the low-tech solutions should be discussed with riparian buffer enhancements.
Funding Sources	Private funding from watershed groups and other interested parties, 319(h) grants, NRCS grants.
Maintenance and Monitoring	Properly installed designs should require minimal maintenance, but site should be frequently checked during first several flood events. Channel stability monitoring may be required and more holistic watershed monitoring to measure cumulative effects.
Costs	Variable. Low tech installations estimated at $15 to $30 per linear foot, while bank grading may run $20 to $30 per linear foot.
	Toe Protection
Description	Bank armoring using hard materials such as rootwads, riprap, boulder toe, and gabions designed to absorb hydraulic impacts and prevent bank failure and erosion.
Responsibility	Landowner, especially in the protection of privately held infrastructure, municipality, or other government agency on public lands. NJDOT, other agencies responsible for roads, and utilities may share responsibility.
Technical Assistance	High degree of technical assistance required for H&H studies, engineering, and installation. County and municipal engineering departments, county Conservation District, watershed management groups, or others may assume design for public entities otherwise private consultants, which may also be used as contractors.
Information and Education	None.
Funding Sources	319(h) grants for public holdings implementation, NRCS grants, NJ Environmental Infrastructure Financing Program, municipal funding, and private funding.
Maintenance and Monitoring	Maintenance should be limited, but visual inspections are necessary. Monitoring may look at bank stability, erosion, and water quality impacts and pre- and post-installation monitoring may be required.
Costs	Costs vary considerably. Installation for rootwads is $500 each, 1 cubic yard of riprap placed is $100, and 1 cubic yard of gabions is $200. Engineering, hydraulic studies, and permitting will vary by site, but $10,000 may represent a starting cost.
	Flow Deflection
Description	Installation of flow deflection devices to redirect erosive flow along streambanks.
Responsibility	Landowner, especially in the protection of privately held infrastructure, municipality, or other government agency on public lands. NJDOT, other agencies responsible for roads, and utilities may share responsibility.
Technical Assistance	High degree of technical assistance required for H&H studies, engineering, and installation. County and municipal engineering departments, county Conservation District, watershed management groups, or others may assume design for public entities otherwise private consultants, which may also be used as contractors.
Information and Education	None.
Funding Sources	319(h) grants for public holdings implementation, NRCS grants, NJ Environmental Infrastructure Financing Program, municipal funding, and private funding.
Maintenance and Monitoring	Maintenance should be limited, but visual inspections are necessary. Monitoring may look at bank stability, erosion, and water quality impacts and pre- and post-installation monitoring may be required.
Costs	Material costs are relatively low relative to installation and design. Channel excavation is estimated at $25 per cubic yard. Rock vanes and similar designs are estimated at $150 per linear foot. Again, engineering, hydraulic studies, and permitting are likely to start around $10,000.

Table 42 (continued): Bed and Bank Stabilization

	Grade Control
Description	Structures such as cross vanes, step pools, and engineered rock riffles to minimize bed incision.
Responsibility	Landowner, especially in the protection of privately held infrastructure, municipality, or other government agency on public lands. NJDOT, other agencies responsible for roads, and utilities may share responsibility.
Technical Assistance	High degree of technical assistance required for H&H studies, engineering, and installation. County and municipal engineering departments, county Conservation District, watershed management groups, or others may assume design for public entities otherwise private consultants, which may also be used as contractors.
Information and Education	None.
Funding Sources	319(h) grants for public holdings implementation, NRCS grants, NJ Environmental Infrastructure Financing Program, municipal funding, and private funding.
Maintenance and Monitoring	Maintenance should be limited, but visual inspections are necessary. Monitoring may look at bank stability, erosion, and water quality impacts and pre- and post-installation monitoring may be required.
Costs	Channel excavation is estimated at $25 per cubic yard. Cross vanes and similar designs are estimated at $150 per linear foot. Again, engineering, hydraulic studies, and permitting are likely to start around $10,000. Costs may be substantially reduced, especially for the installation of rock riffles, if native bed materials are utilized.

12.7 Manure Management

The management of manure in the watershed, while technically an agricultural BMP, has been called out separately due to potential loading issues in the watershed. While not a ubiquitous problem in the watershed the concentrated loading associated with manure handling and disposal in the watershed has called special attention to this issue. For the Sidney Brook watershed low intensity solutions for manure handling have been specified based primarily on the proper handling and spreading as specified by the NJDA. This therefore relies on the formation of manure handling plans which outline various BMP's. Other more technical solutions such as the installation of vegetated buffer strips may be considered where the capacity for storage, topography, or proximity to tributary networks requires it. In such cases technical assistance may be required, but as with most efforts, information and education will be one of the priorities for instituting better manure management practices (Table 43).

Table 43: Manure Management

Manure Management	
Description	Implementation of practices and structural controls to limit NPS bacterial and nutrient loading to the tributary network.
Responsibility	Landowner.
Technical Assistance	Much technical assistance is available including the NRCS, NJ Dept. of Agriculture, NJ Agricultural BMP Manual, Rutgers Cooperative Extension, and the county Conservation District.
Information and Education	Information and education efforts are crucial to this effort and should be based on the wide variety of available materials.
Funding Sources	NRCS Grants, River Friendly Farm Program with NJ RC&D, County Soil Conservation District, Landowner
Maintenance and Monitoring	Maintenance varies considerably with selected method. Vegetated filter strips may require periodic maintenance planting. Monitoring implemented on watershed scale to monitor coliform concentrations and at identified hot-spots.
Costs	Filter strips may run as high as $30,000 per acre but are likely to be less, and simple establishment of vegetated buffers is expected to average $5,000 per acre. The development of manure management plans is expected to be as low as $1,000 per plan.

12.8 Agricultural BMP's

The agricultural BMP's recommended for this watershed are of relatively limited scope to increase the adoption rate. One of the critical components of these BMP's therefore is the outreach component to inform the agricultural community of their benefits. Implementation and technical assistance may be provided by a variety of agricultural authorities including the NRCS, NJDA, and County Conservation District among many others. These authorities may also serve as the primary funding sources for the implementation of these projects. For the most part many of the recommendations are based on changing practices and not the physical installation of structural BMP's, and therefore many of the recommendations are based on the implementation of management plans that are outlined in the NJ Agricultural BMP manual. Some of the more technical methods, such as the installation of grassed waterways to repair eroded drainage features, the development of vegetated filter strips, or improved agricultural stream crossings may require a certain amount of engineering assistance. It should be noted that many of the measurement strategies, such as residue management and cover cropping, are already in use in the watershed, but must be continued to be utilized to maintain water quality. Costs will vary widely according to method but the development of manure management plans, contour cropping, and other methods are generally low cost. No-till methods and other similar measures would represent the cost in the purchase of equipment or resources needed to implement these farming strategies, while grassed waterways or vegetated filter strips may cost up to $15,000 per acre dependent on design, but may be more simply implemented for as low as $1,000 per acre. Minimal costs are associated with the installation of improved stream crossings. Table 44 provides an overview of the technical assistance needs for agricultural BMP's.

Table 44: Agricultural BMP's

Conservation Cover	
Description	The implementation of conservation cover, pasture management, conservation crop rotation, and other measure to limit soil erosion and NPS pollutant loading.
Responsibility	Landowner and Conservation District.
Technical Assistance	NRCS, Conservation District, NJDA, and other agricultural authorities.
Information and Education	High value on the promotion of such techniques and continued promotion. Many of these techniques are standard procedures on agricultural lands in the watershed.
Funding Sources	Variety of NRCS and NJDA grants.
Maintenance and Monitoring	Low. Monitoring should be included in large scale watershed studies.
Costs	Generally low. For the most part this represents a change of procedure. Educational costs estimated to $5,000. Cost with some methods, such as no-till, may require the initial purchase of expensive equipment.
Conservation Tillage	
Description	The implementation of conservation tillage practices to minimize runoff generation and erosion.
Responsibility	Landowner and Conservation District.
Technical Assistance	NRCS, Conservation District, NJDA, and other agricultural authorities.
Information and Education	High value on the promotion of such techniques and continued promotion. Many of these techniques are standard procedures on agricultural lands in the watershed.
Funding Sources	Variety of NRCS and NJDA grants.
Maintenance and Monitoring	Low. Monitoring should be included in large scale watershed studies.
Costs	Low. For the most part this represents a change of procedure. Educational costs estimated to $5,000. Costs will be incurred in a reduction of production area if conservation buffer strips and other measures are implemented.
Grassed Waterways	
Description	The use of grassed waterways and improved conveyance systems to limit potential for erosion and solids loading.
Responsibility	Landowner and Conservation District.
Technical Assistance	NRCS, Conservation District, NJDA, and other agricultural authorities. Engineers and other private consultants may be utilized for the design phase.
Information and Education	High value on the promotion of such techniques and continued promotion.
Funding Sources	Variety of NRCS and NJDA grants.
Maintenance and Monitoring	Periodic maintenance including inspection and replacement of plants or seeding as needed. Monitoring should be included in large scale watershed studies.
Costs	Dependent on design costs can range significantly $1,000 to $15,000 per acre. The simple implementation of no-mow zones, to selective planting, to sod placement and hydroseeding explains the large range.
Improved Stream Crossing	
Description	Improved stream crossing to limit erosion within the channel and the transport of sediments.
Responsibility	Landowner and Conservation District.
Technical Assistance	Limited to NRCS, Conservation District, NJDA, and other agricultural authorities.
Information and Education	High value on the promotion of such techniques and continued promotion.
Funding Sources	Variety of NRCS and NJDA grants.
Maintenance and Monitoring	Periodic replacement of stone as necessary.
Costs	Material costs are low starting at around $500. Permitting and engineering burden is also minimal for small crossings.

12.9 Open Space Preservation

The protection of high quality natural resources, environmental functions, and rural livelihoods through open space preservation programs has been a cornerstone of environmental policy in both Union and Franklin Townships, and must be maintained moving forward. Technical assistance is relatively limited, but conferring the benefits of preservation is paramount to the success of continuing efforts. The identification of properties suitable for preservation will depend largely on the use of natural resource inventories in addition to other programs. A wide variety of funding sources is available for the preservation of open space including established dedicated open space funds and taxes in the municipalities, Green Acres, and Farmland Preservation Program among others. Costs will be extremely variable and outright purchases will depend on market value of specified property, while deed restrictions and easements may depend on other criteria. Table 45 summarizes some of the components of open space preservation programs.

Table 45: Open Space Preservation

	Open Space Protection
Description	Preservation and protection of natural resources and areas as well as agricultural lands.
Responsibility	Landowner and municipality primarily, but other parties such as the county and state.
Technical Assistance	Primarily municipal with a reliance on existing Open Space Plans, also county, NJDA and various stakeholder groups.
Information and Education	Continued education on the value of preserving open spaces.
Funding Sources	Multiple. Municipal open space tax, Green Acres, NJDA Farmland Preservation Program, NRCS, stakeholders, D&R Greenway Land Trust, and others.
Maintenance and Monitoring	Maintenance should include conversion to environmentally friendly land uses where appropriate using a variety of strategies discussed in the WPP. Periodic monitoring to establish resource inventory.
Costs	Variable. Outright purchase will be market value. Conservation easements, deed restrictions, and other similar devices to be determined by appropriate authority and existing policy.

12.10 Monitoring

While monitoring will be discussed in greater detail in Section 15.0 of this report it is important to outline some of the basic efforts and costs associated with the monitoring program. As this document is predicated on the identification of water quality impairments monitoring will be an important step in tracking the progress and success of the WPP. The monitoring referred to in this section is geared towards watershed scale studies rather than site specific efforts that will be designed as part of specific implementation projects. The watershed scale studies will be fairly technical and will require approval from the NJDEP prior to implementation, although the work will be conducted by environmental consultants and may utilize volunteer monitoring to lower costs and increase public participation. Funding will largely follow that of other projects, and money may be utilized from other projects. Costs for monitoring will vary significantly based on the intensity of the design, but at a minimum should continue to monitor problematic nutrients, solids, *in-situ* parameters such as temperature, pH, and dissolved oxygen, and should probably also include hydrology modeling. Periodic review of the material and updates and pollutant loading and hydrology models is also recommended. The following table (Table 46) summarizes the amount of technical and financial assistance associated with monitoring efforts.

Table 46: Monitoring

	Monitoring Program
Description	The implementation of a watershed monitoring program as required by this document to track changes in water quality and environmental function over the course of the project.
Responsibility	Muncipality primarily, but site specific monitoring will be associated with each project.
Technical Assistance	NJDEP will provide technical approval of monitoring plan methodology, but monitoring will likely be conducted by professional consultants and should consider the use of volunteer monitors.
Information and Education	Monitoring results will be communicated regularly to stakeholders and be used to track progress, measure milestones, and drive further efforts.
Funding Sources	Variety of sources including 319(h), Fish and Wildlife, NJDEP, stakeholders, private, and other.
Maintenance and Monitoring	Monitoring should be conducted annually, preferably on a seasonal basis.
Costs	Costs are variable dependent on laboratory fees, level of detail, number of stations, and sampling frequency. Cost is likely to run around $10,000 per year for a thorough watershed monitoring approach. Periodic review of collected material and updates to models recommended at 5 year intervals.

13.0 Information and Education

This section reviews the information and education aspect of the Watershed Protection Plan. More specifically, it deals with identifying and building stakeholder involvement, developing educational and outreach programs and materials, and encouraging the adoption of measures and practices to protect the watershed and water quality. This section corresponds to the fifth USEPA element.

> *An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.*

The protection and preservation of water quality in the Sidney Brook watershed is contingent upon the education of the target audience including elected officials, residents, landowners, farmers, and businesses in the watershed. The goals of information and education programs should include:

- Improve communication, training, and coordination among local, county, and state governments, local committees, and environmental and stakeholder organizations for watershed related activities
- Improve public education and raise awareness to promote stewardship of watershed resources, improve water quality, and reduce nonpoint source pollutants
- Improve environmental and land conservation efforts by preserving open space and sensitive environmental areas and habitats
- Celebrate successes to recognize noteworthy efforts, encourage participation, and continue the implementation of the Sidney Brook Watershed Protection Plan

This WPP has already successfully identified a variety of project partners and stakeholder groups that have the ability and capacity to successfully promote conservation efforts and disseminate educational materials. In addition to the primary grantee and project sponsor Union Township, the following parties have been identified as project partners:

- Franklin Township Environmental Commission
- New Jersey Water Supply Authority
- Hunterdon County Planning Board

A number of outreach activities should be considered for the implementation of this WPP. A survey conducted by Hunterdon County polled residents to determine the efficacy of various outreach programs; the results are listed in Table 47 below. Mailing newsletters was determined to be the most effective outreach tool of those queried, followed by newspaper advertisements and internet content. Information posted at public facilities, flyers sent from schools, and broadcast media were deemed relatively ineffective in communicating information. While these efforts were not as favorably rated much of the loss in effective communication seems likely tied to reduced audience delivery rather than an ineffective format. However, in general these types of information and education outreach efforts can be quite effective and show the willingness of the public in general to review written materials.

Table 47: Outreach Efficacy Survey

Outreach Effort	Effective	Not Effective	Not Sure
Mailing Newsletters	81%	7%	12%
Newspaper Advertisements	69%	15%	16%
Website Publishing and Emails	56%	21%	23%
Brochures, Flyers, and Posters at Public Facilities	41%	31%	28%
Flyers Sent Home from School	40%	49%	11%
TV and Radio Media	32%	39%	29%

In addition to these outreach methods other programs should be considered. Other effective outreach programs include:

- Demonstration projects
- Watershed tours and hikes
- Workshops and staff training seminars
- Volunteer opportunities for cleanups, planting, and monitoring
- Planning efforts and local ordinances

The development of information programs and educational materials should rely heavily on the abundance of available information published by USEPA, NJDEP, and other sources that is specifically focused on the implementation of information and education programs for watershed protection plans and general NPS pollutant reduction strategies. One of the best and most exhaustive sources for the development of outreach programs is the USEPA's *Getting in Step: A Guide for Conducting Watershed Outreach Programs*; this document can be downloaded at:
http://www.epa.gov/OWOW/watershed/outreach/documents/getnstep.pdf.

While the *Getting in Step* document discusses the outreach program development and implementation, the informational and educational materials are also available from a wide variety of sources. One of the more useful sites is the USEPA *Nonpoint Source Outreach Digital Toolbox*, which can be accessed online at: http://www.epa.gov/nps/toolbox. The NJDEP Division of Watershed Management also provides a variety of tools at the outreach and education webpage (http://www.nj.gov/dep/watershedmgt/outreach_education.htm) which discusses a variety of programs such as the New Jersey Watershed Ambassadors Program, Project WET (Water Education for Teachers), and Clean Water Raingers and other educational publications, as well as volunteer monitoring. The various project partners may also provide outreach materials including the Hunterdon County Planning Board and the New Jersey Water Supply Authority.

A sampling of the other groups and websites that should be consulted includes:

- The Groundwater Foundation - www.groundwater.org
- NJDEP Stormwater and Nonpoint Source Pollution – www.njstormwater.org
- The River Network – www.rivernetwork.org
- EPA Handbook on Septic Management - www.epa.gov/owm/septic/pubs/onsite_handbook.pdf
- Association of New Jersey Environmental Commissions - www.anjec.org/
- Green Values Stormwater Toolbox – http://greenvalues.cnt.org/
- North Jersey Resource Conservation and Development Council *River Friendly Farms* - www.raritanbasin.org/RaritanAg/RF_Farm/index.htm
- Center for Invasive Species and Ecosystem Health - www.invasive.org/
- New Jersey NRCS Programs - www.nj.nrcs.usda.gov/programs/
- New Jersey Department of Agriculture - www.state.nj.us/agriculture/

With the variety of available resources it will be necessary to carefully screen these materials to select those consistent with the goals of this WPP. It will also be important to make the document itself available to the public as it represents a thorough documentation of existing natural resources in the watershed with a concentration on characterization of water quality and potential impairments. The completed Sidney Brook Watershed Protection Plan will also be available in digital format on CD-ROM made available at the Union Township Municipal Building. Initial outreach has been conducted through several advertised public meetings, presentations, and press releases.

14.0 Implementation Schedule

This section outlines the implementation schedule for the recommended NPS management measures. This section corresponds to the sixth USEPA element.

> *Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.*

Implementation of the recommended measures is dependent on a number of factors, many of which have been discussed in Sections 10.0, 11.0, and 12.0, as well Appendices IV and V including cost, funding, and the amount of technical assistance required. The schedule should therefore focus on meeting the goals outlined in the document above. This will require a coordinated effort to initiate implementation in a proper and efficient sequence. It should once again be noted that the plan has been designed to be implemented over a number of years in order to distribute costs over time not only for the respective municipality but also for homeowners. A phased implementation schedule also allows project sponsors to more effectively manage a smaller number of projects at any particular juncture and to take advantage of continued education efforts to win support for project adoption. The following sections will outline the short term, medium term, and long term project implementation schedule.

14.1 Short Term Schedule

Short term is defined as a period of implementation lasting approximately 1 to 2 years. This implementation period will focus primarily on initiation tasks including planning activities, additional studies and surveys, identifying and acquiring technical assistance and securing funding. The success of the WPP will be largely dependent on this first phase to identify and mobilize the components necessary to implement NPS pollution reduction measures. It is also important to consider the entire development cycle of many of the discussed measures which may require lengthy hydrology and hydraulics studies as well as permitting and that final implementation may take several years from project initiation.

Most of the various management recommendations should be initiated during this phase. In particular municipal planning will be required to develop an internal timetable for implementation and spending which must include public input. Priority projects, especially those that address public health from a use attainment perspective or have high prominence at a local level, need to be addressed in the short term schedule to fix some of the more egregious problems that have a disproportionate affect on water quality or represent some other severe risk. Education and information communication must be initiated immediately in order to educate and build the public support upon which this plan is contingent. Technical assistance should be retained during this period in order to initiate the requisite studies or design work. Similarly, the non-technical or low cost solutions, such as cultural BMP's, should start to be implemented in order to affect water quality changes almost immediately. A summary table for the short term implementation schedule is provided below (Table 48).

Table 48: Short Term Implementation Schedule

Short Term Implementation (0 to 2 years)	
Activity	**Description**
Planning	Further prioritize project implementation and timelines.
Technical Assistance	Identify and contact parties to provide the technical assistance to initiate project design and implementation.
Secure Funding	Investigate funding including grant oppurtunities and the use of public funds, low interest loans, or other financial vehicles.
Information and Education	Ramp up I/E efforts to effectively communicate message, interface with stakeholders, and build project support .
Priority Projects	Initiate activities for the implementation of priority measures including bank stabilization, septic management, manure management, and infrastructure protection projects.
Other Projects	Initiate projects that require a minimum of technical assistance including no-mow zones, low tech riparian buffer enhancement, cultural BMPs, and invasive species control. Many of these efforts will be predicated on the I/E activities. Open space preservation activities should be maintained during this period.
Monitoring	The monitoring program should be developed and implemented in this period. Early monitoring should focus on the collection of additional baseline data, particularly stream temperature, nutrients, and *E. coli* .

14.2 Medium Term Schedule

The medium term is defined as the period lasting from 2 to 5 years from the adoption of the WPP. This period is the work horse of the WPP and is the period when the bulk of implementation work should be conducted. More importantly, this period should build on the work conducted during the first phase of the schedule, namely implementing projects with consideration to priority, utilizing secured funds, constructing completed designs, and maintaining public participation in implementation garnered through I/E efforts. More specifically, this is the timeframe in which many of the more technically difficult measures are designed and installed including riparian buffer enhancement, structural BMP's, and bed and bank stabilization projects among others. Completion of projects located on public lands should be prioritized, but private projects should also be technically supported during this period. Maintenance of installed BMP's should be fully integrated during this point, and monitoring activities started in earnest to begin to document water quality changes. The table below provides a summary of the implementation activities (Table 49).

Table 49: Medium Term Implementation Schedule

Medium Term Implementation Schedule (2 to 5 years)	
Activity	**Description**
Planning	Utilize the developed planning tools to begin widespread project implementation.
Project Designs	Designs for all selected mitigation measures should be completed during this period. More specifically, this will include designs for riparian buffer enhancement, structural BMPs, bed and bank stabilization, agricultural BMPs, and impoundment removal.
Implementation	Implementation for most measures should be started during this period. Higher priority projects should at least be initiated if not completed and other projects started. Projects on public lands should be completed during this period if possible.
Landowner Projects	Projects initiated by landowners should begin during this period with appropriate assistance for funding and technical concerns provided by the municipality or other responsible agency.
Information and Education	I/E activities are continued as an integral component of the WPP. While education and public participation is still the primary message publicizing implementation success should become more prominent.
Maintenance	Maintenance activities should be fully incorporated into any implementation projects and otherwise adopted for existing BMPs.
Monitoring	Routine monitoring should now be fully integrated into the WPP activities to document the environmental effects of project implementation. This data should be freely available and effectively communicated to stakeholders.

14.3 Long Term Schedule

The long term implementation schedule extends from year 5 to 10. This period is marked by the final implementation of the recommended measures. Most projects should be designed by this time and the focus will be implementing the remaining activities. This period will also involve the implementation of projects for which funding posed a problem. Monitoring will play an increasingly important role during this phase as the monitoring results will be used to assess the efficacy and functionality of the implemented measures versus the listed milestones and SWQS. Consequently, the monitoring results may be used to direct further activity in this period to address any potential shortcomings. Information and education programs continue to be important in this period and should stress not only landowner involvement but successes associated with BMP adoption and the results of the monitoring. The following table provides a summary of the long term implementation schedule (Table 50).

Table 50: Long Term Implementation Schedule

Long Term Implementation Schedule (5 to 10 years)	
Activity	**Description**
Implementation	Project designs should for the most part be completed by this time and finally implemented *in-situ.* Medium priority projects should be implemented first followed by low priority projects. This period will also be utilized to implement projects where funding had been lacking previously. Meeting milestones as indicated by project completion and water quality metrics will be important in this period and may require additional planning to comply with the WPP.
Information and Education	I/E activities are continued as an integral component of the WPP. Education is still important in this period as is the encouragement of landowner participation, but the implementation of specific projects as well as documented changes to water quality and environmental quality should be fully integrated.
Maintenance	Maintenance activities continue to be routine, although the intensity of maintenance may decline as projects are deemed functional.
Monitoring	Monitoring during this period should be strongly focused on meeting water quality and other environmental goals during this period. Comparisons to SWQS are important during this point, and failure to meet goals will be used to assess project implementation and identify additional opportunities to improve water quality.

15.0 Milestones

This section outlines the development of interim milestones used to track project implementation as outlined in the preceding section. Milestone development is an important planning tool to chart progress and sets clear objectives for the implementation process. This section corresponds to the seventh USEPA element.

> *A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.*

The development of milestones is somewhat difficult due to the uncertainty of funding looking ahead and thus some of the longer term milestones are less well defined. However, the ability to follow the implementation schedule and complete the opening phases of the WPP, namely careful planning, the continued identification of project sites, information and education, and public buy-in, will jumpstart the implementation process to make sure that defined goals of improving water quality and protecting natural resources in the watershed are met.

15.1 Reporting

To measure the success of this Watershed Protection Plan a variety of milestones and measurable criteria are suggested related to four basic strategies: Planning and Agency Coordination, Mitigation Projects, Monitoring, and Education. It is recommended that the watershed communities track their progress on implementing the various aspects of this WPP by summarizing their activities in Annual Reports disseminated to stakeholders and submitted to the NJDEP Division of Policy Implementation and Watershed Restoration.

It should be noted that the milestones are configured to assess the implementation progress and other goals in the period preceding the stated objective. Each of the listed milestones, with the exception of Year 1 milestones conforms to the end of an implementation cycle as outlined previously. For example, the Year 5 milestones conform to the medium term implementation schedule and the stated objectives for this milestone will assess project implementation and success from years 2 through 5. Similarly, the Year 10 milestone tracks and assesses the implementation of the long term schedule from years 5 through 10. The short term implementation schedule is tracked by both Year 1 and Year 2 milestones. Increased scrutiny of this period has been proposed to ensure the initiation of the plan, which may be the largest hurdle in meeting specified objectives. Stated somewhat differently the milestones can also be thought of as the specific goals and objectives for the preceding period such that the milestones for Year 5 should be pursued in the implementation period from years 2 through 5. These milestones will then be used to track whether significant progress was made.

15.2 Milestones Year 1

The first year milestones are based on the initiation of the project to lay the groundwork from which to build and subsequently implement creek and watershed restoration and management projects. An important goal during this period of implementation is the adoption of the plan by both Union Township and the NJDEP. Upon plan acceptance planning steps need to be initiated to invite public comment and further identification and prioritization of candidate restoration sites as developed by the EC with the help of this document. At the same time public outreach efforts should be initiated as well as education efforts to generate the technical acumen and the public will to implement many of these measures. While the first year may be primarily a planning period it will also be important to begin identifying technical assistance and seeking funding opportunities to correct the issues noted in Appendices IV and V and any others proposed by the public. The following table (51) shows a list of Year 1 milestones.

Table 51: Milestones Year 1

Milestones Year 1	
Adoption	Have WPP adopted by NJDEP and Union Township.
Information	Publish WPP and make freely available to stakeholders, including residents, landowners, and farmers. At a minimum the adopted plan should be available online and a hardcopy available at the municipal building. A presentation regarding the WPP will be conducted by Princeton Hydro at the municipal building.
Planning	Develop and publish a project priority list based on the WPP and stakeholder recommendations.
Funding and Technical Assistance	Secure technical assistance and apply for grants to implement 50% of high priority projects.
Education	Begin publishing educational materials about the WPP in at least two formats including newsletters and newspaper advertisements.
Monitoring	Initiate monitoring program and publish draft results.
Other Projects	Begin implementation of several demonstration projects including riparian buffer enhancement and cultural BMP adoption.

15.3 Milestones Year 2

The second year milestones become somewhat more diverse and concentrate on developing designs and implementing projects. In effect the milestones in this period are enacting the planning and design elements developed in the first year and assess the overall implementation of the short term schedule. The year 2 milestones also include numeric goals for implementation and public participation, including initiation of all high priority goals and securing participation of 5 landowners. Year 2 will also mark the first point at which monitoring data is utilized to evaluate water quality trends. Education continues to be an important component of WPP implementation and workshops should be held to instruct municipal employees on adopted measures and to further educate the public. The completion of at least one demonstration project is recommended, which would be an ideal location for the public workshop. Milestones set for this period, especially the implementation of design work, will ensure that project implementation is progressing as planned. Any deviation can be addressed and corrected in this period. Table 52 lists the Year 2 Milestones.

Table 52: Milestones Year 2

Milestones Year 2	
Information and Education	Expand these efforts. Develop a website as a clearinghouse for all information pertaining to the WPP including educational materials, priority lists, monitoring results, and the WPP. Update Master Plan to incorporate elements of the WPP.
Workshops	Hold at least two workshops. One should be focused on municipal and county employees to communicate the goals of the WPP and to implement cultural BMPs. The second workshop should focus on community outreach to implement BMPs. Materials such as a standard riparian buffer planting list should be provided as well as plans for cost sharing or funding.
Funding and Technical Assistance	Continue to seek funding and assistance for projects. Initiate implementation plans for the remaining high priority items. Develop initiation plans for 20% of medium priority projects.
Assess Participation	Secure participation of at least 5 landholders for riparian buffer enhancements. Update Master Plan.
Demonstration Project	Complete at least one demonstration project, preferably on publically owned property to showcase project potential. This should probably focus on riparian buffer enhancements, but may also include adopted cultural BMPs. Finn Park is a likely spot to initiate such projects.
Monitoring	Utilize collected data to assess water quality trends.

15.4 Milestones Year 5

The milestones for the fifth year are strongly related to actual *in-situ* installation of NPS management measures and assess project implementation and water quality objectives from years 2 through 5, the medium term implementation schedule. The main components of this milestone include increased functionality of riparian buffers, with a goal of implementing up to 2 stream miles of enhancements, 80% implementation of high priority projects, and 50% implementation of medium priority sites. This period also marks the first point at which monitoring data is routinely used to evaluate implementation projects. In particular goals are set for meeting temperature standards at 50% of the monitoring stations as well as decreased nutrients and solids in stormwater. An evaluation of the open space preservation program should be developed at this point.

A comprehensive review of monitoring data is also in order and may include updated pollutant and hydrology modeling using collected data and up-to-date GIS data. The review of the program in general should be used to direct further project implementation in the watershed and may re-order the priority list. The year 5 milestones are found below in Table 53.

Table 53: Milestones Year 5

Milestones Year 5	
Water Quality Standards	Demonstrate compliance with SWQS for temperature at 50% of monitoring stations. Demonstrate decreased stormwater concentrations of TP, TSS, and *E. coli*. Demonstrate decreased invasive species colonization and decreased rates of erosion. Demonstrate increased HGMI invertebrate and FIBI fish community scoring.
Project Goals	80% implementation of high priority sites and 50% implementation of medium priority sites dependent on the availability of funding. Continue developing plans for the implementation of medium and low priority sites.
Riparian Buffer Enhancement	Demonstrate inititation of riparian buffer enhancement projects on 2 stream miles. Secure participation of 20 landowners.
Monitoring	Prepare a five year plan summarizing collected data and update pollution loading and hydrology models using current NJDEP published GIS databases. Use results to direct further work.
Information and Education	Continue expansion of education program and dispense educational materials on riparian buffer enhancements, septic management, manure management programs, cultural BMPs, and WPP implementation successes.
Open Space	Evaluate open space acquisitions and other preservation measures and identifiy further opportunities for preservation.

15.5 Milestones Year 10

The milestones set for the tenth year are predicated on meeting the final goals of the WPP. In particular this includes the restoration of 4 miles of riparian buffer throughout the watershed as well as demonstrating 10% reduction of TP, TSS, and *E. coli* stormwater concentrations and decreased erosion and invasive species colonization in the watershed. All prioritized items should be addressed at this point given the availability of funding. A final report should be prepared summarizing all project activity and relying heavily on collected water quality monitoring data to analyze affects to water quality. This final report should build on the work conducted over the preceding 10 years to define goals for the future and to continue to implement projects. The year 10 milestones are found in Table 54 below.

Table 54: Milestones Year 10

Milestones Year 10	
Implementation	Complete installation of prioritized items. Complete 4 stream miles of buffer enhancement. Tally new open space preservation.
Water Quality Standards	Meet temperature standards at all monitoring stations. Exhibit 10% reductions in TP, TSS, and *E.coli* stormwater concentrations. Show decreased erosion and invasive species colonization.
Monitoring	Compile final report showing monitoring results. Use the final data to direct future efforts in the watershed.
Planning	Prepare an assessment of the implementation of the WPP and update it to meet new objectives and continue preservation and NPS pollution mitigation in the watershed.

16.0 Monitoring Criteria

This section defines the criteria used to determine NPS loading reductions and other goals. As explained in the USEPA guidance document these criteria are not necessarily the same as the state SWQS or USEPA guidance criteria, but in the case of this project many of the parameters outlined in the SWQS will likely be adopted as criteria. Due to the exhaustive watershed characterization summarized in this WPP many, if not most, of the water quality monitoring tools and other environmental survey methods used in this study should be utilized again for this monitoring effort both as a set of standard metrics and for comparative purposes to monitor progress over time. This section is the eighth USEPA element.

> *A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward obtaining water quality standards.*

As mentioned above, most of the groundwork for the establishment of monitoring criteria was completed in the characterization phase of the WPP. Utilizing those metrics already in place will increase statistical significance of any water quality comparison, a crucial step in determining the performance of implemented projects, especially when assessing cumulative loading reductions. It should be noted that many of the parameters and survey methods are standard limnological metrics and directly address important aspects of NPS loading and stream and watershed function.

16.1 *In-situ* Metrics

The collection of *in-situ* data will be of utmost importance in the monitoring efforts, as water temperature was one of the primary symptoms of degraded water quality in the watershed. In addition to temperature, other *in-situ* parameters should include specific conductance, pH, and dissolved oxygen (concentration and percent saturation). These metrics have been fully characterized in the watershed and represent a comparative baseline for future efforts. These measurements may also be reliable indicators of restoration efforts and are valuable for the ability to integrate physical, chemical, and biological signals.

16.2 Discrete Metrics

Discrete metrics, water samples analyzed by an aqueous chemistry laboratory, are complements to *in-situ* measurements and have been a critical component in characterizing the water quality of the Sidney. Discrete analytes already compiled for the Sidney include: Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total

Suspended Solids (TSS), Total Dissolved Solids (TDS), and Nitrate (NO_3-N). At a minimum, TP and TSS should be included in any monitoring program as these two parameters are the primary NPS pollution targets of many of the recommended management measures. The three remaining analytes may be dropped in future efforts, however SRP still has a place in localized monitoring at Stations 1 and 2, as does TDS at the same stations. Depending on the BMP's adopted, these parameters may be maintained for BMP's that specifically address septic and wastewater management.

In addition to the discrete monitoring of chemical constituents, fecal coliform or *E. coli* monitoring may be considered a discrete analyte. *E. coli* loading was shown to be very high in the watershed, routinely exceeding both acute and chronic standards at the majority of the sampled stations. This exceedance violates recreational use standards, and while swimming may not be a primary recreational activity in the tributary network, elevated *E. coli* concentrations need to be monitored. In addition to normal tracking, some of the recommended management measures specifically target *E. coli* loading and tracking these pathogens will be essential in monitoring the performance of these measures.

Another important consideration in monitoring is the characterization of both baseflow and stormflow events. For the most part *in-situ* monitoring will be confined to the collection of baseflow data, but discrete samples should be collected under both flow regimes due to wide variability under different flow conditions. Indeed, stormflow conditions were important in highlighting exceedances and high concentrations, especially for *E. coli*. As many of the recommended management measures are geared towards the management of stormwater the collection of discrete samples during elevated flow periods is essential to understanding and assessing the function of implemented management measures.

16.3 Hydrology Metrics

A large amount of hydrology data was collected during the characterization phase of this study and considerable focus on the management of stormwater in reducing discharge rates and total volumes in this WPP may suggest utility in further hydrology sampling. In-stream hydrology monitoring would be useful in assessing both baseflow, with a projected increase due to improved infiltration, and decreased stormflows, characterized by decreased hydraulic loading relative to storm intensity with improved stormwater management. These changes in hydrology are related to a variety of recommended measures and should be tracked to monitor progress and NPS pollution reductions.

16.4 Biological Metrics

Several biological metrics should be considered as monitoring criteria as well including macroinvertebrate and fish surveys. Fish communities are described in the state using the NJDEP Fish Index of Biotic Integrity while macroinvertebrates are scored (in this watershed) using the High Gradient Macroinvertebrate Index (HGMI), an update to the older NJIS (New Jersey Impairment Score). Many of the recommended management measures should improve both fish and macroinvertebrate communities through lowering water temperatures and improving habitat by reducing erosion, sedimentation, and nutrient enrichment. The response in these communities should therefore be monitored. It is important to note that both of these survey techniques are periodically performed by NJDEP throughout the state, but in absence of this response these efforts should be part of the monitoring program. It should be noted that the change in macroinvertebrate scoring will not be directly comparable to historic datasets and that the original NJIS scores should be recalculated using the HGMI method if possible.

16.5 Qualitative Assessments

Qualitative and semi-quantitative assessments may factor in the monitoring of the stream to track water quality and environmental changes. This would include employing methodology similar to that used in the Visual Assessment to monitor streamside land uses, erosion, outfalls, invasive species, high value resources, and other properties. Another survey to consider is the Visual Habitat Assessment (VHA) outlined in the EPA Rapid Bioassessment Protocols. All of these techniques have been used to document existing conditions in the watershed and should play a role in documenting progress in the future. These types of assessments may be employed at a low frequency.

16.6 Other Criteria

A variety of other metrics should be tracked to follow implementation progress in the watershed. This would include an accounting of project implementation to assess milestones goals. Records should be maintained about the number and type of projects implemented, the number of linear stream feet restored, the area in acres of restoration programs, and the acres of open space preserved.

16.7 Site Specific Criteria

Site specific monitoring is a distinct exercise from the watershed scale monitoring discussed above. However, some of the same criteria may be utilized as required by NJDEP. Performance monitoring of structural BMP’s is usually specified prior to permitting and is used to measure pre-installation versus post-installation NPS pollutant concentration to demonstrate treatment or similarly measure influent and effluent pollutant concentration to calculate removal capacity. Other monitoring may be related to erosion in bank stabilization projects and general function. Another form of site specific monitoring, and likely the one to be utilized most often, is characterizing vegetation growth in restored sites to ensure maximum benefit and to replace vegetation as necessary.

16.8 Use of Criteria

Besides documenting the progress of implementation and improving water quality conditions, monitoring also serves to document problem areas or identify deficiencies in the implementation program. In such a case these monitoring evaluations can be used to reorder project implementation or priority to address specific shortcomings. At such a juncture this may require the redesign of certain management measures, the implementation of more projects, or an evaluation of the program at large. It is also important to note that monitoring criteria may uncover new perturbations at which point enforcement actions or other responses may be necessary to correct the problem.

17.0 Monitoring Plan

As discussed throughout this document monitoring is a crucial component of identifying, documenting, and assessing water quality impairments. Armed with such data recommendations can then be made and designed around existing conditions. Perhaps even more importantly, monitoring is then used to assess the effectiveness of implemented management measures and to document the general water quality of the system over the long term. This section corresponds to the ninth and final USEPA element.

> *A monitoring component to evaluate the effectiveness of implementation efforts over time, measured against the criteria established to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.*

This monitoring program will mirror many parts of the original characterization effort using similar methodologies to evaluate the criteria listed above. The most significant differences will be in the scope of sampling and it is recommended that sampling frequency and the number of stations be reduced to provide cost savings. In the end, the goal of monitoring is to provide data to track and analyze long-term data trends, document water quality changes, evaluate management measure performance, and provides the requisite data to project sponsors, stakeholders and regulators. All sampling plans will likely require the development of a Quality Assurance Project Plan (QAPP) and approval by NJDEP.

17.1 Quarterly Sampling

Quarterly sampling is recommended for future sampling programs to provide a balance between data collection, data quantity, and cost. Specifically, quarterly sampling, when conducted over a long period, will generate a sizable quantity of data and more specifically allows a seasonal sampling program to generate data throughout the year. This quarterly sampling will focus on the collection of *in-situ* parameters such as temperature, pH, specific conductance, and dissolved oxygen concentration, as well as discrete parameters including TP, TSS, and *E. coli*. Nitrogen species have been omitted as is Total Dissolved Solids (TDS) to control cost and because these parameters have generally been found at acceptable concentrations. *In-situ* measurements shall be made with a calibrated multi-probe water quality meter and discrete samples should be analyzed by a state certified laboratory. This quarterly sampling plan is focused on collecting baseflow data.

The number of stations in this plan is reduced to three. This includes Station 1 on Main Street in Jutland, Station 6 along Race Street downstream of Jutland Lake, and Station 11 at Sidney Road (station numbering adheres to the numbering in this report). These stations are selected for a variety of reasons. Station 1 represents several variables including headwaters and an urbanized catchment that was subject to a variety of impairments including *E. coli* and nutrient loading. Station 6 was chosen as a central point and a point of known temperature impairment, and also neatly describes changes in water quality related to impoundment of the stream. Station 11 is the lowest point in the watershed and in effect integrates the influence the entire watershed area. This station also exhibited a severe *E. coli* problem. A fourth station may be considered to add a control or baseline station that is somewhat less affected by land uses and of generally higher water quality to provide better comparisons to stations that have water quality impairments; Station 4 could serve this purpose.

17.2 Storm Sampling

While the quarterly sampling focuses on the collection of baseflow data, storm sampling is also important because many of the water quality impairments detected previously were most evident under stormflow conditions. Stormflow sampling should be conducted twice a year, once during the growing season (approximately April to October) and again in the non-growing season (November through March) to explicitly show the affect of seasonality. Sampling should be conducted at the same stations identified in the quarterly sampling and consist solely of discrete sampling utilizing the same battery of discrete parameters (TP, TSS, and *E. coli*); *in-situ* sampling may be included but is not necessary. Storm sampling should focus on the collection of samples during elevated flows preferably of a storm with a cumulative precipitation total of an inch or more. Samples may be collected using either an automated sampler or manually composited at a set interval over at least four hours. Ideally the sampling should incorporate the first flush at the beginning of the storm, but elevated flow status is a more important criterion for sampling initiation.

17.3 Continuous Temperature Sampling

Temperature data should be collected continuously throughout the monitoring period to assess water temperature throughout the year. Unlike quarterly sampling events that utilize a water quality meter, continuous temperature data will be collected utilizing dedicated temperature data loggers. These data loggers again should be installed at the locations described above and should be set to collect discrete data points approximately once per hour.

17.4 Hydrology Sampling

Hydrology sampling needs to be implemented in the Sidney to validate hydrology models and to determine if implemented management measures are in fact altering the hydrology of the system. More specifically this discharge data will be used to determine a number of hydrologic and hydraulic properties including average flow, baseflow, response to storm events, and seasonality.

As discussed above stage-discharge ratings curves were developed during the characterization phase of this project at Stations 4, 6, and 11. Stage data will be collected with a pressure transducer data logger which will collect continuous stage data at a set interval; sub-hour sampling frequency is recommended for this exercise. The data loggers should be installed in close proximity to the existing staff gages.

17.5 Biological Sampling

Biological sampling, including fishery surveys and macroinvertebrate sampling, is periodically conducted by NJDEP personnel, but supplemental sampling may be necessary. Sampling should probably be conducted approximately once every five years, although replicate samples may be considered during each sampling event. Fishery surveys will follow protocol outlined in the FIBI for wadable high-gradient rivers and will focus on electrofishing techniques. Macroinvertebrate surveys will follow the methodology outlined in the High Gradient Macroinvertebrate Index (HGMI) in the AMNET SOP. This method focuses on the collection of macroinvertebrates with D-nets and limited counts (>100) to roughly a family level taxonomy.

17.6 Other Sampling

Additional sampling should focus on the use of the qualitative or semi-quantitative assessments discussed above. Visual Habitat Assessments, as outlined in the USEPA Rapid Bioassessment Protocols, should be conducted concurrently with macroinvertebrate sampling. Other large scale efforts, like those employed during the Visual Assessment component of this study should probably be conducted at the conclusion of the implementation period to evaluate the widespread results.

17.7 Analysis and Reporting

Analyzing the collected data and presenting it in a useful fashion is important to objectively assess implementation and effectively communicate with stakeholders. This will be accomplished in part by compiling yearly reports summarizing results and monitoring activities. Analysis in these reports should focus on comparative trend analyses using baseline characterization data and framing the report towards meeting milestones and management goals. In addition to this reporting periodic review of the entire dataset needs to be conducted. At this period, including the five and ten year milestones, updates should be made to both hydrology and pollutant models using newly available GIS data as well as all collected data to explore the results of the WPP.

18.0 EPA Nine Elements of a Watershed Protection Plan

As described in Section 1.0 of this document, the Sidney Brook Watershed Protection was developed and written to satisfy the EPA nine elements of a Watershed Protection Plan as identified in the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA, 2008). To reiterate, the nine elements are as follows in an abbreviated form:

1. Identification of causes of impairments and pollutant sources
2. An estimate of load reductions expected from management measures
3. A description of NPS management measures and implementation sites
4. Estimate the amount of technical and financial assistance to implement
5. Information and education of the public and inclusion in plan development
6. Schedule for implementing the NPS management measures
7. A description of interim measurable milestones for implementation
8. Developing criteria to determine loading reduction and achievement of standards
9. Monitoring to evaluate implementation effectiveness utilizing developed criteria

While many sections of the report touch on multiple elements, each of the nine elements was given a dedicated section of the report with the full element description featured prominently in the introduction to section. The following will summarize compliance with each of the elements.

18.1 Element 1

This element focuses on identification of the causes of impairments and pollutant sources in the watershed. This is discussed broadly in Sections 4.0 through 7.0, respectively detailing the Visual Assessment, Water Quality Monitoring, Pollutant Loading, and Hydrology, it is addressed specifically in Section 8.0 Identified Impairments. This sections identifies eight specific impairments in the Sidney Brook watershed: water temperature, total dissolved solids and specific conductance, total phosphorus, *E. coli*, benthic macroinvertebrates, erosion and sedimentation, invasive species, and streambank encroachment and buffer impairments. This section lists both the impacts and the causes of each of these impairments.

18.2 Element 2

Element 2 investigates an estimate of load reductions from management measures. This is discussed specifically in Section 9.0 Estimate of Load Reduction. This section discusses in the listed impairments and what would be required to demonstrate compliance with applicable regulations, specifically the SWQS. It also discusses the pollutant removal efficiencies of various BMP’s and management measures.

18.3 Element 3

The third element is a description of nonpoint source management measures that corresponds to Section 10.0 Description of Nonpoint Source Management Measures. This section describes a variety of management measures, from regulations and legal requirements, to BMP's. The BMP's are described generally including in which situations and how they can be used, efficacy, and other important factors. They are also described specifically, including 20 candidate sites identified by Princeton Hydro, an additional five sites by NJWSA, and a map coverage of priority reaches produced by NJWSA. Additional information can be found in Section 11.0 Project Site Selection and Demonstration Project and in Appendix IV Candidate Restoration Sites and Appendix V New Jersey Water Supply Authority Supporting Tasks and Restoration Sites.

18.4 Element 4

This element builds on the third element, and estimates the amount of technical and financial assistance needed for the proffered management actions. Again, this is done generally for each class of outlined BMP and specifically for each of the candidate sites. This corresponds to Section 12.0 Technical and Financial Assistance with additional supporting information in Appendices IV and V.

18.5 Element 5

Element 5 is discussed in Section 13.0 Information and Education. This section describes effective methods of outreach and identifies a wide variety of outreach materials that can be used to promote these specific types of projects. While this component is meant to facilitate informational exchange upon adoption of this plan, it also discusses where this document can be obtained and outreach to date.

18.6 Element 6

The sixth element requires the development of an implementation schedule as outlined in Section 14.0 Implementation Schedule. For this element, three timetables were developed that look at short term, medium term, and long term implementation scheduling. As such, it describes actions to be taken immediately upon final approval of the plan through implementation and monitoring.

18.7 Element 7

A description of measurable milestones is required to satisfy Element 7. As outlined in Section 15.0 Milestones, a variety of milestones are set for years 1, 2, 5, and 10 that correspond to the implementation schedule of Section 14.0 and the sixth element.

18.8 Element 8

This element is one of the most important and describes the monitoring criteria used to evaluate the success of implemented measures as listed in Section 16.0 Monitoring Criteria. This sections looks at a variety of metrics covering water quality monitoring, hydrological and biological metrics, qualitative assessments, development of site specific criteria, and how this type of data is properly used to ensure that goals are being met.

18.9 Element 9

The final element covered in Section 17.0 Monitoring Plan describes monitoring activities that build on the monitoring criteria of Element 8. This section describes the development of monitoring plans for periodic sampling, storm sampling, and various water quality, hydrology, biology, and other sampling schemes. Analysis and reporting of the collected data is also discussed.

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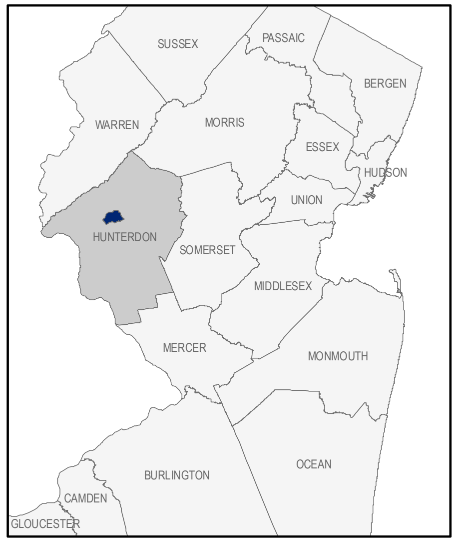
Appendix I
Maps

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig01_2007Aerial.mxd April 07, 2010, Copyright Princeton Hydro, LLC.

NEW JERSEY COUNTY MAP



PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
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RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. 2007 aerial photographs obtained from NJGIN Information Warehouse.
4. Roads obtained from NJDOT website.

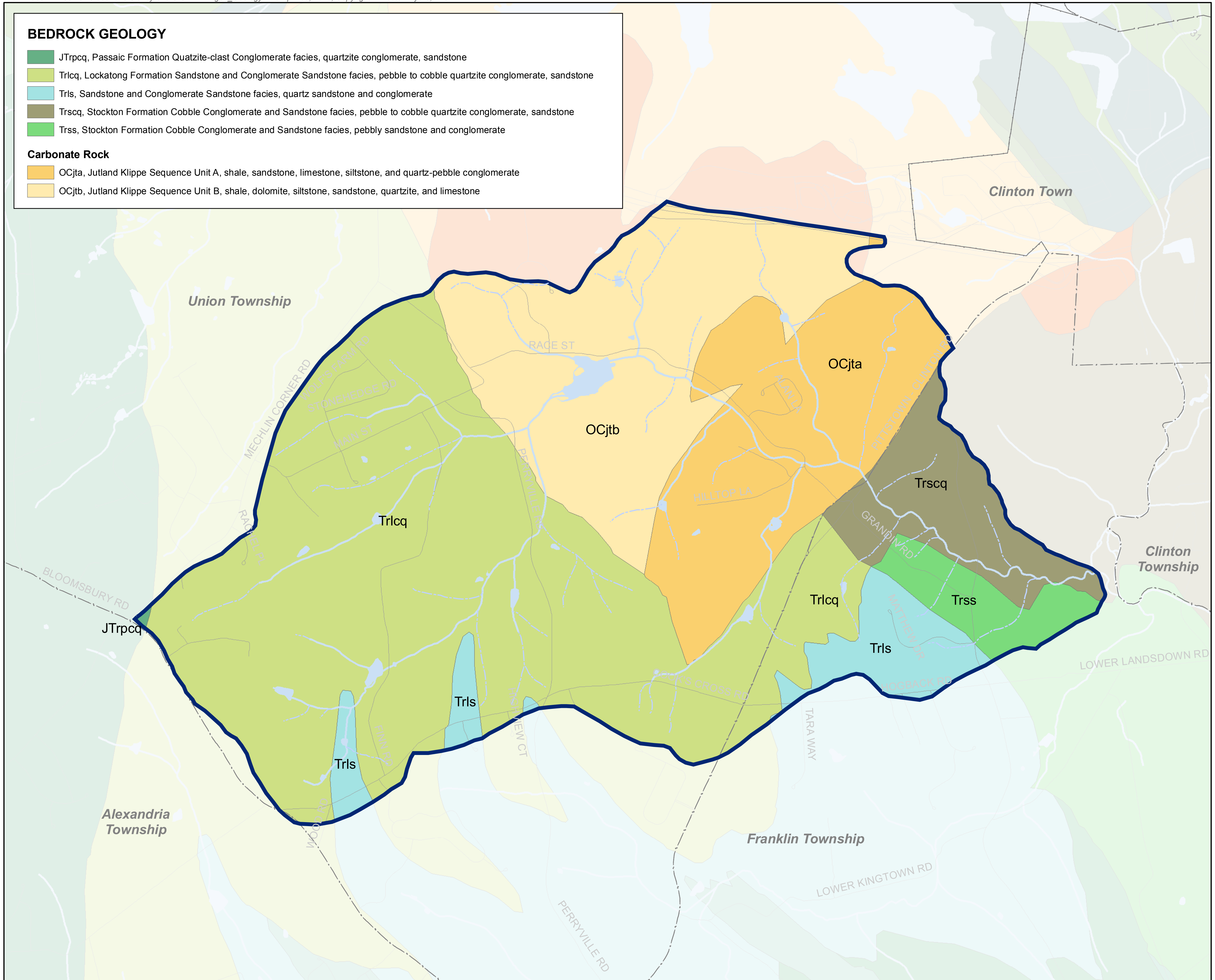
FIGURE 1:
2007 AERIAL PHOTOGRAPHY

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- Streams
- **SCS Streams**
- **Municipal Boundary**
- **Study Area**

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig02_Geology.mxd April 09, 2010, Copyright Princeton Hydro, LLC.



NEW JERSEY COUNTY MAP

SUSSEX, PASSAIC, BERGEN, WARREN, MORRIS, ESSEX, HUDSON, UNION, HUNTERDON, SOMERSET, MIDDLESEX, MERCER, MONMOUTH, BURLINGTON, OCEAN, CAMDEN, GLOUCESTER

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SOURCES:

1. Streams, lakes, and bedrock geology obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

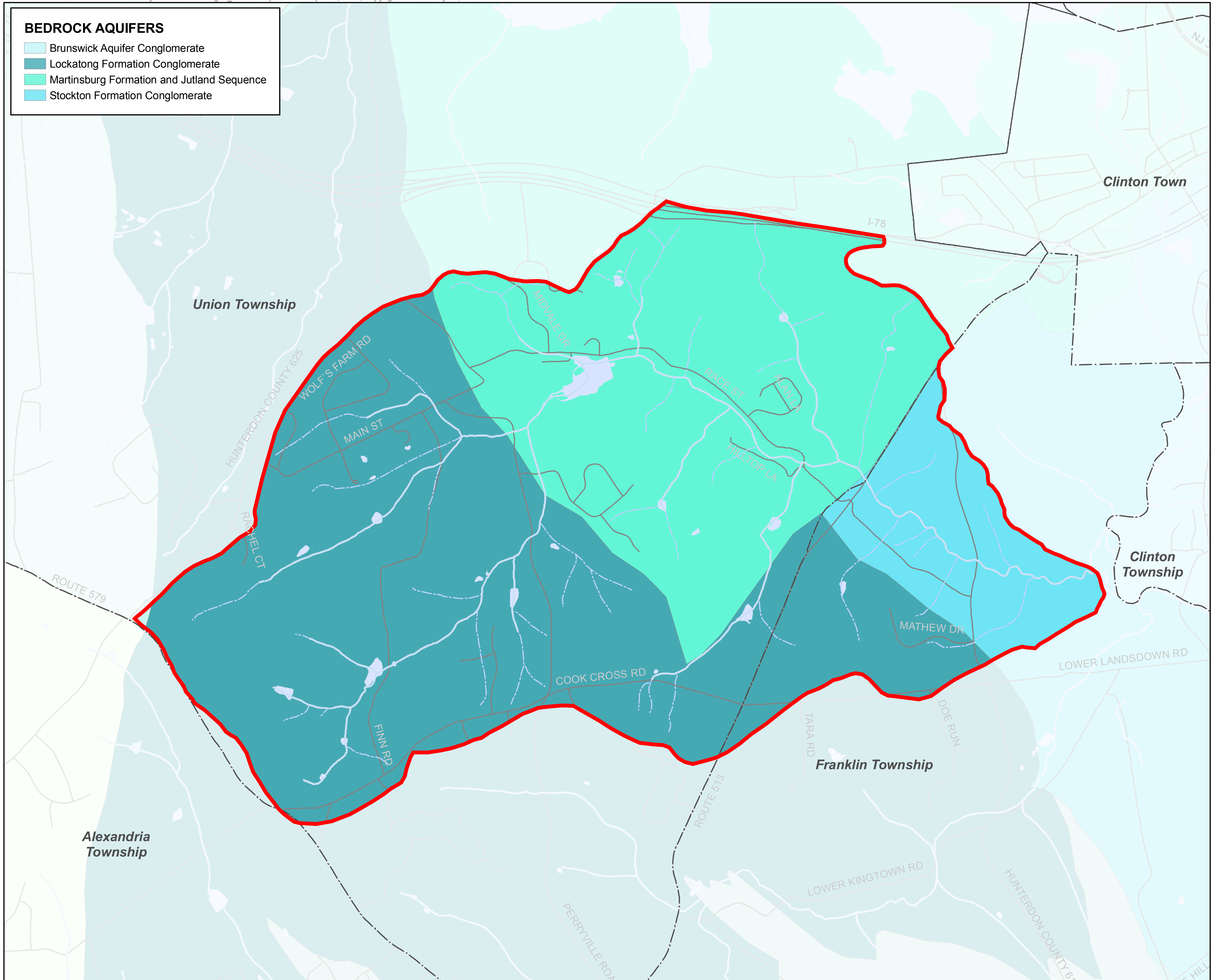
FIGURE 2: BEDROCK GEOLOGY

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig03_BedrockAquifers.mxd April 07, 2010, Copyright Princeton Hydro, LLC.



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SOURCES:

1. Streams, lakes, and bedrock aquifers as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

FIGURE 3:
BEDROCK AQUIFERS

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UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area

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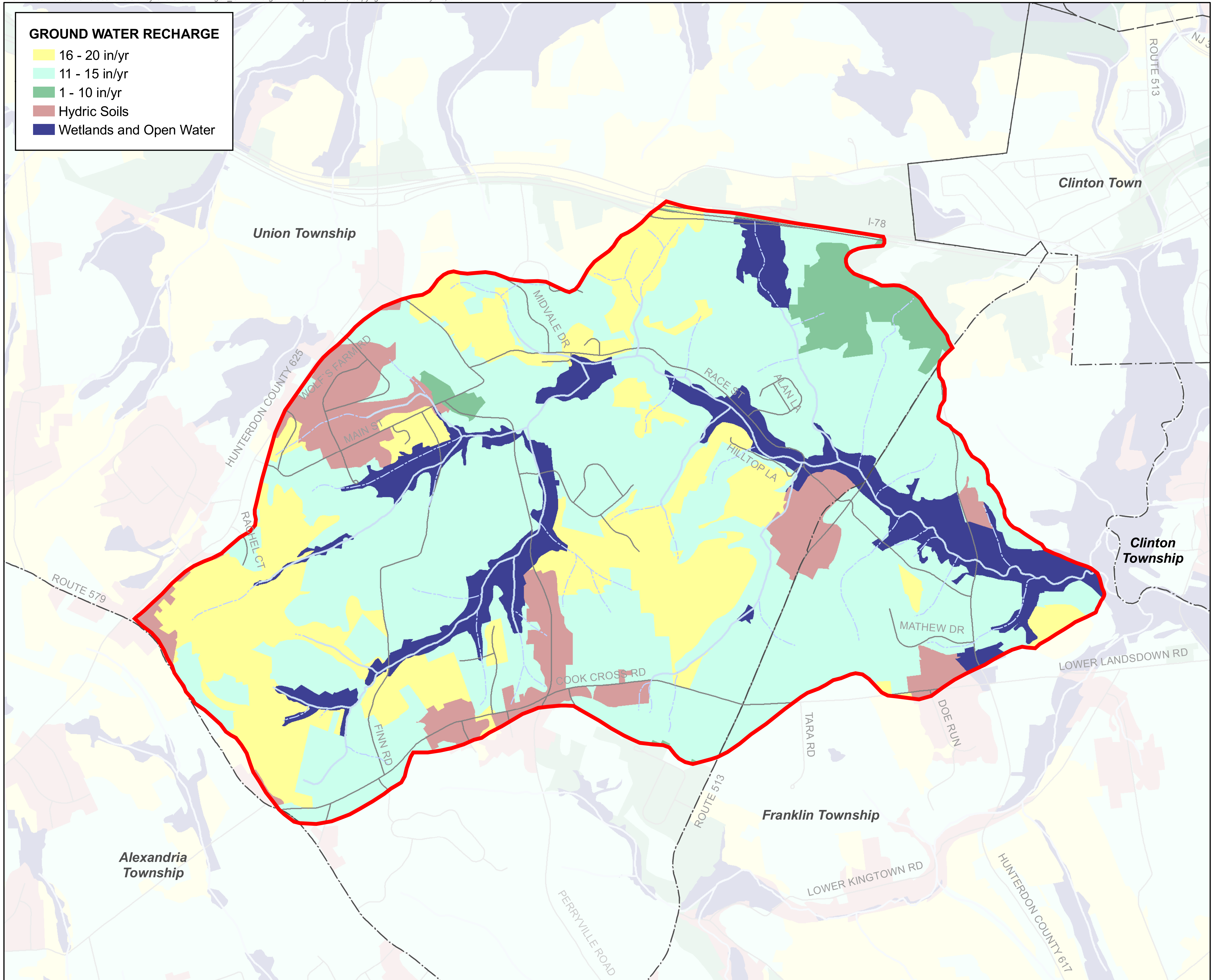

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SOURCES:

1. Streams and groundwater recharge as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitzed from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

FIGURE 4:
GROUNDWATER RECHARGE

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Municipal Boundary
- Study Area

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SSURGO SOILS

- ANWTB, Annandale and Gladstone gravelly loams, 3 to 8 percent slopes
- ANWTC, Annandale and Gladstone gravelly loams, 8 to 15 percent slopes
- BefB, Bedington channery silt loam, 2 to 6 percent slopes
- BefC2, Bedington channery silt loam, 6 to 12 percent slopes, eroded
- BegB, Berks channery loam, 2 to 6 percent slopes
- BegC2, Berks channery loam, 6 to 12 percent slopes, eroded
- BegD2, Berks channery loam, 12 to 18 percent slopes, eroded
- BhnC2, Birdsboro silt loam, 6 to 12 percent slopes, eroded
- BoyAt, Bowmansville silt loam, 0 to 2 percent slopes, frequently flooded
- ChcB, Chalfont silt loam, 2 to 6 percent slopes
- ChfB, Chalfont-Quakertown silt loams, 0 to 6 percent slopes
- DufB, Duffield silt loam, 2 to 6 percent slopes
- HdyB, Hazleton channery loam, 2 to 6 percent slopes
- HdyD, Hazleton channery loam, 12 to 18 percent slopes
- KkoC, Klinesville channery loam, 6 to 12 percent slopes
- LbmB, Lansdale loam, 2 to 6 percent slopes
- LbmC2, Lansdale loam, 6 to 12 percent slopes, eroded
- LbtB, Lansdowne silt loam, 2 to 6 percent slopes
- MemB, Meckesville gravelly loam, 2 to 6 percent slopes
- MemC2, Meckesville gravelly loam, 6 to 12 percent slopes, eroded
- NotB, Norton loam, 2 to 6 percent slopes
- NotC2, Norton loam, 6 to 12 percent slopes, eroded
- NotD2, Norton loam, 12 to 18 percent slopes, eroded
- PHG, Pits, sand and gravel
- PdtB, Pattenburg gravelly loam, 2 to 6 percent slopes
- PdtC2, Pattenburg gravelly loam, 6 to 12 percent slopes, eroded
- PdtD, Pattenburg gravelly loam, 12 to 18 percent slopes
- PdtE, Pattenburg gravelly loam, 18 to 40 percent slopes
- PdtmB, Pattenburg gravelly loam, moderately wet, 2 to 6 percent slopes
- PeoB, Penn channery silt loam, 2 to 6 percent slopes
- PeoC2, Penn channery silt loam, 6 to 12 percent slopes, eroded
- PeoD, Penn channery silt loam, 12 to 18 percent slopes
- QukB, Quakertown silt loam, 2 to 6 percent slopes
- QukC2, Quakertown silt loam, 6 to 12 percent slopes, eroded
- ROPF, Rough broken land, shale
- RarB, Raritan silt loam, 3 to 8 percent slopes
- RorAt, Rowland silt loam, 0 to 2 percent slopes, frequently flooded
- Water

NEW JERSEY COUNTY MAP

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SOURCES:

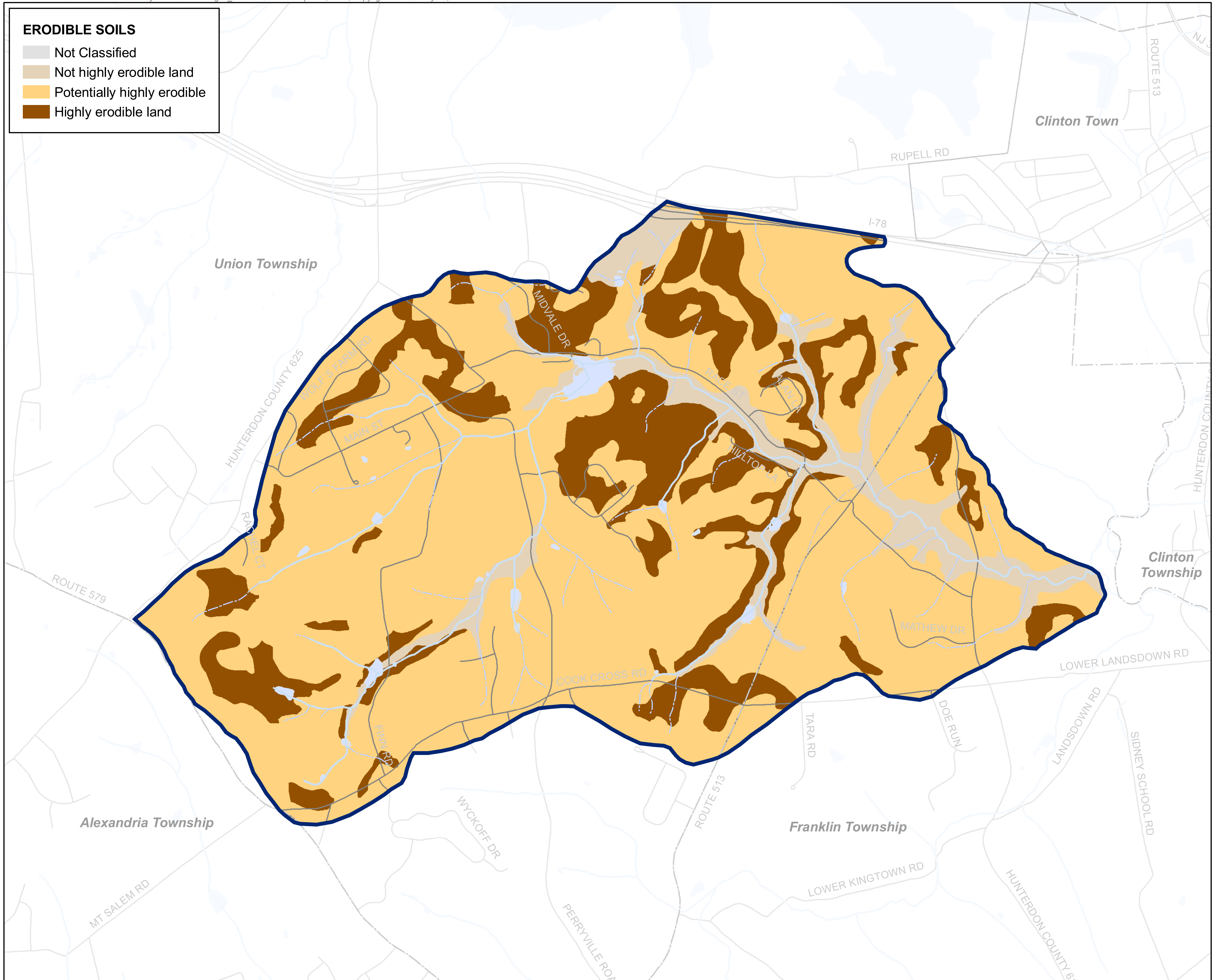
1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitzed from the Hunterdon County Soils Conservation Service handbook.
3. SSURGO soils obtained from Natural Resources Conservation Service.

FIGURE 5: SSURGO SOILS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area



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NEW JERSEY COUNTY MAP

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SOURCES:

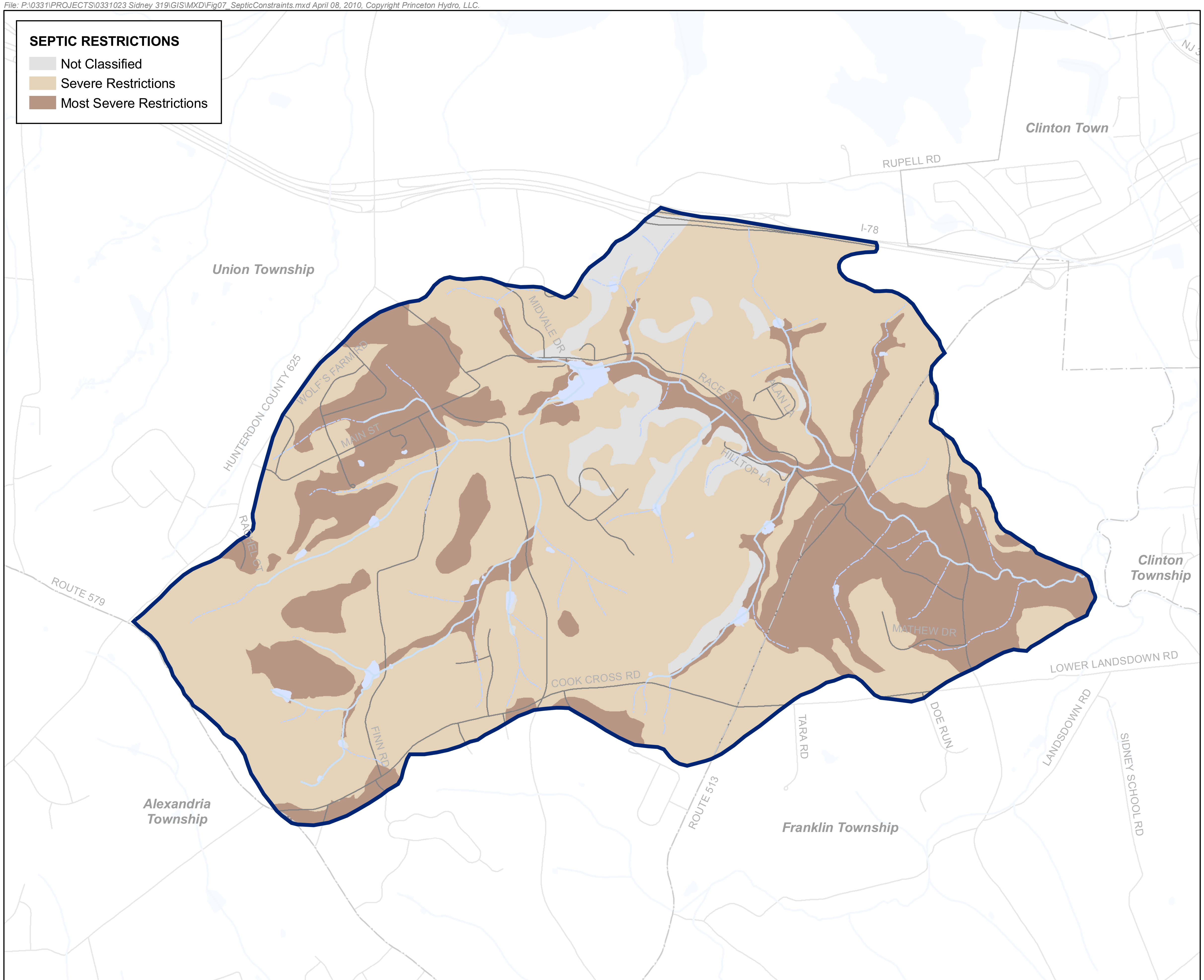
1. Streams and lakes obtained from the NJDEP GIS website.
2. SCS streams heads-up digitzed from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. Soil erodibility determined using SSURGO soils data obtained from the from Natural Resources Conservation Service.

FIGURE 6:
ERODIBLE SOILS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area



NEW JERSEY COUNTY MAP

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1 inch = 2,000 feet

SOURCES:

1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitzed from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. Septic constraints determined using SSURGO soils data obtained from the from Natural Resources Conservation Service.

FIGURE 7:
SEPTIC SYSTEM CONSTRAINTS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area

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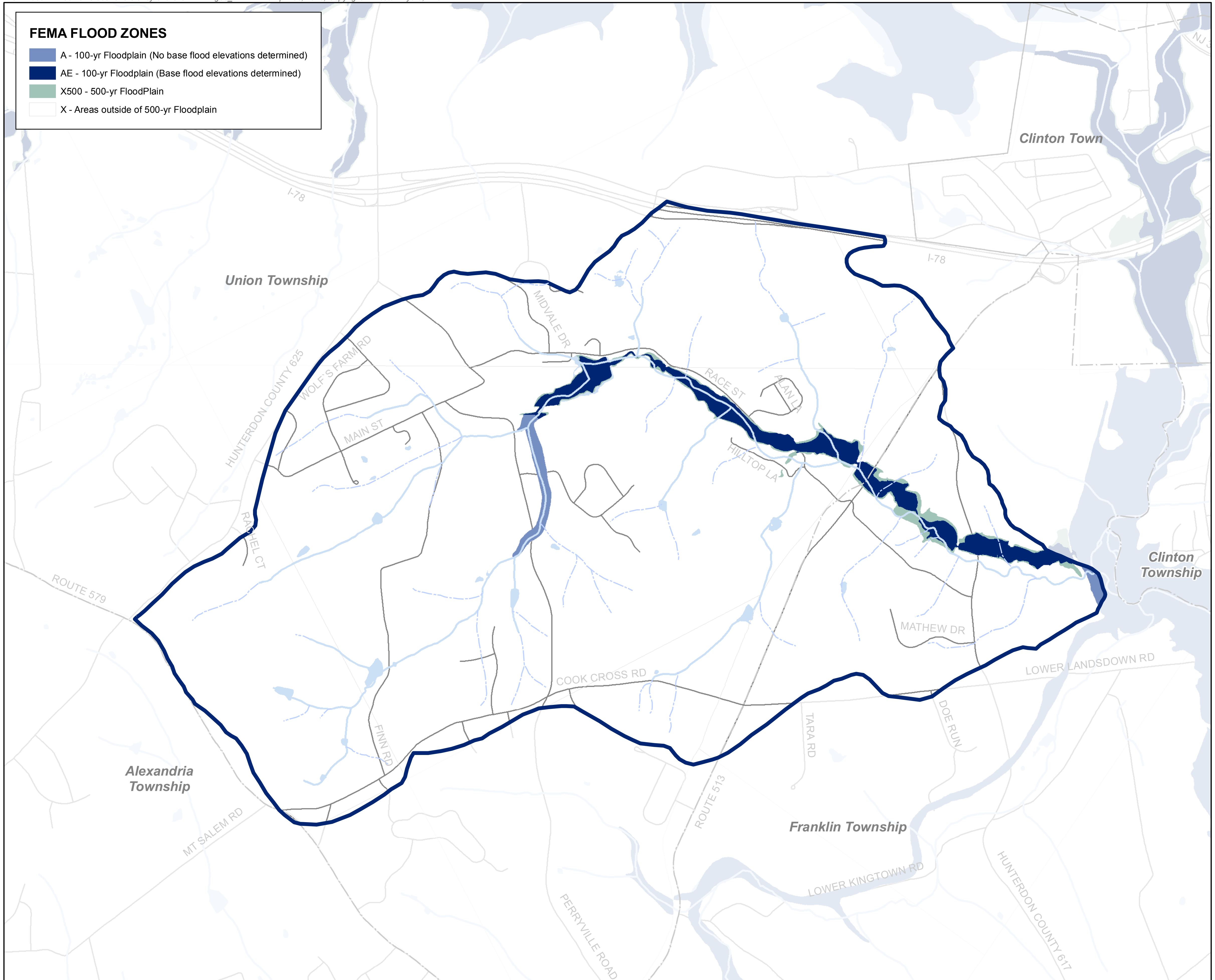

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NEW JERSEY COUNTY MAP

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Feet
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1 inch = 2,000 feet

SOURCES:

1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. FEMA flood zone data as obtained from the Federal Emergency Management Agency National Flood Insurance Program Q3 Flood Data (Disc 18 New Jersey)

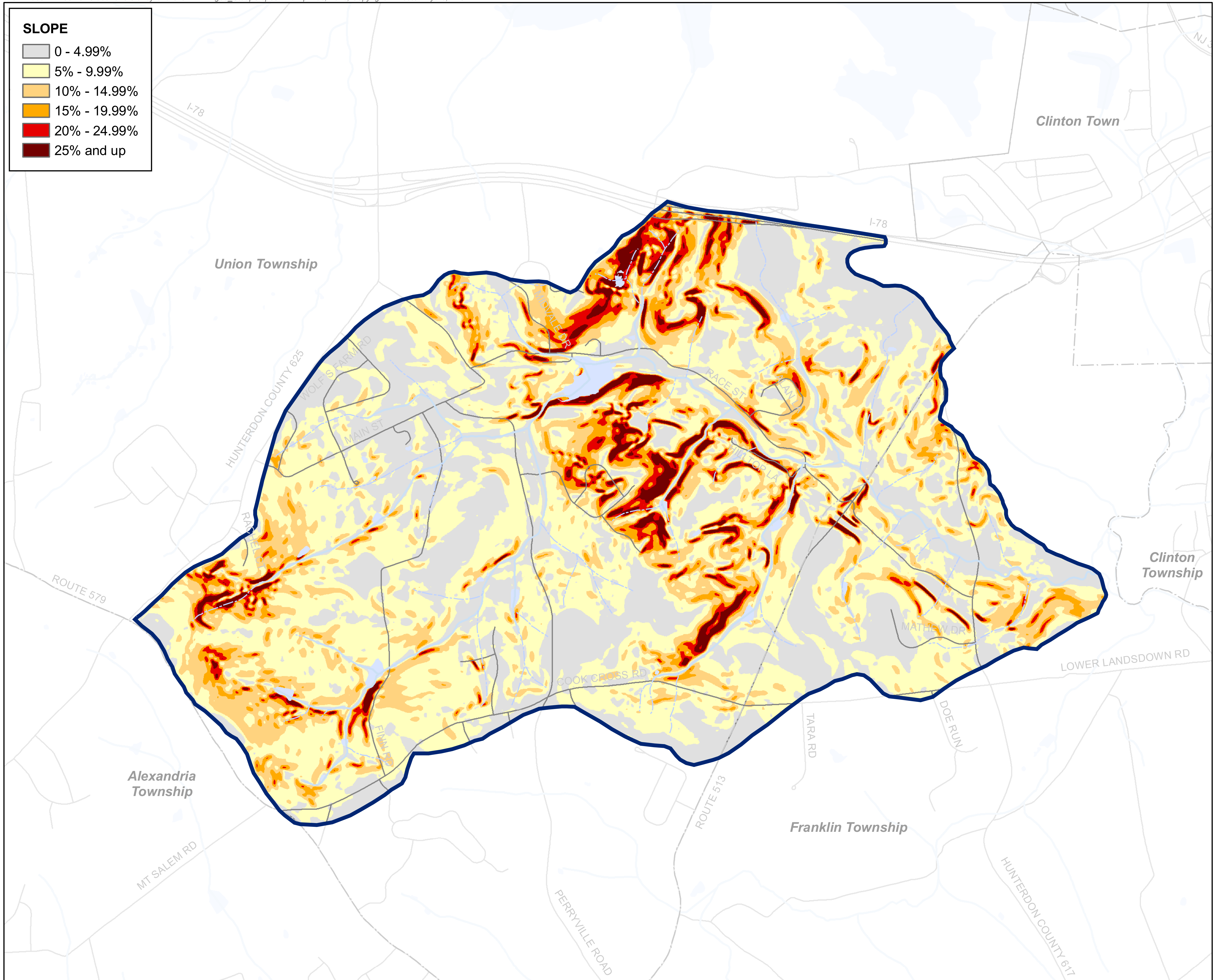
FIGURE 8:
FEMA FLOOD ZONES

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig09_SteepSlopes.mxd April 08, 2010, Copyright Princeton Hydro, LLC.



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

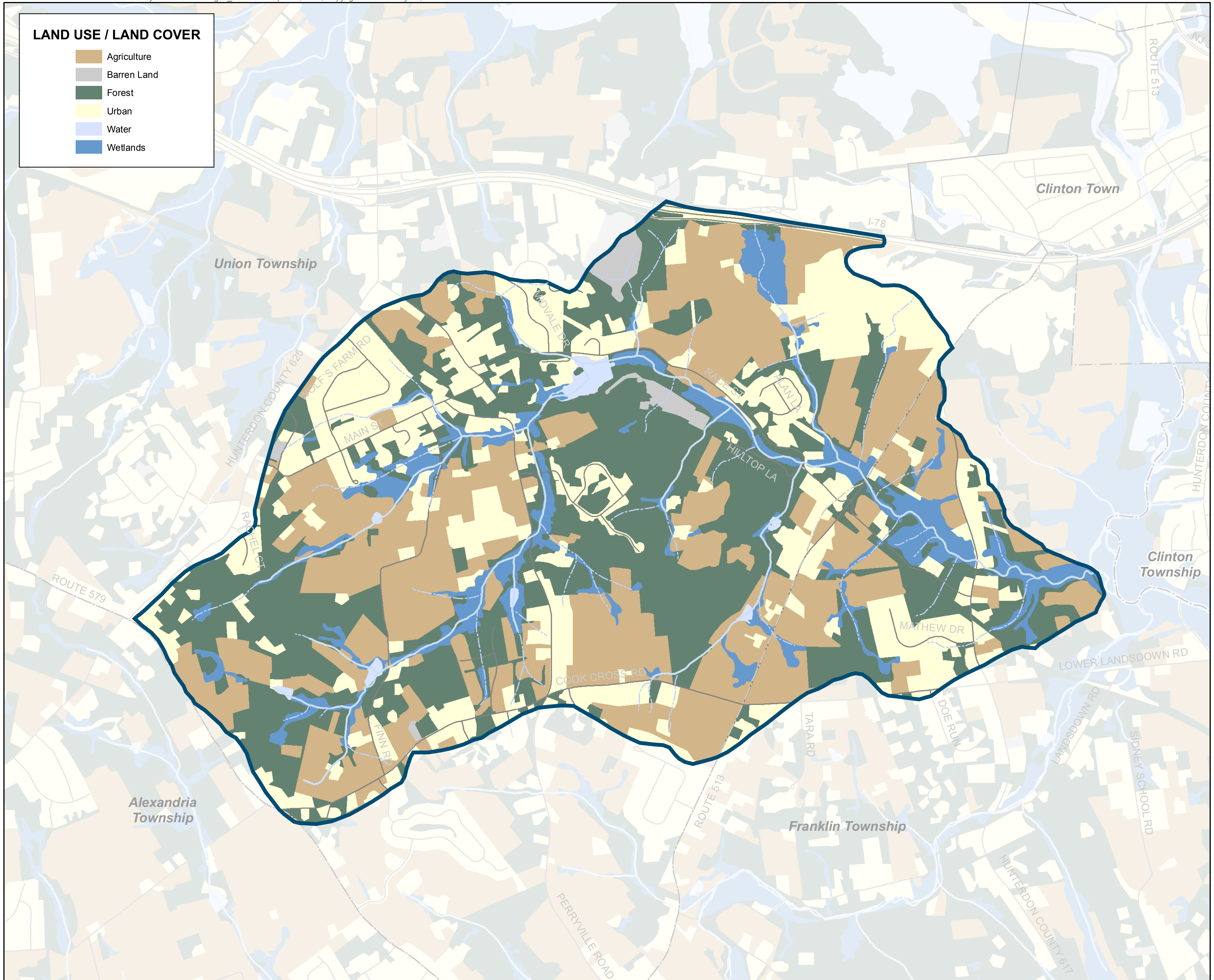
1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. Slopes derived from USGS DEM obtained from the NJDEP GIS website.

FIGURE 9:
STEEP SLOPES

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams and 2002 Land Use/Land Cover as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

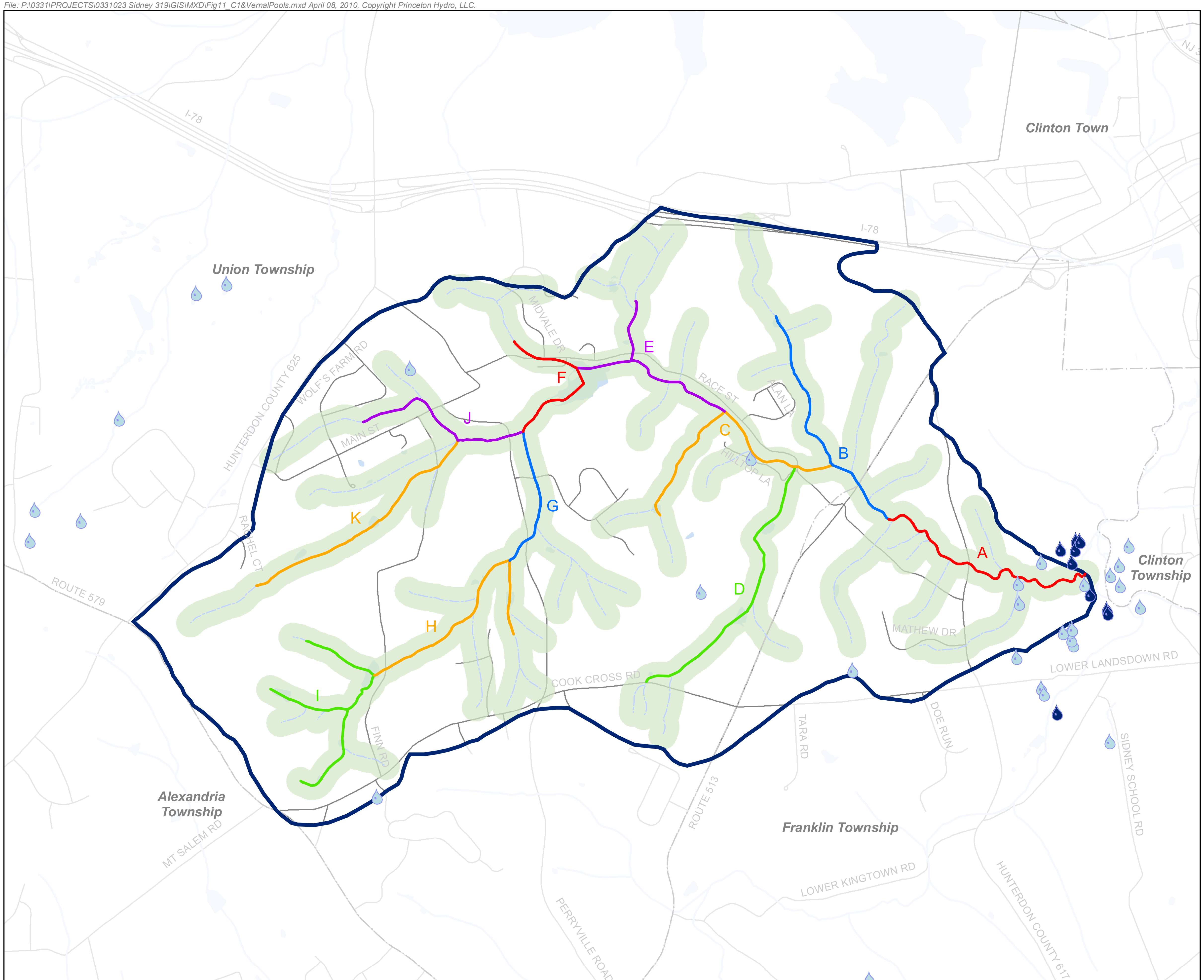
FIGURE 10:
LAND USE / LAND COVER

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Municipal Boundary
- Study Area

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig11_C1&VernalPools.mxd April 08, 2010, Copyright Princeton Hydro, LLC.



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. Vernal pools obtained from Rutgers University Mapping Vernal Pools in New Jersey website.

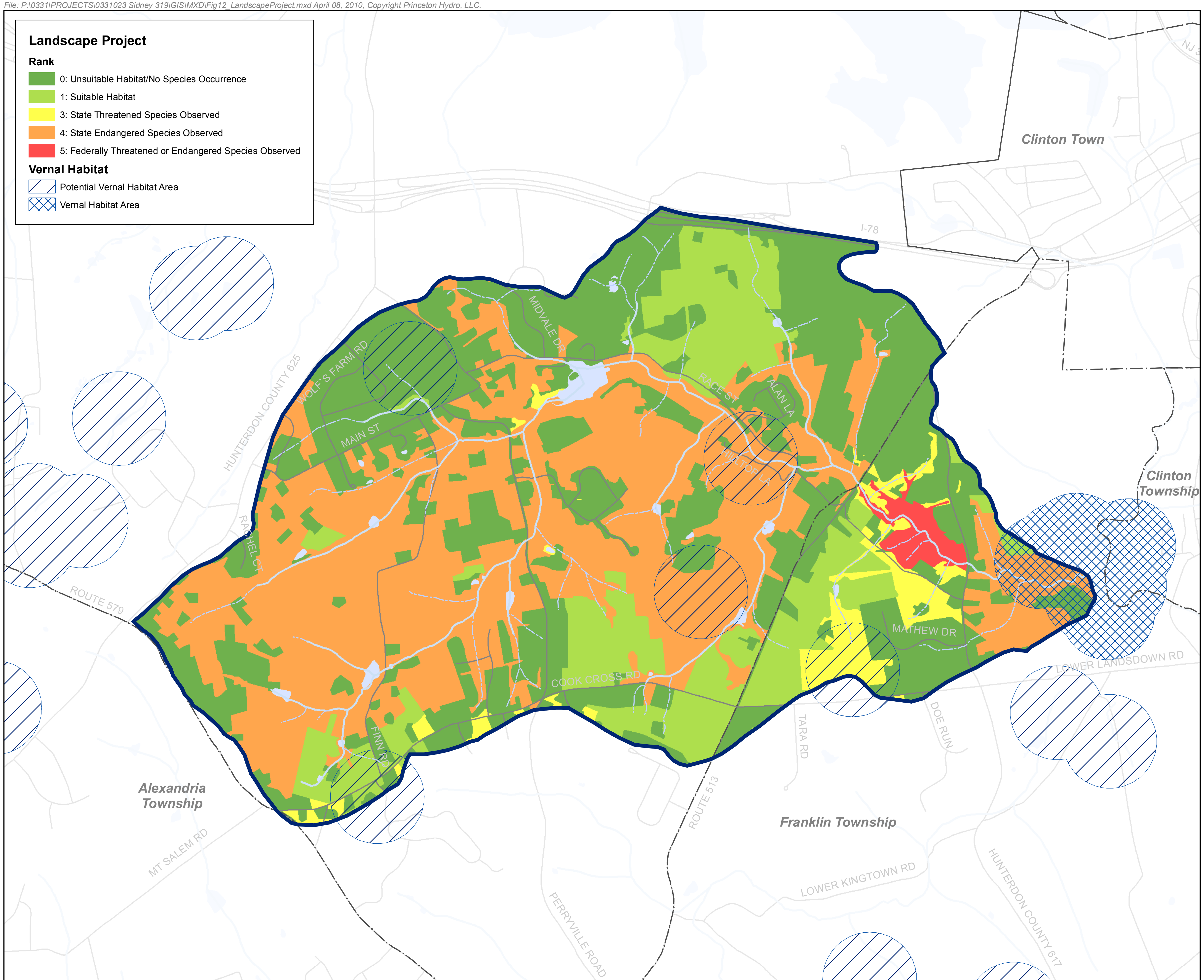
FIGURE 11:
C1 STREAM BUFFERS & VERNAL POOLS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

Vernal Pools
- Certified
- Not Certified
- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area

Stream Segments
- A, F
- B, G
- C, H, K
- D, I
- E, J
- C1 300' Buffers



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

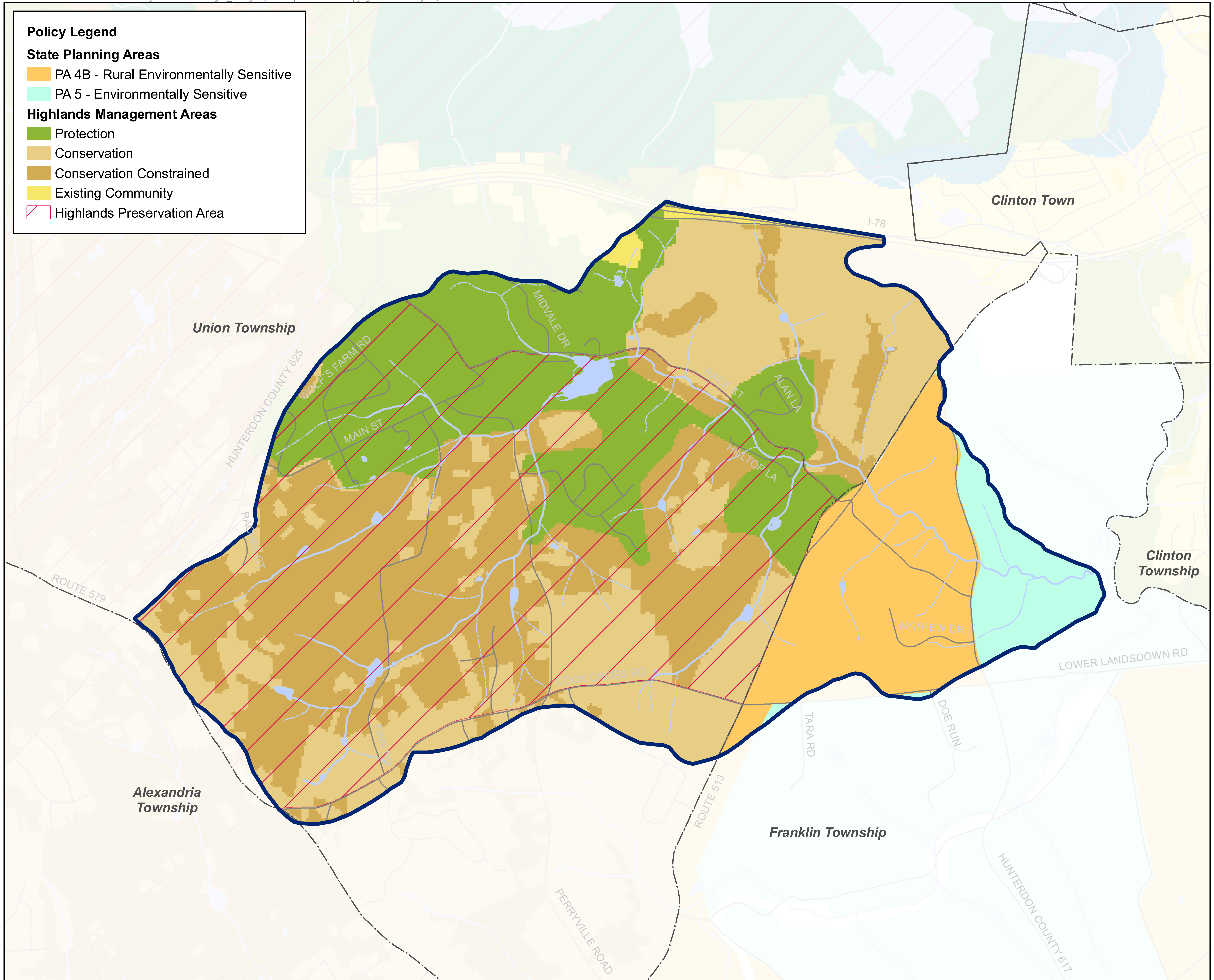
1. Streams, lakes, and Landscape Project data version 3.0 as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

FIGURE 12:
NJDEP LANDSCAPE PROJECT

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area



NEW JERSEY COUNTY MAP

Princeton Hydro

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

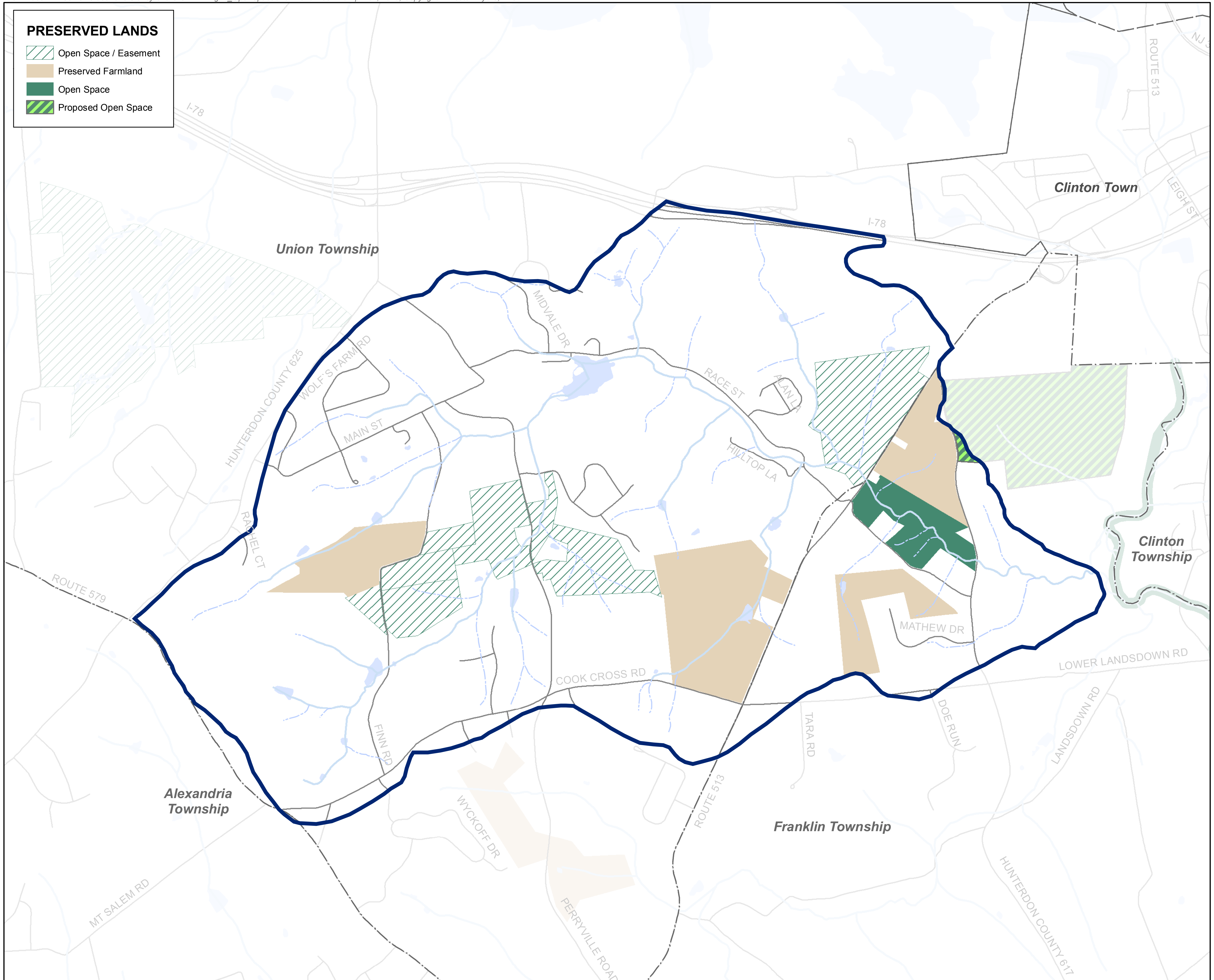
1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. State Planning Areas obtained from NJ Department of Community Affairs GIS website.
5. Highlands Management Areas obtained from NJ Highlands Council GIS website.

FIGURE 13:
POLICY MAP

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

N
S
Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitzed from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. Preserved Farmland as obtained from NJDEP GIS website.
5. Union Twp Open Space obtained through block and lot from the Union Township website.

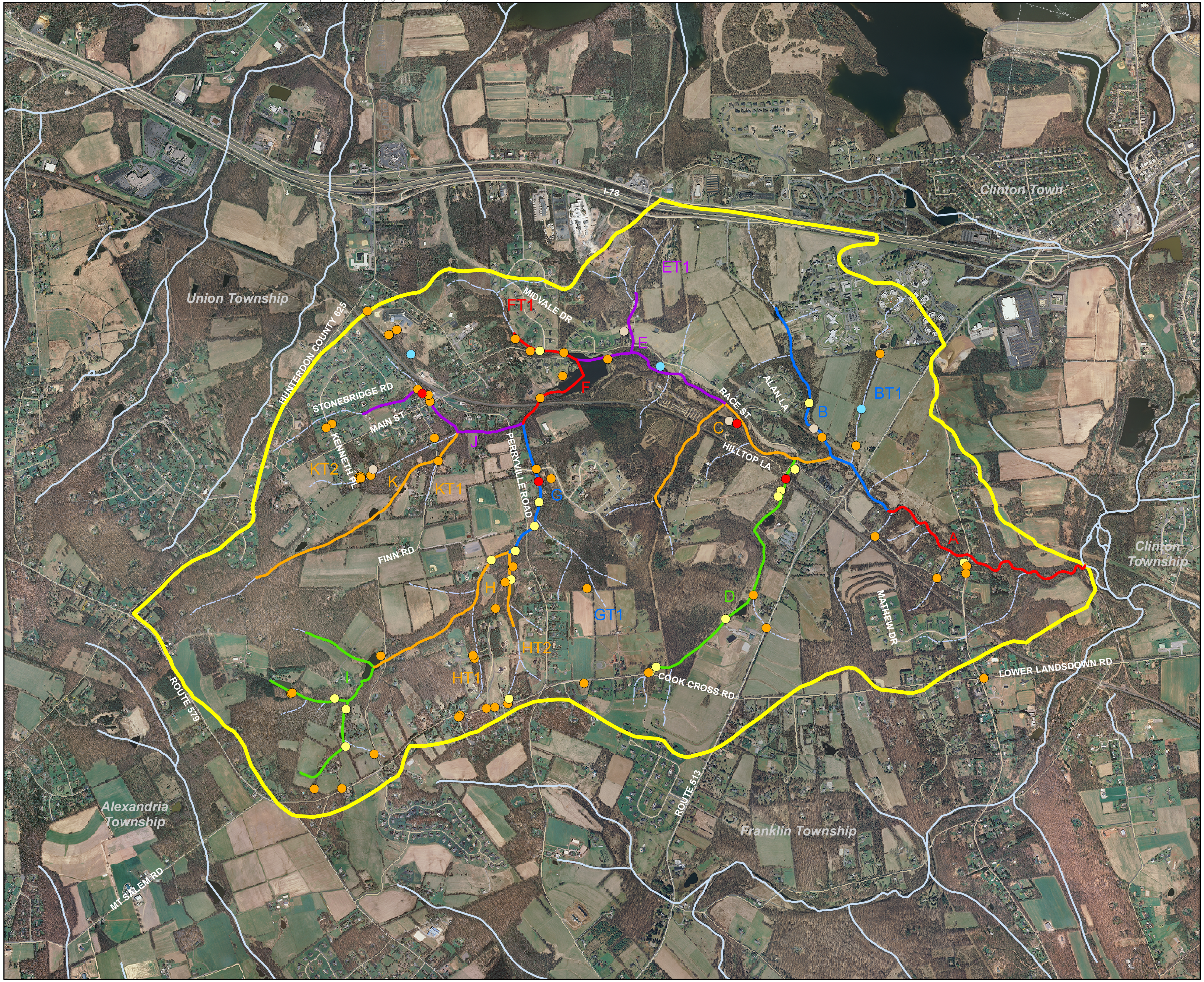
FIGURE 14:
PRESERVED OPEN SPACE
& FARMLANDS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

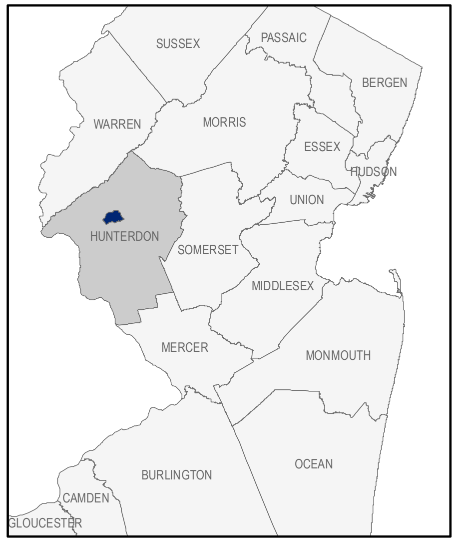
LEGEND

- Roads
- Streams
- SCS Streams
- Lakes
- Municipal Boundary
- Study Area

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig15_VisualAssessment.mxd April 08, 2010, Copyright Princeton Hydro, LLC.



NEW JERSEY COUNTY MAP



Princeton Hydro

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

N

Feet

0 1,000 2,000

1 inch = 2,000 feet

SOURCES:

1. Streams as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitzed from the Hunterdon County Soils Conservation Service handbook.
3. 2007 aerial photographs obtained from NJGIN Information Warehouse.
4. Roads obtained from NJDOT website.
5. Visual assessment performed by Princeton Hydro, LLC staff in March of 2008.

FIGURE 15:
SIDNEY BROOK VISUAL ASSESSMENT FINDINGS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

Roads
SCS Streams
Streams
Municipal Boundary
Study Area

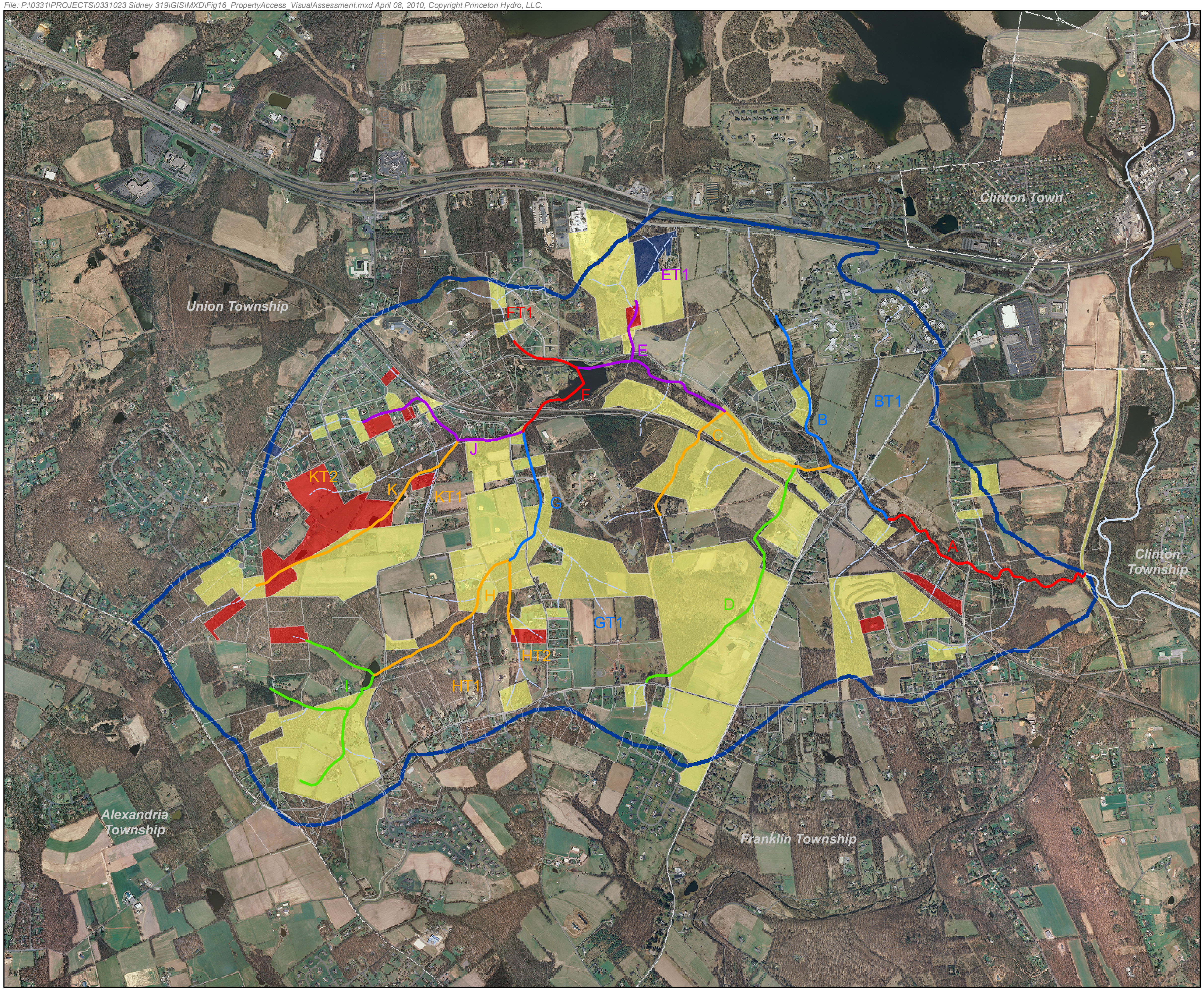
StreamSegments

A, F
B, G
C, H, K
D, I
E, J

Visual Assessment

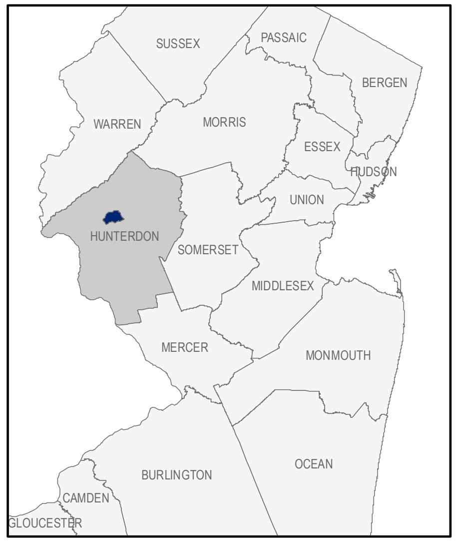
Bog
Potential clean up site
Erosion
Outfall
Vernal pool

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig16_PropertyAccess_VisualAssessment.mxd April 08, 2010, Copyright Princeton Hydro, LLC.



Princeton Hydro

NEW JERSEY COUNTY MAP



PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. 2007 aerial photographs obtained from NJGIN Information Warehouse.

FIGURE 16:
PROPERTY ACCESS FOR THE VISUAL ASSESSMENT

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

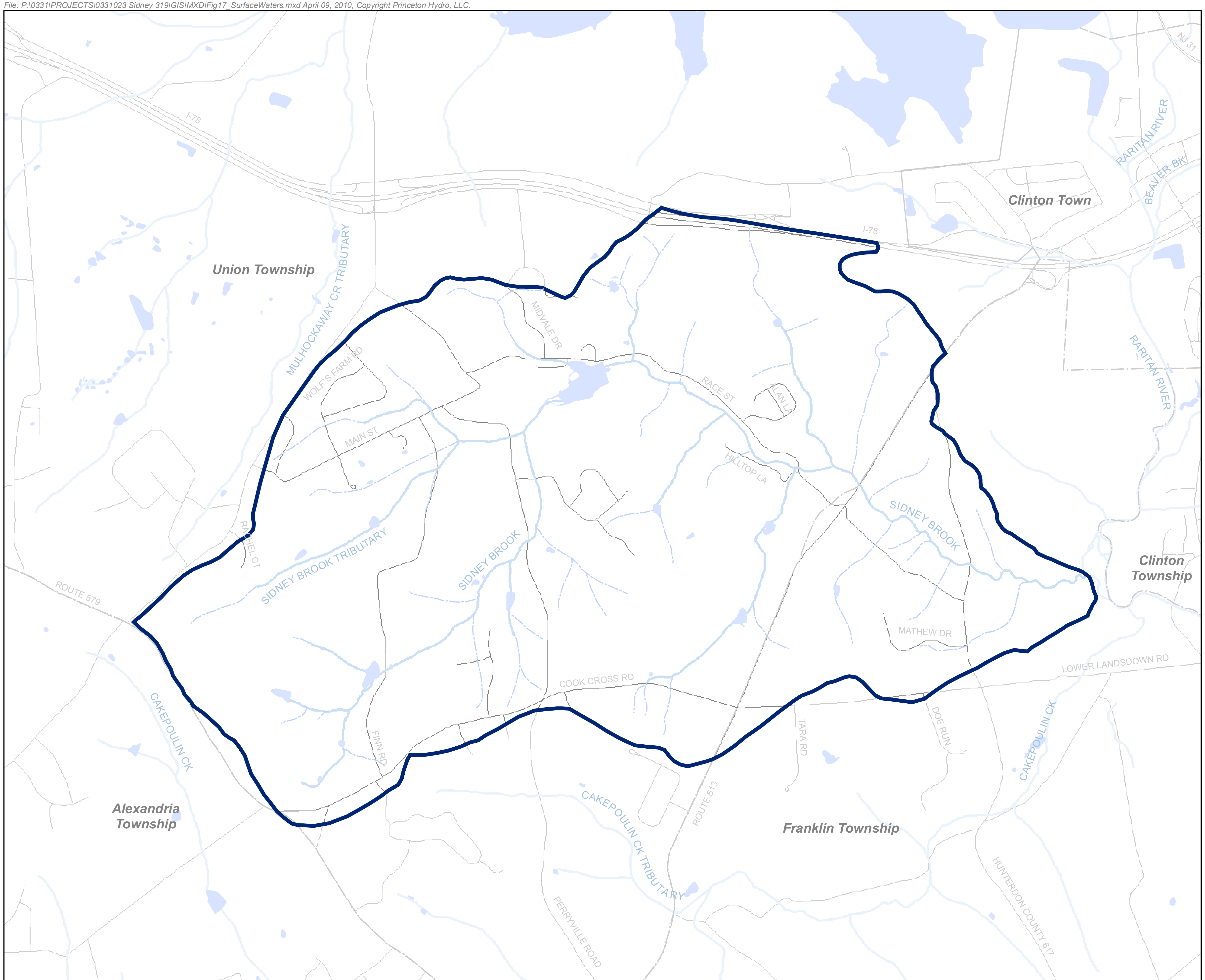
LEGEND

SCS Streams
Streams
Parcels
Municipal Boundary
Study Area

Property Access
Access Denied
Access Approved
Access Approved with Limitations

Stream Segments
A, F
B, G
C, H, K
D, I
E, J

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig17_SurfaceWaters.mxd April 09, 2010, Copyright Princeton Hydro, LLC.



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

N S

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

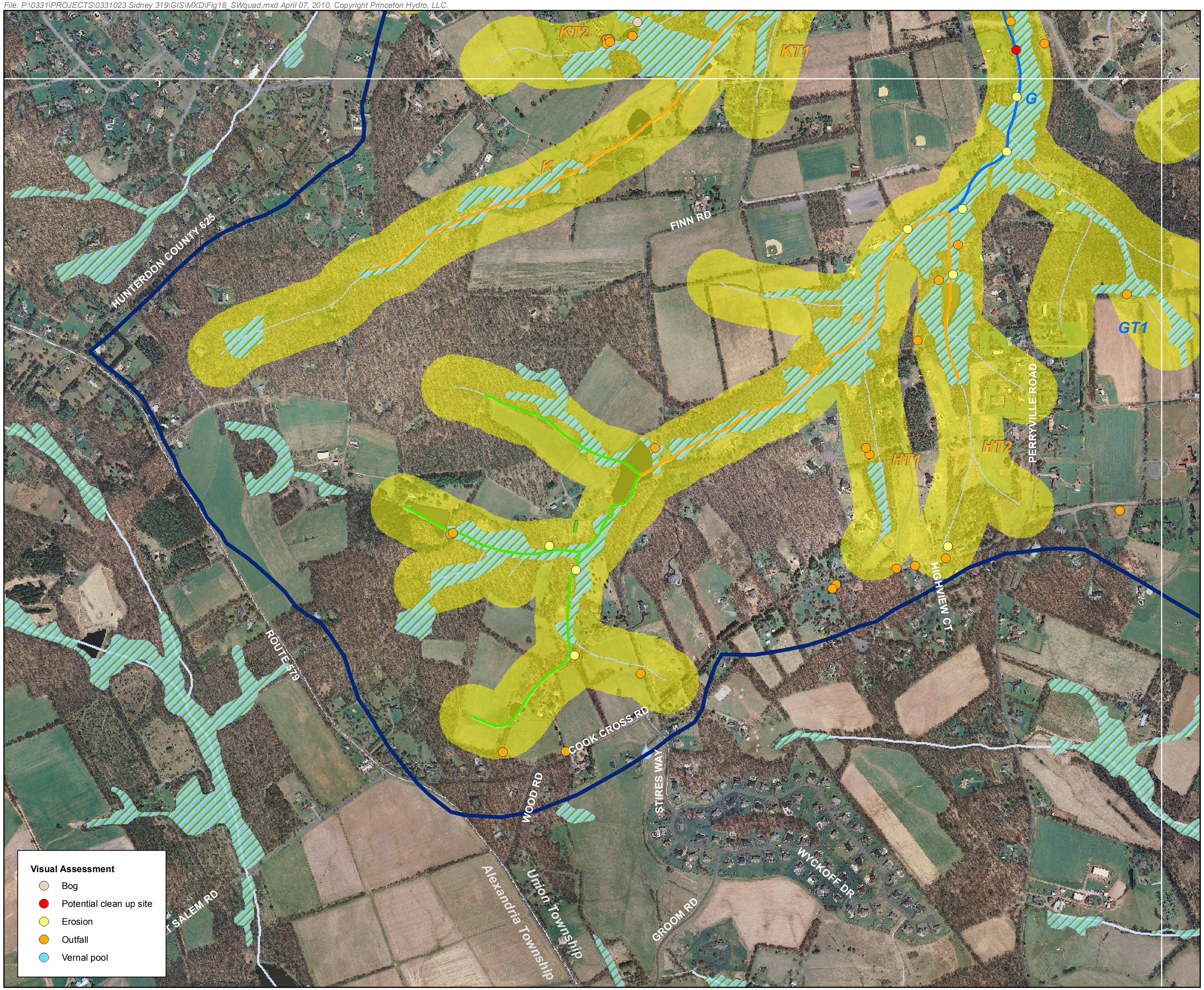
1. Streams and lakes as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

FIGURE 17: SURFACE WATERS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

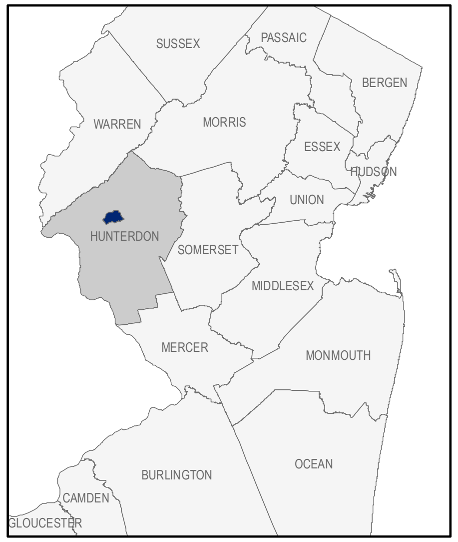
LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area



Visual Assessment
- Bog
- Potential clean up site
- Erosion
- Outfall
- Vernal pool

NEW JERSEY COUNTY MAP



Princeton Hydro

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 437.5 875
1 inch = 875 feet

SOURCES:

1. Streams and wetlands (2002 LULC) obtained from the NJDEP GIS website.
2. SCS streams digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. 2007 aerial photographs obtained from NJGIN Information Warehouse.
5. Vernal pools obtained from Rutgers University Mapping Vernal Pools in New Jersey website.

FIGURE 18:
SW QUADRANT OF THE
SIDNEY BROOK WATERSHED

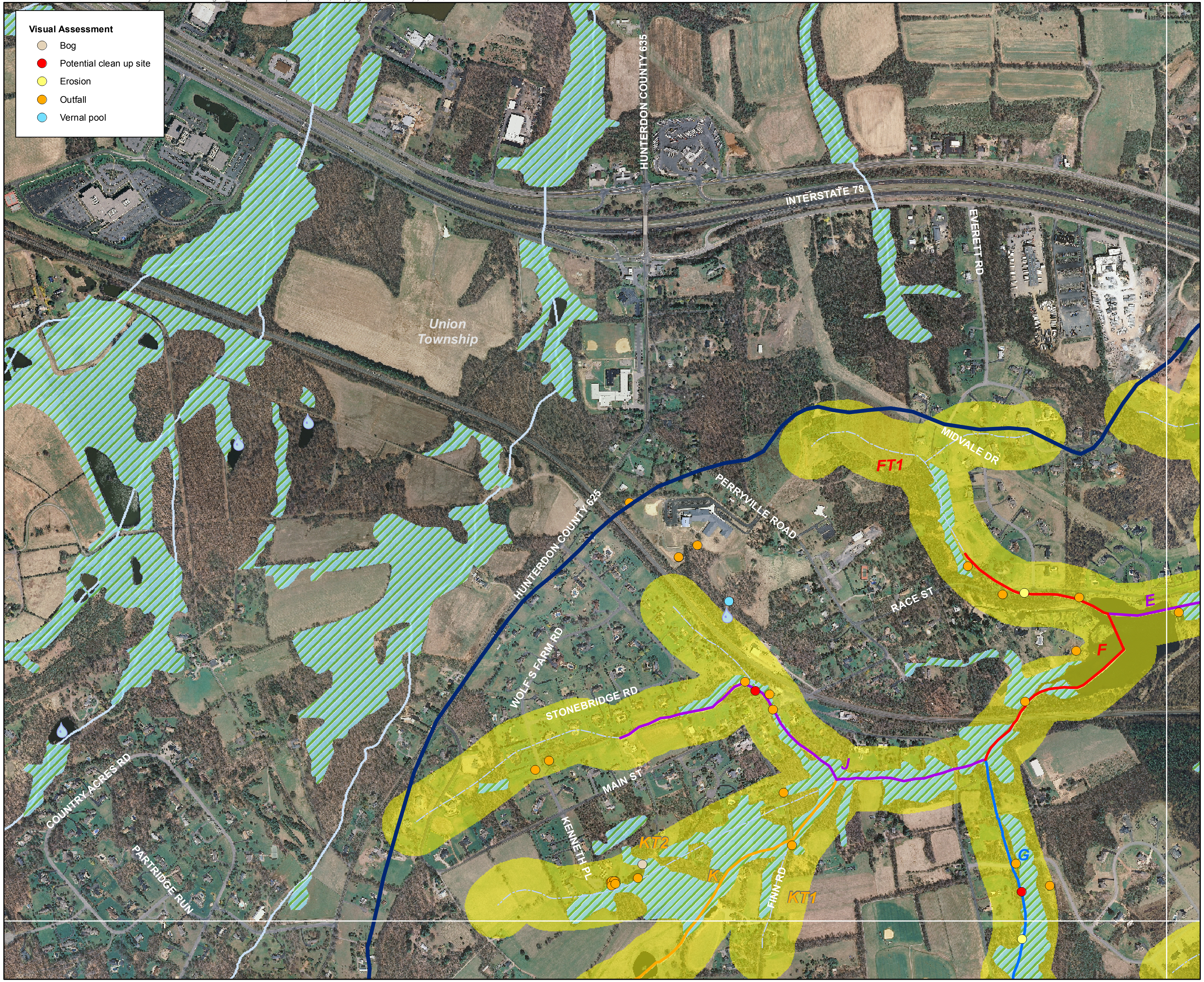
SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

Vernal Pools
- Certified
- Not Certified
- SCS Streams
- Streams
- 300' C1 Stream Buffer
- Municipal Boundary
- Study Area

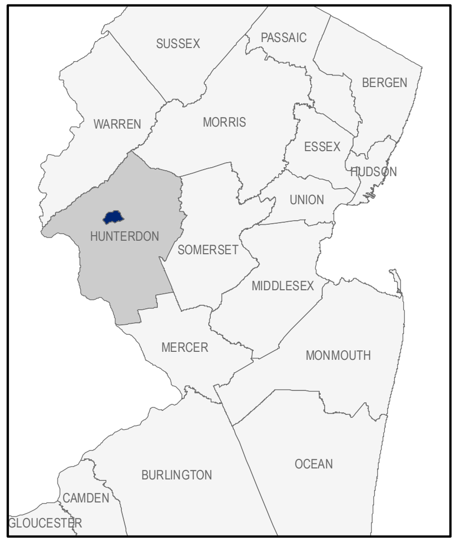
Stream Segments
- A, F
- B, G
- C, H, K
- D, I
- E, J
- Wetlands

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig19_NWquad.mxd April 07, 2010, Copyright Princeton Hydro, LLC.



Princeton Hydro

NEW JERSEY COUNTY MAP



PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

N

Feet

0 437.5 875

1 inch = 875 feet

SOURCES:

1. Streams and wetlands (2002 LULC) obtained from the NJDEP GIS website.
2. SCS streams digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. 2007 aerial photographs obtained from NJGIN Information Warehouse.
5. Vernal pools obtained from Rutgers University Mapping Vernal Pools in New Jersey website.

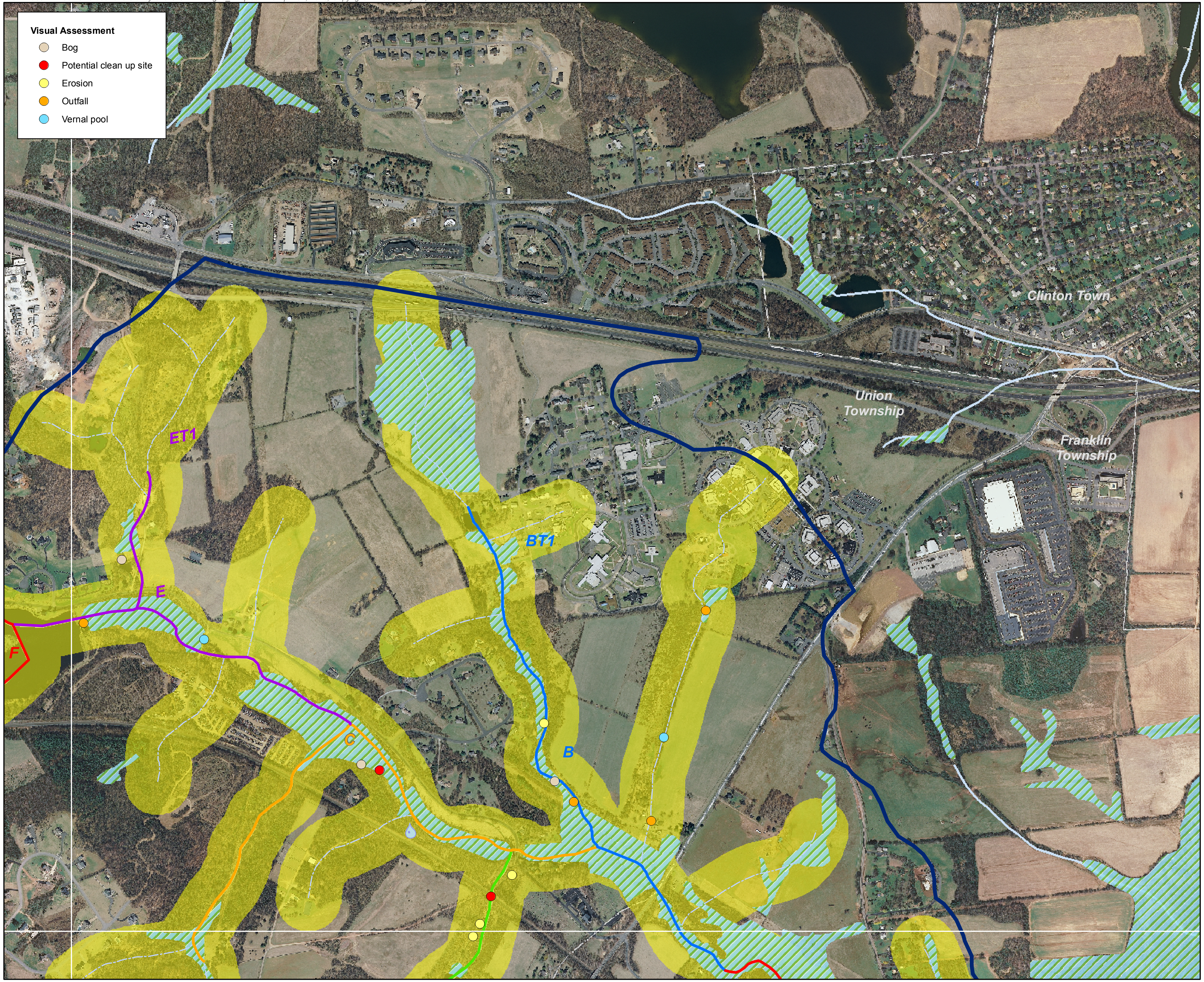
FIGURE 19:
NW QUADRANT OF THE
SIDNEY BROOK WATERSHED

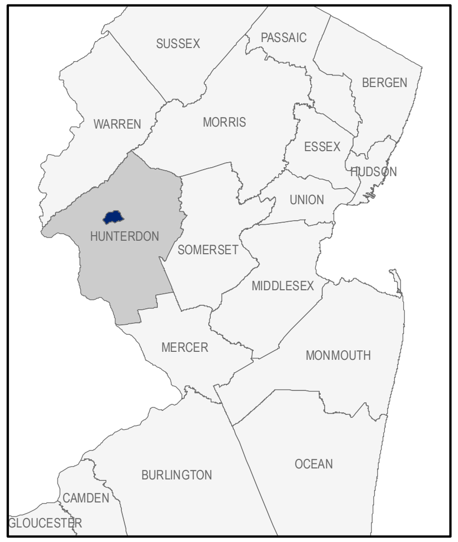
SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

Vernal Pools
Certified
Not Certified
SCS Streams
Streams
300' C1 Stream Buffer
Municipal Boundary
Study Area

Stream Segments
A, F
B, G
C, H, K
D, I
E, J
Wetlands





Princeton Hydro

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 437.5 875
1 inch = 875 feet

SOURCES:

1. Streams and wetlands (2002 LULC) obtained from the NJDEP GIS website.
2. SCS streams digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. 2007 aerial photographs obtained from NJGIN Information Warehouse.
5. Vernal pools obtained from Rutgers University Mapping Vernal Pools in New Jersey website.

FIGURE 20: NE QUADRANT OF THE SIDNEY BROOK WATERSHED

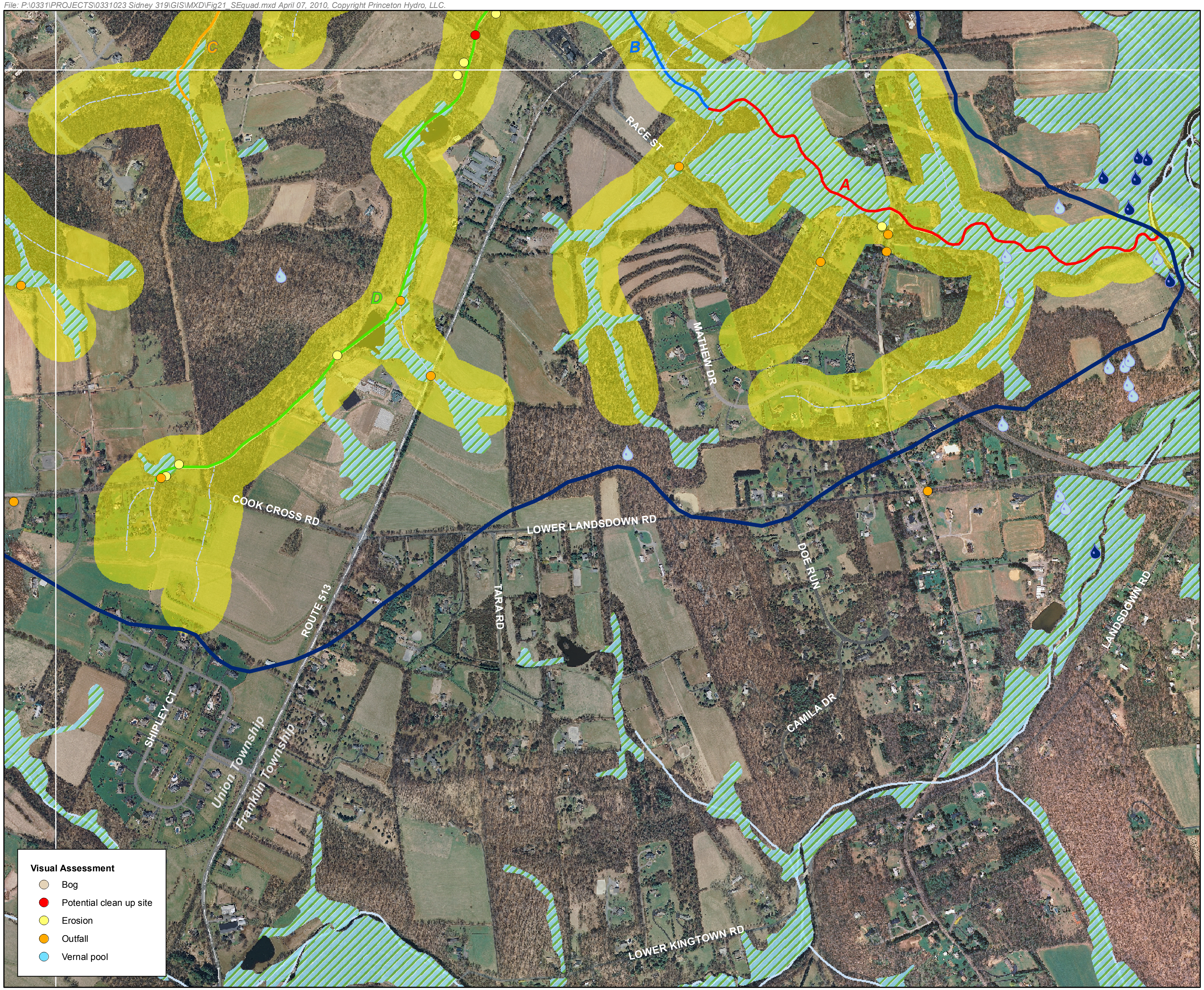
SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

Vernal Pools
- Certified
- Not Certified
- SCS Streams
- Streams
- 300' C1 Stream Buffer
- Municipal Boundary
- Study Area

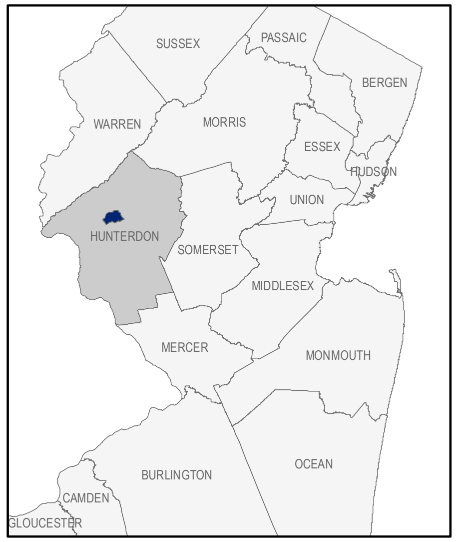
Stream Segments
- A, F
- B, G
- C, H, K
- D, I
- E, J
- Wetlands

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig21_SEquad.mxd April 07, 2010, Copyright Princeton Hydro, LLC.



Princeton Hydro

NEW JERSEY COUNTY MAP



PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 437.5 875
1 inch = 875 feet

SOURCES:

1. Streams and wetlands (2002 LULC) obtained from the NJDEP GIS website.
2. SCS streams digitzed from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. 2007 aerial photographs obtained from NJGIN Information Warehouse.
5. Vernal pools obtained from Rutgers University Mapping Vernal Pools in New Jersey website.

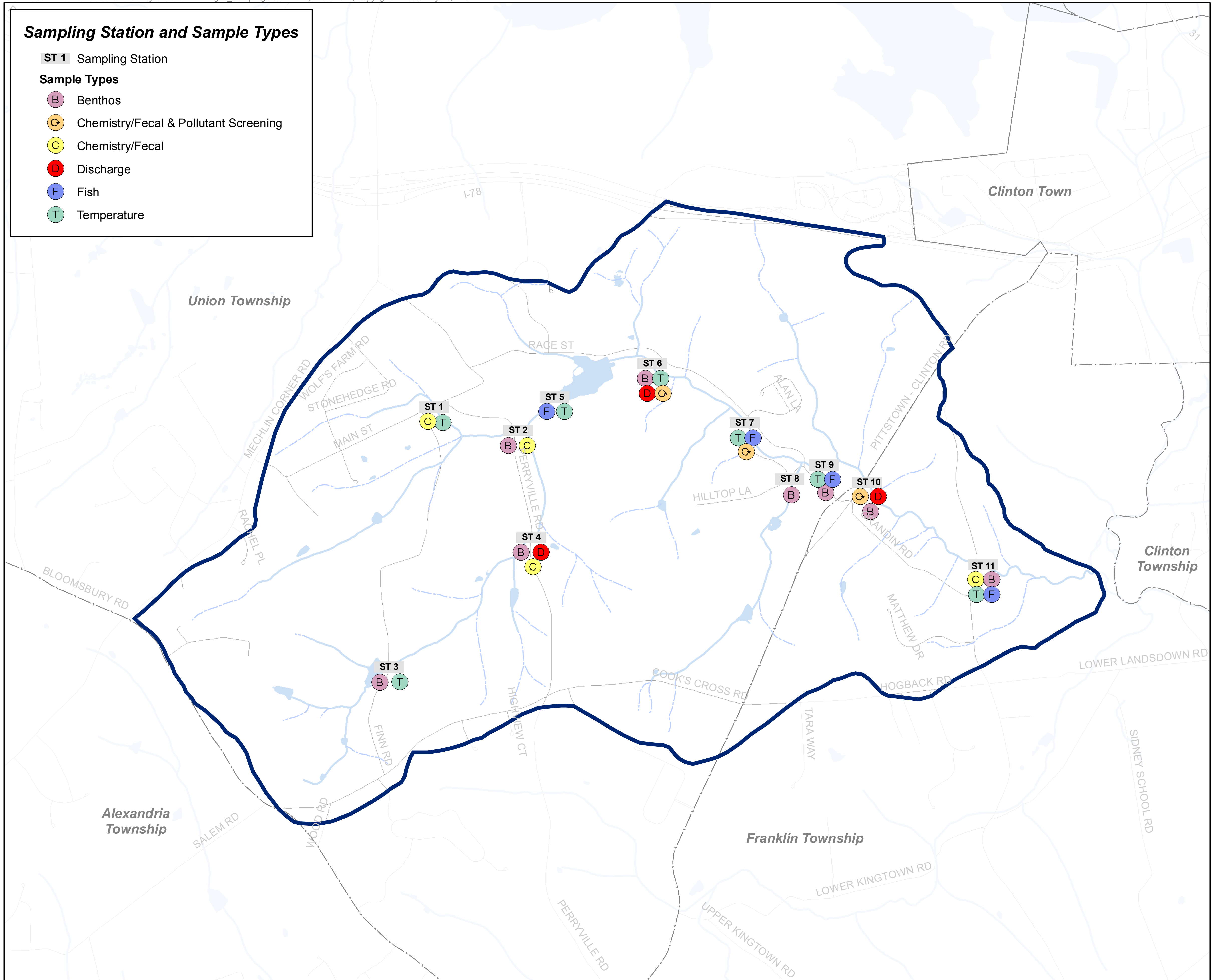
FIGURE 21:
SE QUADRANT OF THE
SIDNEY BROOK WATERSHED

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

Vernal Pools
- Certified
- Not Certified
- SCS Streams
- Streams
- 300' C1 Stream Buffer
- Municipal Boundary
- Study Area

Stream Segments
- A, F
- B, G
- C, H, K
- D, I
- E, J
- Wetlands



Princeton Hydro

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams and lakes obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

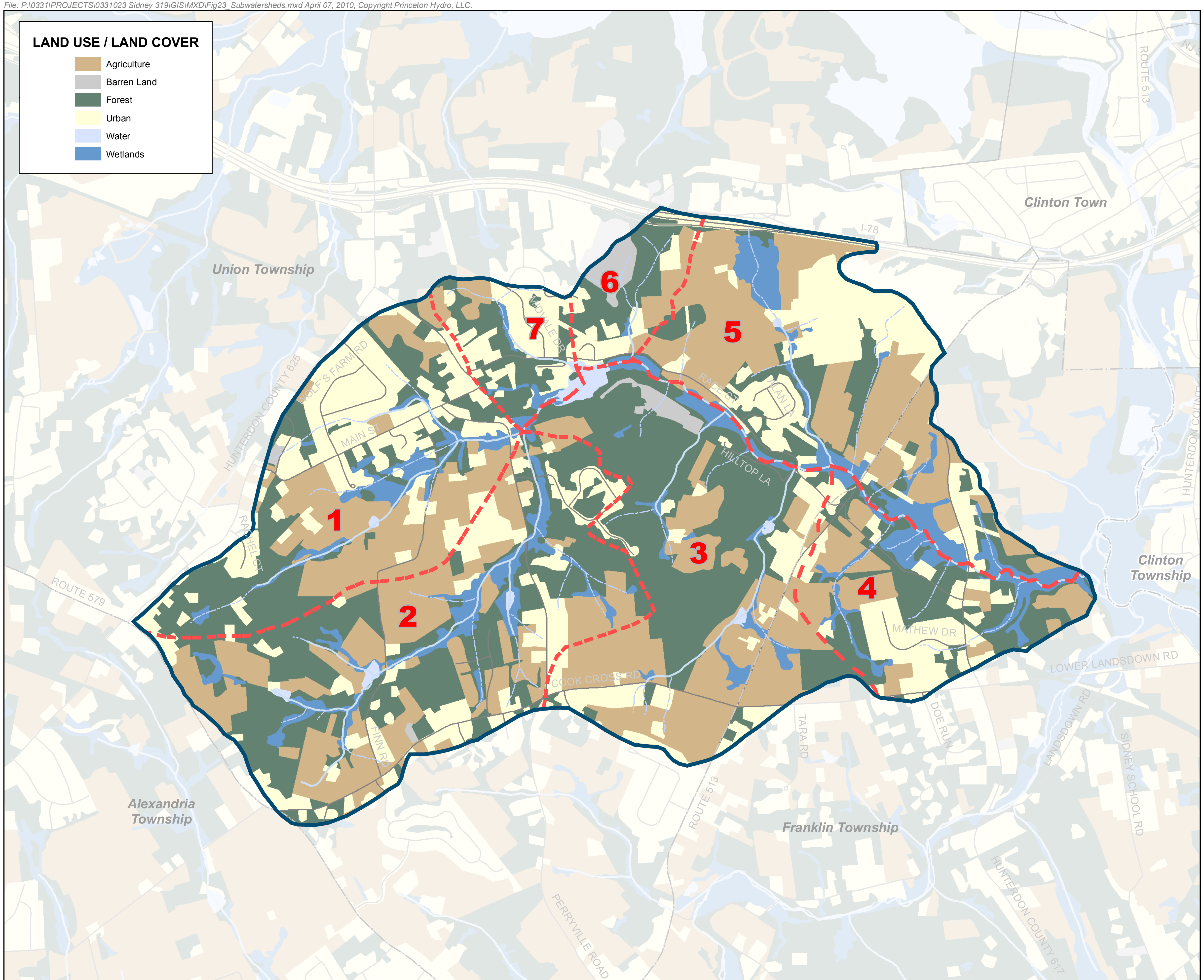
FIGURE 22: SAMPLING STATIONS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Lakes
- Municipal Boundary
- Study Area

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig23_Subwatersheds.mxd April 07, 2010, Copyright Princeton Hydro, LLC.



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams and 2002 Land Use/Land Cover as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitized from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.

FIGURE 23: SUBWATERSHEDS

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

- Roads
- SCS Streams
- Streams
- Municipal Boundary
- Subwatersheds
- Study Area

Appendix II
Visual Assessment Report

STREAM VISUAL ASSESSMENT
for the
SIDNEY BROOK WATERSHED
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

Submitted for the Section 319(h) NPS
Pollution Control and Management Implementation Grant
Sidney Brook Watershed Protection Plan
Contract # 07-003

Submitted to:
Union Township Environmental Commission
And the
New Jersey Department of Environmental Protection
Division of Watershed Management
P.O. Box 418
Trenton, New Jersey 08625-0418

Prepared by:
Princeton Hydro, LLC
P.O. Box 720
1108 Old York Road, Suite 1
Ringoes, New Jersey 08551

May 2008/ Revised June 2008

SIDNEY BROOK WATERSHED VISUAL ASSESMENT REPORT
TABLE OF CONTENTS

APPENDICES- SIDNEY BROOK WATERSHED

1.0 Introduction and Project Background

Union Township was formed from the southern part of Bethlehem Township in 1853. The Union Township website explains that the community was named for the Union Furnace forge which was producing iron as early as 1700, and produced cannon balls for the Revolutionary War, as well as farm implements and shoes for horses and oxen. Over the centuries, forests gave way to farm fields as trees were cut down to stoke the furnace. A farming community dominated the landscape for centuries until the expansion of Route 78 which has encouraged suburban development pressures.

The Sidney Brook Watershed is located in Union and Franklin Townships, within the North & South Branch Raritan Watershed Management Area (WMA) #8. Sidney Brook is a 2nd order tributary to the South Branch Raritan River with a watershed drainage area of 5.5 square miles that spans much of southern Union Township and the northern portion of Franklin Township in Hunterdon County (Figure 1). The New Jersey Department of Environmental Protection (NJDEP) designated Sidney Brook as a Category 1 stream in April 2003.

In 2006, Union Township Environmental Commission received a Section 319(h) Nonpoint Source grant from the New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management to develop a Watershed Protection Plan for the Sidney Brook watershed. Their project partners currently include the NJDEP Division of Watershed Management and the AmeriCorp Watershed Ambassadors; Union and Franklin Township Environmental Commissions; the New Jersey Water Supply Authority (NJWSA); Hunterdon County Planning Department; and Princeton Hydro, LLC as a subcontractor. An initial task of the project includes conducting a Visual Assessment of the stream network to document the overall health of the stream system and to identify both problem spots and areas with good ecological health. The Visual Assessment field work was performed by members of Princeton Hydro and AmeriCorp Watershed Ambassadors. Summary tables of the Visual Assessment results for each quadrant of the Sidney Brook Watershed are presented in Appendix B.

2.0 Objectives and Intended Use of the Visual Assessment Data

The need for the Sidney Brook Watershed Protection Plan stems from both the limited water quality data for this Category 1 stream and from the variation of regional land use policies across that watershed that may affect land development. Limited water quality and biological data have been collected for the Sidney Brook, and this is problematic considering the populations of important, threatened and endangered water-dependent species such as bog turtle and wood turtle, and trout that have been documented within the watershed. The Sidney Brook Watershed Protection Plan will accomplish two goals: documenting the existing Sidney Brook water quality and the ecological integrity; and identifying the actions to protect Sidney Brook and reduce non-point source pollution in Sidney Brook and thereby improve the water quality of this extraordinary natural resource. The Visual Assessment of the stream plays a vital role in the identification of potential pollutant sources, areas of stream impacts, and towards the development of the necessary watershed protection and restoration plans. Future water quality monitoring will be based on the findings of the Visual Assessment, and conducted under a separate Water Monitoring Quality Assurance Project Plan (QAPP).

3.0 Stream Access

An integral part of the stream assessment protocol is gaining access to walk the streams, headwaters, wetlands and riparian corridors that include privately owned lands. To obtain this access, the NJWSA mailed letters in January and February 2008 to approximately 250 property owners, along with a postcard that upon return would grant the requisite access. The NJWSA worked in concert with members of the Union Township (UTEC) and Franklin Township Environmental Commissions to track property owners, and obtain the access permissions. Initially approximately 30% of the requested access was granted. Several critical property owners were subsequently personally notified. In addition, the UTEC mailed a newsletter to all town residents explaining the watershed project, and a public meeting was held by the UTEC on March 11, 2008 to explain the upcoming field work and respond to any questions. Figure 2 identifies the parcels where access was granted. Access was not obtained on portions of stream segments A, B, C, E, J, H and K. The draft access letters and UTEC newsletter are enclosed as Appendix C.

4.0 Stream Visual Assessment Protocol

Princeton Hydro and the AmeriCorp Watershed Ambassadors utilized the Stream Visual Assessment Protocol Plan (VAPP, August 2007) developed by the NJDEP Division of Watershed Management to perform a comprehensive assessment of stream conditions, to gather initial information regarding "stream health". This field work was conducted from late February through March 2008 by members of Princeton Hydro LLC with assistance from the NJDEP Watershed Ambassador AmeriCorp program. It was necessary to complete the visual assessments in the early spring in order to avoid dense vegetative growth and to utilize the data towards the proposed stream sampling efforts scheduled to be initiated from April-November 2008.

The five data sheets for the NJDEP VAPP were developed from the Department's original "Water Watch" RATS (River Assessment Teams) volunteer monitoring programs, the Natural Resource Conservation Service's Stream Visual Assessment Protocol (SVAP) and the EPA's Rapid Bio-Assessment Protocol and Volunteer Monitoring Manual. Information for Sidney Brook collected utilizing the NJDEP VAPP data sheets is incorporated in the Visual Assessment Summary Tables in Appendix B, and the VAPP Data sheets and the instructions to complete these forms are attached as Appendix D.
http://www.state.nj.us/dep/watershedmgt/DOCS/319(h) RfP/VAPPaug07.pdf

The NJDEP Stream VAPP Protocol was used to qualitatively assess each stream reach based on several indicators, including:

1. The Stream General Sheet includes data to identify the stream and watershed area, GPS coordinates, field team, weather conditions and a site sketch.

2. The Stream Monitoring Sheet evaluates: stream width, depth, flow, velocity, sinuosity, pool and riffle variability, and stream substrate, embeddedness, bank stability, vegetative cover, aquatic vegetation, channel alteration, water color and odor.
3. The Streamside Assessment evaluates land use within 50 feet and ¼ mile of the stream, including: residential, commercial, industrial, institutional, roadway, agricultural, and recreational uses, as well as preserved forest and wetland land use.
4. The Drainage and Outfall Inventory will assist in locating and evaluating the condition of drainage features and drainage infrastructure throughout the watershed. This information on drainage ditches, culverts or outfalls can also be incorporated into the state mandated Stormwater Plans required pursuant to N.J.A.C. 7:8 for each municipality and county.
5. The Invasive Plant Survey will identify where invasive species may dominate the riparian corridor.

It should be noted that because the Sidney Brook field work occurred in the late winter, it was difficult to accurately assess aquatic vegetation. This time frame is also not optimal for the documentation of wetland habitats. However, these specific conditions will be re-evaluated during the spring, summer and fall when stream sampling is conducted.

5.0 Preliminary GIS Data Review

Prior to conducting the field effort for the Visual Assessment several GIS data layers were reviewed and maps were created in order to focus the field activities. A brief summary of these findings is provided here and more detailed discussion will be provided in the Watershed Characterization Assessment Report. The accompanying maps are enclosed in Attachment A.

- ***Land Use and Land Cover (LU/LC)***
  Figure 3 in Appendix A depicts the Land Use and Land Cover (LU/LC) for the Sidney Brook Watershed. Based on the NJDEP 2002 GIS data, approximately 32.3% remains forest, 32.3% are farmlands, 9% are wetlands and 26% are developed lands primarily as residential housing and commercial developments.

  The Sidney Brook watershed currently contains a mix of land uses that result in varied non-point source pollutants being introduced into Sidney Brook. Significant features include Interstate 78, the Hunterdon Developmental Center and the Edna Mahan Correctional Facility for Women in the north and residential areas interspersed with small forested tracts and agricultural lands in the west. The southern and central portions of the watershed contain large forested and agricultural tracts of land and some lower density residential areas. The watershed's landscape is threatened by additional intensive land use change due to the pressures of suburban sprawl within this region. This GIS data is six years old and new developments have been completed or are underway, including the Union Township Elementary School.

- ***Highlands Boundaries***
  Figure 4 depicts the planning zones in Union and Franklin Townships defined by the Highlands Water Protection and Planning Act (HWPPA), and includes portions of the Highlands Preservation, the Highlands Planning, and non-Highlands areas. The

combination of heavy development pressure and the variety of land use policies in the watershed can lead to land use changes to the watershed that could potentially will degrade the existing water quality and harm environmentally sensitive species and habitats within the Sidney Brook watershed. A detailed discussion of the various Highland's policies will be provided in the Characterization Assessment Report.

- ***NJDEP Landscape Project and Natural Heritage Data***
  Figures 5, 6 and 7 depict the NJDEP Landscape Project and Natural Heritage Data for habitats for designated Threatened and Endangered Species in New Jersey. In the wetland areas this includes habitat for the Federally Endangered bog turtle, State Threatened wood turtle, and critical vernal pools. During the Visual Assessment specific areas were noted where bog habitat or vernal pools may be present, but no additional species sightings were documented.

  Critical grassland and forested habitats are also depicted on Figures 6 and 7. Within the watershed area, the grassland habitats include parklands and farms where rare, federally endangered grassland bird species have been documented. The forested areas include habitat areas for the state threatened wood turtle.

- ***Open Space and Farmland Preservation***
  Figure 8 is a draft map that depicts the properties acquired for open space preservation by the Townships, County, State, as well as private farmlands that have enrolled in the Hunterdon County Farmland Preservation program, such as the Peaceful Valley Orchard, located on Route 513. The Union Township open space includes Finn Park and Milligan Farm, where active and passive recreational uses are provided, and critical habitats are documented. Union Township also has a conservation easement for the Talka Property along the Sidney Brook corridor and Perryville Road (Block 25, lot 32) where limited public access is provided, and the forested riparian corridor is protected. These areas were visited and evaluated during the Visual Assessment.

  Franklin Township owns 55 acres along Sidney Brook and Grandin Road at Block 4, lot 3.01, with access to the stream from Route 513 and Sidney Road. Franklin Township is currently working with Hunterdon County to acquire 174 acres on parcel Block 5, lot 5 to be used as active and passive recreational parklands. Preserved farmlands in Franklin Township include the Nouiga farm on Block 4, lot 3, and the Vitale farm on Block 10, lot 4, which also provides a Green Acres conservation easement.

- ***Surface Water***
  The Sidney Brook Watershed lies within the NJDEP designated Watershed Management Area #8, hydrologic unit, HUC 02030105020070. Sidney Brook is a second order tributary to the South Branch of the Raritan River with a watershed drainage area of 5.5 square miles that spans much of southern Union Township and the northern portion of Franklin Township in Hunterdon County. Within the NJDEP mapping (NJGS stream GIS layer) and regulatory programs (N.J.A.C. 7:9B State Water Quality Standards), Sidney Brook is also referenced as Grandin Stream. The NJDEP adopted Sidney Brook as a Category 1 stream in April 2003 based on the populations of state-threatened wood turtles (*Glyptemys*

insculpta) documented in Sidney Brook and the bog turtle (*Glyptemys muhlenbergii*) habitat within the watershed. In addition, initial biological and habitat surveys of Sidney Brook conducted by the NJDEP near the South Branch Raritan River confluence indicated diverse fish and invertebrate communities and high-quality stream habitat conditions.

Figure 9 depicts the NJDEP 2001 AMNET macroinvertebrate data, and sampling from Sidney Brook as well as upstream and downstream received a non-impaired rating. Additional macroinvertebrate sampling was conducted by Princeton Hydro at three stations on Sidney Brook in August and November 2003, which identified all three stations as non-impaired (Race Street, Pittstown Road and Sidney Road). Limited chemical sampling conducted by Princeton Hydro in November 2003 identified nitrate concentrations ranging from 1.7 to 2.4 mg/L at the stations downstream of the Race Street crossing, and fecal coliform was detected at 300 (CFU) at the Race Street station.

NJDEP Fish Index of Biological Integrity (FIBI) data was collected in 2001 at Sidney Road (Route 617) in Franklin Township (location FIB1008). The stream segment received an optimal habitat assessment rating (score of 164) and the FIBI rating was excellent (score of 46). One brook trout was identified (with a length of 13 inches) and 15 largemouth bass were collected. The presence of a brook trout in August is an indication of good water quality. The three most prevalent fish species included: tesselated darter (123); blacknose dace (112); and longnose dace (105). In August 2003, Princeton Hydro recorded finding a juvenile brown trout at the Race Street crossing just upstream of the Route 513 Bridge. Based on this information, the NJDEP proposed in May 2007 to upgrade the upper segment of Sidney Brook downstream to the Route 513 Bridge to a Category 1-Trout Maintenance designation. The segment downstream of Route 513 would remain designated by NJDEP as a Category 1 Non-Trout stream. However, it should be noted that the brook trout identified by NJDEP in the sample FIB1008 was collected at Sidney Road (Route 617) downstream of Route 513.

- ***Riparian Corridors***

  Figure 5 depicts Sidney Brook and the 300 foot riparian corridors, which are protected for Category 1 streams under the NJDEP Stormwater and Flood Hazard Area regulations. As noted in the aerial much of the land use along the main stem and tributaries of Sidney Brook remain intact forests, while much of the headwater tributaries are farmed. Riparian corridors were somewhat developed in older communities along reach J (Wolf Farm Development) and reach F (Midvale Road). Newer housing developments were designed to restrict encroachments to the riparian corridors (reach G and H).

  Upon review of the 2002 NJDEP GIS data the land use within the 300 foot Special Water Resource Protection Area (SWRPA) or 300 foot riparian buffer for the Category 1 stream is as follows: approximately 34% of the riparian corridors remain intact forests, 18% are wetlands, 24% are farmed, and 21% have been developed.

LULC Type	Acreage	Percentage
AGRICULTURE	356.07	23.63%
BARREN LAND	26.74	1.77%
FOREST	513.68	34.10%
URBAN	291.67	19.36%
WATER	23.57	1.56%
WETLANDS	275.03	18.25%

- ***Steep Slopes, Soils, Groundwater Recharge, and Bedrock Aquifer Mapping***
  Figures 10, 11, and 12 depict areas where development may be constrained by steep slopes, septic limitations, and soil erodibility. Figures 13 and 14 depict local bedrock aquifers and areas of groundwater recharge based on mapping recently developed for the Highlands Regional Master Plan, December 2007. Groundwater recharge is affected by slopes, soils, geology and depth to bedrock. The Townships may wish to consider this information in regard to future planning and zoning.

- **Known Contaminated Sites**
  During the assessment of potential impacts to the quality of Sidney Brook, the NJDEP GIS data was reviewed and no Known Contaminated Sites (KCS) were identified within the watershed boundary for Sidney Brook. However, two Known Contaminated Sites (KCS) were identified at the State Correctional Facility and County Development Center, and these are depicted on Figure 17. These sites could be (former) underground storage tanks, but their status is unknown and the area was inaccessible during the Visual Assessment. Other areas of potential concern within the watershed include: a quarry, an automobile junkyard on Race Street, the storage yard for the Union Township Dept of Public Works, and areas of discarded debris, including old tires and drums observed near the railroad line. Sampling near these locations was proposed.

6.0 Viable Trout Habitat

The viability of brook trout in Sidney Brook and habitat conditions will be assessed as part of the Sidney Brook Watershed Plan by sampling and evaluating fish surveys, macroinvertebrates, and water quality monitoring. In addition, the Visual Assessment field work evaluated habitat conditions, which are discussed generally in summary section 10.

Brook trout *Salvelinus fontinalis* are native to the northeastern United States and Canada, and are important species for recreation and an indicator of high water quality. A recent study entitled *Conserving the Easter Brook Trout,* [1] completed for the International Association of Fish and Wildlife Agencies reported that wild brook trout populations in the eastern United States are significantly impaired, and 27% of the assessed subwatersheds identified severely reduced brook

[1] Conservation Strategy Work Group Eastern Brook Trout Joint Venture, December 2005, "Conserving the Eastern Brook Trout: An Overview of Status, Trends and Threats"
http://www.mmbtu.org/Conserving_Eastern_Brook_Trout.pdf

trout populations from historic levels. Intact brook trout populations were found in only 5% of all subwatersheds assessed across the historic eastern range from Maine to Georgia. Moderately reduced brook trout populations were found in 9% of the assessed watersheds. This study also identified the top impacts to trout populations as: high water temperature, agriculture, riparian condition, competition from non-native fish species, and urbanization. This is a regional concern for all the eastern states.

The NJDEP Division of Fish & Wild and the New Jersey Chapter of Trout Unlimited together sponsor a program entitled "Trout in the Classroom." The guidance from this program explains that brook trout require clean, clear, cold streams with temperatures ranging from 53° F to 65° F, and can tolerate temperatures of 72° F for only a few hours. Trout prefer streams with a substrate of gravel, cobble, and boulders, with many pools and riffles. Riffles are areas where the water is shallow and runs swiftly over rocks. Young trout are not easily spotted by predators in the riffle, and the fast current enriches the stream with oxygen, and brings a constant food supply. Brook trout are mostly carnivorous, and feed on insects such as mayflies, caddisflies, midges and beetles that are adapted to live in stream riffles and on land. The swimming mayfly is streamlined to avoid being swept away with the current. The black fly larvae attach themselves to the riffle substrate and the stonefly has a flat body and sprawling legs, to stay close to the surface of the rocks where there is a slower current. As they grow, trout move into the deep pools, which are the slower moving stream sections with smooth surface water, and hide in undercut banks, under large rocks, in pools with overhanging trees. Trees provide shade to cool the water, keep the banks stable and offer a hiding place for fish.

In New Jersey and throughout the eastern United States, brook trout are facing threats to their habitat:

- Land use practices related to development and agriculture that remove streambank vegetation, the stream's canopy or excessive clear-cutting within a watershed can reduce the shade and increase water temperatures. Reducing woody debris in streams, also negatively impacts trout habitat.
- Activities that removes vegetative cover, disturbs the soil, reduces runoff infiltration, decreases soil moisture storage, or increases overland flow has the potential to negatively affect streams by causing higher peak runoff and stream flows and increases sediment loads and pollutant sources to the stream.
- Sediment deposition in streams can adversely affect brook trout by degrading habitats for trout and the insects they consume. Sediment deposition can increase water temperatures, decrease dissolved oxygen, clog gills, smother eggs and embryos in redds (nesting sites) and aggrading (fill) pools, causing a loss of over wintering habitat. Brook trout are susceptible to turbidity levels because it reduces their ability to locate food.
- Shallow ponds and lakes are susceptible to warming during the summer, which can be stressful or lethal to trout downstream from these impounded areas.
- Man-made barriers, such as dams or culverts that obstruct fish passage can fragment brook trout populations and prevent migration to suitable spawning habitat, to cool water refuges during warm periods during the summer, and to over wintering habitat. This can be particularly problematic during low and high flow situations
- Pesticides, herbicides, deicing salts, oil, gasoline that can be washed into streams can impact young brook trout populations and the insects they rely upon.

The NJDEP is working with the Eastern Brook Trout Joint Venture to implement range-wide strategies that sustain healthy, fishable, brook trout populations by: providing educational programs, encouraging partnerships, and enhancing brook trout populations impacted by habitat modification or other disturbances.

7.0 Headwater Streams Documentation

Documenting the headwater streams or intermittent streams is an important component of the aquatic and terrestrial ecosystems of Sidney Brook, and a critical component of the Visual Assessment effort. Headwater streams "comprise the largest total number and most linear miles of streams in the United States", accounting for up to 80% of all waterways, as reported by *American Rivers* (2003).[2] Headwater streams may include first and second order streams that provide important sources of nutrients and energy for higher order streams. Furthermore, headwater streams are often associated with wetland complexes and riparian areas that are important ecological features of the landscape, harboring plants, aquatic species, organisms, and terrestrial wildlife that are unique to the ephemeral or intermittent flow characteristics of these waterbodies.

In general, headwater or intermittent streams are often not identified on USGS maps or state and local GIS maps, because of their intermittent nature or remote locations. However, they are sometimes identified on the county soil survey maps produced by the USDA – Natural Resource Conservation Service (NRCS). This basic lack of mapping and documentation contributes to a lack of protection and the continuing degradation or disturbance of these vital headwater streams. Similar to wetlands, the value of headwater streams has only been recently recognized, and regulations in the past allowed intermittent or headwater streams to be altered, ditched, filled, developed, diverted to storm sewers, or replaced by highly engineered stormwater basins. By formally mapping these waterways, the applicable New Jersey regulations for "regulated water resources" (e.g., State Surface Water Quality Standards (N.J.A.C. 7:9B or the Flood Hazard Area Control Rules (N.J.A.C. 7:13)) can be appropriately and legally applied to the newly mapped and verified headwater streams. This is especially important considering that headwater tributaries have a direct impact on the water quality of higher order waterbodies downstream.

7.1 Regulated Waters and Riparian Buffers

In November 2007, the NJDEP adopted the revised Flood Hazard Area Control Rules (N.J.A.C. 7:13-4.1), which apply a protective 50 foot riparian zone buffer to <u>all freshwater regulated waters</u> in New Jersey that are *not* Category 1 streams. This riparian buffer restricts disturbances, and can be expanded to 150 feet in width for the following regulated waters and their upstream waters, including tributaries within one mile:

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[2] Meyer, J. L. 2003. Where rivers are born: The scientific imperative for defending small streams and wetlands. Washington DC: American Rivers, Sierra Club.

i. trout production or trout maintenance water and
ii. any segment of a water flowing through an area that contains documented habitat for a threatened or endangered species of plant or animal, which is critically dependent on the regulated water for survival, and all upstream waters including tributaries within one mile

The Flood Hazard Area Control Rules (N.J.A.C. 7:13-2.2) identifies that all waters in New Jersey are regulated including water segments that drain less than 50 acres, if they have a discernible channel. Waterways that are confined within a lawfully existing, manmade conveyance structure such as a pipe, culvert, ditch, channel or basin, and any waterways that historically possessed a naturally-occurring, discernible channel, which were placed in a pipe, culvert, ditch, or similarly modified, are not regulated by these rules.

The State's Water Quality Standards (N.J.A.C 7:9B) define Category 1 waters as high quality waters subject to the State's anti-degradation policies (N.J.A.C 7:9B-1.5(d)). Such waters are protected under these policies from any measurable (including calculable or predicted) changes to existing water quality.

In addition, the Stormwater Management Rules (N.J.A.C. 7:8) adopted in 2004, establish a 300 foot Special Water Resource Protection Area (SWRPA) for all Category 1 streams. This regulation also allows for the riparian buffer to be reduced to 150 feet, if the riparian lands are actively farmed. Disturbance of the riparian corridor or SWRPA is highly regulated by the NJDEP, and this rule creates a legal mechanism to protect any alteration or loss of the lands immediately adjacent to Category 1 streams. As stated previously, Sidney Brook was designated as a Category 1 stream by the NJDEP in 2003. As such, the headwater streams and tributaries to these Category 1 waters which were identified and newly mapped through this assessment are subject to these regulatory protections.

Protecting the riparian corridors along streams and the natural vegetative cover, creates a stable boundary between land and water features. An undisturbed riparian buffer helps to reduce the potential erosion of stream banks; and reduce pollutants such as fertilizers, pesticides, manure and septic leachate from degrading stream quality. Maintaining a natural vegetative cover along riparian corridors provides the shade needed to cool water temperatures, and provides habitats for wildlife. A riparian corridor can also provide a natural buffer between neighborhood developments and increase the aesthetics of the community.

7.2 Defining and Mapping Headwater Streams

For the purpose of the Sidney Brook Headwater Visual Assessment, the following criteria were relied upon to define and map headwater streams in accordance with the definitions provided by the NJDEP in the Flood Hazard Control Rules (N.J.A.C. 7:13), the NJDEP Model Ordinance to protect *Riparian Buffer Conservation Zones*, March 2005, and definitions provided by the US Geological Service (USGS). Full details of these definitions are provided in Appendix E.

The Sidney Brook Visual Assessment defines Headwater Streams as:

- An intermittent or ephemeral surface water body which flows seasonally, or when it receives water from precipitation, melting snow or groundwater springs.
- Intermittent streams shown as a dashed line on either the USGS topographic quadrangle maps or the USDA-NRCS County Soil Survey Maps.
- A surface water segment that has a discernible channel with definitive bed and banks in which there may not be a permanent flow of water. A channel depth equal or greater than 6 inches was used for this assessment.

The initial step in the headwater mapping was to utilize existing stream mapping coverage as a baseline for field verification. United States Geological Survey (USGS) blue line streams, which are the base data of most perennial stream maps, are known to exclude small order, intermittent streams in their mapping coverage. Therefore, Princeton Hydro also utilized the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) County soil survey data, which provides a higher resolution of stream mapping. The NRCS data generally shows intermittent streams that are tributaries to the larger, higher order USGS blue line streams. Princeton Hydro initially created a GIS (geographic information system) base map of the streams including the existing USGS blue line streams and digitized NRCS intermittent streams. The resulting maps were initially analyzed with respect to topography and soils as well as the most recent available digital land use and land cover data to ascertain the basic validity of the newly identified stream segments. This step is necessary as much of the NRCS stream data is dated and subject to alteration by more recent land development activities.

Field verification of the newly mapped headwater streams was preformed to confirm whether these waterway features were viable headwaters, with defined channels, bed and bank. GIS maps were revised as necessary depicting the streams and headwater segments in four quadrants of the Sidney Brook watershed utilizing the NJDEP GIS data, the County Soil Surveys, and the criteria listed above.

7.3 Evaluating the Headwater and Stream Conditions

Initially, the NJDEP GIS 2002 database had included 10.43 miles of the Sidney Brook stream. Based on the methodologies outlined in this report, 11.84 miles of previously unidentified or unmapped headwater stream segments were added to the Sidney Brook stream maps, doubling the known stream length. These headwater streams are visually depicted on the Watershed Aerial Maps (Figures 1 and 5-8). A limited number of these intermittent streams are located on farmlands, private lands or behind homes, and these streams are likely present but their channel depth was not confirmed due to their inaccessibility. All of the newly mapped intermittent streams that were accessible and assessed have a discernible stream bank height greater than one foot. Most of these waterways had stream flow at the time of the field verification. The presence of a defined bank and the existence of flow fully validate the classification of these waterways as regulated streams.

The newly mapped streams and headwater stream segments identified herein should be provided to and utilized by the Planning and Zoning Boards, Environmental Commissions, and Engineering Staff of Union Township and Franklin Township to ensure that future development plans identify these headwater streams and preserve the applicable Category 1 riparian corridor protections or Special Water Resource Protection Area (SWRPA) of 300 feet for forested areas and 150 feet for farmed lands (Figures 1, and Figures 16-19). Franklin and Union Township could also consider officially adopting this headwater information and this mapping as Appendices to their Township Environmental Resource Inventories to ensure the application of state and local ordinances.

8.0 Narrative Tour of the Sidney Brook Watershed

For this Visual Assessment, the Sidney Brook watershed was divided into eleven stream reaches approximately one mile in length, labeled from A to K, as depicted on Figure 1. Each stream reach in turn was divided into stream segments, each approximately ¼ mile in length dependent upon field conditions, such as the confluence of tributaries, road crossings, varying land uses, stream conditions, riparian corridor health, and stream access. In addition, the headwater tributaries that were assessed are also identified on the maps such as BT1, ET1, etc. To facilitate the data review, the Sidney Brook watershed has been divided into four quadrants to enlarge the aerial maps of these study areas. Limited information regarding headwater tributaries, roadways and wetlands are included onto these maps to assist the field work and data interpretation (Appendix A, Figures 15 through 18).

The overall objectives of the stream visual assessment and the intended use of the data are to:

- Document the general stream conditions, overall health of the stream and assess aquatic habitats within the Sidney Brook watershed;
- Document headwater tributaries to Sidney Brook;
- Identify potential non-point pollution sources (NPS) including urbanized lands, unregulated or illicit discharge points, Known Contaminated Sites, or Classification Exception Areas;
- Identify and document stormwater outfall conditions, erosion sites, and areas of flooding concerns.
- Identify potential monitoring sites for the Sidney Brook project, with particular attention to access locations, the confluence of tributaries, stormwater outfalls, and existing monitoring data.
- Identify and document the integrity and health of the state regulated 300-foot riparian corridor, by assessing the vegetative buffer width, the vegetative condition, canopy cover and possible encroachments in the riparian corridor. These conditions are especially important to shading the stream and moderating water temperature, which is critical to the health of trout and aquatic species.
- Identify and document stream bank stability and potential riparian stabilization and or mitigation sites within the Sidney Brook watershed.
- Identify and document barriers to fish movement, such as culverts, dams or diversions, as well as water withdrawals.

The NJDEP protocol utilized for this stream visual assessment is primarily a qualitative assessment of twenty-six different criteria, as described on the NJDEP VA forms in Appendix D. Each criterion is assessed in a descriptive manner, and an overall score or ranking is not possible using this format. The field data collected utilizing the NJDEP VA data forms are summarized in separate tables for each of the four quadrants, to highlight general stream conditions and concerns (Appendix B). The results of the Visual Assessment are portrayed on Figures 19 and 20. A photographic tour of the watershed is also provided in Appendix I, and is provided in a CD form, as a power point presentation. The summary of the field work begins in the southwest quadrant with the uppermost headwater regions and incorporates data downstream to its confluence with the South Branch of the Raritan River, in the southeast quadrant, south of Sidney Road (Route 617).

8.1 Southwest Quadrant – Sidney Brook Reaches I, H, G , Figure 15

Reach I

The land use for Reach I is primarily forest and hayfields and the immediate riparian corridor is forested. The stream has a 4-8 foot width, a clear fast, shallow flow, frequent riffles and shallow pools, and a stable, cobble substrate. There are five large farm ponds on this segment of Sidney Brook: two small ponds approximately 1 acre in size, and three larger ponds greater than 2 acres in size. In each situation the stream banks are eroded downstream of the pond outfalls, possibly due to the high storm flows from the outfalls, steep slopes, and erodible soils as noted on the enclosed watershed maps (Figures 10 and 12). The ponds are located on the following parcels: Block 28, lot 33, 25, 24, 23and Block 27, lot 10.01. Runoff from Cooks Crossing Road flows to the Reach I tributaries and ponds. High runoff volumes and velocities are the likely cause of the observed eroded banks and turbid pond conditions. Modifications to the Cooks Crossing Road drainage swales and inlets should be considered.

After a storm event, the three downstream ponds on Reach I were observed to have turbid water conditions. Generally the streambanks were eroded at a height of 2-3 feet throughout Reach I, even though the stream riparian corridor is an intact forest habitat. Scour pools were evident at each pond outfall, and the addition of rip rap may help reduce the erosive force from these outfalls. Geese were present at each pond and can also impair water quality on this segment.

Reach H

The land use for Reach H is primarily forest with large lot residential development (8 acre lots), and much of the 300 foot riparian corridor is generally intact forest habitat. Access was not permitted for a portion of the main stem of reach H, but headwater tributaries were assessed. The stream has a 4-8 foot width, a clear fast, shallow flow, frequent riffles and shallow pools, and a stable, cobble substrate. Significant erosion (4 feet) is evident on the tributary HT2 at High View Court and Cooks Crossing Road, which in turn causes sediment deposition within the Sanctuary pond.

The **Sanctuary Development** of 12 homes built on 8 acre lots was constructed after 2003, and the 300 foot buffer for this segment and its tributaries was preserved. This development is not depicted on the project aerials; however, an aerial was obtained via Google Earth and Union Township provided a copy of the development Lot and Blocks, which are enclosed as Figures 22 and 23. A small headwater tributary and wetland area (HT1) runs parallel to the entrance roadway of the development, Asher Smith Road. At Stirling Place the wetlands and tributary (HT1) were dammed to create a wetland stormwater basin. A small 3-inch orifice allows continuous flow under the roadway, and during storm events the outfall structure restricts and detains runoff within the wetland basin south of Stirling Place. North of Stirling Place there is a large 48-inch culvert which drains to wetlands. Thick multi-floral rose prevents access to this area. Eventually the HT1 tributary drains to the main stem of Segment H which runs behind the homes, where access was also prohibited. Runoff from five lots is captured by the wetland basin and detained before it drains to Segment H.

The Sanctuary Pond located on the Policastro property (Block 27, lot 3.14) receives runoff without detention from five lots within the Sanctuary development as well as five additional home lots on Cooks Crossing Road and Perryville Road. The Sanctuary developers, Toll Brothers Inc., reinforced the pond dam with gabion structures, and refurbished the emergency spillway with gabions. The pond is approximately 2 acres in size and 8 feet deep; however, and the property owner reports that it becomes very turbid after storm events. Sediment deposition was observed at the mouth of pond and within the pond. The pond owner estimates that a foot of sediment may have been deposited in the pond in the last five years. Severe erosion (4 feet) was evident from the pond emergency spillway and additional rip rap had been added to this discharge area. Discharges over the spillway appear to happen frequently, and modifications to raise the spillway could be considered. In addition, re-aligning the angle of the spillway may also reduce the erosion. Runoff from homes on lots 3.12 and 3.13 and the Asher Smith Road, drains without detention to a grassed drainage easement that bypasses the Sanctuary Pond. This runoff is not detained and connects with the discharge from the Sanctuary Pond, which has flooded a downstream property (Block 27, lot 2). A lengthy, private driveway may also be restricting some stormwater runoff that exacerbates the flooding on this parcel.

The Sanctuary Development and pond in the top corner are depicted in this aerial. This development was recently constructed and is not displayed on the report figures, which are based on the NJDEP 2002 aerials.

High View Court - Severe bank undercutting (4 feet for approximately 200 feet) is evident at the stormwater outfall at Cooks Crossing Road and High View Court (Block 27, lot 3.02), which is the likely source of high flows and sediment deposition to the Sanctuary Pond. This outfall receives runoff from at least seven inlets on Cooks Crossing Road, as well as 9 homes on Woodsedge Court and 7 homes on High View Court. The stormwater is conveyed via 2 feet wide storm sewer pipelines. There are no stormwater basins in these older developments. The outfall and conveyance systems could be evaluated to reduce flows, reduce velocities, and reduce erosion, flows and turbidity to the Sanctuary Pond. Both High View Court and Woodsedge Court have large (60 feet) wide cul de sacs where a bioretention rain garden basin could be constructed to collect and reduce some of the stormwater flows.

Reach G

The land use for Reach G is primarily farmland and a large mature red cedar forest, and the majority of the 300 foot riparian corridor is generally intact forest habitat. Flow to the headwater tributaries begins in a farm field where a constructed berm directs runoff to the tributary via a 12 inch PVC outfall. The tributary GT1 has a 5 foot width, a clear fast, shallow flow, and a stable, clay loam soil substrate. Downstream at the confluence of Reach G and the GT1 tributary there are eroded streambanks of approximately 2-3 feet in height. The GTI tributary runs through the Talka property (block 25, lot 32) and may be protected from development under a conservation easement.

The Crestview Homes located on Hill & Dale Road was constructed on very steep slopes, but the vegetated detention basin, seems to function well. The stream appears in good healthy condition here with a 25 foot width, a clear fast, shallow flow, frequent riffles and shallow pools, and a stable, cobble substrate. No erosion was noted, even at the 48-inch stormwater outfall on the south side of Hill & Dale Road; rip rap was present at this outfall. A large deep pool, good for fishing was observed south of the bridge crossing. In addition, a deck has been washed into Sidney Brook just upstream of the Hill & Dale Road on the right side of the development entrance, possibly during a severe flooding event (Block 25, lot 31). This deck should be removed from the stream.

Finn Park Stormwater Measures – Other concerns for Reach G include the frequent flooding of Perryville Road from uncontrolled stormwater runoff from Finn Park, which has eroded the drainage swales (1.5 feet) along the road (Block 26, lot 12). Limited stormwater swales exist at the park, but no stormwater detention/ retention facilities are present. To reduce stormwater runoff from Finn Park, the Township could consider allowing the grass fields and slopes that are not used for active recreation to grow higher by reducing the mowing, which can help detain and slow some of the runoff. The Township could also consider reducing the mowing of the existing drainage swales. In addition, eleven separate stormwater measures such as the installation of bio-infiltration swales and bioretention basins, and retrofitting stormwater culverts have been recommended to reduce the stormwater runoff from Finn Park that continues to flood Perryville Road. Details of these measures and an accompanying site map of Finn Park were prepared under a separate contract and are included as Appendix F.

8.2 Northwest Quadrant – Reach K, j, F, figure 16

Reach K

The land use for Reach K is currently hayfields and forest, and the immediate riparian corridor for Reach K is forested. Reach K as it crosses Finn Road appears in healthy condition with a 6 foot width, a clear fast, shallow flow, and a stable, cobble substrate. No erosion was observed at the Finn Road crossing.

A small tributary KT1 runs parallel to Finn Road, within a forested, wetland area, thick with multi-floral rose. No erosion was noted at this bridge crossing. A second tributary, KT2 runs from the Kenneth Place cul de sac and crosses Finn Road via a 48-inch culvert. A large scour hole has formed at this crossing, and approximately 100 feet downstream the stream banks are eroded (3-4 feet erosion) on both sides of stream. Also an old landfill area was observed within the woods on right side of stream. Multiple old glass bottles and rusty cans were observed on the ground surface that might interest the local historical society. The area is thick with multi-floral rose (Block 26, lot 16 and 7).

At the Kenneth Place cul de sac a small stormwater basin and private pond discharge to the KT2 tributary. Maintenance of basin could be improved to remove a one foot thick cover of leaf litter. In addition, a tree should be removed from the outfall scour hole, and additional rip rap may be warranted, because significant erosion was noted downstream. The basin outfall could also be retrofitted with a smaller orifice and a trash rack installed. Erosion (1-2 feet) was noted at the pond inlet channel and downstream of an 8-inch PVC outfall from the pond to the KT2 tributary the stream bank is eroded 2-3 feet for about 150 feet (Block 28, lot 13).

In 2002, a bog turtle sighting was reported to the NJDEP by Brian Kirpatrick, a Union Township Planning Board member, using the NJDEP Endangered and Threatened Wildlife Report Form. The sighting was along the Finn Road drainage swale, near the tributary KT1. Information on the bog turtle sightings, the NJDEP reports and photographs of potential sites within the Sidney Brook Watershed are provided in Appendix G. A bog wetland habitat was observed with tussock sedge hummocks just beyond the mowed lawn for the Kenneth Place resident, and this may be bog turtle habitat. The lawn area is mowed to the woods, but it is very wet and may be within the wetland transition area. The residents should be informed regarding the potential habitat area and encouraged to reduce mowing and ensure the habitat area is undisturbed (Block 28, lot 13).

Reach J

The new Union Township Elementary School was built on Perryville Road, and a large retention and detention basins were constructed that discharge to a large forested wetland area and tributary behind the Crop Production Center (similar to an Agway Center). The stormwater drainage from the school site leads to a large possible vernal pool located in the forested wetlands behind the Crop Production Center. The vernal pool, wetlands and intermittent tributaries found on these parcels were not noted on state GIS maps (Block 21, lot 1 and 15).

The land use for Reach J near Main Street is primarily single family homes, and the immediate riparian corridor is lawn with a thin forest canopy of 25 feet. The stream is approximately 6-8 feet in width, with a clear fast, shallow flow, and a stable, cobble substrate. However, a dark brown algae was prevalent on the substrate throughout this segment during our assessment, and can be indicative of excessive nutrient loading, possibly from fertilizers or septic systems.

A large 48-inch stormwater culvert crosses under Wolf Farm Road, and slight erosion of the downstream tributary was noted. Stormwater for the development is directed via street storm sewers to a wetland stormwater basin in the corner of Stonebridge Road. Previous regulations allowed this basin to be privately owned and maintained, and significant maintenance to remove vegetative growth from the outfalls is needed (Block 21, lot 29.12). Downstream of this outfall stream banks were eroded by 2-4 feet on both sides, just upstream of the Main Street crossing. Evidence of high fast flows, flooding, erosion and down trees were also noted downstream of Main Street (Block 21, lot 19). Slight erosion (2 feet) was observed downstream from the crossing with Perryville Road. New and older homes in the area rely on septic systems that may be impacting stream water quality, and significant brown algae growth was noted in the stream Reach J up and downstream from Main Street. PVC pipes discharging to the stream were observed, and are likely from sump pumps.

Reach F - Jutland Lake or Lakeside Estates

Reach F begins at the confluence of Reach G and J, where observations confirmed a healthy stream and floodplain, and an intact forested riparian corridor. However, some erosion along Reach J and downstream of the confluence (G and J) is occurring and could be a source of sediment loading to Jutland Lake. Jutland Lake is owned and maintained by the newly formed Lakeside Estates Homeowners Association. The Lake is located along Race Street, and access is available only to the private Association residents. The riparian corridor for Jutland Lake is primarily single family homes, lawns and some forest. Reach F as it enters Jutland Lake is approximately 20 feet in width, with a clear fast, and shallow flow, with a stable, cobble substrate. The Lake is approximately 10 acres in size, over 10 feet deep, with a dam and spillway that are approximately 75 feet wide. After a 1.5 inch rain event in March 2008, the Lake was very turbid, and residents stated that this turbid condition is a frequent occurrence, and algal blooms occur in the late summer months. The spillway and dam appear to be in good condition, but a formal inspection was not conducted. Below the dam and spillway, a deep pool exists and there is no evidence of erosion downstream.

The open space community area for Lakeside Estates has sparse soil covering, and sparse vegetation. Rain gardens and additional landscaping with willows, river birch, or red osier dogwood can enhance this area, and address minor runoff concerns.

The Lakeside Estates and Jutland Lake are depicted in this aerial, and sediment depositional areas in the Lake are visible.

Midvale Road Development - A small tributary (FT1), receives significant runoff from the Midvale Road housing development and flows to Jutland Lake. This development includes approximately 40 homes constructed on steep slopes (>20%) which are vegetated with only lawn and a few thin saplings. The steep slopes, streets and lawn surfaces can cause flashy runoff to occur. A retention stormwater basin was constructed with a small 3-inch orifice on the outlet structure. The basin discharges to the FT1 tributary and wetland, and some erosion (1-2 feet) was noted on the streambanks downstream of the outfall. A second outfall at Race Street is nearly completely clogged with sediment.

Runoff from the Midvale development flows downstream under the Race Street Bridge, where significant erosion has occurred within a small ravine. A down tree appears to cause the stream flow to fork, and is causing an oxbow formation and 3-4 foot eroded streambank along Race Street. This erosion may also be a secondary source of sediment loading to Jutland Lake. Some rip rap has been added along the Race Street slope to reduce the erosion. The stormwater flow and the oxbow formation should be evaluated (Block 25, lot 2).

Renaissance Development - In the near future, the FT1 tributary and ravine will receive additional runoff from the proposed Renaissance town house development. This ravine should be monitored and mitigation measures conducted to ensure Race Street is not undermined, and the Lake does not receive addition sediment loadings. The Renaissance Development was the subject of recent COAH litigation which has been resolved, and this community will be served by 6 communal septic systems. A headwater tributary on the Renaissance parcel will receive a 150 feet buffer because this section of the parcel was previously farmed. The proposed development will be served by 2 bioretention basins. Significant forested areas will be cleared to accommodate the homes. Union Township has adopted a woodland clearing ordinance, requiring mitigation for the clearing of forested lands, but it is unclear whether this ordinance will be applied to this project.

8.3 Northeast Quadrant – Reaches E, C, and B, Figure 17

Reach E

Much of Reach E runs parallel with Race Street and is privately owned and access was not permitted. The upland, farmed portion of the parcel (north of Race Street) is currently being reviewed for a housing development of approximately 12 homes on 8 acre lots, serviced by septic systems and wells. A headwater tributary was noted on the NRCS soil survey maps but a defined stream bank was not observed from the road. A road culvert does convey stormwater runoff from the farm and a stormwater basin is proposed near this location.

Limited access to Sidney Brook was provided from the entrance road and bridge to the Cozzi auto junkyard (Block 25, lot 6). Because full access was not provided a complete assessment was not conducted. However, the land use and immediate riparian corridor for Reach E is primarily forest and wetlands. From the bridge to the auto salvage yard, the stream was noted as approximately 20 feet in width, with a clear fast, shallow flow, and a stable, cobble substrate, and no erosion was observed at this location. A tributary to Sidney Brook is noted on the aerials but the salvage yard operator stated that this tributary was not present. Wetlands appear to extend further than shown in the NJDEP data layer and a potential large vernal pool was photographed near the access road to the salvage yard. Sampling the stream near the bridge can be conducted.

Full access was granted to assess the ET1 tributary, which receives flow from a quarry pond north of Race Street. The land use and immediate riparian corridor for Reach ET1 is primarily forest and wetlands. The quarry pond was turbid, but discharge to the stream was clear during our field assessment and appears in healthy condition. Below the quarry pond the stream width is only 3 feet, with a clear, slow, shallow flow, and a stable, cobble substrate (Block 22, lots 29 and 30). Further downstream the ET1 tributary widens to 15 feet then to a 40 foot wide wetland bog habitat, and then the tributary flows into an old farm pond before it crosses under Race Street. The wetland area is located where a former bridge crossing had been removed and the area regraded. This area is also crossed by a gas pipeline and includes a mowed meadow. The bridge previously provided access to a former rifle range. (Appendix G)

Reach C

Reach C includes a wide floodplain that runs parallel along Race Street, and the land use and immediate riparian corridor for Reach C is primarily a forest and wetland floodplain. The forest area has a high density of multi-floral rose, and the wetland meadow includes a combination of shrub/scrub and grass. Reach C appears in healthy condition, with a 15 foot width, and a clear, fast, shallow flow, and a stable, cobble substrate. The stream mapping noted that a tributary may cross under the train trestle running perpendicular to reach C, but this area had limited access and it was not observed. However, a small tributary was found flowing from a ravine east of the Cozzi salvage yard, and we also observed greater than 50 tires and debris in this ravine (Block 25, lot 6 and 6.01). This tributary was flowing parallel with the rail line and the confluence was forked not perpendicular as mapped. The confluence of this tributary and the main stem of Sidney Brook met within a cattail wetland area, approximately 1 acre in size. Within this wetland area a small area of tussock sedge hummocks was observed and photographed as possible bog turtle habitat (Appendix G). The wetlands and floodplain likely help dissipate the energy from high storm flows.

Further downstream as Sidney Brook crosses under Race Street, the land use is a wet meadow floodplain. Race Street is not significantly elevated (possibly 2 feet) above Sidney Brook at this crossing, and the stream often over-tops the road, causing its closure. Rip rap has been added near the Race Street crossing to reduce erosion, but this does not address the flooding issues. Elevating Race Street could be evaluated in order to reduce the flooding frequency, but this would be a major construction project. Frequent flooding has also caused streambank erosion of 2-3 feet, damaged the historic bridge (1867) at Hill Top Road, and impacts the farm, riparian lands and properties east of the Race Street crossing (Block 22, lot 11).

Reach B

The Hunterdon County Development Center and the Edna Mahan Correctional Facility for Woman are located in the headwater area of this reach, and access was not obtained to these areas (Block 22, lot 18). The aerial maps show a stormwater pond for each facility, but no other obvious stormwater controls were observed in the aerial maps. Segment B flows from these ponds is joined by a tributary (BT1) that runs through Milligan Farm, which is being acquired by Union Township for open space preservation (Block 22, lot 20).

Reach B includes a wide wetland meadow floodplain that runs parallel with Race Street, and flows under the Route 513 Bridge. The land use and immediate riparian corridor for Reach B is an open, wetland meadow floodplain with some forested areas. The forest area has a high density of multi-floral rose, and the wetland meadow includes a combination of shrub/scrub and grass. Reach B has a 5 foot width, and a clear, fast, shallow flow, and a stable, cobble substrate. Overall the stream and tributaries appeared clear and healthy.

Tributary BT1 flows south through Milligan Farm, and a forested riparian corridor of at least 25 feet exists along the entire length. Beyond the narrow riparian corridor, the site is farmed. In some places the corridor extended to 50 feet and included unmowed meadow grasses and woody vegetation, which is predominately multi-floral rose. Stream banks in this reach were stable. The NRCS soil maps indicate that tributary TB1 extends the entire north-south property length of the Farm; however, a defined bed and bank did not exist in the northern half of the farm. A stormwater pond for the prison discharges to a wetland in the northern portion of the Milligan Farm site, but a continuous tributary was not found. The area can be described as a scrub/shrub wetland/meadow but a discernible stream was not detected. The headwaters for tributary TB1 were found in a second wetland bog area of tussock sedge hummocks, where bog turtle may find suitable habitat. North of this wetland the tributary was indiscernible (Appendix G).

The main stem of Reach B of the Sidney Brook flows through an open wetland meadow floodplain, described as shrub/scrub and grass. The stream was running clear, full and strong with snow melt. The stream had good sinuosity and riffles throughout this reach. The stream has good access to its natural floodplain. The confluence of segments B and C is stable and erosion was not noted

A ponded wetland area was observed in a southern field on Milligan Farm and an old 2 foot steel pipe had been positioned to drain this area into reach B. Two additional areas of potentially suitable bog turtle habitat were observed north of this area, and east of the housing development on Patrick Drive (Appendix G). Some streambank erosion (about 2 feet) was noted on this northern segment of reach B, possible caused by steep slopes in the yards of these Patrick Drive homes, and possibly from high runoff flows from the Development Center located further upstream.

8.4 Southeast Quadrant – Reaches D and A, Figure 18

Reach D
Three large farm ponds exist on this segment, and water quality was fairly turbid in each pond during our assessment. In general, reach D includes a wide floodplain that runs parallel to Route 513, and this tributary joins the Sidney Brook main stem at the historic Hilltop Road Bridge, at Race Street. The land use and immediate riparian corridor for Reach D includes primarily wetland scrub/shrub floodplain, farmed lands and some forested areas. The floodplain area has a high density of multi-floral rose and is inaccessible in several sections. The wetland meadow includes a combination of shrub/scrub and grass. Generally Reach D varies in width from 5-10 feet wide, and has a clear, fast, shallow flow, and a stable, cobble substrate.

Cooks Crossing Rd – Wood Hollow Rd -
Runoff to reach D begins along Cooks Crossing Road. A stormwater detention basin that serves approximately 16 homes in the Wood Hollow Road development discharges directly to the Cooks Crossing Road, and high storm flows overwhelm the road drainage swales. While the Woods Hollow basin is well maintained, the discharge directly to the roadway is a poor design. The discharge from the basin's 2 foot outfall floods Cooks Crossing Road and causes erosion and flooding downstream. An upstream road swale also accepts street flow, but it may need modifications and regrading to direct flow to the basin. Additional drainage from homes and the roadway is intercepted into the road drainage swales and street sewer systems, adding to the downstream flooding. This detention basin should be evaluated and possibly modified to a retention basin to reduce flows and flooding on Cooks Crossing Road. In addition, the road swales may need widening and modifications to convey this runoff in a manner that reduces downstream flooding of the road and properties. Ownership and maintenance responsibilities for this basin are unknown, and may rest with a small homeowner association (Block 30, lot 1.13).

Woods Hollow Road Basin discharges directly to Cooks Crossing Rd.

Sotres Horse Farm – Cooks Crossing Road

The Sotres Farm is an active horse farm, with stables, riding and paddock areas, and gently sloping pastures. Runoff from these grassed meadows and hillsides can add turbidity and nutrient loading to the farm pond and stream, and can add flow to the eroding streambanks. The farm owner should be encouraged to allow more vegetative cover along the drainage swales in the fields, and along the streams (Block 25, lot 37).

A historic spring house exists on the Sotres Farm, and its foundation has been severely damaged and undermined by uncontrolled runoff from Cooks Crossing Road. A natural spring and drainage swales were present near the spring house. On our visit on February 12th there was significant flow in the outfall at Cooks Crossing Road. The Township had recently regraded the road swale which has helped, but stormwater runoff problems remain.

A second outfall flows under a historic stone bridge on Cooks Crossing Road onto the Sotres Farm and adds to the flooding and erosion of the reach D. This flow originates from only few homes and fields, but they are located on fairly steep slopes south of Cooks Crossing Road, causing the high flows. A small portion of Reach D as it exits the Sotres Farm has severely eroded and incised stream banks with a height of 4 feet.

Installing a stormwater bioretention basin near this location may help address the erosion at the Sotres Farm and reduce flows, flooding and erosion downstream at the Peaceful Valley Farm.

Peaceful Valley Farm

Nearly 50% of the Peaceful Valley Farm remains in forest, but the majority of the riparian corridor along this segment of Reach D flows through an open scrub/shrub wetland and floodplain. The farm is fairly sloped which increases the runoff flow. Reach D is approximately 3-4 feet wide on Peaceful Farm, but during significant storms the stream overtops the stream banks, inundating greater than 50 feet of the floodplain area. Sediment deposition was evident over top of the stream banks. Sediment deposition and high turbidity also affect the farm pond. Downstream of the farm pond, the steam widens to a 15 foot, stable, cobble stream bed, where erosion and flooding was not evident (Block 25, lot 35).

An old stone culvert exists under County Route 513 that conveys stormwater runoff under the road and into a wetland area, and the outfall needs repair.

Care Center for Seniors
Reach D flows through a forested riparian corridor into a large pond down gradient from the Care Center facility. During our visit a large septic field system was being re-constructed. While sediment controls were in place, runoff from the site and stockpiles of soil contributed to very turbid conditions in the pond. Hopefully the area will be regraded and vegetated soon to reduce sediment transport to the pond. Downstream from the pond the riparian corridor returned to a shrub/scrub floodplain, and the stream flow in reach D was clear. The floodplain both upstream and downstream of the pond included a thick cover of multi-floral rose, which prevented access (Block 25, lot 18.8 and 18.03).

Hilltop Road
Reach D flows under a 20 foot wide train trestle before flowing under the historic Hilltop Road bridge at Race Street. Debris, tires and drums are strewn on the hillside north and south of the train tracks and should be removed. There is also a 3 foot eroded bank as the stream bends, just upstream of the Hilltop Road Bridge that should be stabilized. This historic bridge is also in need of repair and restoration (Block 25, lot 11).

Reach A – Franklin Township
The land use for Reach A is primarily forest, with residential houses on 1-2 acre lots, and much of the 300 foot riparian corridor is generally intact forest. The stream has a 20 foot width, and a clear fast, shallow flow, frequent riffles, shallow pools, and a stable, cobble substrate. Franklin Township acquired 55 acres of forested floodplain land through which the main stem of Sidney Brook flows (Block 4, lot 3.01). Access to Sidney Brook is available from Pittstown Road (Route 513) and Sidney Road (Route 617), but the stream flows were high during our spring field visits and were not entirely walked. Access to the lower segment of Sidney Brook downstream of Route 617 was not obtained as it flows behind private homes, and the assessment was performed primarily from the Sidney Road (Route 617) bridge crossing.

The main stem of Sidney Brook flows under the Route 513 Bridge, and just downstream a large, deep pool has formed which offers good fishing opportunities and is frequented by fisherman. The area is stocked with trout each April by the NJDEP Division of Fish & Wildlife. Thick multi-flora rose inhibits easy access to this segment of the stream. This parcel is owned by Franklin Township and could be enhanced to provide a gravel access road and parking from Grandin Road, this would also increase public accessibility and safety from the busy Route 513 Bridge. Limited trails to the stream and trash cans could be provided to service the recreational fishing.

Fishermen also access the stream from the Sidney Road Bridge (Route 617), but private homes are adjacent to this area, no trespassing signs are posted and public access is limited. Public access near the Route 513 Bridge may be more appropriate.

On February 29th a spill of home heating oil near the bridge on Sidney Road was reported to the NJDEP. The Sidney Road crossing site was visited on Monday March 3, 2008 and an oil boom was deployed on the tributary and the main stem of the stream. The boom appeared fairly clean, but there was some oil sheen and oily foam on the water. The site was revisited on March 7th and again on March 25th and the booms were still present and the spill appears to have been properly addressed.

The housing development at Matthews Court is serviced by a grassed stormwater detention basin, in good maintained condition. This basin could be retrofitted as a retention basin or enhanced with plantings to retain stormwater, and increase infiltration. Two intermittent steams cross under Grandin Road and minor erosion at the outfalls have been addressed with rip rap.

Sidney Brook flows east into the South Branch of the Raritan River. Access to this confluence is on a private farm and was not provided. The South Branch at the Hampton Road Bridge has evidence of sediment deposition and eroded stream banks. The stream banks are also severely eroded near the intersection of Hampton Road and Lansdowne Road undermining the road and exposing a 2 foot stormwater outfall with little to no support. This undermining road condition may have been there for several months, and this area requires significant streambank mitigation.

9.0 Data Documentation and Management

Proper documentation of all field activities is essential. Field data was recorded at the time of collection on the VAPP field data sheets. In addition to these sheets, a hand drawn map and aerial photographs were used to mark the approximate locations of the reach and each notable feature. Princeton Hydro reviewed each data sheet for completeness and accuracy (100%) and incorporated this data into a spreadsheet. On occasion modifications were made to ensure that the field recorded data was done in a consistent manner, and that the summary tables accurately reflected site conditions. Each site was also photo documented and a virtual tour of each reach throughout the watershed was completed via a power point presentation of these photos (Appendix I). The Visual Assessment report, GPS data, and the photographic tour will be submitted on CDs to the project partners.

9.1 Data Completeness

Certain portions of the Sidney Brook Watershed were inaccessible during the Visual Assessment including private residences, farmlands, the State Correctional facility and the Hunterdon County Development Center. However, an evaluation of stream segments downstream of these points was accomplished. In addition, the assessment included an evaluation of aerial photography, and various NJDEP GIS data layers, and this information was incorporated into the watershed assessment.

9.2 Geographic Information System/Global Positioning System (GPS)

Princeton Hydro collected GPS data to document important watershed features such as outfalls, erosion sites and important habitats. These locations and GPS data were noted on the VAPP data sheets, downloaded, summarized by GIS professionals, and transferred to various watershed maps. Princeton Hydro originally proposed to collect GPS data utilizing either the Trimble ProXH GPS unit or the Trimble ProXRS GPS unit. This equipment is worn as a back pack with a 3 foot antenna. An attempt was made to use this equipment in the field; however, based on the narrow stream widths and thick density of multi flora rose, it was impossible to walk the streams without being entangled. Therefore, a hand held Magellan – Meridian Gold GPS unit was employed for this project. The Magellan GPS unit also has the following capabilities:

- The unit is WAAS enabled with built-in calibration abilities
- The GPS data can be enter and saved, and downloaded into a GIS database, and excel spreadsheet.

9.3 NJDEP Electronic Data Management System

Princeton Hydro had proposed to enter the Visual Assessment data into the electronic database that was developed by the NJDEP, Division of Watershed Management for the Volunteer Monitoring Program. This database is intended to correlate with the NJDEP VAPP Data Sheets. At the time of the submittal of this Visual Assessment report, the details for the necessary training and data incorporation for this database had not been completed. Information regarding this database is available at: http://www.nj.gov/dep/online

10.0 Summary and Recommendations for the Sidney Brook Watershed

It should be noted that the following preliminary recommendations were based on the data collected from the Visual Assessment efforts, and additional recommendations to protect and enhance the water quality and ecological habitats of the Sidney Brook Watershed will be forthcoming as part of the overall Watershed Protection Plan.

1. **Public Outreach & Notice**: Time spent on public outreach, notices and gaining access are worthwhile efforts. In addition to gaining the necessary access, the field staff was also able to garner first hand specific information, and usually very relevant data related to stormwater runoff, flooding, nutrients and sediment loading concerns, wetlands and habitats. Some of these issues may not be obvious during field visits, and without the information from community officials and land owners many of the findings would not have been documented.
   - Future Visual Assessments should include tasks to meet with local town environmental commissions, town council members, or the township engineers to garner information about the stream and stormwater concerns.
   - The news article and public meeting were also good tools to communicate with landowners and by providing contact information we were able to talk with landowners, gain access, and better understand their concerns related to the stream.

2. **Mapping Headwater Streams**: As discussed in section 6.0 of this report, the mapping and field verification of headwater streams are tasks that should be added to future Visual Assessments. Headwater tributaries offer a variety of ecological and economical benefits for downstream waterways and water management, such as reducing flooding and water treatment costs. During the Sidney Brook Visual Assessment we were able to increase the mapped tributaries of Sidney Brook by greater than 100%, and we identified potential wetland habitats and areas of erosion associated with several headwater streams. In addition, we identified and mapped several outfalls and culverts on these intermittent

streams. But most importantly, these headwater streams are more fully protected by state regulations when they are mapped and documented.

3. **Summary of the Visual Assessment Findings**: In summary, the field work identified the following information and concerns. This information is also visually presented on Figure 1, 19 and 20, and in the Visual Assessment Summary Tables (Appendix B):
    - Identified an additional 11.84 miles of newly mapped headwater streams
    - Identified two (2) large potential vernal pools within forested wetlands
    - Identified five (5) wetland habitats with tussock sedge hummocks present
    - Identified sixteen (16) sites of erosion for possible stabilization efforts
    - Identified seven (7) areas with frequent and serious flooding concerns

4. **Debris Cleanup Areas** - Four (4) areas with debris, including tires, drums, and a deck, were observed during the Visual Assessment where potential cleanups could be scheduled. These sites are identified on Figure 19.

5. **Stormwater Infrastructure** - During the field work, GPS coordinates were collected for forty-two (42) stormwater culverts, outfalls and inlets which were mapped. This data is summarized in Appendix H and can be included into the Township Stormwater Plan.

6. **Ecological Health of the Stream** - In regard to characterizing the stream ecological health, the Visual Assessment field protocol included an evaluation of stream width and depth, channel flow, stream sinuosity, stream variability. The assessment also described stream habitats for macroinvertebrates and fish, including pool size and depth and the frequency of riffle occurrences. This data is summarized in the tables in Appendix B. In addition, the narrative of each Reach includes a general statement describing the buffer conditions, stream variability, and stream habitats. For example, the narrative for Reach H reads… "The stream has a 4-8 foot width, with a clear, fast shallow flow, frequent riffles and shallow pools, and a stable cobble substrate." Pool variability is important in order to provide habitats for large and small fish, and provide deeper pools that retain water during times of drought or low stream flow, and over wintering habitat.

    Trout and some macroinvertebrates prefer fast shallow currents with stable, gravel and cobble substrates, with limited sediment embeddedness. An abundance of sediment embeddedness or sediment deposition can be detrimental to fish spawning and survival. Sediment can clog gills, smother eggs, and blanket habitat areas. During the visual assessment it was observed that the Sidney Brook stream substrates were generally stable, gravel and cobble substrates, with an occasional sediment bar or depositional area upstream or downstream of a culvert or bridge. However, within portions of the lower stream segments including reach B and A the sediment deposition was more prevalent and heaviest at the bridge crossings at Route 513 and Route 617. The details regarding sediment embeddedness for each reach are summarized in the Appendix B tables.

    In regard to the ecological health of the stream the visual assessment field work and data reflects limited preliminary findings. After the stream is sampled for chemical parameters, macroinvertebrates and fish, additional evaluations of ecological health of the stream and habitats will be provided in the Watershed Characterization & Assessment Report.

7. **Riparian Corridor Integrity -** The Visual Assessment field protocol included an evaluation of buffer width and conditions, and tree canopy cover. As previously discussed intact forested riparian corridors help to maintain water quality by filtering pollutants, provide bank stability, provide shade to maintain cooler water temperatures, and reduce the risk of flood damage. The majority of the 50 foot riparian corridors for Sidney Brook were intact forests, with the exception of limited encroachments from housing and roads on reach H, J and K. Reach HT2 has severe erosion and the stream buffer is a mowed lawn. The 300 foot buffers were also impacted on these reaches and farming reduced the buffers on reach D and B. This data is summarized in the tables in Appendix B.

8. **Invasive Plant Species Dominance -** Multi-floral rose was present in medium to high densities throughout most of the assessed stream reaches, impacting access to the stream and lowering the diversity of plant species in the riparian corridor.

9. **Streambank Erosion** and undercut banks were observed on small stream segments in all of the Stream Reaches of Sidney Brook, reaches A through K. On very few of the stream segments the banks were incised, with limited access to the floodplain. These incised streambanks occurred on Reach J upstream of the Main Street crossing; Reach I downstream of the third pond; Reach G downstream of the Perryville Road crossing; and a small segment on Reach D at the Sotres Farm (Figure 20).

10. **Dams and Impoundments –** Nineteen private lakes and ponds of various sizes are depicted on the watershed aerials. Several of the ponds on reaches I, H, F, E and D were very turbid after rain events that occurred in March and April 2008. Several property owners expressed concerns regarding sediment deposition in their ponds and overabundant algal growth in the summer months. Educational programs regarding pond management and nutrient loadings could be sponsored for local residents by the Environmental Commission.

11. **Wetland Habitats -** In regard to the wetland habitats, the Visual Assessment field work identified two (2) large potential vernal pools within forested wetlands, and five potential (5) wetland habitats where tussock sedge hummocks were present. However, bog turtles prefer very wet, mucky, organic habitats and these observed wetland sites may not provide the necessary characteristics of nesting areas. These locations are identified on the wetland map (Appendix A, Figures 5 and Figure 19), and the accompanying photographs and reports are provided in Appendix G. Additional field work should be conducted to verify these potential findings; however, access and permission should be obtained and verified for this purpose.

12. **Fishing Access -** The fishing area on the main stem of Sidney Brook near the Route 513 Bridge is owned by Franklin Township, and it could be enhanced to provide better access, parking, trails, and trash cans to service the recreational fishing.

13. **Jutland Main Street –** The land use and buffers along this segment of Sidney Brook are highly developed, which increases the potential impacts to the stream from stormwater runoff and potential non-point pollution sources (NPS). Several recommendations to reduce these impacts are outlined in the tables in section 10.1, including improving maintenance at the Union Township Public Works yard and streambank restorations at the former Town Hall property. The following recommendations could also be considered to reduce these potential impacts.

    - The Wolf Farm Road housing development is approximately 15-20 years old and the riparian corridors for reach J are narrow (approximately 25 feet) and consist primarily of multi-floral rose. Encourage homeowners in this area to increase the riparian buffer by reducing the mowed lawn and planting shrubs and trees along this segment.
    - The stormwater from the Wolf Farm Road development is directed to a large wetland basin on the corner property near the railroad lines on Stonebridge Road. The maintenance of this wetland basin and its outfalls may be the responsibility of one landowner. Trees are growing too close to the outfalls and outlet structures and these shrubs and trees should be removed.
    - The stormwater basins for the Union Township Elementary School are fairly new and some settling has occurred near the basin outlet structure that should be repaired. Leaves and debris from the winter were covering the inlets and outlets and routine maintenance was needed. Additional plantings along drainage swales and within the basins would also be beneficial to increase infiltration, slow runoff and could be educational for the school children.

14. **Industrial Impacts to Sidney Brook** - During the assessment of potential impacts to the quality of Sidney Brook, the NJDEP GIS data was reviewed, and there were no Known Contaminated Sites (KCS) identified within the Sidney Brook watershed. However, two known contaminated sites were located within the State Correctional Facility and the Hunterdon County Development Center. These sites could be (former) underground storage tanks, but their status is unknown and the area was inaccessible during the Visual Assessment. Other areas of potential concern within the watershed include: a quarry, an automobile salvage yard on Race Street, the storage yard for the Union Township Department of Public Works, and areas of discarded debris, including old tires and drums observed near the railroad line. Water quality sampling near these locations is proposed.

15. **Stormwater Recommendations –**Recommendations for stormwater mitigation projects are provided in Section 10.1 and in Appendix F regarding Finn Park.

16. **Proposed Water Quality Sampling -** Based on the findings from the Visual Assessment Program the water quality sampling program outlined in the December 2007 Water Quality Monitoring- Quality Assurance Project Plan (QAPP) should be implemented as proposed. The sampling plan is highlighted on Figure 22, Appendix A.

17. **Photographic Tour** - A photographic tour of the watershed is provided in Appendix I, and provided in a CD format.

10.1 Preliminary Recommendations for Stormwater Plan Mitigation Projects

The Table 1 and 2 below include a summary of the preliminary recommendations for both Union Township and Franklin Township, based on the field observations from the Visual Assessment. The tables highlight recommendations for specific properties, and the property ownership information. Those parcels identified as publicly owned or parcels with a public easement could be eligible for additional implementation funding under the federal Clean Water Act 319 (h) program. Private farmlands could be eligible for implementation funding under various USDA NRCS grant programs. The preliminary recommendations are numbered and these locations are identified on Figure 20, Appendix A.

In regard to the stormwater basins in Union Township, the developers of certain housing projects were permitted to build stormwater facilities on private lots and individual homeowner became responsible for the long term maintenance of the stormwater facilities. These privately owned basins serve large developments and regional roadways, and some are in need of maintenance and repair. These basins can be referenced within the Township Stormwater Plan, on the Township Stormwater Mitigation List, in order that these repairs may be funded through future development projects. In addition, by including these items in the Sidney Brook Watershed Protection Plan, they could become eligible for funding under the Clean Water Act Section 319(h) funding program.

Table 1: Preliminary Findings for Union Township Potential Stormwater Plan Mitigation List Measures				
Locations		**Owner / Block & Lot**	**Stormwater Concern**	**Proposed Stormwater Mitigation Measures**
1	Stormwater Detention Basin Cooks Crossing Rd. near Woods Rd. Reach I	Cooks Crossing Rd. Block 28, Lot 25 (may have a drainage easement)	• Insufficient stormwater detention/ retention and control from Cooks Crossing Road is causing erosion on downstream farms. • Turbid water conditions occur in farm ponds.	• Regrade and modify road drainage swales and inlets. • Consider installing a stormwater bioretention basin near Cooks Crossing Road
2*	Incised stream bank (3-4 ft) Reach I downstream of the third pond	Block 28, Lot 24	• Incised streambank • Reduce streambank erosion & sediment loading to the C1 stream • Restore access to floodplain	• Streambank Restoration & riparian plantings
3	Stormwater Outfalls Cooks Crossing Road & High View Court Reach H	Cooks Crossing Road Block 27, Lot 3.02 (may have a drainage easement) Union Twp owns roadways	• Insufficient stormwater detention and control from Cooks Crossing Road • Upstream erosion, and sediment loading to the Sanctuary pond	• Install bioretention basins at Woodsedge & High View Court • Repair Cooks Crossing Road inlets and outfall • Stablize stream banks at High View Court
4	Sanctuary Stormwater Pond Perryville Rd Reach H	Block 27, Lot 12 Perryville Rd (may have a drainage easement)	• Insufficient stormwater detention and control from Cooks Crossing Road • Upstream erosion, and sediment loading to the Sanctuary pond • Downstream flooding and erosion below Sanctuary Pond	• Modify spillway for Sanctuary Pond • Stabilize eroded banks near the spillway
5	Stormwater Control Measures Finn Park Perryville Rd Reach G	Union Township Finn Park Block 26, Lot 12	• Uncontrolled runoff from the athletic fields routinely inundates Perryville Road.	• Implement the proposed 11 stormwater management measures (App F)

* Private farmland and USDA -NRCS grants may be available.

Table 1: Preliminary Findings for Union Township Potential Stormwater Plan Mitigation List Measures				
Locations		**Owner / Block & Lot**	**Stormwater Concern**	**Proposed Stormwater Mitigation Measures**
6	Incised streambank downstream of the Perryville Road crossing Reach G	Union Township Block 25, Lot 31	• Incised streambank • Reduce streambank erosion & sediment loading to the C1 stream • Restore access to floodplain	• Streambank Restoration & riparian plantings
7	Stormwater Detention Basin Kenneth Place Reach K	Block 28, Lot 13 (may have a drainage easement)	• Added headwater stream. • Downstream eroded stream banks • Repairs needed on basin at Kenneth Place cul de sac. • Encourage reduced mowing to protect bog habitat.	• Improve basin maintenance - remove leaf litter; remove tree from outfall scour hole; add rip rap to reduce downstream erosion. • Retrofit basin outfall with a smaller orifice and trash rack.
8	Union Twp Elementary School Reach J	Union Twp Board of Education Block 21, Lot 1	• Provide additional stormwater infiltration & TSS removal in drainage swales	• Provide plantings in stormwater swales & basins and reduce mowing
9	Stormwater Detention Basin Wolf Farm Rd. Development Reach J	Corner of Stonebridge Road Block 21, Lot 29.12 (may have a drainage easement)	• Basin is fully vegetated with cattails • Outfalls require maintenance to remove tree & shrub growth • Downstream eroded stream banks	• Remove vegetative growth from outfalls • Stabilize banks downstream
10	Union Township Public Works Yard Reach J	Union Township Block 21, Lot 19	• Improve maintenance and runoff controls from the Union Township Public Works yard to reduce NPS.	• Update the Stormwater Spill Prevention Plan for the Public Works yard • Implement runoff controls.
11	Incised streambank (4 ft) upstream of the Main Street crossing Reach J	Union Township Block 21, Lot 19	• Incised streambank • Reduce streambank erosion & sediment loading to the C1 stream • Access to floodplain	• Streambank Restoration & riparian plantings

Table 1: Preliminary Findings for Union Township Potential Stormwater Plan Mitigation List Measures				
Locations		**Owner / Block & Lot**	**Locations**	**Locations**
12	Finn Road Eroded streambank downstream of road culvert Reach K	Block 26, lot 16 (may have a drainage easement)	• Reduce streambank erosion & sediment loading to the C1 stream	• Streambank Restoration & riparian plantings
13	Race Street by Midvale Rd Eroded streambank downstream of road culvert Reach F	Block 22, lot 2 (may have a drainage easement)	• Reduce streambank erosion & sediment loading to the C1 stream	• Streambank Restoration & riparian plantings
14	Stormwater Detention Basin Woods Hollow Rd & Cooks Crossing Rd. Reach D	Cooks Crossing Rd. Block 30, Lot 1.02 (may have a drainage easement)	• Insufficient stormwater detention/ retention and control to Cooks Crossing Road • Downstream flooding and erosion, especially on the Sotres Farm.	• Retrofit detention basin as a retention basin. • Regrade and modify road drainage swales.
15*	Cooks Crossing Rd Incised streambank (4 ft) at the Sotres Farm Reach D	Sotres Farm Block 25, Lot 37	• Incised streambank • Reduce streambank erosion & sediment loading to the C1 stream • Restore access to floodplain	• Streambank Restoration & riparian plantings • Evaluate stormwater bioretention pond
16*	Eroded streambanks Peaceful Valley Farms	Peaceful Valley Farms Block 25, Lot 35	• Reduce streambank erosion & sediment loading to the C1 stream and farm pond	• Streambank Restoration & riparian plantings • Bioretention basin • Dredge pond
17	Race Street Eroded streambank upstream of Race Street Historic Bridge Reach D	Union Township Block 25, lot 11	• Reduce streambank erosion & sediment loading to the C1 stream	• Streambank Restoration & riparian plantings
18	Race Street Severe flooding at Race Street Crossing Reach C	Union Township Block 25, lot 11	• Reduce streambank erosion & flooding	• Elevate roadway and bridge. • Streambank Restoration & riparian plantings

* Private farmland and USDA -NRCS grants may be available.

Table 2: Preliminary Findings for Franklin Township Potential Mitigation List Measures				
Locations		**Block & Lot / Owner**	**Stormwater Concern**	**Proposed Stormwater Mitigation Measures**
19	Sidney Brook Bridge Rte 513 Reach B	Franklin Township Block 4, Lot 3	• Improve the fishing area on the main stem of Sidney Brook near the Route 513 Bridge.	• Provide better access, parking, trails, and trash cans to service the recreational fishing. • Reduce multi-floral rose, an invasive plant species.
20	Streambank Erosion by Sidney Rd -Rte 617 Bridge Reach A	Franklin Township Block 4, Lot 3	• Reduce streambank erosion & sediment loading to the C1 stream	• Streambank Restoration & riparian plantings

10.0 References

Conservation Strategy Work Group Eastern Brook Trout Joint Venture, December 2005, "Conserving the Eastern Brook Trout: An Overview of Status, Trends and Threats" http://www.mmbtu.org/Conserving_Eastern_Brook_Trout.pdf

Meyer, J. L. 2003. Where rivers are born: The scientific imperative for defending small streams and wetlands. Washington D.C., American Rivers and Sierra Club

NJDEP GIS 2002 Database for land use, landscape project data, wetlands, known contaminated sites, streams, etc, http://www.nj.gov/dep/gis/

NJDEP, Visual Assessment Project Plan (VAPP) Guidance
August 2007
http://www.state.nj.us/dep/watershedmgt/DOCS/319(h) RfP/VAPPaug07.pdf - 268.9KB

NJDEP VAPP Instructions
www.state.nj.us/dep/wms/bfbm/vm/docs/Instruction%20Manual%20for%20AmeriCorpv2.pdf

NJDEP Visual Monitoring webpage
http://www.state.nj.us/dep/wms/bfbm/vm/visual.html

Appendix A

Sidney Brook Watershed – Visual Assessment

Sidney Brook Watershed Maps

Appendix B

Sidney Brook Watershed – Visual Assessment

Summary Table of the Visual Assessment Results

Appendix B - Table 1 Sidney Brook
Southwest Quadrant - Reaches I,H and G

Sidney Bk Reach/ Segment	Stream Width and Flow	General Stream Sinuosity &	Stream Substrate & Stability	Aquatic Vegetation	Bank Erosion*		Riparian Corridor - Vegetation Canopy & Land Use						Invasive Species Dominance	Channel Alteration	Outfall/ Drainage			Flooding Concerns	NPS Impact	Habitats Observed	Other	Potential DPW Cleanup/Mitigation
					L	R	<25 ft		25-50 ft		300 ft -LULC				Size	Condition	GPS Coord					
							L	R	L	R	L	R										
I1 Goldberg - Steiger Farm ponds #1&2	8' / fast, shallow	mod bends/frequent shallow pools& riffes	stable cobble, 25-50% embedded with fine sediments	rooted submergent	Mod-Unstable 2ft eroded banks at bends	Mod-Unstable 2ft eroded banks at bends	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands	forest, wetlands , Hayfields	Med - Multifloral rose	>2 Ac pond outfall causing erosion downstream	24"/conc		40.60603N/ 074.97538W	no		pond, wetlands, forest,possibl e vernal pool areas	300 ft wooded buffer intact. Outfall from pond causing erosion of headwater stream banks.	
I2 Pond #3	4' / slow, shallow	mod bends/frequent shallow pools& riffes	loose gravel, cobble, 25% embedded with fine sediments	duckweed present near pond	Mod-Unstable 2-3ft eroded banks at bends	Mod-Unstable 2-3ft eroded banks at bends	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands	forest, wetlands , Hayfields	Med - Multifloral rose	>1 Ac pond outfall causing erosion downstream	24"/steel Inflow to pond 12" conc outfall		I2OF 40.60253N/ 074.96907W I2erosion 40.60298N/ 074.97124 W	no	waterfowl by pond	forest, wetlands, pond	300 ft wooded buffer intact. Signficant erosion noted upstream of pond (2-3ft) and downstream of pond outfall (2-3 ft).	Steep slopes, mowed fields cause signficnat runoof. Landowner may consider to allow portions of field to grow taller to slow runoff.
I3- Pond #4 at Finn Rd	6-8' / fast, shallow	slight bends/frequent shallow pools& riffes	stable cobble, 25% embedded with fine sediments	little duckweed present	Mod-Unstable 2-3ft eroded banks at bends	Mod-stable 1-2ft eroded banks at bends	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands	forest, wetlands , Hayfields	Med - Multifloral rose	at end of segment >3 Ac pond outfall causing erosion downstream	4 conc/steel inlet pipes to pond/ 24"steel & conc / 24"steel outfall from pond	pond inlet dam and pipes are rock structure - seems unstable.	I3confluence 40.60515N/ 074.97114W I3 inlet to pond 40.60604N/ 074.97529 W H1 pond outfall 40.60821N/ 074.96861W	possible flooding downstream of pond	waterfowl by pond 8"PVC pipe noted in stream above pond, and foam noted in stream.	forest, wetlands, pond	300 ft wooded buffer intact. Signficant erosion noted upstream of pond (2-3ft) and downstream of pond outfall (2-3 ft).	Pond #3 discharge may cause erosion downstream, and sediment loading to pond #4.
H1 - DS Finn Rd Pond (access limited)	5' / fast, shallow	slight bends/frequent shallow pools& riffes	stable cobble, 25% embedded with fine sediments		Stable	Mod-Unstable 2-3ft eroded banks at bends	lawn	76-100% forested	lawn	76-100% forested	lawn, forest, wetlands	forest, wetlands	Med - Multifloral rose	pond on front yard	15"	stone outfall from pond in disrepair		possible flooding of pond	geese	forest, wetlands, pond	erosion noted downstream of pond (2-3ft) . Possible flooding on other portions of property.	
HT1 wetland, drainage basin for Sancutary	5' / slow, shallow	slight bends/ infrequent shallow pools & riffles	Clay loam 75% embedded with fine sediments/ some sed deposition	none	Mod-Stable	Mod-Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands	forest, wetlands	High - Multifloral rose	created basin in wetlands/ basin filled rose	24"/conc 42"/conc	multi stage outlets - new cond.		no	lawns, septic, roads, sediment	wetlands	300 ft buffer preserved. Only accessed small segment due to lack of permission.	
HT2- High View Ct drainage	3' / today slow, shallow - but very fast/deep/ torrid during runoff events	slight bends/ infrequent shallow pools & riffles	Clay loam/ cobble 75% embedded with fine sediments/ some sed deposition	none	Mod-Stable 2ft eroded banks	Unstable 3-4ft eroded banks at bends	25% forested	25% forested	50% forest	mowed lawn	forest	mowed lawn	med - Multifloral rose	Signficant runoff from Cooks Crossing Rd directed to this tributary/swale	2 outfalls 15" conc 24" eliptical conc	serious erosion by outfall / tributary 11.5 ft wide / 4 ft eroded banks		no	lawns, septic, roads, sediment		7-8 inlets at Cooks Crossing Road discharge at this point causing serious erosion at High View Ct and downstream, adding to sediment loading to the Sanctuary pond.	Possible basin installation at High View Ct & Woodsedge cul de sac to reduce runoff, possible streambank stabilization project, modify outfall & rip rap at High View Ct, evaluate CCR inlets.
HT2B- Sanctuary Pond	Pond =2 acre 8ft depth discharge 5' / fast, shallow	slight bends above lake inlet /sharp bends after Lake discharge/ infrequent shallow pools & riffles	Clay loam 51%-75% embedded with fine sediments	none	Mod Unstable 3ft eroded banks for 100 ft at lake discharge	Mod Unstable 3ft eroded banks for 100 ft at lake outfall	pond meadow grasses	76-100% forested	pond meadow grasses	76-100% forested	forest, wetlands	forest, wetlands	Med - Multifloral rose	pond / grassed drainage swale from Sancutary/ gabion berms, gabion spillway, rip rap	18"/conc outfall / wide 20 ft low spillway			Yes - frequent overtopping of spillway/ eroded streambanks DS of spillway	lawns, septic, roads, sediment /	Pond, wetlands	Heavy sediment loading to pond from Cooks Crossing Rd/ very turbid waters after storm events	
HT2C below Sanctuary Pond	4' /slow, shallow	slight bends/ Frequent shallow pools & riffles	stable, cobbles, <25% embedded with fine sediments	none	Stable	Stable	50% forested, mowed lawn	50% forested, mowed lawn	50% forested, mowed lawn	50% forested, mowed lawn	forest, wetlands,	forest, wetlands	high - Multifloral rose	road culverts			40.61338N /074.95865W culvert	Yes - Sancutary pond overtops spillway/ floods DS property	sediment	wetlands	flooding of property downstream of Sancutary Development	
H2 Main Stem by Finn Park	9' / fast, shallow	straight/ Frequent shallow pools & riffles	Gravel/cobbles, <25% embedded with fine sediments	none	Stable	Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands,	forest, wetlands, Recreation al Fields	high - Multifloral rose				40.61412N/ 074.95996W erosion on Farm 40.61375N / 074.96033W	No	Ag, sediment	wetlands	4 ft eroded streambank on farm property as stream bends- private land just upstream of Finn Park.	
H3 Confluence with HT2 and H main stem	10-13' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles, <25% embedded with fine sediments	none	Mod Unstable / 3 ft eroded bank at bends	Mod stable- 1-2 ft eroded at bends	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands,	forest, wetlands,	high - Multifloral rose	confluence with HT2 trib eroding bank			40.61428N/ 074.95851W site of erosion	No	sediment	wetlands	red clay fragipan present on stream bottom	eroded streambanks - but difficult to access to stabilize.
G1-G2 upstream and downstream of Perryville Bridge	10' /fast, shallow	slight bends/ Frequent shallow pools & riffles	stable, cobbles, <25% embedded with fine sediments	some duckweed	Stable	Mod Unstable erosion of 2-3 ft at bends	50% forested	50% forested	50% forested	50% forested	forest, wetlands,	forest, wetlands, mowed lawn	high - Multifloral rose	Perryville Road Bridge			G1AER 40.61573N / 074.95705W erosion G1AER2 40.61767N / 074.95608W erosion G1AER3 40.61712N / 074.95673W erosion	flooding near Perryville Bridge	sediment	wetlands	red clay fragipan present on stream bottom upstream of Perryville Rd	Erosion noted upstream of bridge DS of confluence with H trib & eroded streambanks downstream of bridge near confluence owth G4 but may be difficult to access to stabilize/ possibly on private lands
G4 tributary from farmland	8' / slow, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles 25%-50% embedded with fine sediments	none	Stable / 3 ft eroded bank at sharp bend 100 yds DS from outfall	Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands, Ag	forest, wetlands, Ag	low - Multifloral rose	outfall from Ag cropland	12" PVC outfall from Ag land	good / scour hole some rip rap		No	Ag, sediment	wetlands		

Appendix B - Table 2 Sidney Brook
Northhwest Quadrant - Reaches K,J , G and F

Sidney Bk Reach/ Segment	Stream Width and Flow	General Stream Sinuosity &	Stream Substrate & Stability	Aquatic Vegetation	Bank Erosion*		Riparian Corridor - Vegetation Canopy & Land Use						Invasive Species Dominance	Channel Alteration	Outfall/ Drainage			Flooding Concerns	NPS Impact	Habitats Observed	Other	Potential DPW Cleanup/Mitigation
							<25 ft		25-50 ft		300 ft -LULC				Size	Condition	GPS Coord					
					L	R	L	R	L	R	L	R										
KT2A Tributary behind Kennth Place	4' / fast, shallow	sl-mod bends/ Frequent shallow pools & riffles	clay loam with cobbles	none	Mod-Stable 3ft eroded banks for 100 ft	Mod-Stable 2ft eroded banks for >100 ft	76-100% forested	resid lawn	76-100% forested	resid lawn	forest, wetlands, Ag	forest, wetlands, housing	med - Multifloral rose	SW basins, outfalls, pond	18 "conc basin outfall 1-8" PVC from pond	basin filled with leaf litter, outfall filled with sediment, tree, eroded stream bank			geese, lawns, septic, Ag, sediment	wetlands - tussock sedge humocks- possible Bog turtle habitat	Added headwater stream. Repairs needed on basin at Kenneth Place cul de sac. Encourage reduced mowing to protect bog habitat.	Improve Basin Maintenance - remove leaf litter; remove tree from outfall scour hole; add rip rap to reduce downstream erosion. Retrofit basin outfall with a smaller orifice and trash rack.
KT2B Tributary crossing Finn Road	7' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments	none	Mod Unstable 3ft eroded banks for 100 ft	Mod Unstable 3ft eroded banks for >100 ft	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands, housing, roads	forest, wetlands, housing, roads	Hi -Multifloral rose	Finn Rd Bridge	48" conc	conc/gd cond/ deep scour hole	U13 marked on bridge 40.62076 N / 074.96464 W	Yes	lawns, septic, roads, sediment	wetlands	Added headwater stream. Only accessed small segment near Bridge. Inaccessible from rose/ and lack of permission. Old landfill observed on right bank.	
K1 & KT1 Finn Road	10' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments	none	Stable	Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands, Ag	forest, wetlands, Ag	Hi -Multifloral rose	Finn Rd Bridge	20Ft		40.61945 N / 074.96464 W		Ag, sediment	wetlands	Only accessed small segment near Bridge. Inaccessible from rose/ and lack of permission. Added KT1 headwater tributary.	
J1 Tributary in Wolf Farm Development	3 ft slow/shallow	slight bends	clay loam/Gravel 50% embedded with fine sediments	none	Mod Stable 1-2 ft eroded banks	Mod Stable 1-2 Ft eroded banks	25% forest wetlands, lawn	25% forested wetlands, lawn	25% forested wetlands, lawn	25% forested wetlands, lawn	forest, wetlands, lawn, housing, roads	forest, wetlands, lawn, housing, roads	high - Multifloral rose	Street sewers, swales, outfall	36" outfall	eroded bank 1-2 ft in yard		no	lawns, septic, roads, sediment,		encourage wider buffers & less mowing	
J2-J3 Main St upstream and downstream	6' / fast, shallow	slight bends/ Frequent shallow pools/riffles	Gravel/cobbles <26-50% embedded with fine sediments	Dk brown algae- high /prevalent	Mod Unstable 2-3ft eroded banks for >100 ft	Mod Unstable 3-4ft eroded banks for >100 ft	50-75% forested	50-75% forested	50-75% forested	50-75% forested	forest, wetlands, housing, roads	forest, wetlands, housing, roads	Hi -Multifloral rose	upstream of Main St Bridge/	4-2ft OF at Main St 2ft OF - DPW yard 2-36" basin OF 2 8"PVC pipes	Wolf Farm Basin needs Veg removed	Main St OF 40.62325 N/074.96512W J2OF 40.62356 N/074.96593W J3OF 40.62333 N/074.96558W	Yes	lawns, septic, roads, sediment, DPW, Ag Center	wetlands		Drums & debris found in woods, DPW yard cleanup recommended, veg removal from basin outfalls
J4 upstream of Perryville Rd	12' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments	none	Mod-Stable	Mod-Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands, housing, roads	forest, wetlands, housing, roads	Hi -Multifloral rose	upstream of Perryville Rd Bridge/ road swales are eroded 1-2'	30Ft		U6 marked on bridge 40.62123 N / 074.95913 W	Yes	lawns, septic, roads, sediment	wetlands. Observed dozen fish 3-6 " in scour hole by bridge	Only accessed small segment near Bridge. Inaccessible from rose/ and lack of permission.	
J5 downstream of Perryville Rd	15' / fast, shallow	sl-mod bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments/ some sed deposition	none	Mod-Stable 2ft eroded banks for 100 ft	Mod-Stable 2ft eroded banks for 100 ft	50% forested	50% forested	50-100% forested	50-100% forested	forest, wetlands, housing, roads	forest, wetlands, housing, roads	Med - Multifloral rose	downstream of Perryville Rd Bridge/ road swales are eroded 1-2'	30Ft		U6 marked on bridge 40.62123 N / 074.95913 W	Yes	lawns, septic, roads, sediment	wetlands	Only accessed small segment near Bridge. Inaccessible from rose/ and lack of permission.	
G3 - Crestview Estates	20' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments	none	Stable	Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands	forest, wetlands, roads	Hi -Multifloral rose	Hill & Dale Rd Bridge	50Ft bridge / 48" conc outfall from SW basin	good	40.61888 N / 074.95694 W	No	lawns, septic, roads, sediment	wetlands / deep pool DS of bridge good fish habitat	Wooded deck wedged in stream debris - should be removed. Only accessed small segment near Bridge.	Remove deck from stream
F1 Confluence of G and J	13' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments	none	Stable	Stable - Portions of J are unstable with 1-2 ft eroded banks	50-76% forested wetlands	50-76% forested wetlands	50-76% forested wetlands	50-76% forested wetlands	forest, wetlands, Ag	forest, wetlands, Ag	high - Multifloral rose	Downstream flows under train trestle			confluence 40.62191N/ 074.95776W	No	sediment	wetlands	stream swollen from rain - but downstream of the confluence it appears that some erosion may be occuring and stream appears more turbid than at the confluence - however, stream was too swollen to wade.	A property left side of tributary G has a large old farm dump along the hillside -behind a greehouse structure. The dump is visible from train tracks and should be addressed by the property owner.
F2 inlet to Jutland Lakeside	25' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles 25% embedded with fine sediments	none	Stable	Mod Stable - one small 40 ft 2-3 ft eroded bank DS of trestle	25% forested wetlands, lawn	25% forested wetlands, lawn	25% forested wetlands, lawn	25% forested wetlands, lawn	forest, wetlands, lawn	forest, wetlands, lawn	med - Multifloral rose	flows under train trestle into lake			confluence 40.62308N/ 074.95670W	No	sediment	wetlands	from train tracks it appears that some erosion may be occuring just upstream of trestle and stream appears somewhat turbid	Development open space fhas some sheet flow & erosion gullies could be enhanced by landscaping, river birch and willow. Nice patch of native pussy willow.
F3 trib behiind Midvale Development	2-4' / fast, shallow	slight bends/ Frequent shallow pools	clay loam/Gravel 50% embedded with fine sediments	duckweed by outfall	Stable	Mod Stable - 1-2 ft eroded bank DS of outfall for 75 ft	25% forest wetlands meadow	25% forested wetland meadow	25% forested wetland meadow, lawn	25% forested wetland meadow, lawn	forest, wetlands, lawn	forest, wetlands, lawn	high - Multifloral rose	flows from outfall enters small trib & weltand area	36" outfall to wetlands	new - multi outlet basin structure	outfall 40.62650N/ 074.95858W	No	sediment, nutrients	wetlands	steep slopes & little vegetative canopy in Midvale Develop cause significant runoff volume & velocities	
F4 trib at Midvale & Race St	12'/ fast, shallow	Oxbow formation/ mod-sharp bends/ Frequent shallow pools & riffles	Gravel/cobbles 25%-50% embedded with fine sediments	water cress	Mod Unstable 3ft eroded banks for 100 ft	Mod Unstable 3ft eroded banks for 100 ft	50% forested / steep slope	50% forested / road	50-76% forested / steep slope	50% forested / road	forest, pond, housing, roads	forest, pond, housing, roads	low -Multifloral rose	Bridge & drainage from Race St and outfall from housing	24" conc outfall from Midvale Rd housing develop - silt deposition by outfall	silt deposition/ oxbow formation from erosion	40.62580 N / 074.95743 W	Yes	Housing, road, sediment	wetlands	Signficant existing erosion in this ravine - and area will receive additional runoff from approved Renaissance Development - monitor for mitigation	Erosion could undermine Race St, rip rap was added/ DPW should monitor/ remove silt from outfall / mitigate oxbow/ stablize Race St

Table 3- Sidney Brook
Northeast Quadrant - Reaches E, C B and D

Sidney Bk Reach/ Segment	Stream Width and Flow	Stream Sinuosity & Variability	Stream Substrate & Stability	Aquatic Vegetation	Bank Erosion* L	Bank Erosion* R	Riparian Corridor - Vegetation Canopy & Land Use: <25 ft L	<25 ft R	25-50 ft L	25-50 ft R	300 ft -LULC L	300 ft -LULC R	Invasive Species Dominance	Channel Alteration	Outfall/ Drainage: Size	Condition	GPS Coord	Flooding Concerns	NPS Impact	Habitats Observed	Other	Potential DPW Cleanup/Mitigation
E1 - recieves discharge from Quarry pond	3' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments	none	Stable	Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands	forest, wetlands	low -Multifloral rose	Quarry 1 acre pond discharge via seep			40.62959 N / 074.95009 W		Sediment	wetlands		
E2	15' / slow, shallow	slight bends/ infrequent shallow pools & riffles	clay loam with cobbles, >75% embedded with fine sediments	rooted emergent, rushes, sedges in wetlands	Stable	Stable	<50% forested	<50% forested	<50% forested	<50% forested	forest, wetlands, Ag	forest, wetlands, Ag	low -Multifloral rose	former small access bridge removed/ wetland are regraded/ farm pond DS			40.62697 N / 074.95035 W bog wetland		Ag, sediment	wetlands - tussock sedge humocks- possible Bog turtle habitat	Stream is forested but bog wetland is open wet meadow with sedges and rushes	
E3 below Jutland Lakeside Dam	18' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments/ some sed deposition	none	Stable	Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands, meadow	forest, wetlands, meadow	Med - Multifloral rose	downstream of Race St - Lakeside Dam & Pond	100 ft dam/ spillway / 48" outfall in spillway	gd	near Dam spillway 40.62537 N / 074.95160W	Yes	geese, sediment, lawns, septic, roads	pond, wetlands	Water is very turbid with high sediment loading after storm events. Only accessed small segment near dam spilway. Inaccessible from lack of permission.	
C1	15' / fast, shallow	slight bends/ Frequent shallow pools & riffles	clay loam with cobbles/ 51%-75% embedded with fine sediments	rooted emergent, rushes, sedges in wetlands	Stable	Stable	76-100% forested	76-100% forested	76-100% forested	76-100% forested	forest, wetlands	forest, wetlands	high - Multifloral rose					Undisturbed Floodplain	Sediment / junkyard	cattail wetlands with tussock sedge humocks- possible Bog turtle habitat	Photographed tires and debris in ravine upstream of cattail wetlands.	Property owner should remove tires and debris from wetlands and floodplain.
C2 West of Race St	20' / fast, shallow	slight bends/ Frequent shallow pools & riffles	cobbles/ too turbid to observed embeddedness	none	Stable	Stable	100% forested wetlands	100% forested, wetlands	100% forested wetlands	100% forested, wetlands	forest, wetlands, meadows	forest, wetlands, meadows	high - Multifloral rose	2 Bridges at Race St		degraded	bridge 40.61950N / 074.93718W	Race St frequently flooded and closed	Sediment	wetlands		Major rmodifications to Race Street and Bridges needed to reduce flooding.
C3 East of Race St	15' / fast, shallow	slight bends/ Frequent shallow pools & riffles	cobbles/ too turbid to observed embeddedness	none	mod Unstable 1-2 ft eroded banks / floodwall detached	Stable	25% forested, lawns	25% forested, wet meadow	25% forested, lawns	25% forested, wet meadow	forest, wetlands, meadows	forest, wetlands, meadows	med - Multifloral rose	2 Bridges at Race St		degraded	bridge 40.61950N / 074.93718W	Race St frequently flooded and closed	Sediment	wetlands		Major rmodifications to Race Street and Bridges needed to reduce flooding. Historic stone bridge needs repair
B1	10' / fast, shallow	slight bends/ Frequent shallow pools & riffles	Gravel/cobbles <25% embedded with fine sediments	none	Stable	Stable	25% forest/ Ag hayfield	25% forest/ Ag hayfield	25% forest/ Ag hayfield	Ag hayfield	Ag hayfields	Ag hayfields	Hi -Multifloral rose				40.62144 N / 074.93601 W bog wetland 40.62092 N / 074.93535 W outfall OF1		Ag, sediment	wetlands - tussock sedge hummocks- possible bog turtle habitat	Milligan Farm -UT Open Space Lands	
B2	4' / fast, shallow	slight bends/ Frequent shallow pools & riffles	clay loam with cobbles <50% embedded with fine sediments	duckweed	Mod Unstable	Mod Unstable	76-100% forest	76-100% forest	75% forest/ Ag hayfield	Ag hayfield	Ag hayfields	Ag hayfields	Hi -Multifloral rose				40.62290 N / 074.93637 W		Ag, sediment		Milligan Farm -UT Open Space Lands	
BT1 - receive SW runoff from prison pond	5' / slow, shallow	naturally straight/ occassional shallow pools & riffles	clay loam with cobbles <50% embedded with fine sediments	rooted emergent	Stable	Mod Unstable	50-75% forest/ Ag hayfield	<25% forest/ Ag hayfield	<50% forest/ Ag hayfield	Ag hayfield	Ag hayfields	Ag hayfields	Hi -Multifloral rose		2pipes - 36 "conc	some rip rap scour hole, flow disappears into wetlands & field	Prison Pond Outfall bog wetlands 40.62199 N / 074.93276 W	Undisturbed floodplain	Ag, sediment		Milligan Farm -UT Open Space Lands	
BT2	4' / fast, shallow	slight bends/ occasional shallow pools & riffles	clay loam with cobbles	rooted emergent	Stable	Stable	<25% forest/ Ag hayfield	<25% forest/ Ag hayfield	Ag hayfield	Ag hayfield	Ag hayfields	Ag hayfields	Hi -Multifloral rose		24" conc / concrete splashpad	Historic stone headwall/2 ft scour hole	40.62013 N / 074.93286 W culvert	floodplain	Ag, sediment		Milligan Farm -UT Open Space Lands	
B3 confluence of B main stem and B tributary	6' / fast/ shallow to deep	slight bends/ mix of shallow & deep pools	clay loam with cobbles <50% embedded with fine sediments	rooted emergent / duckweed	Stable	Stable	<25% forest/ Ag hayfield	<25% forest/ Ag hayfield	<50% forest/ Ag hayfield	Ag hayfield	Ag hayfields	Ag hayfields	Hi -Multifloral rose				40.61895 N / 074.93277 W	Undisturbed active floodplain	Ag, sediment		Milligan Farm -UT Open Space Lands	

R L Determinations made looking upstream

Table 4- Sidney Brook
Southeast Quadrant - Reaches D, B and A

Sidney Bk Reach/ Segment	Stream Width and Flow	Stream Sinuosity & Variability	Stream Substrate & Stability	Aquatic Vegetation	Bank Erosion*		Riparian Corridor - Vegetation Canopy & Land Use						Invasive Species Dominance	Channel Alteration	Outfall/ Drainage			Flooding Concerns	NPS Impact	Habitats Observed	Other	Potential DPW Cleanup/Mitigation
					L	R	<25 ft		25-50 ft		300 ft -LULC				Size	Condition	GPS Coord					
							L	R	L	R	L	R										
D1 Sodres Horse Farm	5-8' /slow, shallow	slight bends/ Frequent shallow pools & riffles	loose, cobbles <50% embedded with fine sediments/ some sed deposition	none	Unstable 3-4 ft eroded bank	Unstable 3ft eroded bank	50% forested	50% forested	50% forested	50% forested	forest, wetlands, meadow	forest, wetlands, horse pasture	Med - Multifloral rose	High SW flows from Cooks Crossing Rd eroded banks.			Bridge erosion 40.60736N/ 074.94823W erosion 40.60767 N / 074.94763W	Yes	horse, geese, sediment, lawns, septic, roads	pond, wetlands	Farm pond water is turbid with sediment loading after storm events. Storm runoff from Cooks Crossing Rd undermined foundation of historic spring house	Evaluate Cooks Cr Rd inlets. Consider NRCS grants to stabilize spring house, stablize stream banks.
D2 Peaceful Valley Farm - upstream of pond	4' /fast, shallow	slight bends/ Frequent shallow pools & riffles	loose, cobbles <50% embedded with fine sediments/sed deposition over banks	rooted emergent	Mod Unstable 2 ft eroded bank	Mod Unstable 2ft eroded bank	25% forested, meadow floodplain	25% forested, meadow floodplain	25% forested, meadow floodplain	50% forested, meadow floodplain	Ag, cropland and orchards	forest, wetlands,	Med - Multiflorial rose	High SW flows overtop stream banks, erode banks.	swale and 24" conc outfall to farm pond			Yes	goats, geese, sediment, fertilizers, pesticides	pond, wetlands	Farm pond water is turbid with sediment loading after storm events.	Possible retention basin at Cooks Crossing Rd - Upstream of farm. Consider NRCS grants to construct vegetated swales at edge of parking lot & at edge of cropland to reduce sed loading, stablize stream banks.
D3 Peaceful Valley Farm - downstream of pond	10' /fast, shallow	mod bends/ Frequent shallow pools & riffles	stable, cobbles <50% embedded with fine sediments/sed deposition over banks	rooted emergent	Stable	Stable	25% forest, wetland meadow, floodplain	25% forested, meadow floodplain	wetland meadow, floodplain	25% forested, meadow floodplain	wetland meadow, floodplain	25% forest, wetlands, meadow	Med - Multifloral rose	Outfall from Rte 513, Outfall from pond, farm access bridge	swale and 48" stone historic Cty Rd outfall to drainage swale		Cty Rte 513 OF 40.61312N/ 074.9244W Farm Bridge 40.61182N / 074.94050W	no	goats, geese, sediment, fertilizers, pesticides	pond, wetlands	Farm pond water is turbid with sediment loading after storm events.	Consider NRCS grants to construct vegetated swales at edge of parking lot & at edge of cropland to reduce sed loading, stablize stream banks, stablize swale crossing.
D4 Senior Care Center with lg pond	not observed						100% forest	100% forested	100% forest	100% forested	100% forested	100% forested	high - Multifloral rose	Dam/ berm for pond / culverts to pond/ pond dam &spillway				no	sediment, septic	pond, wetlands	Could not access the stream or view culverts or outfalls due to excessive thick mulit floral rose. Pond water is very turbid with sediment loading from runoff and possible from ongoing upgrade of septic fields.	
D5 south of train trestle	10' /fast, shallow	mod bends/ Frequent shallow pools & riffles	stable, cobbles <25% embedded with fine sediments/sed deposition over banks	rooted emergent	Mod Stable	Mod Unstable 2ft eroded bank	50% forest, wetland meadow, floodplain	50% forested, wetland meadow floodplain	50% forest, wetland meadow, floodplain	50% forested, wetland meadow floodplain	50% forested, wetland meadow, floodplain	50% forest, wetlands, meadow floodplain	high - Multifloral rose				Erosion D2ER3 40.61752N / 074.93867W	no	goats, geese, sediment, fertilizers, pesticides	pond, wetlands	Farm pond water is turbid with sediment loading after storm events.	Consider NRCS grants to construct vegetated swales at edge of parking lot & at edge of cropland to reduce sed loading, stablize stream banks, stablize swale crossing.
D6 up Race Street bridge	30' /fast, shallow	mod bends/ Frequent shallow pools & riffles	stable, cobbles <25% embedded with fine sediments/sed deposition over banks		Mod Unstable 3-4 ft eroded bank at bends	Mod stable	50-75% forest	50-75% forest	50-75% forest	50-75% forest	50% forested, wetland meadow,	50% forest, wetlands, meadow	high - Multifloral rose	Stream flows under 30 ft train trestle, and historic bridge at Race St			Erosion D1ER1 40.61907N / 074.93739W	no	sediment	forest, wetlands		Property owner or Township should remove debris near train line. Dumping occuring -North of train line >15 old rusty drums & debris. South of train line >50 tires.
B4 east of Rte 513 bridge	30-15' / deep pool by bridge/ fast/ shallow	slight bends/ mix of shallow & deep pools	heavy sedimentation by bridge / 30 yd becomes cobbles	none	Stable	Stable	100% forested wetlands	100% forested, wetlands	100% forested wetlands	100% forested, wetlands	forest, wetlands, Ag hayfield	forest, wetlands, Ag hayfields	Hi -Multifloral rose	Rte 513 bridge			rte 513 bridge pool 40.61858 N / 074.93237 W	Undisturbed active floodplain	Ag, sediment		Milligan Farm -UT Open Space Lands	Bridge where trout are stocked. Trash and litter - maybe from fishing site. May consider trash can.
AT1- Mathew Drive to Race St	2 ft drainage swale						100% forested wetlands	100% forested, wetlands	100% forested wetlands	100% forested, wetlands	forest, wetlands, Ag, residential	forest, wetlands, Ag, residnetial	Med - Multifloral rose	culvert under Race Street/ rip rap	24"			possible	Sediment, roadway		Tributary drains behind homes - did not access / some erosion at culvert at Race St - flooding possible. Matthew Drive detention basin drains east towards Sidney Rd	
A1 west up of Sidney Rd bridge	30-20' / deep pool by bridge/ fast/ shallow	slight bends/ mix of shallow & deep pools	heavy sedimentation by bridge / 30 yd upstream becomes cobbles	none	Mod Unstable 3 ft eroded bank for about 150 ft	Stable	50% forest lawn	100% forested, wetlands	50% forest lawn	100% forested, wetlands	forest, wetlands, residential	forest, wetlands, Ag - cow farm	Hi -Multifloral rose	Sidney Rd Bridge			Erosion 40.61375N / 074.92459 W		Ag, sediment, cows upstream, heating oil spill Feb 2008, septic		heating oil spill occurred in Feb 2008- NJDEP notified and booms remained on the trib and stream for > month. Looks resolved.	Little or no public access - no trespassing signs posted. Bridge where trout are stocked. Trash and litter - maybe from fishing site. May consider trash can.
A2 east ds of Sidney Rd bridge	30-20' / deep pool by bridge/ fast/ shallow	slight bends/ mix of shallow & deep pools	heavy sedimentation by bridge / 30 yd downstream becomes cobbles	none	Stable	Stable	50% forest lawn	50% forest lawn	50% forest lawn	50% forest lawn	forest, residential	forest, residential	Hi -Multifloral rose	Sidney Rd Bridge	24" conc / rip rap		Sidney Rd bridge outfall 40.61355 N / 074.92440 W	possibly flooding impacts residential yards	Ag, sediment, heating oil spill Feb 2008, septic		heating oil spill occurred in Feb 2008- NJDEP notified and booms remained on the trib and stream for > month. Looks resolved.	Little or no public access - no trespassing signs posted. Bridge where trout are stocked. Trash and litter - maybe from fishing site. May consider trash can.

Appendix C

Sidney Brook Watershed

NJDEP Visual Assessment Data Sheets

VISUAL ASSESSMENT PROJECT PLAN

#1 General Sheet

Segment ID #: ____________________ **Water Body Name:** ___________________________

Watershed Management Area: ___________ **Grant Identifier**: _RP#___________________________

County: ____

Segment Identification

Beginning at Latitude/Longitude: ____

Ending at Latitude/Longitude: ____

Survey Team: ____ **Date/Time:** ________________

Weather: 1. Clear 2. Overcast 3. Light rain/Showers 4. Steady Rain 5. Heavy Rain 6. Snow 7. Heavy Snow Melt

Today	Last 48 Hours	Past Week

Days since last rain: ___________________

Air Temperature: ______________________ ° F

Site Sketch: include flow direction, riffles, pools, runs, ditches, riprap, outfalls, roads, sampling locations, photo reference #, GPS reference #'s

VISUAL ASSESSMENT PROJECT PLAN

#2 Monitoring Sheet

(right and left stream bank are determined facing upstream)

Stream Width		**For Non-Wadable Streams**: 1. Constant 2. Widening 3. Mild constrictions 4. Sharp constriction **For Wadable Streams**: Stream Width average _________________ (ft)
Stream Velocity		Velocity average in feet per second (divide10 (D) by the average time (T) ; V = D/T)
Stream Depth / Velocity Combinations		1. Slow, deep 2. Fast, deep 3. Fast, shallow 4. Slow, shallow
Stream Sinuosity		1. Straight – natural 2. Straight – channelized 3. Slight bends 4. Moderate bends 5. Sharp bends (oxbows)
Stream Flows		1. Slow 2. Moderate 3. Swift 4. Combination
Pools & Riffles		1. Frequent occurrence 2. Infrequent occurrence 3. Occasional occurrence 4. Flat water
Pool Variability		1. Even mix of large-shallow, large-deep, small-shallow, small-deep pools present. 2. Majority of pools large-deep; very few shallow 3. Shallow pools much more prevalent than deep pools 4. Majority of pools small-shallow or pool absent
Channel Flow Status		1. Base of both lower banks 2. Water fills greater than 75% 3. Water fills 25-75% 4. Very little water
Stream Substrate		1. Fine particles (silt, clay, mud) 2. Sand 3. Gravel 4. Cobble 5. Boulder 6. Bedrock 7. Other
Stream Substrate		1. Loose 2. Stable
Embeddedness (Gravel, Cobble, & Boulders)		1. 0 – 25% surrounded by fine sediment 2. 26 – 50% surrounded by fine sediment 3. 51 – 75% surrounded by fine sediment 4. Greater than 75% surrounded by fine sediment

Sediment on Stream Bottom		1. Little deposit 2. Some deposit 3. Moderate deposit 4. Heavy deposits
Epifaunal Substrate Available Cover		High gradient Stream: 1. Greater than 70% stable habitat 2. 40-70% stable habitat 3. 20-40% stable habitat 4. less than 20% stable habitat Low Gradient Stream: 1. greater than 50% stable habitat 2. 30-50% stable habitat 3. 10-30% stable habitat 4. 10% or less stable habitat
Bank Stability	Right Bank Left Bank	1. Stable, evidence of erosion or bank failure absent or minimal; <5% of bank affected 2. Moderately Stable, small areas of erosion, mostly healed over; <5 – 30% of bank in reach has areas of erosion 3. Moderately Unstable; 31 – 60% of bank in reach has areas of erosion, high erosion potential during flooding 4. Unstable, many eroded areas, "raw" areas frequent; obvious bank sloughing; 60% or > of bank erosional scars
% of Tree Canopy Above Stream		1. 0 – 25% 2. 26 – 50% 3. 51 – 75% 4. 76 – 100%
Riparian Vegetation	Right Bank Left Bank	1. > 50 ft. width 2. 35 – 50 ft. width 3. 15 – 35 ft. width 4. < 15 ft. width
Woody Debris		1. None 2. In spots 3. Heavy throughout reach
Woody Debris		1. Free floating 2. Attached
Predominant Aquatic Vegetation		1. Rooted emergent 2. Rooted submergent 3. Rooted floating 4. Free floating
Algae Location		1. None 2. On streambed 3. On surface 4. Both
Algae Color		1. Light green 2. Dark green 3. Brown 4. Other

Channel Alteration		1. Stream with normal pattern 2. Some channelization present, usually in areas of bridges, etc… 3. Channelization extensive, 40 – 80% of the stream reach 4. Over 80% of the stream channelized, gabion baskets and/or riprap, and/or concert present

Structures	Bridges	Culverts	Dams	Other

Water Conditions		
Odor:		1. Normal 2. Sewage 3. Petroleum 4. Chemical 5. Anaerobic 6. Other
Color:		1. Clear 2. Tea 3. Milky 4. Muddy 5. Other
Surface Coating		1. None 2. Oily 3. Foam 4. Scum 5. Other

Observations: (indicate locations on map, including left or right bank)

Photo Reference #'s

GPS Reference #'s

VISUAL ASSESSMENT PROJECT PLAN

#3 Assessment Sheet

Streamside Land Use				
	Within 50 ft. of top of bank		Within ¼ mile of site May be coordinated with GIS aerial views	
	Left Bank	Right Bank	Left Bank	Right Bank
Residential single-family housing				
Residential multifamily housing				
Residential Lawns				
Residential Pets				
Commercial / Institutional				
Commercial / Institutional Lawns				
Roads Paved				
Roads Unpaved				
Construction Underway For: Housing Development				
Commercial				
Road / Bridge: Construction Repair				
Agricultural Grazing Land				
Agricultural Feed Lots / Animal Holding Areas				
Agricultural Cropland				
Inactive Agricultural Land / Fields				
Recreational Power Boating				

Recreational Golfing				
Recreational Camping				
Recreational Swimming / Fishing / Canoeing				
Recreational Hiking / Paths				
Recreational Athletic Fields				
Waterfowl (with approximate #)				
Pet Waste				
Preserved Open Space				
Woodland				
Wetlands				
Cemetery				
Recycling/Waste Facility				
Industrial				
Other				

Observations: (indicate locations on map)

____

____

Photo Reference #'s

____

GPS Reference #'s

____

____

#4 Pipe & Drainage Ditch Inventory Sheet

(fill out one sheet for each one)

Outfall Pipe Reference # ___________________________ Pipe Diameter: ______________________(in. or ft)_______________

Type: ____ **1. Storm drain 2. Residential discharge 3. Industrial Discharge (NJPDES#___________________)**

4. Combined sewer overflow 5. Other

Pipe Material: ____ **1. Concrete 2. Steel 3. PVC 4. Clay 5. Other_________________________________**

Pipe Location: ____ **1. In stream 2. In stream bank 3. Near stream**

Pipe Flow/Appearance: ____________________________ **1. None 2. Trickle 3. Intermittent 4. Steady 5. Heavy**

Flow Color: ____

Is streambank at outfall eroded? ______________________________

Stream channel downstream: _________________________________ **1. Stable 2. Eroded**

Drainage Ditch # ____ **1. Unknown 2. Outfall pipe 3. Parking Lot 4. Settlement Basin / Pond**

5. Agricultural field 6. Livestock Operation

Begins At: ____

Ditch Lining: ___________________________ **1. Stone 2. Vegetation 3. Concrete 4. Mud** Ditch Is: ______________________ **1. Stable 2. Eroding**

Ditch Flow: _________________________________ **1. None 2. Intermittent 3. Steady**

Flow Appearance: ____________________________ **1. Clear 2. Turbid 3. Oily 4. Foamy 5. Colored** ____________________

Stream channel downstream: ____ **1. Stable 2. Eroded**

Observations: (indicate locations on map)

____

____

____

____

GPS Reference #'s

____

____

____

VISUAL ASSESSMENT PROJECT PLAN

#5 Invasive Plant Survey Sheet

Date (mm/dd/yy): ________________ **Stream ID:** _________ **Reach No:** __________

Time: ____________________ **Observer Name(s):** _________________________________

If there are invasive species present on the site, approximately what percentage of the plant community is made up of invasives?____

If invasive plant species are present, specify below the type and degree of dominance throughout the reach..*For degree of dominance in community indicate if the species has low (L), medium (M) or high (H) dominance. This is not a comprehensive list. See resources below for other invaders.

**** S= shrub; V= vine; H= herbaceous; T= tree**

Invasive Plant**	**Species Dominance** (L, M, or H)*****
Canada thistle (H) (*Cirsium arvense*)	
Spotted Knapweed (H) (*Centaurea maculosa*)	
Common reed (H) (*Phragmites australis*)	
Curly Leaf Pondweed (H) (*Potamogeton crispus*)	
Cut leaved Teasel (H) *(Dispacus laciniatus)*	
Eurasian Water-milfoil (H) (*Myriophyllum spicatum*)	
Garlic mustard (H) *(Alliaria petiolata)*	
Japanese knotweed (H) (*Polygonum cuspidatum*)	
Japanese Stilt Grass (H) *(Microstegium vimineum)*	
Lesser celandine (H) (*Ranunculus ficaria*)	
Purple loosestrife (H) (*Lythrum salicaria*)	
Reed Canary Grass (H) (*Phalaris arundinacea*)	
Wild Teasel (H) *(Dispacus fullonum)*	

Invasive Plant**	**Species Dominance** (L, M or H)*****
Autumn olive (S/T) (*Elaeagnus umbellata*)	
Japanese barberry (S) *(Berberis thunbergii)*	
Japanese honeysuckles (*Lonicera*) (V/S)	
Japanese Hops (V) (Humulus japonicus)	
Mile-a-Minute (V) (*Polygonum perfoliatum*)	
Multiflora rose (S) (*Rosa multiflora*)	
Oriental bittersweet (V) (*Celastrus orbiculatus*)	
Tree of Heavan (T) *(Ailanthus altissima)*	
Winged burning bush (S) *(Euonymus alata)*	
Other:	

Comments: ____

____

____

____.

Resources:

- An overview of nonindigenous plant species in New Jersey. NJDEP, Natural Heritage Program www.state.nj.us/dep/parksandforests/natural/heritage/InvasiveReport.pdf
- Plant Invaders of Mid-Atlantic Natural Areas. National Park Service US Fish and Wildlife Service http://www.nps.gov/plants/alien/pubs/midatlantic/
- Pennsylvania Field Guide- Common Invasive Plants in Riparian Areas www.acb-online.org/pubs/projects/deliverables-145-1-2004.pdf
- Mid-Atlantic Exotic Pest Council www.ma-eppc.org/

Watershed Maps

Appendix D

Sidney Brook Watershed

Draft Access Letter and UTEC Newsletter

NEW JERSEY WATER SUPPLY AUTHORITY

74 East Main Street, Somerville, NJ (908) 685-0315 • (908) 685-0195 (FAX)

January 14, 2008

«ONA»
«OST1»
«OCIT», «ZIP»

Subject: Stream Assessment of Sidney Brook

Dear: «ONA»

The New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management has partnered with the New Jersey Water Supply Authority (NJWSA), Union Township, and their subcontractor Princeton Hydro, LLC to study Sidney Brook. The purpose of this study is to gain an overall assessment of the health of the stream, its water quality and ecosystem. The field work includes the following tasks:

- Walking the Sidney Brook to visually document physical stream characteristics such as stream depth, width, flows, stream bank stability and vegetative cover and stormwater outfall conditions.

- Conducting limited assessments and surveys of stream crossings to identify areas of wildlife habitats, flooding, erosion, or where plantings may be beneficial for stream health.

- Conducting water quality sampling to characterize the water quality, sediments and the biology of the stream, including fish and other organisms that live in the stream.

The field work will include the entire Sidney Brook and its tributaries, and will be scheduled throughout 2008.

Because your property is located along the stream, the project team is seeking your permission to access the stream channel that is located on your property. Enclosed is a postage-paid card authorizing us to access your property for purposes of the stream survey. Please return the card by January 30th, 2008.

We look forward to your response and greatly appreciate your assistance. Please contact Tara Petti [(908) 685-0315 ext.233, tpetti@raritanbasin.org] with any questions. Thank you in advance for your time and cooperation.

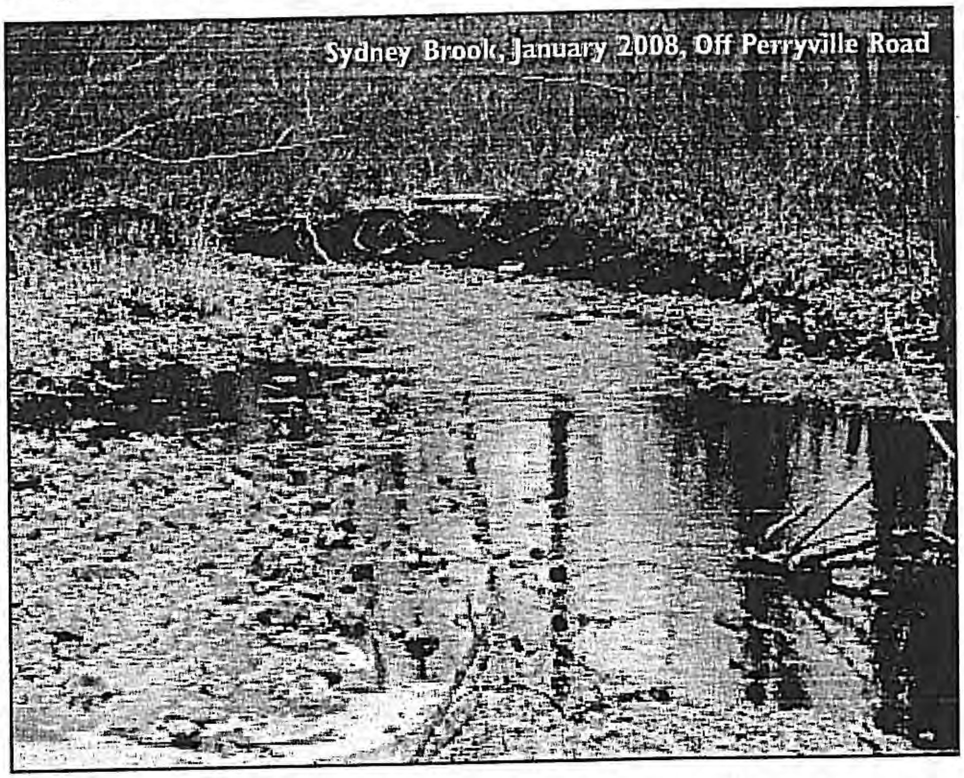
Sincerely,

Tara Petti
Assistant Watershed Protection Specialist
New Jersey Water Supply Authority

Sydney Brook Assessment Update

How old were you on your first fishing trip? Are you gearing up for some trout fishing this April? The New Jersey Division of Fish & Wildlife has stocked rainbow and brook trout in Sidney Brook for about twenty years. Brook trout are native beauties with an olive green back and bright red dots on their sides. Trout are not only fun to catch, but are a good indicator if the stream is healthy, because trout require clean, cold waters. The New Jersey Chapter of Trout Unlimited reported that trout survive in less than half of their original range in New Jersey, and have disappeared from nearly 38% of the watersheds studied. These declines have been attributed to increases in sediment loading to streams, increased runoff, dams, and warm water temperatures. These impacts degrade streams, reduce water quality, and harm a variety of wildlife.

In 2003, the New Jersey Department of Environmental Protection (NJDEP) designated Sidney Brook as a Category One (C1) stream, which protects the stream from degradation and requires a 300 foot buffer along the stream corridor. Currently, there is little data available for Sidney Brook, but a study is currently underway to evaluate the health of the stream, its water quality, ecosystems, and potential impacts to the stream. This study is being conducted by the NJDEP, Division of Watershed Management along with its partners Union and Franklin Townships Environmental Commissions and, the New Jersey Water Supply Authority (NJWSA) and their subcontractor Princeton Hydro, LLC. The Sidney Brook watershed includes a mix of farmlands, housing, commercial tracts, forests, and wetlands. This watershed also supports exceptional natural resources and wildlife habitats for wood turtle, and bog turtle, which are listed by NJDEP as threatened and endangered species. Native brook trout have also been observed in the stream. The goal of the Sidney Brook Watershed study is to protect the valuable natural resources that are dwindling in New Jersey.


Sydney Brook, January 2008, Off Perryville Road

During the upcoming months, members of the Township Environmental Commissions along with the project partners will be hiking the stream and its tributaries to perform this work. Generally the field work will include:

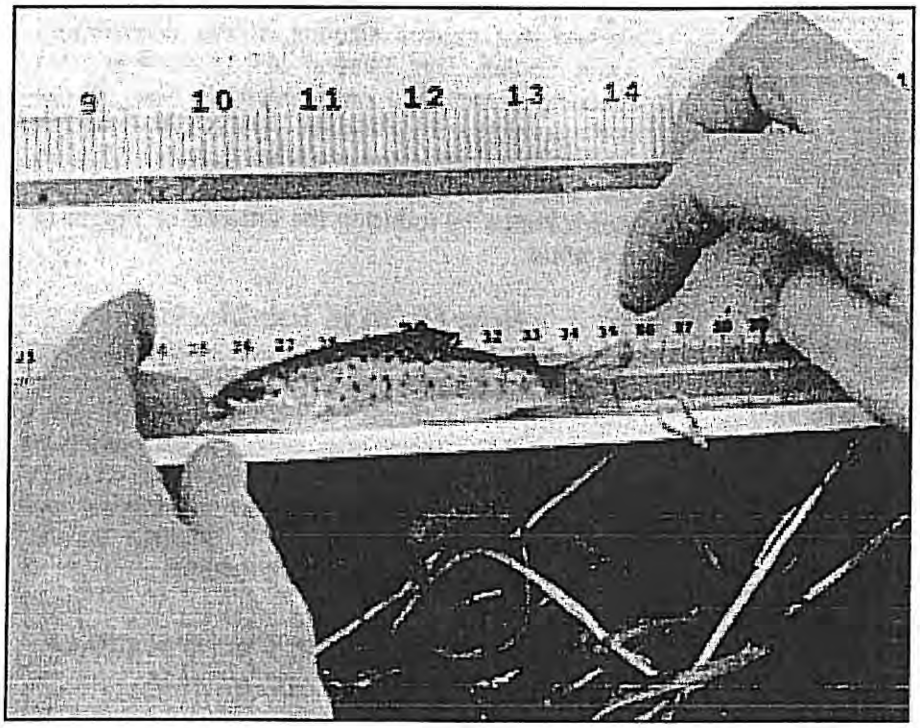
- Princeton Hydro will perform visual assessments along Sidney Brook by walking the stream to document the stream depth, width, flows, and vegetative cover along the stream, outfall conditions, and the stability of the stream banks. These hikes are scheduled from February to April 2008, while there is less vegetative cover.

Sydney Brook Assessment Update

• Based on this field work approximately eleven sampling stations will be selected and samples will be collected to characterize the water quality, sediments and the biology of the stream, including fish, crustaceans, and insects that live in the stream. Sampling events will be conducted by Princeton Hydro during the spring, summer and fall 2008.

• Where areas of frequent flooding or eroded streambanks are identified these areas may be revisited by the NJWSA to survey and evaluate the extent of the problem, and identify solutions, such as plantings to reduce the erosion.

Over 200 residents received letters in January informing them of these upcoming activities and seeking permission to allow the project contractors to walk the streams. Your help and cooperation on this study is greatly appreciated. If you have any questions about the work please do not hesitate to contact Tara Petti at the NJWSA (908) 685-0315 extension 233, tpetti@raritanbasin.org or your municipal town hall. The Union and Franklin Township Environmental Commissions are overseeing this work and can also answer your questions. In addition, the Union Township Environmental Commission will host an information session for local residents on March 11 at 7:00 PM at the Union Township Municipal Building to discuss the upcoming field work for Sidney Brook.



Sidney Brook is a tributary to the South Branch Raritan River with a watershed drainage area of 5.5 square miles that spans much of southern Union Township and the northern portion of Franklin Township. The Sidney Brook Watershed Protection Plan is funded by a federal grant for $237,361 provided by the USEPA under the Clean Water Act 319(h) to the New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management. The project will address vulnerable areas in the watershed and develop a series of recommended actions to maintain the ecological integrity of Sidney Brook, including educating the local residents about the sensitive nature of the stream. The Sidney Brook Watershed Protection Plan will also outline recommendations to help guide planning and future development actions throughout the watershed. Union Township will provide the necessary 25% funding match through in-kind services provided by the Township officials, staff and volunteer board members.

A young brook trout fry was found in Sidney Brook, indicating that the stocking program and a healthy stream may be producing wild brook trout. This is something to celebrate!

Appendix E
Defining Headwaters

The New Jersey Department of Environmental Protection (NJDEP) provided guidance and a Model Ordinance to protect *Riparian Buffer Conservation Zones* in March 2005, as part of their Stormwater Management rules. The NJDEP model ordinance definition of streams and buffers were utilized during the headwater inventory within Raritan Township.
http://www.state.nj.us/dep/watershedmgt/DOCS/pdfs/StreamBufferOrdinance.pdf

- **Intermittent Stream** means surface water drainage channels with definite bed and banks in which there is not a permanent flow of water. Streams shown as a dashed line on either the USGS topographic quadrangle maps or the USDA County Soil Survey Maps of the most recent edition that includes hydrography are included as intermittent streams.
- **Lake, pond, or reservoir** means any impoundment, whether naturally occurring or created in whole or in part by the building of structures for the retention of surface water, excluding sedimentation control and stormwater retention/detention basins and ponds designed for treatment of wastewater.
- **Perennial stream** means a stream that flows continuously throughout the year in most years. These streams usually appear as a blue line on USGS topographic quadrangle maps or on USDA County Soil Survey Maps.
- **Riparian Buffer Conservation Zone (RBCZ)** means an area of land or water within or adjacent to a Surface Water Body within the municipality and designated on the Riparian Buffer Conservation Zone Map. Note: the Model Ordinance suggested that the RBCZ extend from: 150 feet buffer from the top of the bank of intermittent and perennial streams, and steep slopes greater than 10%; 75 feet from lakes, ponds and reservoirs and steep slopes greater than 15%; and incorporate the entire designated floodway areas.
- **Riparian Buffer Conservation Zone Management Plan** means a plan approved by the Engineer of *[municipality]*. The plan shall be prepared by a landscape architect, professional engineer or other qualified professional, and shall evaluate the effects of any proposed activity/uses on any RBCZ. The plan shall identify existing conditions, all proposed activities, and all proposed management techniques, including any measures necessary to offset disturbances to any affected RBCZ.
- **Surface Water Body** means any perennial stream, intermittent stream, lake, pond, or reservoir, as defined herein. In addition, any state open waters identified in a letter of interpretation issued by the New Jersey Department of Environmental Protection Land Use Regulation Program shall also be considered surface water bodies.

The US Geological Service (USGS) also provides the following definitions for streams and headwaters.

- **Stream.** A general term for a body of flowing water. In hydrology the term is generally applied to the water flowing in a natural *channel* as distinct from a canal. Streams in natural channels may be classified as follows (after Meinzer, 1923, p. 5658):
  - **Perennial.** One which flows continuously.
  - **Intermittent or seasonal**. One which flows only at certain times of the year when it receives water from springs or from some surface source such as melting snow in mountainous areas.
  - **Ephemeral.** One that flows only in direct response to precipitation, and whose channel is at all times above the water table.

Appendix F

Sidney Brook Watershed

Stormwater Recommendations for Finn Park

Appendix E – Sidney Brook Watershed
Finn Park Proposed Stormwater Measures

Uncontrolled runoff from the Finn Park recreational fields routinely inundates Perryville Road. Some initial measures that Union Township can consider include reduce mowing the parkland in order to allow taller grass that will help infiltrate and slow stormwater runoff from the site.

- reduce mowing the fields, slopes and areas that are not used for active recreation.
- reduce mowing the existing drainage swales,

In addition, eleven separate stormwater measures have been recommended to reduce the stormwater runoff from Finn Park that continues to flood Perryville Road. Details of these measures and an accompanying site map of Finn Park are included in this Appendix.

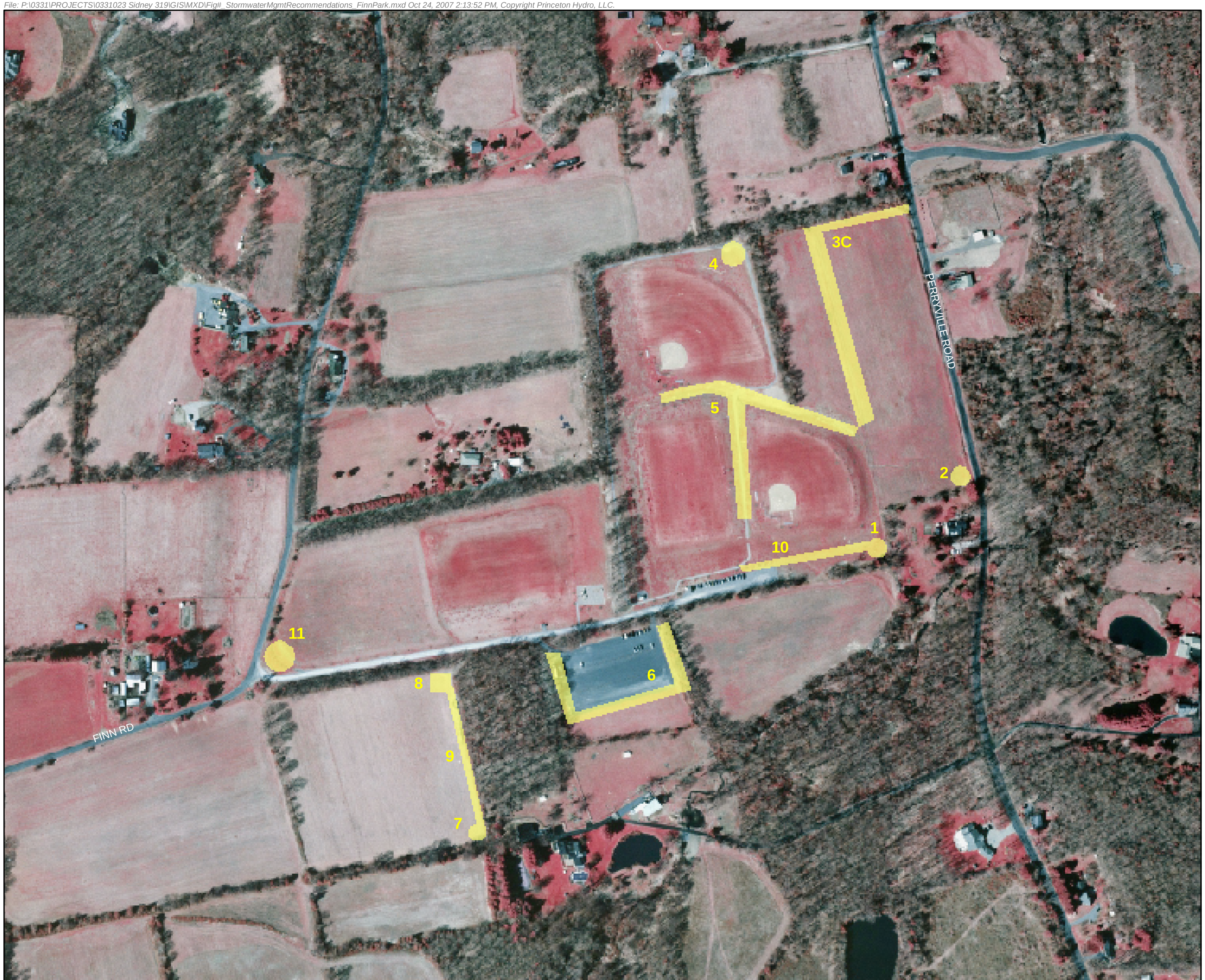
1. Construct a bioretention basin for the northeast portion of drainage area "B"
2. Upgrade the Perryville road drainage swale by replacing the 15" existing culvert that runs under the road with a 24" culvert to aid in the draining of the swale.
3. Redesign the drainage swale for area "C" by creating a shallow, broad swale along the northern side of the walking path. Plant the swale with warm season grasses, and mow only 2-3 times annually. Enable drainage of the swale to the redesigned Perryville Road swale at either drainage point B or C. In order to stop the erosion that is now occurring within the farm field, conveyance of the swale's runoff to Perryville Road may require installation of pipe (possibly a perforated pipe set in a stone channel) or the creation of a new, stone lined or vegetated swale.
4. Construct a biofiltration basin for the drainage area "D"
5. Construct an Infiltration Type Swale System for Drainage Area 5, that includes 11 acres of playing fields, walking paths, and parkland. In general, we propose the use of a combination of swales and perforated pipe set in stone beds. It will likely be necessary to install small catch basins or "scuppers" to collect runoff in a controlled manner, and direct it to either to the swale or the pipe system.
6. Gravel Parking Lot, Drainage Area "E" -Install a low berm, equipped with a weir type control structure, along the eastern edge of the parking area to detain the 1 to 2-year storm event. Renovate the soils along the northern and eastern edges of the parking area (existing conditions too compacted) and plant with warm season, low maintenance grasses.
7. Install a multi-chambered catch basin at the southern entrance to the lot, primarily for sediment control. The basin's function would be largely to intercept and contain eroded soil and gravel from the driveway. The collect runoff would be discharged to the detention area created as part of Project 6 above.
8. Control the runoff from the small parking area (<0.5 acres) by creating a small, bermed, vegetated detention area at the foot of the parking lot. The collected runoff would then be discharged or allowed to sheet flow over a portion of the berm to the renovated swale constructed at part of Project 9 below.

9. Install a check dam swale system for drainage area “F” by installing a shallow, broad swale system, including a series of low check dams, along the northern edge of DA “F”. Drainage from DA “F”, which includes the above noted parking area and most of the southern most ball field, has caused erosion problems at Drainage Point F and further down gradient, off-site of the park. The swale should be designed with a sand, or perforated pipe, under drain system, sized for at least the water quality storm (1.25”/2-hr) but perhaps the 2-year event. The check dams, or in-line berms, would be designed to pond up water temporarily within the swale to promote infiltration, a reduction in flow and the settling of sediments.

10. Entrance Drive to Finn Park (Northern End) There is a considerable amount of erosion and sediment transport that occurs along the edges of the gravel drive, especially along the eastern edge of the northern portion of the drive. Install a series of small, shallow multi-chambered catch basins. The primary purpose of the catch basins would be to collect gravel and sediment as well as to slow down some of the flow. Each basin would be designed to discharge via a riprap protected outlet control to the adjoining woodlot. It may be necessary to install at least 4 to 6 of these structures. Each chamber could be constructed on site using block and a pre-cast concrete base. Each unit would likely be 3’ by 10’ and perhaps 2 –3 feet in depth.

    A longer-range project would be to partially clear the adjoining woodlot, create a wildflower type retention basin and direct the flow from each catch basin to this detention area. The basin could be designed as a passive recreational area with a walking path, benches and interpretive signage. Discharge from the basin would be eventually directed as overland runoff to Drainage Point A, which terminates at Sidney Brook.

11. Entrance Drive to Finn Park (Southern End) This is a large-scale project involving the alteration of the drainage swale system along Finn Road, outside the boundaries of the park.



Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 150 300
1 inch equals 300 feet

SOURCES:

1. New Jersey 2002 High Resolution Orthophotography obtained from the New Jersey Image Warehouse.

FIGURE #:
STORMWATER MANAGEMENT RECOMMENDATIONS - FINN PARK

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

LEGEND

Stormwater Management Recommendations

Appendix G

Potential Bog Habitat Information

for the

Sidney Brook Watershed

United States Department of the Interior

FISH AND WILDLIFE SERVICE
927 North Main Street
Pleasantville, New Jersey 08232
Phone: (609) 646-9310 Fax: (609) 646-0352
http://njfieldoffice.fws.gov

In Reply Refer To:
ES-06/037

MAR 2 8 2006

Christopher L. Mikolajczyk, Senior Project Scientist
Princeton Hydro, LLC
1108 Old York Road
Ringoes, New Jersey 08551
Fax Number: (908) 237-5666

Reference: Threatened and endangered species review in the vicinity of the former Milligans Farms Site, Union Township, Hunterdon County, New Jersey

The U. S. Fish and Wildlife Service's New Jersey Field Office (Service) has received your request for information regarding occurrences of federally listed threatened and endangered species within the vicinity of the above referenced project/property. From the information provided, the Service is unable to determine if any federally listed threatened and endangered species will be affected by the proposed project. To assist you in determining the potential impacts on any federally listed species, the Service requests that you provide the following additional information to this office.

____ A brief description of the proposed project, including proposed utilities and stormwater management.

____ A description of the natural characteristic of the property and surrounding area (forested areas, freshwater wetlands, open waters, and soils). Additionally, please include a description of surrounding land use (residential, agricultural, or commercial).

____ A description of the area to be impacted by the proposed project, including trees to be removed.

____ The name(s) of any federal agency providing authorization or funding for the proposed project.

____ The location of the above referenced property and extent of any project-related activities or discharges clearly indicated on a copy of a USGS 7.5 Minute Topographic Quadrangle (Quad) with the name of the Quad(s) clearly labeled. Pleas provide the maps at a scale depicting at least a 1-mile radius surrounding the project site.

_X_ Other: **Documented habitat for the bog turtle located within and to adjacent to subject property, with a known bog turtle occurrence documented adjacent to the subject property. Please provide this office with detailed project plans for any activity associated with the Milligans Farms site.**

Section 9 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (ESA) prohibits unauthorized taking of listed species and applies to federal and non-federal activities. Additionally, endangered species and their habitats are protected by Section 7(a)(2) of the ESA, which requires federal agencies, in consultation with the Service, to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. An assessment of the potential direct, indirect, and cumulative impacts is required for all federal actions that may affect listed species.

Project construction or implementation must not commence until all requirements of the ESA have been fulfilled. If you have any question or require further assistance regarding threatened or endangered species, please contact the Reviewing Biologist at (609) 646-9310. Please refer to the above document control number in future correspondence. The Service will respond to your request within 30 days of receipt of the additional requested information.

Reviewing Biologist: Lisa P. Arroyo ext. 49

Authorizing Supervisor: [signature]

331.021

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

JON S. CORZINE
Governor

Division of Parks and Forestry
Office of Natural Lands Management
Natural Heritage Program
P.O. Box 404
Trenton, NJ 08625-0404
Tel. #609-984-1339
Fax. #609-984-1427

LISA P. JACKSON
Acting Commissioner

January 26, 2006

JAN 28 2006

Christopher L. Mikolajczyk
Princeton Hydro, LLC
1108 Old York Road, Suite 1
P.O. Box 720
Ringoes, NJ 08551

Re: Milligan Farm (Block 22, Lot 20)

Dear Mr. Mikolajczyk:

Thank you for your data request regarding rare species information for the above referenced project site in Union Township, Hunterdon County.

Searches of the Natural Heritage Database and the Landscape Project (Version 2) are based on a representation of the boundaries of your project site in our Geographic Information System (GIS). We make every effort to accurately transfer your project bounds from the topographic map(s) submitted with the Request for Data into our Geographic Information System. We do not typically verify that your project bounds are accurate, or check them against other sources.

We have checked the Natural Heritage Database and the Landscape Project habitat mapping for occurrences of any rare wildlife species or wildlife habitat on the referenced site. Please see Table 1 for species list and conservation status.

Table 1 (on referenced site).

Common Name	Scientific Name	Federal Status	State Status	Grank	Srank
eastern box turtle	*Terrapene carolina*		Special Concern	G5	S5B
Fowler's toad	*Bufo woodhousii fowleri*		Special Concern	G5	S4
northern copperhead	*Agkistrodon contortrix contortrix*		Special Concern	G5T5	S4
northern spring salamander	*Gyrinophilus p. porphyriticus*		Special Concern	G5T5	S3
wood turtle	*Clemmys insculpta*		T	G4	S3

We have also checked the Natural Heritage Database and the Landscape Project habitat mapping for occurrences of any rare wildlife species or wildlife habitat within 1/4 mile of the referenced site. Please see Table 2 for species list and conservation status. This table excludes any species listed in Table 1.

Table 2 (additional species within 1/4 mile of referenced site).

Common Name	Scientific Name	Federal Status	State Status	Grank	Srank
bog turtle	*Clemmys muhlenbergii*	LT	E	G3	S2
Cooper's hawk	*Accipiter cooperii*		T/T	G5	S3B,S4N
eastern meadowlark	*Sturnella magna*		D/S	G5	S3B,S4N
great blue heron	*Ardea herodias*		S/S	G5	S2B,S4N
longtail salamander	*Eurycea l. longicauda*		T	G5T5	S2
veery	*Catharus fuscescens*		Special Concern	G5	S3B

We have also checked the Natural Heritage Database for occurrences of rare plant species or natural communities. The Natural Heritage Database does not have any records for rare plants or natural communities on or within 1/4 mile of the site.

Attached is a list of rare species and natural communities that have been documented from Hunterdon County. If suitable habitat is present at the project site, these species have potential to be present.

Status and rank codes used in the tables and lists are defined in the attached EXPLANATION OF CODES USED IN NATURAL HERITAGE REPORTS.

If you have questions concerning the wildlife records or wildlife species mentioned in this response, we recommend that you visit the interactive I-Map-NJ website at the following URL, http://www.state.nj.us/dep/gis/depsplash.htm or contact the Division of Fish and Wildlife, Endangered and Nongame Species Program.

PLEASE SEE THE ATTACHED 'CAUTIONS AND RESTRICTIONS ON NHP DATA'.

Thank you for consulting the Natural Heritage Program. The attached invoice details the payment due for processing this data request. Feel free to contact us again regarding any future data requests.

Sincerely,

Herbert A. Lord

Herbert A. Lord
Data Request Specialist

cc: Robert J. Cartica
Lawrence Niles
NHP File No. 06-4007458

"ll"

ENDANGERED AND THREATENED WILDUFE SIGHTING REPORT FORM

(Report form must be fully completed and accompanied by a map with the location plotted.)

Date 17 June 2002

Common Name Bog turtle Scientific Name Clemmys muhlenbergii

Directions to location with landmarks which will enable the future location of the site where the species was sighted Roadside between 38 and 39 Finn Road, Pittstown (Union twp) New Jersey

Municipality/Township Union twp County Hunterdon

Topo Quad (if known) Pittstown Land Owner(s) (If known) ?

Date(s) and time(s) of sighting(s) 16 June 2002 7:30 AM

Number of individuals of each age group sighted: Adult X Immature ____ Larval ____ Unknown ____

Describe sighting and activity observed (ie. nesting, feeding, resting, etc.) Moving upstream along roadside

How frequently has this species been sighted at this location and over how long a period of time?
1st sighting this location

Howwas spedes identification made? (ie. 'igt\ting, caJl, road kiU, ete. sighting

Describe phys[ca_ features that Identify sighted animal as species .you are rap ortfng. Ust man u.a!s used or experts consulted to verify Identification -.-__. '=

Describe ha_t at the point of sighting and habitat in the general.area of the sighting location
PSS1 and PFO1 wetlands, seep

Provide bal;kground on wiLdlife knowledge and/or experience or additional information that would add to the va6dityofthesighting.-- (,Ie, . ..t. biologist

Were photos faken;X Would you accompany a biologist to the site i;need;d? Y

Are you aware of any iml1\efl late plans to develop. o_ disturb. the $ite?:t- If $0" cribe.
pl[illegible] similar habitat [illegible] watercourse subject of

NAME "u [illegible] n Kirkpatrick Return to: -.-n'. --_--- Freshwater Wetlands

STREET 21 Finn Road

CITY Pittstown STATE NJ ZIP 08867

DAYTIME PHONE 732 560-9000 x 4316

Endangered iind Nongame Speci_ ProgrJ! "i1k
NJ Division 01 FiSh and Wildlife
PO Bolt 400 'Itenloo. NJ
0862&0400 609-292-9400

N.J. Department of Environmental Protection. DMsiol'l of Fish. Game and Wildlife

CO
CL
PF

ET NO.
E
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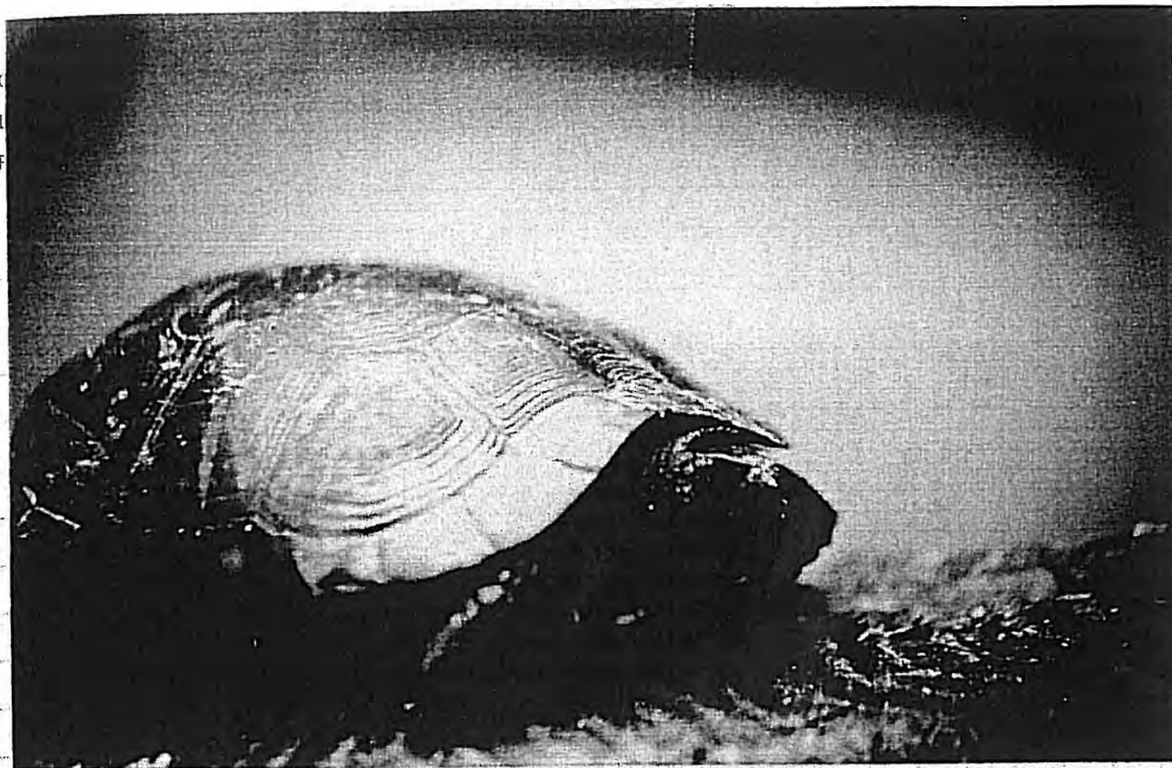
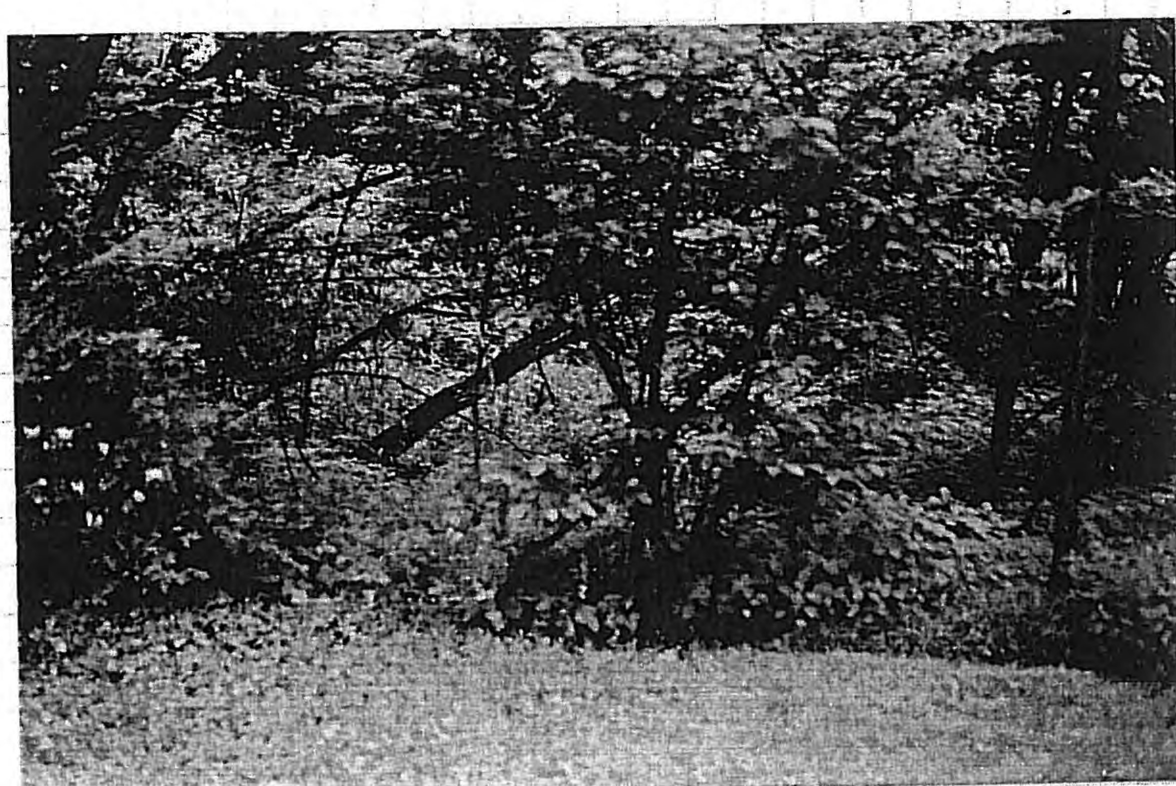


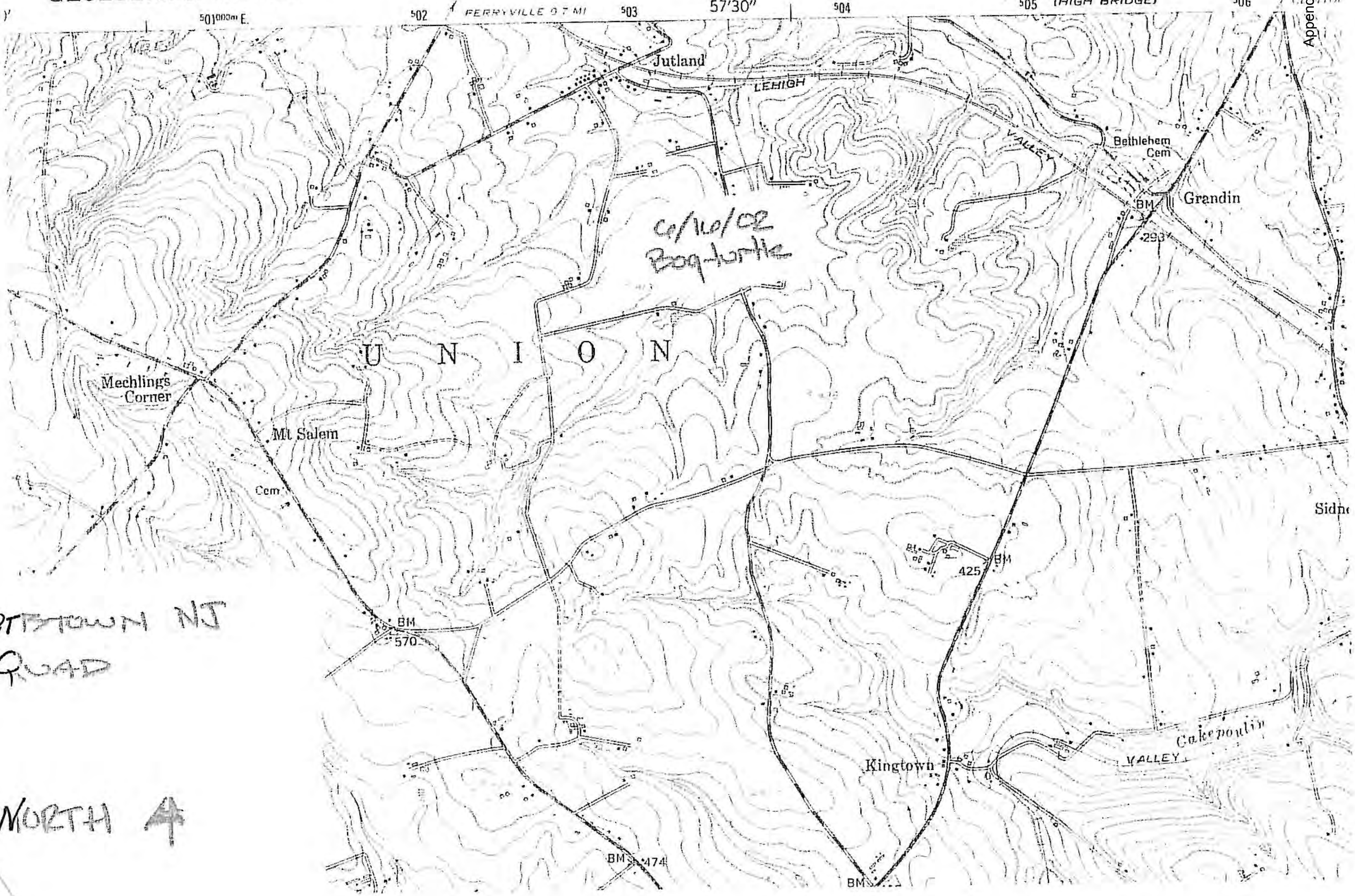
Bog turtle (Clemmys muhlenbergii)
♀ captured 16 June 2002 between
38-39 Finn Road Union twp Hunterdon County



Typical habitat - Overstory : Salix nigra
Understory : Carex stricta, Impatiens capensis
Phragmites australis

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS



PITTSTOWN NJ
QUAD

NORTH

Sidney Brook Watershed – Potential Bog Turtle Habitat

Reach K

Reach E

Reach E

Reach C

Reach C

Reach B - Tributary BT1

Reach B

Appendix H

Sidney Brook Watershed

Visual Assessment GPS Data for Outfalls, Erosion Sites and Cleanups, etc

Sidney Brook Watershed
GPS Locations for Outfalls, Erosion Sites Bridges, etc.

Reach ID/ NAMI	DESCRIPTION	LATITUDE	LONGITUDE	ALTITUDE _FT	LATITUDE	LONGITUDE
A2OF1	Outfall	N40°36.425'	W74°55.383'	200	40.60708333	-74.92305000
A1ER	Erosion	N40°36.825'	W74°55.476'	157	40.61375000	-74.92460000
A2OF3	Outfall	N40°36.813'	W74°55.464'	184	40.61355000	-74.92440000
B1T2	Outfall	N40°37.227'	W74°55.968'	187	40.62045000	-74.93280000
B1OF1	Outfall	N40°37.255'	W74°56.122'	240	40.62091667	-74.93536667
B1BOG	Bog	N40°37.286'	W74°56.160'	190	40.62143333	-74.93600000
B2ER	Erosion	N40°37.374'	W74°56.182'	243	40.62290000	-74.93636667
C5BOG	Bog	N40°37.310'	W74°56.544'	200	40.62183333	-74.94240000
D6ER	Erosion	N40°37.144'	W74°56.244'	249	40.61906667	-74.93740000
D2ER2	Erosion	N40°37.070'	W74°56.307'	236	40.61783333	-74.93845000
D5ER	Erosion	N40°37.051'	W74°56.320'	249	40.61751667	-74.93866667
D3OF	Outfall	N40°36.787'	W74°55.467'	266	40.61311667	-74.92445000
D3BR	Bridge Culvert	N40°36.709'	W74°56.430'	256	40.61181667	-74.94050000
EVP	VernalPool	N40°37.498'	W74°56.857'	272	40.62496667	-74.94761667
E2BOG	Bog	N40°37.618'	W74°57.021'	262	40.62696667	-74.95035000
F4BR	Bridge Culvert	N40°37.548'	W74°57.446'	292	40.62580000	-74.95743333
F2OF1	Outfall	N40°37.463'	W74°57.299'	295	40.62438333	-74.95498333
F3OF	Outfall	N40°37.590'	W74°57.515'	302	40.62650000	-74.95858333
F2Inlet	Basin Inlet	N40°37.386'	W74°57.400'	289	40.62310000	-74.95666667
F3IL	Inlet	N40°37.544'	W74°57.294'	262	40.62573333	-74.95490000
G3OF	Outfall	N40°37.141'	W74°57.417'	305	40.61901667	-74.95695000
G1ER	Erosion	N40°36.944'	W74°57.423'	328	40.61573333	-74.95705000
G1ER3	Erosion	N40°37.027'	W74°57.404'	322	40.61711667	-74.95673333
G5OF1	Outfall	N40°36.729'	W74°57.183'	331	40.61215000	-74.95305000
GOF8	Outfall	N40°37.108'	W74°57.349'	282	40.61846667	-74.95581667
H2ER	Erosion	N40°36.826'	W74°57.619'	335	40.61376667	-74.96031667
H3ER	Erosion	N40°36.857'	W74°57.510'	344	40.61428333	-74.95850000
HT2OF	Outfall	N40°36.152'	W74°58.144'	482	40.60253333	-74.96906667
HT2ER	Erosion	N40°36.179'	W74°58.275'	479	40.60298333	-74.97125000
HT2BDAM	Outfall	N40°36.493'	W74°58.117'	420	40.60821667	-74.96861667
H2AOF	Outfall	N40°36.803'	W74°57.519'	390	40.61338333	-74.95865000
I3ER	Erosion	N40°36.308'	W74°58.273'	489	40.60513333	-74.97121667
I3BER	Erosion	N40°36.344'	W74°58.326'	472	40.60573333	-74.97210000
I3DAM	DAM	N40°36.361'	W74°58.523'	486	40.60601667	-74.97538333
I3IL	Pond Inlet	N40°36.363'	W74°58.517'	466	40.60605000	-74.97528333
J2OF1	Outfall	N40°37.372'	W74°57.900'	325	40.62286667	-74.96500000
J2OF2	Outfall	N40°37.395'	W74°57.907'	325	40.62325000	-74.96511667
J3OF3	Outfall	N40°37.414'	W74°57.956'	335	40.62356667	-74.96593333
J3OF4	Clean up site	N40°37.400'	W74°57.935'	322	40.62333333	-74.96558333
J2OF5	Outfall	N40°37.293'	W74°58.344'	371	40.62155000	-74.97240000
J2OF6	Outfall	N40°37.279'	W74°58.371'	397	40.62131667	-74.97285000
J2OF7	Outfall	N40°37.110'	W74°58.220'	390	40.61850000	-74.97033333
J2OF8	Outfall	N40°37.111'	W74°58.211'	367	40.61851667	-74.97018333
Union Township Elementary School						
J6ELMSKBOL	Basin outlet	N40°37.601'	W74°58.089'	374	40.62668333	-74.96815000
J6ELMOF2	Outfall	N40°37.602'	W74°58.089'	384	40.62670000	-74.96815000
J6VP	VernalPool	N40°37.535'	W74°57.988'	469	40.62558333	-74.96646667
J6ELMOF4	Outfall	N40°37.620'	W74°58.052'	367	40.62700000	-74.96753333
J6ELM5	Outfall	N40°37.684'	W74°58.187'	390	40.62806667	-74.96978333
J6DAM	Outfall	N40°37.522'	W74°57.096'	279	40.62536667	-74.95160000
KT2B	Outfall	N40°37.246'	W74°57.878'	364	40.62076667	-74.96463333
K1BR	Rd Bridge Culvert	N40°37.167'	W74°57.861'	325	40.61945000	-74.96435000
KT2OL1	Outlet	N40°37.111'	W74°58.218'	377	40.61851667	-74.97030000
KT2OF2	Outfall	N40°37.111'	W74°58.213'	381	40.61851667	-74.97021667
KT2OF3	Outfall	N40°37.104'	W74°58.218'	377	40.61840000	-74.97030000
KT2OF4	Outfall	N40°37.107'	W74°58.211'	381	40.61845000	-74.97018333
KT2OF5	Outfall	N40°37.116'	W74°58.166'	397	40.61860000	-74.96943333
KT2BOG	Bog	N40°37.137'	W74°58.157'	371	40.61895000	-74.96928333
Cooks Crossing Road						
COOK1	Erosion	N40°36.442'	W74°56.894'	295	40.60736667	-74.94823333
COOKSP	Outfall	N40°36.439'	W74°56.904'	358	40.60731667	-74.94840000
COOKER	Erosion	N40°36.460'	W74°56.868'	387	40.60766667	-74.94780000
CO0KOF2	Outfall	N40°36.402'	W74°57.195'	367	40.60670000	-74.95325000
COOKOF	Outfall	N40°36.329'	W74°57.540'	456	40.60548333	-74.95900000

Sidney Brook Watershed
GPS Locations for Outfalls, Erosion Sites Bridges, etc.

Reach ID/ NAMI	DESCRIPTION	LATITUDE	LONGITUDE	ALTITUDE _FT	LATITUDE	LONGITUDE
COOKIL1	Inlet	N40°36.317'	W74°57.600'	436	40.60528333	-74.96000000
COOKIN2	Inlet	N40°36.313'	W74°57.637'	459	40.60521667	-74.96061667
COOKIL3	Inlet	N40°36.288'	W74°57.757'	466	40.60480000	-74.96261667
COOKIL4	Inlet	N40°36.282'	W74°57.764'	472	40.60470000	-74.96273333
Sancutary Pond						
SANOF2	Outfall	N40°36.485'	W74°57.692'	423	40.60808333	-74.96153333
SANOF3	Outfall	N40°36.495'	W74°57.699'	404	40.60825000	-74.96165000
SANOF4	Outfall	N40°36.658'	W74°57.598'	440	40.61096667	-74.95996667
SC PondER	Erosion	N40°36.758'	W74°57.528'	377	40.61263333	-74.95880000
SCBasinOF2	Outfall	N40°36.749'	W74°57.556'	367	40.61248333	-74.95926667

Appendix I

Sidney Brook Watershed

Photographic Tour of the Watershed

Sidney Brook
Visual Assessment Watershed Tour
February –March 2008

Christine Altomari
Princeton Hydro
908-237-5660
www.princetonhydro.com

Assisted by NJDEP Watershed Ambassadors Lauren Theis & Stuart Cobb

Reach J -Union Elementary School Drainage

Improve with plantings and less mowing

J- Elementary School Basin 1

Unmapped drainage areas & wetlands

J – Elementary School Basin 2

Steep slopes, unmapped streams and wetlands.

J – Elementary School Drainage from Basin 2

Unmapped streams, wetlands, possible vernal pools.

Reach J - Main Street

Eroded stream banks and flooding are concerns on Main Street.

High algae levels could indicate nutrient loadings.

J – Township Historic Bldg & Public Works Yard

Discharge pipe, 3-4 ft eroded banks, runoff, & debris

Reach J – Wolf Farm Development

Maintenance on outfalls, eroded banks, voluntarily reduce mowing & increase stream buffers

J- Wolf Farm Basin & Outfalls

Outfall maintenance needed, protect stream buffers & address eroded stream banks. Algae prevalent in stream.

J – Downstream Main Street

Address eroded stream banks, flooding concerns, prevalent algae, increase stream buffers.

Reach K Tributary – Kenneth Place

- **Newly mapped KT2 tributary**
- **SW basin & private pond- geese & deer present**
- **Possible bog turtle habitat – reduce mowing.**

KT2 Tributary – Kenneth place

Address basin & outfall maintenance, eroded stream bank, reduce mowing.

KT2 Tributary Erosion – Kenneth Place

KT2 Tributary at Finn Rd

- 48 inch culvert,
- significant 2-3 ft eroded streambanks on both sides.
- Historic landfill on right stream bank

Reach J at Perryville Rd

Stream receives high storm flows, loose substrate, some erosion and deposition, intact forested buffer and floodplain. Fish present.

Reach I – Series of 4 Ponds

- Reach I includes a series of 4 ponds with 2-3 ft eroded stream banks below each outfall, possibly caused by high volume discharges.
- Each pond becomes turbid after storms.
- Stream Buffers include intact forests and wetland habitats.

Reach I- Pond #1

Pond #1 is >2 acres with a 2 ft outfall and 2-3 ft eroded stream banks below the outfall, possibly caused by high discharges.

Stream Buffers include intact forests and wetland habitats.

Reach I –Cooks Crossing Rd Goldberg Farm

Runoff from Cooks Crossing Rd causing erosion, pond turbidity and flooding downstream.

Reach I – Pond #2

- 1-2 ft eroded tributaries to pond and after pond.
- Pond becomes muddy or turbid with sediment after each rain.
- Geese present at pond.

Reach I- Downstream of Pond #2

Reach I includes 2-3 ft eroded stream banks below pond #2.

Reach I – Upstream of Pond #3

Tributary receives runoff from Cooks Crossing Rd & farm fields. Runoff is eroding or undermining tree line, and adding silt to pond #3.

Reach I- Pond #3

Extensive erosion (2-3 ft) was noted throughout this segment, both above and downstream of the pond and outfalls. Steep slopes and high runoff from fields & pond contribute to the erosion.

Geese & duckweed present along pond and downstream.

Reach I- Below Pond #3

Extensive erosion (2-3 ft) was noted throughout this segment, above and downstream of pond #3.

Steep slopes and high runoff contribute to the erosion, buffers are intact forests and wetlands.

A PVC Outfall was observed and foam was noted downstream.

Reach I – Finn Rd Pond #4




Land use by Pond #4 is primarily hayfields and flooding and erosion is evident downstream of the 2 ft outfall.

The inlets and dam for pond #4 may need repair. Each pond receives heavy sediment depositions from storm runoff.

Reach H Tributary 1
Sanctuary Development

- **2 tributaries were mapped for Reach H**
- **Some runoff is retained by a created large wetland basin**
- **Some roadway runoff is directed to a long grassed swale without detention**

Reach H Tributary 2
High View Ct -Cooks Crossing Rd

Over 8 storm sewer road inlets discharge to the outfall at High View Ct. with excessive flows and velocities, eroding the stream banks extensively.

Reach H Tributary 2– High View Ct- Cooks Crossing Rd

- Address greater runoff detention, outfall modifications, and stabilize streambanks to address extensive erosion downstream from the High View Ct outfall.
- Possibly place basins within 2 cul de sacs at High View Ct & Woodsedge Ct

Reach H Trib 2-Sanctuary Pond

High runoff and erosion from Reach HT2 & High View Ct cause sediment depositions in the pond and cause additional downstream flooding & erosion.

Sanctuary Pond




High runoff and erosion cause very turbid conditions in the pond, sediment depositions, and contribute to algal blooms each summer.

HT2 Discharge from -Sanctuary Pond

Runoff from High View Ct cause sediment depositions in the pond, and additional downstream erosion and flooding. Spillway improvements may be needed to reduce the frequent discharges over the spillway, causing additional erosion.

Main Stem of Reach H Downstream of The Sanctuary

High runoff from Reach HT2, High View Ct & the Sanctuary pond cause additional downstream erosion and flooding.

Reach G – Perryville Rd Crossing

High stormwater flows cause 2-3ft erosion and sediment deposition along Reach G.

Reach G -Finn Park & Perryville Rd

Uncontrolled runoff from Finn Park causes significant flooding on Perryville Rd.

Reach G- Crestview Development

Flooding along Perryville Rd caused a deck to be washed into Reach G of Sidney Brook by Hill & Dale Rd.

Reach G has intact forested buffers, working retention basin, and a healthy stream morphology in this portions.

Confluence of Reach J and G

Some sediment noticeable at confluence of Reach J & G.

Stream flows under train trestle into the Jutland Lakeside Lake.

Reach F- Jutland Lakeside Estates

Heavy sediment loadings & depositions noticeable at inlet to Lakeside Estates from confluence of G &J.

Reach F- Jutland Lakeside Estates

Heavy sediment depositions occurs at Lakeside Estates.

F Tributary 1- Midvale Road

Added unmapped tributary F1.

Wetland and tributary receives runoff from Midvale Development.

F1 Tributary – Midvale Rd Basin

Steep slopes, impervious cover and little vegetative canopy contributes to high runoff flows, along with high fertilizer loading.

Duckweed present at outfall.

F1 Tributary – Lakeside Estates

High flows from Midvale Development caused significant erosion, oxbow formation, and could undermine Race Street, as well as contributing sediment to Lakeside lake.

F1 Tributary- Lakeside

High flows from Midvale Development caused significant erosion, and contribute sediment to Lakeside lake.

Reach E Downstream of Lakeside Dam

- Reach E has an intact forested buffer and floodplain, but receives high stormwater flows.
- Access was limited in this section.

E Main Stem – Race Street
Cozzi Junkyard

Access was limited to this reach.

A tributary under the train trestle was not observed, but >50 tires were found near ravine.

Possible large vernal pool observed near bridge crossing to junkyard.

Reach E - Quarry Tributary

Quarry pond was heavily silted, but downstream tributary was clear, with intact forested buffers, and no observed erosion.

E Quarry Tributary

Mapped new tributary, former gun club site, & bog wetland habitat.

Reach C Main Stem upstream of Race Street

Reach C includes a wide intact floodplain with wetland meadows and forested wetland buffers.

Possible bog turtle habitat was observed, with Tussock sedge hummocks.

Reach C is bordered by steep slopes along the train line, where some erosion occurs.

High flows can be very turbid.

Flooding at Race Street – Reach C

- Major flooding occurs at the Race Street bridge, and road closings are frequent.

- Major construction to elevate Race Street over the stream may be needed.

Flooding at Race Street – Reach C
April 2007

Reach D – Cooks Crossing Road

Outfall for Woodedge Development discharges directly to road swale – causing downstream flooding and erosion.

D – Cooks Crossing Rd Outfall Impacts at Sodres Farm

Road runoff undermining spring house & eroding tributaries

D – Sodres Farm

High sheet flow from fields, turbid pond, severe 4 ft erosion downstream.

Horses & geese contribute to water quality issues.

D – Peaceful Farm

- High runoff from Cooks Crossing Rd overflows narrow tributary and spreads out >50 ft.
- Sediment deposition noted over banks.
- Causing pond turbidly and downstream flooding.

D- Peaceful Farm

SW measures to consider to reduce flows and sediment loads include:

•install basin at Cooks Crossing Rd to reduce flows coming onto property.

• vegetated swales at edge of cropland to reduce flow and sediment loads

•Install vegetated swales at edge of parking lot

Reach D -Peaceful Farm Rte 513

Historic stone outfall on County Rte 513 is in need of repair.

Discharge from this outfall runs across the farm access road and field.

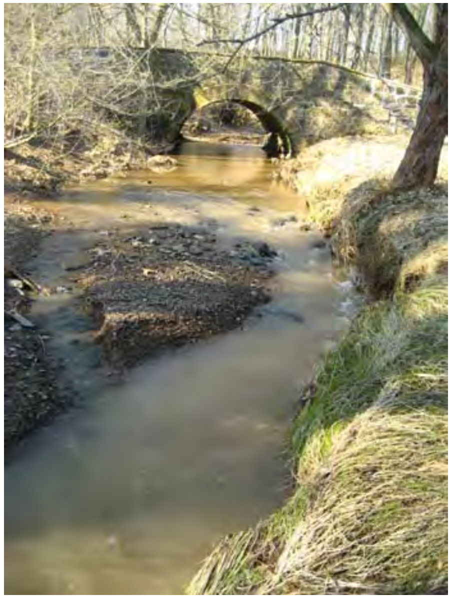
D – Downstream of Peaceful Farm

Downstream of the Peaceful Farm pond the stream appears clear and healthy and stream banks are stable.

Reach D -Care Center

Septic system for the Care Center nursing home was under repair in March 2008. Sediment controls were installed but pond was very turbid. Could not access upstream of pond due to thick multi flora rose

Reach D- Upstream of Race Street



Reach D very turbid this day. Historic Bridge at Hilltop Rd needs repair.

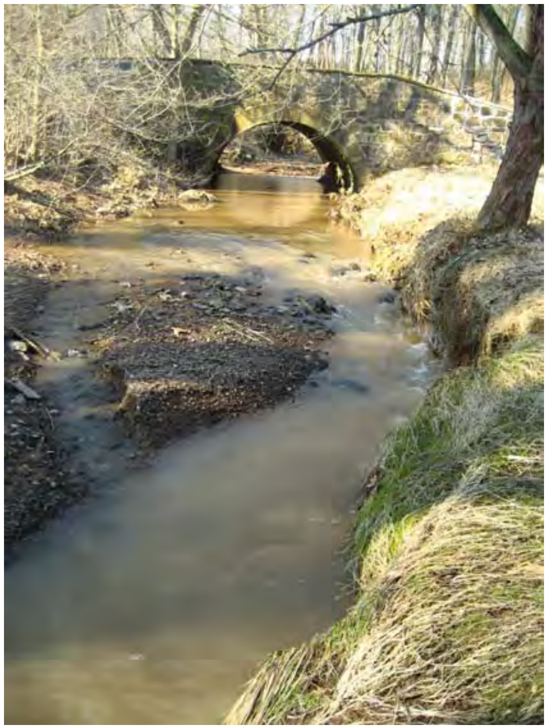
D flows under train trestle and erodes bend 3 ft for a length > 100 ft.

Reach D – Cleanup Areas

Drums and debris north of train trestle should be removed by township or property owner.

Tires south of train trestle should be removed by township or property owner.

Reach B – Downstream of Race Street



High turbid flows, slightly eroded stream banks, frequently flooded floodplain.

Sediment deposition noted and a floodwall/ retaining wall by resident is in need of repair.

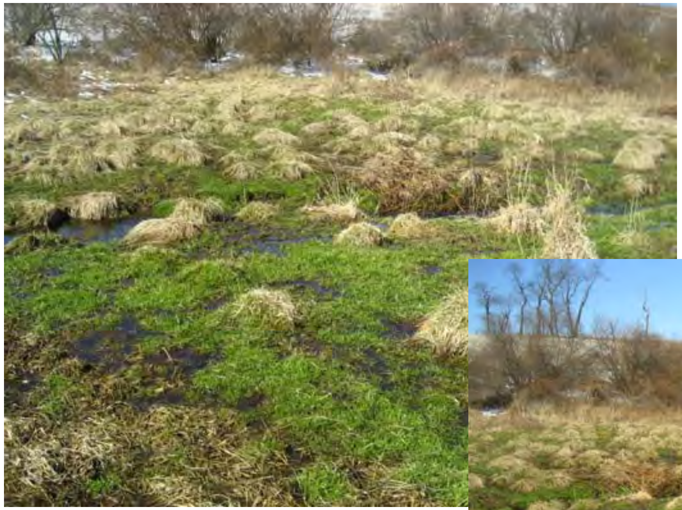
Reach B- Prison Pond

Reach B is fed from runoff and discharges from the Prison pond.

Discharges via two 24 inch pipes to a wetland and swale, but the runoff infiltrates into the ground and a defined stream bank was not observed.

Reach B Tributary – Milligan Farm

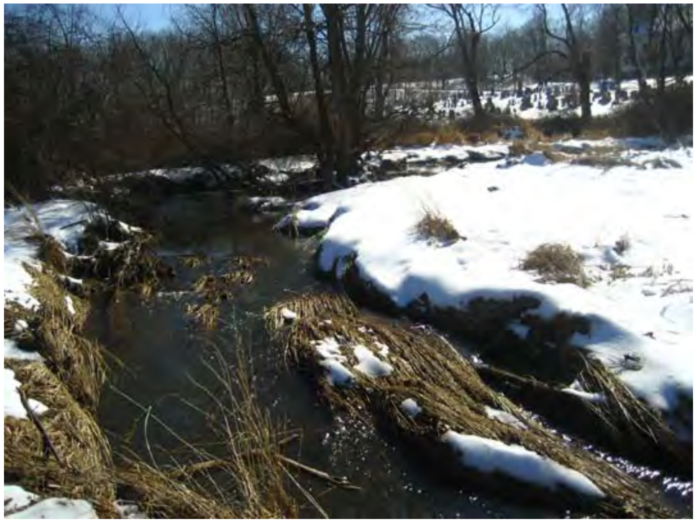
Wetland and Potential Bog Turtle Habitat



B Tributary by Milligan Farm House

Confluence of B Trib1 and B Main Stem

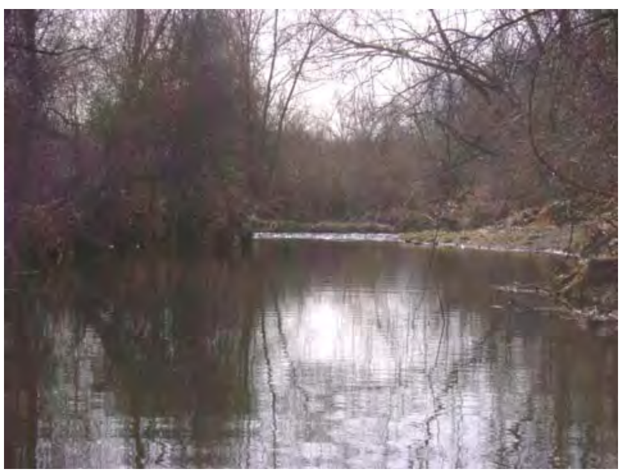
Reach B – Main Stem Wet Meadow Floodplain



B Tributary 2 – Floodplain, wetland and possible bog habitat

B Tributary 2 – eroded banks from housing & Development Center

Reach B-Downstream of Rte 513 Bridge



Intact buffers and floodplain.

Deep fishing pool by bridge, with1-2 foot sediment deposition by pool.

Reach A – Sidney Rd Bridge

3-4 foot eroded banks upstream of bridge. Deep pool by bridge, with some sediment deposition.

Private lands and access limited downstream.

Reach A – Sidney Rd Bridge

Home heating oil spill in February appears resolved, and booms should be removed.

Large tree by bridge overpass may need removal.

Trash can needed to address debris left by fisherman.

Downstream of Sidney Brook
South Branch of Raritan River




High flows cause sediment deposition and eroded stream banks near Hampton Rd .

Hampton Road being eroded and undermined by high storm flows.

Appendix III
Data Tables

Sidney Brook In-Situ Data - by Date						
Date	**Station ID**	**Temp. °C**	**SpC mS/cm**	**DO mg/L**	**DO % Sat.**	**pH S.U.**
7/10/2008	Stn 1 - Main Street	18.07	0.303	7.56	86.1	7.64
	Stn 2 - Perryville Road (1)	19.47	0.261	8.19	89.2	7.50
	Stn 4 - Perryville Road (2)	20.83	0.163	7.02	78.4	7.54
	Stn 6 - Cozze Bros.	25.84	0.210	6.02	74.0	7.6
	Stn 7 - Race Street	23.17	0.238	7.26	84.9	7.67
	Stn 10 - Rte. 513	21.45	0.294	7.88	89.2	7.68
	Stn 11 - Sidney Road	21.96	0.295	8.55	97.8	7.77
8/29/2008	Stn 1 - Main Street	16.27	0.302	5.98	61.0	7.78
	Stn 2 - Perryville Road (1)	16.37	0.274	7.77	79.4	7.85
	Stn 4 - Perryville Road (2)	17.75	0.146	7.64	80.3	7.71
	Stn 6 - Cozze Bros.	19.91	0.197	6.41	69.5	7.74
	Stn 7 - Race Street	19.11	0.201	7.32	79.2	7.90
	Stn 10 - Rte. 513	17.86	0.291	8.47	89.2	7.96
	Stn 11 - Sidney Road	17.92	0.287	8.17	86.2	8.11
12/23/2008	Stn 1 - Main Street	3.30	0.571	14.04	105.4	7.71
	Stn 2 - Perryville Road (1)	0.70	0.362	15.30	106.8	7.90
	Stn 4 - Perryville Road (2)	0.10	0.170	14.94	102.3	7.65
	Stn 6 - Cozze Bros.	0.34	0.339	14.70	101.6	7.78
	Stn 7 - Race Street	0.78	0.327	14.76	103.0	7.83
	Stn 10 - Rte. 513	1.37	0.422	13.72	97.7	7.75
	Stn 11 - Sidney Road	1.36	0.419	14.45	102.9	7.76

Sidney Brook In-Situ Data - by Station						
Station ID	**Date**	**Temp. °C**	**SpC mS/cm**	**DO mg/L**	**DO % Sat.**	**pH S.U.**
Stn 1 - Main Street	7/10/2008	18.07	0.303	7.56	86.1	7.64
	8/29/2008	16.27	0.302	5.98	61.0	7.78
	12/23/2008	3.30	0.571	14.04	105.4	7.71
Stn 2 - Perryville Road (1)	7/10/2008	19.47	0.261	8.19	89.2	7.50
	8/29/2008	16.37	0.274	7.77	79.4	7.85
	12/23/2008	0.70	0.362	15.30	106.8	7.90
Stn 4 - Perryville Road (2)	7/10/2008	20.83	0.163	7.02	78.4	7.54
	8/29/2008	17.75	0.146	7.64	80.3	7.71
	12/23/2008	0.10	0.170	14.94	102.3	7.65
Stn 6 - Cozze Bros.	7/10/2008	25.84	0.21	6.02	74.0	7.6
	8/29/2008	19.91	0.197	6.41	69.5	7.74
	12/23/2008	0.34	0.339	14.70	101.6	7.78
Stn 7 - Race Street	7/10/2008	23.17	0.238	7.26	84.9	7.67
	8/29/2008	19.11	0.201	7.32	79.2	7.90
	12/23/2008	0.78	0.327	14.76	103.0	7.83
Stn 10 - Rte. 513	7/10/2008	21.45	0.294	7.88	89.2	7.68
	8/29/2008	17.86	0.291	8.47	89.2	7.96
	12/23/2008	1.37	0.422	13.72	97.7	7.75
Stn 11 - Sidney Road	7/10/2008	21.96	0.295	8.55	97.8	7.77
	8/29/2008	17.92	0.287	8.17	86.2	8.11
	12/23/2008	1.36	0.419	14.45	102.9	7.76

Sidney Brook Discrete Data - by Date							
Date	**Station ID**	**Nitrate-N mg/L**	**SRP-P mg/L**	**TP-P mg/L**	**TDS mg/L**	**TSS mg/L**	**Base/Storm**
7/10/2008	Stn 1 - Main Street	2.10	0.073	0.08	195	ND<3	Base
	Stn 2 - Perryville Road (1)	1.90	0.064	0.08	173	4	Base
	Stn 4 - Perryville Road (2)	0.68	0.051	0.09	107	ND<3	Base
	Stn 6 - Cozze Bros.	0.50	0.043	0.09	159	3	Base
	Stn 7 - Race Street	0.68	0.041	0.08	134	3	Base
	Stn 10 - Rte. 513	0.79	0.034	0.06	181	ND<3	Base
	Stn 11 - Sidney Road	1.00	0.035	0.06	176	ND<3	Base
8/11/2008	Stn 1 - Main Street	5.80	0.134	0.17	242	6	Storm
	Stn 2 - Perryville Road (1)	2.90	0.067	0.10	188	6	Storm
	Stn 4 - Perryville Road (2)	0.77	0.039	0.06	109	3	Storm
	Stn 6 - Cozze Bros.	0.50	0.019	0.14	142	12	Storm
	Stn 7 - Race Street	0.60	0.024	0.13	140	9	Storm
	Stn 10 - Rte. 513	0.68	0.027	0.07	186	5	Storm
	Stn 11 - Sidney Road	0.81	0.028	0.05	159	ND<3	Storm
8/29/2008	Stn 1 - Main Street	2.80	0.057	0.07	281	ND<3	Base
	Stn 2 - Perryville Road (1)	2.00	0.062	0.08	394	ND<3	Base
	Stn 4 - Perryville Road (2)	1.20	0.037	0.05	179	ND<3	Base
	Stn 6 - Cozze Bros.	1.20	0.030	0.09	208	5	Base
	Stn 7 - Race Street	1.10	0.030	0.07	209	3	Base
	Stn 10 - Rte. 513	1.30	0.020	0.04	286	5	Base
	Stn 11 - Sidney Road	1.20	0.016	0.04	738	ND<3	Base
9/26/2008	Stn 1 - Main Street	4.10	0.109	0.17	158	4	Storm
	Stn 2 - Perryville Road (1)	1.40	0.065	0.11	145	4	Storm
	Stn 4 - Perryville Road (2)	0.46	0.027	0.05	101	ND<3	Storm
	Stn 6 - Cozze Bros.	0.29	0.003	0.05	123	4	Storm
	Stn 7 - Race Street	0.32	0.004	0.05	125	ND<3	Storm
	Stn 10 - Rte. 513	0.44	0.010	0.05	144	ND<3	Storm
	Stn 11 - Sidney Road	0.47	0.016	0.06	156	ND<3	Storm
12/16/2008	Stn 1 - Main Street	3.30	0.188	0.20	174	ND<3	Storm
	Stn 2 - Perryville Road (1)	1.50	0.079	0.10	147	ND<3	Storm
	Stn 4 - Perryville Road (2)	1.00	0.020	0.05	93	ND<3	Storm
	Stn 6 - Cozze Bros.	1.30	0.017	0.05	115	3	Storm
	Stn 7 - Race Street	1.20	0.015	0.06	111	6	Storm
	Stn 10 - Rte. 513	1.30	0.016	0.04	153	3	Storm
	Stn 11 - Sidney Road	1.70	0.018	0.05	157	3	Storm
12/23/2008	Stn 1 - Main Street	3.20	0.071	0.09	376	ND<3	Base
	Stn 2 - Perryville Road (1)	2.00	0.036	0.05	220	ND<3	Base
	Stn 4 - Perryville Road (2)	1.40	0.019	0.03	115	ND<3	Base
	Stn 6 - Cozze Bros.	1.40	0.014	0.04	209	ND<3	Base
	Stn 7 - Race Street	1.30	0.012	0.03	184	ND<3	Base
	Stn 10 - Rte. 513	1.60	0.013	0.04	221	ND<3	Base
	Stn 11 - Sidney Road	1.80	0.015	0.03	231	ND<3	Base

Sidney Brook Discrete Data - by Station							
Station ID	**Date**	**Nitrate-N mg/L**	**SRP-P mg/L**	**TP-P mg/L**	**TDS mg/L**	**TSS mg/L**	**Base/Storm**
Stn 1 - Main Street	7/10/2008	2.10	0.073	0.08	195	ND<3	Base
	8/11/2008	5.80	0.134	0.17	242	6	Storm
	8/29/2008	2.80	0.057	0.07	281	ND<3	Base
	9/26/2008	4.10	0.109	0.17	158	4	Storm
	12/16/2008	3.30	0.188	0.20	174	ND<3	Storm
	12/23/2008	3.20	0.071	0.09	376	ND<3	Base
Stn 2 - Perryville Road (1)	7/10/2008	1.90	0.064	0.08	173	4	Base
	8/11/2008	2.90	0.067	0.10	188	6	Storm
	8/29/2008	2.00	0.062	0.08	394	ND<3	Base
	9/26/2008	1.40	0.065	0.11	145	4	Storm
	12/16/2008	1.50	0.079	0.10	147	ND<3	Storm
	12/23/2008	2.00	0.036	0.05	220	ND<3	Base
Stn 4 - Perryville Road (2)	7/10/2008	0.68	0.051	0.09	107	ND<3	Base
	8/11/2008	0.77	0.039	0.06	109	3	Storm
	8/29/2008	1.20	0.037	0.05	179	ND<3	Base
	9/26/2008	0.46	0.027	0.05	101	ND<3	Storm
	12/16/2008	1.00	0.020	0.05	93	ND<3	Storm
	12/23/2008	1.40	0.019	0.03	115	ND<3	Base
Stn 6 - Cozze Bros.	7/10/2008	0.50	0.043	0.09	159	3	Base
	8/11/2008	0.50	0.019	0.14	142	12	Storm
	8/29/2008	1.20	0.030	0.09	208	5	Base
	9/26/2008	0.29	0.003	0.05	123	4	Storm
	12/16/2008	1.30	0.017	0.05	115	3	Storm
	12/23/2008	1.40	0.014	0.04	209	ND<3	Base
Stn 7 - Race Street	7/10/2008	0.68	0.041	0.08	134	3	Base
	8/11/2008	0.60	0.024	0.13	140	9	Storm
	8/29/2008	1.10	0.030	0.07	209	3	Base
	9/26/2008	0.32	0.004	0.05	125	ND<3	Storm
	12/16/2008	1.20	0.015	0.06	111	6	Storm
	12/23/2008	1.30	0.012	0.03	184	ND<3	Base
Stn 10 - Rte. 513	7/10/2008	0.79	0.034	0.06	181	ND<3	Base
	8/11/2008	0.68	0.027	0.07	186	5	Storm
	8/29/2008	1.30	0.02	0.04	286	5	Base
	9/26/2008	0.44	0.01	0.05	144	ND<3	Storm
	12/16/2008	1.30	0.016	0.04	153	3	Storm
	12/23/2008	1.60	0.013	0.04	221	ND<3	Base
Stn 11 - Sidney Road	7/10/2008	1.00	0.035	0.06	176	ND<3	Base
	8/11/2008	0.81	0.028	0.05	159	ND<3	Storm
	8/29/2008	1.20	0.016	0.04	738	ND<3	Base
	9/26/2008	0.47	0.016	0.06	156	ND<3	Storm
	12/16/2008	1.70	0.018	0.05	157	3	Storm
	12/23/2008	1.80	0.015	0.03	231	ND<3	Base

Sidney Brook *E. coli* Data - Summer Geomean						
Station ID	**7/22/2008**	**7/24/2008**	**8/11/2008**	**8/21/2008**	**9/9/2008**	**Summer 2008 Geomean**
Stn 1 - Main Street	1,600	4,600	4,400	240	25,000	2,869
Stn 2 - Perryville Road (1)	2,000	5,900	1,400	490	35,000	3,094
Stn 4 - Perryville Road (2)	410	3,200	470	470	34,000	1,580
Stn 6 - Cozze Bros.	270	400	320	70	4,000	395
Stn 7 - Race Street	360	510	360	250	3,800	575
Stn 10 - Rte. 513	300	1,700	460	360	21,000	1,121
Stn 11 - Sidney Road	280	2,400	430	4,400	88,000	2,569

Samples less than single maximum value of 235 CFU 100ml
Geomean less than 126 CFU 100ml

Sidney Brook *E. coli* Data - Baseflow Geometric Mean								
Station ID	7/22/2008	8/21/2008	10/7/2008	11/12/2008	12/4/2008	**Summer Baseflow Geomean**	**Fall Baseflow Geomean**	**2008 Baseflow Geomean**
Stn 1 - Main Street	1,600	240	470	50	340	620	200	314
Stn 2 - Perryville Road (1)	2,000	490	1,400	370	490	990	633	757
Stn 4 - Perryville Road (2)	410	470	140	70	30	439	66	141
Stn 6 - Cozze Bros.	270	70	120	40	200	137	99	113
Stn 7 - Race Street	360	250	90	260	120	300	141	191
Stn 10 - Rte. 513	300	360	130	140	60	329	103	164
Stn 11 - Sidney Road	280	4,400	140	170	50	1,110	106	271

Samples less than single maximum value of 235 CFU 100ml
Geomean less than 126 CFU 100ml

Sidney Brook *E. coli* Data - Storm Flow Geometric Mean							
Station ID	7/24/2008	8/11/2008	9/9/2008	10/28/2008	11/13/2008	11/25/2008	**2008 Storm Geomean**
Stn 1 - Main Street	4,600	4,400	25,000	38,000	20,000	3,300	10,405
Stn 2 - Perryville Road (1)	5,900	1,400	35,000	45,000	28,000	8,000	11,951
Stn 4 - Perryville Road (2)	3,200	470	34,000	61,000	1,800	3,000	5,063
Stn 6 - Cozze Bros.	400	320	4,000	3,100	480	110	662
Stn 7 - Race Street	510	360	3,800	3,300	800	130	788
Stn 10 - Rte. 513	1,700	460	21,000	8,200	290	7,200	2,560
Stn 11 - Sidney Road	2,400	430	88,000	18,000	810	2,600	3,886

Samples less than single maximum value of 235 CFU 100ml
Geomean less than 126 CFU 100ml

Sidney Brook Fishery Data - Station 5								
Species	**Size Class**							**Total**
	0-3"	3-6"	6-9"	9-12"	12-15"	15-20"	20-25"	
American Eel								**0**
Blacknose Dace	410	150						**560**
Bluegill								**0**
Common Shiner								**0**
Creek Chub	1	16	5					**22**
Fallfish								**0**
Green Sunfish		2						**2**
Largemouth Bass								**0**
Longnose Dace								**0**
Margined Madtom								**0**
Pumpkinseed		1						**1**
Redbreast Sunfish								**0**
Smallmouth Bass								**0**
Tesselated Darter	2							**2**
White Sucker	14	92						**106**
Yellow Perch								**0**
Totals	**427**	**261**	**5**	**0**	**0**	**0**	**0**	**693**

Sidney Brook Fishery Data - Station 7								
Species	**Size Class**							**Total**
	0-3"	3-6"	6-9"	9-12"	12-15"	15-20"	20-25"	
American Eel		6	4	2		5		**17**
Blacknose Dace	11	4						**15**
Bluegill	2							**2**
Common Shiner			7					**7**
Creek Chub		6	1					**7**
Fallfish		23	18	3				**44**
Green Sunfish								**0**
Largemouth Bass	2							**2**
Longnose Dace		20						**20**
Margined Madtom		2						**2**
Pumpkinseed								**0**
Redbreast Sunfish		1						**1**
Smallmouth Bass								**0**
Tesselated Darter	5	1						**6**
White Sucker								**0**
Yellow Perch	1							**1**
Totals	**21**	**63**	**30**	**5**	**0**	**5**	**0**	**124**

Sidney Brook Fishery Data - Station 9								
Species	**Size Class**							**Total**
	0-3"	3-6"	6-9"	9-12"	12-15"	15-20"	20-25"	
American Eel			1	2		3		**6**
Blacknose Dace	17	6						**23**
Bluegill	5	3						**8**
Common Shiner		9	3					**12**
Creek Chub		9						**9**
Fallfish		10	5	2				**17**
Green Sunfish								**0**
Largemouth Bass	4	1						**5**
Longnose Dace	2	23						**25**
Margined Madtom		6						**6**
Pumpkinseed	2	9						**11**
Redbreast Sunfish		1	1					**2**
Smallmouth Bass								**0**
Tesselated Darter	8	5						**13**
White Sucker		12	16	5	4			**37**
Yellow Perch		1						**1**
Totals	**38**	**95**	**26**	**9**	**4**	**3**	**0**	**175**

Sidney Brook Fishery Data - Station 11								
Species	**Size Class**							**Total**
	0-3"	3-6"	6-9"	9-12"	12-15"	15-20"	20-25"	
American Eel			1	3		3	1	**8**
Blacknose Dace	23	12						**35**
Bluegill	2	2						**4**
Common Shiner		2						**2**
Creek Chub		3						**3**
Fallfish								**0**
Green Sunfish								**0**
Largemouth Bass	3	1						**4**
Longnose Dace	4	18						**22**
Margined Madtom								**0**
Pumpkinseed	1	4						**5**
Redbreast Sunfish								**0**
Smallmouth Bass	1							**1**
Tesselated Darter	16	9						**25**
White Sucker	4	7	5	2				**18**
Yellow Perch	1							**1**
Totals	**55**	**58**	**6**	**5**	**0**	**3**	**1**	**128**

Sidney Brook Macroinvertebrate Sampling Data										
Order	**Family**	**Station ID**								
		2	**3**	**4**	**6**	**8**	**9**	**10**	**11**	**AMNET**
Ephemeroptera	Caenidae	0	0	0	0	1	4	2	5	0
	Ephemerellidae	54	0	4	0	0	2	7	1	22
	Heptageniidae	0	1	13	3	2	9	6	9	9
	Baetidae	0	0	0	0	0	0	0	0	4
Odonata	Calopterygidae	0	1	0	0	0	0	0	0	0
	Coenagrionidae	0	0	0	1	0	0	1	1	1
	Gomphidae	0	0	1	0	0	0	0	1	1
Plecoptera	Perlidae	0	0	1	0	0	1	1	0	0
	Taeniopterygidae	0	0	6	0	0	0	0	0	0
	Nemouridae	0	0	0	0	0	0	0	0	1
Coleoptera	Elmidae	26	49	5	29	35	22	12	1	14
	Psephenidae	3	5	1	2	8	11	5	2	10
Megaloptera	Corydalidae	0	0	0	0	0	2	0	0	0
Diptera	Chironomidae	7	10	9	15	28	7	29	61	13
	Ceratopogonidae	0	0	0	1	1	0	0	0	0
	Empididae	0	3	1	1	0	0	0	0	3
	Simuliidae	0	2	2	7	1	1	1	0	0
	Stratiomyidae	1	0	0	0	0	0	0	0	0
	Tipulidae	5	1	1	0	3	1	2	3	0
Trichoptera	Glossosomatidae	0	0	0	0	0	0	0	0	2
	Helicopsychidae	0	0	0	0	0	0	1	0	0
	Hydropsychidae	30	14	52	41	16	48	28	23	9
	Hydroptilidae	0	0	0	3	0	0	2	1	2
	Lepidostoma sp.	0	0	0	0	0	0	2	0	1
	Leptoceridae	0	1	0	1	1	0	2	1	0
	Limnephilidae	0	0	0	0	0	0	0	0	1
	Philopotamidae	12	29	9	13	18	15	0	1	1
Gastropoda	Ancylidae	0	0	2	0	0	0	0	1	0
Annelida	Erpobdellidae	0	2	0	0	0	0	0	0	0
	Hirudinea	0	0	5	0	0	0	0	0	0
	Lumbriculidae	0	0	0	0	0	0	1	0	1
	Naididae	0	0	0	0	0	0	1	2	2
	Tubificidae	0	1	0	0	0	0	0	0	0
Acari	Hygrobatidae	0	0	0	0	0	0	2	3	0
	Lebertiidae	1	0	0	0	0	0	0	0	0
	Sperchontidae	0	0	1	0	0	0	1	0	0
	Torrenticolidae	2	0	1	0	0	0	0	0	0
Crustacea	Asellidae	1	5	0	1	0	0	0	0	0
	Gammaridae	9	1	1	0	3	1	6	1	0
Other	Planariidae	0	1	0	0	0	0	1	0	0
	Tetrastemmatidae	0	0	0	0	0	0	0	1	3

Sidney Brook PP+40 Data						
Client ID:	**STN 6**		**STN 7**		**STN 10**	
Matrix:	**Aqueous**		**Aqueous**		**Aqueous**	
Volatiles (ppb)	Conc	MDL	Conc	MDL	Conc	MDL
Chloromethane	ND	0.500	ND	0.500	ND	0.500
Vinyl chloride	ND	0.500	ND	0.500	ND	0.500
Bromomethane	ND	0.500	ND	0.500	ND	0.500
Chloroethane	ND	0.500	ND	0.500	ND	0.500
Trichlorofluoromethane	ND	0.500	ND	0.500	ND	0.500
Acrolein	ND	10.0	ND	10.0	ND	10.0
1,1-Dichloroethene	ND	0.500	ND	0.500	ND	0.500
Methylene chloride	ND	2.00	ND	2.00	ND	2.00
Acrylonitrile	ND	10.0	ND	10.0	ND	10.0
trans-1,2-Dichloroethene	ND	0.500	ND	0.500	ND	0.500
1,1-Dichloroethane	ND	0.500	ND	0.500	ND	0.500
Chloroform	ND	0.500	ND	0.500	ND	0.500
1,1,1-Trichloroethane	ND	0.500	ND	0.500	ND	0.500
Carbon tetrachloride	ND	0.500	ND	0.500	ND	0.500
1,2-Dichloroethane (EDC)	ND	0.500	ND	0.500	ND	0.500
Benzene	ND	0.500	ND	0.500	ND	0.500
Trichloroethene	ND	0.500	ND	0.500	ND	0.500
1,2-Dichloropropane	ND	0.500	ND	0.500	ND	0.500
Bromodichloromethane	ND	0.500	ND	0.500	ND	0.500
2-Chloroethyl vinyl ether	ND	0.500	ND	0.500	ND	0.500
cis-1,3-Dichloropropene	ND	0.500	ND	0.500	ND	0.500
Toluene	ND	0.500	ND	0.500	ND	0.500
trans-1,3-Dichloropropene	ND	0.500	ND	0.500	ND	0.500
1,1,2-Trichloroethane	ND	0.500	ND	0.500	ND	0.500
Tetrachloroethene	ND	0.500	ND	0.500	ND	0.500
Dibromochloromethane	ND	0.500	ND	0.500	ND	0.500
Chlorobenzene	ND	0.500	ND	0.500	ND	0.500
Ethylbenzene	ND	0.500	ND	0.500	ND	0.500
Total Xylenes	ND	1.00	ND	1.00	ND	1.00
Bromoform	ND	0.500	ND	0.500	ND	0.500
1,1,2,2-Tetrachloroethane	ND	0.500	ND	0.500	ND	0.500
1,3-Dichlorobenzene	ND	0.500	ND	0.500	ND	0.500
1,4-Dichlorobenzene	ND	0.500	ND	0.500	ND	0.500
1,2-Dichlorobenzene	ND	0.500	ND	0.500	ND	0.500
TOTAL VO's:	ND		ND		ND	
TOTAL TIC's:	ND		ND		ND	
TOTAL VO's & TIC's:	ND		ND		ND	

Sidney Brook PP+40 Data						
Client ID:	STN 6		STN 7		STN 10	
Matrix:	Aqueous		Aqueous		Aqueous	
Semivolatiles - BNA (ppb)						
N-Nitrosodimethylamine	ND	1.00	ND	1.00	ND	1.00
Phenol	ND	1.00	ND	1.00	ND	1.00
Aniline	ND	1.00	ND	1.00	ND	1.00
Bis(2-chloroethyl) ether	ND	1.00	ND	1.00	ND	1.00
2-Chlorophenol	ND	1.00	ND	1.00	ND	1.00
1,3-Dichlorobenzene	~	~	~	~	~	~
1,4-Dichlorobenzene	~	~	~	~	~	~
Benzyl alcohol	ND	1.00	ND	1.00	ND	1.00
1,2-Dichlorobenzene	~	~	~	~	~	~
2-Methylphenol	ND	1.00	ND	1.00	ND	1.00
Bis(2-chloroisopropyl) ether	ND	1.00	ND	1.00	ND	1.00
4-Methylphenol	ND	1.00	ND	1.00	ND	1.00
N-Nitrosodi-n-propylamine	ND	1.00	ND	1.00	ND	1.00
Hexachloroethane	ND	1.00	ND	1.00	ND	1.00
Nitrobenzene	ND	1.00	ND	1.00	ND	1.00
Isophorone	ND	1.00	ND	1.00	ND	1.00
2-Nitrophenol	ND	1.00	ND	1.00	ND	1.00
2,4-Dimethylphenol	ND	1.00	ND	1.00	ND	1.00
Bis(2-chloroethoxy) methane	ND	1.00	ND	1.00	ND	1.00
Benzoic acid	ND	1.00	ND	1.00	ND	1.00
2,4-Dichlorophenol	ND	1.00	ND	1.00	ND	1.00
1,2,4-Trichlorobenzene	ND	1.00	ND	1.00	ND	1.00
Naphthalene	ND	1.00	ND	1.00	ND	1.00
4-Chloroaniline	ND	1.00	ND	1.00	ND	1.00
Hexachlorobutadiene	ND	1.00	ND	1.00	ND	1.00
4-Chloro-3-methylphenol	ND	1.00	ND	1.00	ND	1.00
2-Methylnaphthalene	ND	1.00	ND	1.00	ND	1.00
Hexachlorocyclopentadiene	ND	1.00	ND	1.00	ND	1.00
2,4,6-Trichlorophenol	ND	1.00	ND	1.00	ND	1.00
2,4,5-Trichlorophenol	ND	1.00	ND	1.00	ND	1.00
2-Chloronaphthalene	ND	1.00	ND	1.00	ND	1.00
2-Nitroaniline	ND	1.00	ND	1.00	ND	1.00
Dimethyl phthalate	ND	1.00	ND	1.00	ND	1.00
2,6-Dinitrotoluene	ND	1.00	ND	1.00	ND	1.00
Acenaphthylene	ND	1.00	ND	1.00	ND	1.00
3-Nitroaniline	ND	1.00	ND	1.00	ND	1.00
Acenaphthene	ND	1.00	ND	1.00	ND	1.00
2,4-Dinitrophenol	ND	1.00	ND	1.00	ND	1.00
4-Nitrophenol	ND	1.00	ND	1.00	ND	1.00
2,4-Dinitrotoluene	ND	1.00	ND	1.00	ND	1.00
Dibenzofuran	ND	1.00	ND	1.00	ND	1.00
Diethyl phthalate	ND	1.00	ND	1.00	ND	1.00

Sidney Brook PP+40 Data						
Client ID:	**STN 6**		**STN 7**		**STN 10**	
Matrix:	**Aqueous**		**Aqueous**		**Aqueous**	
Semivolatiles - BNA (ppb)						
Fluorene	ND	1.00	ND	1.00	ND	1.00
4-Chlorophenyl phenyl ether	ND	1.00	ND	1.00	ND	1.00
4-Nitroaniline	ND	1.00	ND	1.00	ND	1.00
4,6-Dinitro-2-methylphenol	ND	1.00	ND	1.00	ND	1.00
N-Nitrosodiphenylamine	ND	1.00	ND	1.00	ND	1.00
1,2-Diphenylhydrazine	ND	1.00	ND	1.00	ND	1.00
4-Bromophenyl phenyl ether	ND	1.00	ND	1.00	ND	1.00
Hexachlorobenzene	ND	1.00	ND	1.00	ND	1.00
Pentachlorophenol	ND	1.00	ND	1.00	ND	1.00
Phenanthrene	ND	1.00	ND	1.00	ND	1.00
Anthracene	ND	1.00	ND	1.00	ND	1.00
Carbazole	ND	1.00	ND	1.00	ND	1.00
Di-n-butyl phthalate	ND	1.00	ND	1.00	ND	1.00
Fluoranthene	ND	1.00	ND	1.00	ND	1.00
Benzidine	ND	1.00	ND	1.00	ND	1.00
Pyrene	ND	1.00	ND	1.00	ND	1.00
3,3'-Dimethylbenzidine	ND	1.00	ND	1.00	ND	1.00
Butyl benzyl phthalate	ND	1.00	ND	1.00	ND	1.00
3,3'-Dichlorobenzidine	ND	1.00	ND	1.00	ND	1.00
Benzo[a]anthracene	ND	1.00	ND	1.00	ND	1.00
Chrysene	ND	1.00	ND	1.00	ND	1.00
Bis(2-ethylhexyl) phthalate	ND	1.00	ND	1.00	ND	1.00
Di-n-octyl phthalate	ND	1.00	ND	1.00	ND	1.00
Benzo[b]fluoranthene	ND	1.00	ND	1.00	ND	1.00
Benzo[k]fluoranthene	ND	1.00	ND	1.00	ND	1.00
Benzo[a]pyrene	ND	1.00	ND	1.00	ND	1.00
Indeno[1,2,3-cd]pyrene	ND	1.00	ND	1.00	ND	1.00
Dibenz[a,h]anthracene	ND	1.00	ND	1.00	ND	1.00
Benzo[g,h,i]perylene	ND	1.00	ND	1.00	ND	1.00
TOTAL BNA'S:	ND		ND		ND	
TOTAL TIC's:	ND		ND		ND	
TOTAL BNA'S & TIC's:	ND		ND		ND	

Sidney Brook PP+40 Data						
Client ID:	STN 6		STN 7		STN 10	
Matrix:	Aqueous		Aqueous		Aqueous	
PCB's (ppb)						
Aroclor-1016	ND	0.050	ND	0.050	ND	0.050
Aroclor-1221	ND	0.050	ND	0.050	ND	0.050
Aroclor-1232	ND	0.050	ND	0.050	ND	0.050
Aroclor-1242	ND	0.050	ND	0.050	ND	0.050
Aroclor-1248	ND	0.050	ND	0.050	ND	0.050
Aroclor-1254	ND	0.050	ND	0.050	ND	0.050
Aroclor-1260	ND	0.050	ND	0.050	ND	0.050
Pesticides (ppb)						
alpha-BHC	ND	0.010	ND	0.010	ND	0.010
beta-BHC	ND	0.010	ND	0.010	ND	0.010
gamma-BHC (Lindane)	ND	0.010	ND	0.010	ND	0.010
delta-BHC	ND	0.010	ND	0.010	ND	0.010
Heptachlor	ND	0.010	ND	0.010	ND	0.010
Aldrin	ND	0.010	ND	0.010	ND	0.010
Heptachlor epoxide	ND	0.010	ND	0.010	ND	0.010
Endosulfan I	ND	0.010	ND	0.010	ND	0.010
4,4'-DDE	ND	0.010	ND	0.010	ND	0.010
Dieldrin	ND	0.010	ND	0.010	ND	0.010
Endrin	ND	0.010	ND	0.010	ND	0.010
Endosulfan II	ND	0.010	ND	0.010	ND	0.010
4,4'-DDD	ND	0.010	ND	0.010	ND	0.010
Endrin aldehyde	ND	0.010	ND	0.010	ND	0.010
Endosulfan sulfate	ND	0.010	ND	0.010	ND	0.010
4,4'-DDT	ND	0.010	ND	0.010	ND	0.010
Chlordane	ND	0.125	ND	0.125	ND	0.125
Toxaphene	ND	0.125	ND	0.125	ND	0.125
Metals (ppb)						
Antimony	ND	1.00	ND	1.00	ND	1.00
Arsenic	ND	1.00	ND	1.00	ND	1.00
Beryllium	ND	1.00	ND	1.00	ND	1.00
Cadmium	ND	0.500	ND	0.500	ND	0.500
Chromium	ND	2.00	ND	2.00	ND	2.00
Copper	ND	2.00	ND	2.00	ND	2.00
Lead	ND	0.500	ND	0.500	ND	0.500
Mercury	ND	0.300	ND	0.300	ND	0.300
Nickel	1.26	1.00	1.56	1.00	1.42	1.00
Selenium	ND	4.00	ND	4.00	ND	4.00
Silver	ND	0.500	ND	0.500	ND	0.500
Thallium	ND	0.500	ND	0.500	ND	0.500
Zinc	14.2	4.00	15.3	4.00	18.4	4.00
General Analytical						
Cyanide, Total-ppb	ND	14.0	ND	14.0	ND	14.0
Total Recoverable Phenols-ppb	ND	7.00	ND	7.00	ND	7.00
~ - Not Sampled						

Sidney Brook PP+40 Data						
Client ID:	**STN 6**		**STN 7**		**STN 10**	
Matrix:	**Sediment**		**Sediment**		**Sediment**	
Volatiles (ppm)	Conc	MDL	Conc	MDL	Conc	MDL
Chloromethane	ND	0.0013	ND	0.0012	ND	0.0012
Vinyl chloride	ND	0.0013	ND	0.0012	ND	0.0012
Bromomethane	ND	0.0013	ND	0.0012	ND	0.0012
Chloroethane	ND	0.0013	ND	0.0012	ND	0.0012
Trichlorofluoromethane	ND	0.0013	ND	0.0012	ND	0.0012
Acrolein	ND	0.026	ND	0.024	ND	0.024
1,1-Dichloroethene	ND	0.0013	ND	0.0012	ND	0.0012
Methylene chloride	ND	0.0026	ND	0.0024	ND	0.0024
Acrylonitrile	ND	0.026	ND	0.024	ND	0.024
trans-1,2-Dichloroethene	ND	0.0013	ND	0.0012	ND	0.0012
1,1-Dichloroethane	ND	0.0013	ND	0.0012	ND	0.0012
Chloroform	ND	0.0013	ND	0.0012	ND	0.0012
1,1,1-Trichloroethane	ND	0.0013	ND	0.0012	ND	0.0012
Carbon tetrachloride	ND	0.0026	ND	0.0024	ND	0.0024
1,2-Dichloroethane (EDC)	ND	0.0013	ND	0.0012	ND	0.0012
Benzene	ND	0.0013	ND	0.0012	ND	0.0012
Trichloroethene	ND	0.0013	ND	0.0012	ND	0.0012
1,2-Dichloropropane	ND	0.0013	ND	0.0012	ND	0.0012
Bromodichloromethane	ND	0.0013	ND	0.0012	ND	0.0012
2-Chloroethyl vinyl ether	ND	0.0026	ND	0.0024	ND	0.0024
cis-1,3-Dichloropropene	ND	0.0026	ND	0.0024	ND	0.0024
Toluene	ND	0.0013	ND	0.0012	ND	0.0012
trans-1,3-Dichloropropene	ND	0.0026	ND	0.0024	ND	0.0024
1,1,2-Trichloroethane	ND	0.0013	ND	0.0012	ND	0.0012
Tetrachloroethene	ND	0.0013	ND	0.0012	ND	0.0012
Dibromochloromethane	ND	0.0026	ND	0.0024	ND	0.0024
Chlorobenzene	ND	0.0013	ND	0.0012	ND	0.0012
Ethylbenzene	ND	0.0013	ND	0.0012	ND	0.0012
Total Xylenes	ND	0.0026	ND	0.0024	ND	0.0024
Bromoform	ND	0.0013	ND	0.0012	ND	0.0012
1,1,2,2-Tetrachloroethane	ND	0.0013	ND	0.0012	ND	0.0012
1,3-Dichlorobenzene	ND	0.0013	ND	0.0012	ND	0.0012
1,4-Dichlorobenzene	ND	0.0013	ND	0.0012	ND	0.0012
1,2-Dichlorobenzene	ND	0.0013	ND	0.0012	ND	0.0012
TOTAL VO's:	ND		ND		ND	
TOTAL TIC's:	ND		ND		ND	
TOTAL VO's & TIC's:	ND		ND		ND	

Sidney Brook PP+40 Data						
Client ID:	**STN 6**		**STN 7**		**STN 10**	
Matrix:	**Sediment**		**Sediment**		**Sediment**	
Semivolatiles - BNA (ppm)						
N-Nitrosodimethylamine	ND	0.043	ND	0.040	ND	0.041
Phenol	ND	0.043	ND	0.040	ND	0.041
Aniline	ND	0.043	ND	0.040	ND	0.041
Bis(2-chloroethyl) ether	ND	0.043	ND	0.040	ND	0.041
2-Chlorophenol	ND	0.043	ND	0.040	ND	0.041
1,3-Dichlorobenzene	ND	0.043	ND	0.040	ND	0.041
1,4-Dichlorobenzene	ND	0.043	ND	0.040	ND	0.041
Benzyl alcohol	ND	0.043	ND	0.040	ND	0.041
1,2-Dichlorobenzene	ND	0.043	ND	0.040	ND	0.041
2-Methylphenol	ND	0.043	ND	0.040	ND	0.041
Bis(2-chloroisopropyl) ether	ND	0.043	ND	0.040	ND	0.041
4-Methylphenol	ND	0.043	ND	0.040	ND	0.041
N-Nitrosodi-n-propylamine	ND	0.043	ND	0.040	ND	0.041
Hexachloroethane	ND	0.043	ND	0.040	ND	0.041
Nitrobenzene	ND	0.043	ND	0.040	ND	0.041
Isophorone	ND	0.043	ND	0.040	ND	0.041
2-Nitrophenol	ND	0.043	ND	0.040	ND	0.041
2,4-Dimethylphenol	ND	0.043	ND	0.040	ND	0.041
Bis(2-chloroethoxy) methane	ND	0.043	ND	0.040	ND	0.041
Benzoic acid	ND	0.043	ND	0.040	ND	0.041
2,4-Dichlorophenol	ND	0.043	ND	0.040	ND	0.041
1,2,4-Trichlorobenzene	ND	0.043	ND	0.040	ND	0.041
Naphthalene	ND	0.043	ND	0.040	ND	0.041
4-Chloroaniline	ND	0.043	ND	0.040	ND	0.041
Hexachlorobutadiene	ND	0.043	ND	0.040	ND	0.041
4-Chloro-3-methylphenol	ND	0.043	ND	0.040	ND	0.041
2-Methylnaphthalene	ND	0.043	ND	0.040	ND	0.041
Hexachlorocyclopentadiene	ND	0.043	ND	0.040	ND	0.041
2,4,6-Trichlorophenol	ND	0.043	ND	0.040	ND	0.041
2,4,5-Trichlorophenol	ND	0.043	ND	0.040	ND	0.041
2-Chloronaphthalene	ND	0.043	ND	0.040	ND	0.041
2-Nitroaniline	ND	0.043	ND	0.040	ND	0.041
Dimethyl phthalate	ND	0.043	ND	0.040	ND	0.041
2,6-Dinitrotoluene	ND	0.043	ND	0.040	ND	0.041
Acenaphthylene	ND	0.043	ND	0.040	ND	0.041
3-Nitroaniline	ND	0.043	ND	0.040	ND	0.041
Acenaphthene	ND	0.043	ND	0.040	ND	0.041
2,4-Dinitrophenol	ND	0.043	ND	0.040	ND	0.041
4-Nitrophenol	ND	0.043	ND	0.040	ND	0.041
2,4-Dinitrotoluene	ND	0.043	ND	0.040	ND	0.041
Dibenzofuran	ND	0.043	ND	0.040	ND	0.041
Diethyl phthalate	ND	0.043	ND	0.040	ND	0.041

Sidney Brook PP+40 Data						
Client ID:	STN 6		STN 7		STN 10	
Matrix:	Sediment		Sediment		Sediment	
Semivolatiles - BNA (ppm)						
Fluorene	ND	0.043	ND	0.040	ND	0.041
4-Chlorophenyl phenyl ether	ND	0.043	ND	0.040	ND	0.041
4-Nitroaniline	ND	0.043	ND	0.040	ND	0.041
4,6-Dinitro-2-methylphenol	ND	0.043	ND	0.040	ND	0.041
N-Nitrosodiphenylamine	ND	0.043	ND	0.040	ND	0.041
1,2-Diphenylhydrazine	ND	0.043	ND	0.040	ND	0.041
4-Bromophenyl phenyl ether	ND	0.043	ND	0.040	ND	0.041
Hexachlorobenzene	ND	0.043	ND	0.040	ND	0.041
Pentachlorophenol	ND	0.043	ND	0.040	ND	0.041
Phenanthrene	ND	0.043	ND	0.040	0.120	0.041
Anthracene	ND	0.043	ND	0.040	0.030	0.041
Carbazole	ND	0.043	ND	0.040	ND	0.041
Di-n-butyl phthalate	ND	0.043	ND	0.040	ND	0.041
Fluoranthene	ND	0.043	ND	0.040	0.182	0.041
Benzidine	ND	0.043	ND	0.040	ND	0.041
Pyrene	ND	0.043	ND	0.040	0.151	0.041
3,3'-Dimethylbenzidine	ND	0.043	ND	0.040	ND	0.041
Butyl benzyl phthalate	ND	0.043	ND	0.040	ND	0.041
3,3'-Dichlorobenzidine	ND	0.043	ND	0.040	ND	0.041
Benzo[a]anthracene	ND	0.043	ND	0.040	0.069	0.041
Chrysene	ND	0.043	ND	0.040	0.097	0.041
Bis(2-ethylhexyl) phthalate	ND	0.043	ND	0.040	ND	0.041
Di-n-octyl phthalate	ND	0.043	ND	0.040	ND	0.041
Benzo[b]fluoranthene	ND	0.043	ND	0.040	0.063	0.041
Benzo[k]fluoranthene	ND	0.043	ND	0.040	0.056	0.041
Benzo[a]pyrene	ND	0.043	ND	0.040	0.051	0.041
Indeno[1,2,3-cd]pyrene	ND	0.043	ND	0.040	ND	0.041
Dibenz[a,h]anthracene	ND	0.043	ND	0.040	ND	0.041
Benzo[g,h,i]perylene	ND	0.043	ND	0.040	ND	0.041
TOTAL BNA'S:	ND		ND		0.819	
TOTAL TIC's:	ND		ND		0.352	
TOTAL BNA'S & TIC's:	ND		ND		1.17	

Sidney Brook PP+40 Data						
Client ID:	**STN 6**		**STN 7**		**STN 10**	
Matrix:	**Sediment**		**Sediment**		**Sediment**	
PCB's (ppm)						
Aroclor-1016	ND	0.00215	ND	0.00204	ND	0.00205
Aroclor-1221	ND	0.00215	ND	0.00204	ND	0.00205
Aroclor-1232	ND	0.00215	ND	0.00204	ND	0.00205
Aroclor-1242	ND	0.00215	ND	0.00204	ND	0.00205
Aroclor-1248	ND	0.00215	ND	0.00204	ND	0.00205
Aroclor-1254	ND	0.00215	ND	0.00204	ND	0.00205
Aroclor-1260	ND	0.00215	ND	0.00204	ND	0.00205
Pesticides (ppm)						
alpha-BHC	ND	0.00043	ND	0.000408	ND	0.00041
beta-BHC	ND	0.00043	ND	0.000408	ND	0.00041
gamma-BHC (Lindane)	ND	0.00043	ND	0.000408	ND	0.00041
delta-BHC	ND	0.00043	ND	0.000408	ND	0.00041
Heptachlor	ND	0.00043	ND	0.000408	ND	0.00041
Aldrin	ND	0.00043	ND	0.000408	ND	0.00041
Heptachlor epoxide	ND	0.00043	ND	0.000408	ND	0.00041
Endosulfan I	ND	0.00043	ND	0.000408	ND	0.00041
4,4'-DDE	ND	0.00043	ND	0.000408	ND	0.00041
Dieldrin	ND	0.00043	ND	0.000408	ND	0.00041
Endrin	ND	0.00043	ND	0.000408	ND	0.00041
Endosulfan II	ND	0.00043	ND	0.000408	ND	0.00041
4,4'-DDD	ND	0.00043	ND	0.000408	ND	0.00041
Endrin aldehyde	ND	0.00043	ND	0.000408	ND	0.00041
Endosulfan sulfate	ND	0.00043	ND	0.000408	ND	0.00041
4,4'-DDT	ND	0.00043	ND	0.000408	ND	0.00041
Chlordane	ND	0.00538	ND	0.0051	ND	0.00513
Toxaphene	ND	0.00538	ND	0.0051	ND	0.00513
Metals (ppm)						
Antimony	ND	0.330	ND	0.310	ND	0.313
Arsenic	9.75	0.330	6.83	0.310	3.89	0.313
Beryllium	1.34	0.264	0.816	0.248	0.537	0.250
Cadmium	ND	0.165	ND	0.155	ND	0.156
Chromium	16.9	0.660	17.9	0.620	13.2	0.625
Copper	17.0	0.660	18.9	0.620	14.7	0.625
Lead	10.6	0.165	9.06	0.155	10.9	0.156
Mercury	0.022	0.00749	0.017	0.00705	0.015	0.00752
Nickel	25.2	0.660	16.5	0.620	13.5	0.625
Selenium	ND	1.32	1.24	1.24	ND	1.25
Silver	ND	0.165	ND	0.155	ND	0.156
Thallium	ND	0.165	ND	0.155	ND	0.156
Zinc	62.5	2.64	51.9	2.48	52.2	2.50
General Analytical						
Cyanide, Total	ND	0.915	ND	0.865	ND	0.865
pH/Corrosivity	6.73	NA	7.08	NA	6.99	NA
Total Recoverable Phenols	ND	0.458	ND	0.433	ND	0.433
Total Organic Carbons (TOC)	4150	500	4370	500	4650	500

Sidney Brook PP+40 Data						
Client ID:	**STN 6**		**STN 7**		**STN 10**	
Matrix:	**Sediment**		**Sediment**		**Sediment**	
Particle Size %						
% GRAVEL	52.92	NA	71.97	NA	61.97	NA
% COARSE SAND	26.93	NA	15.4	NA	17.68	NA
% MEDIUM SAND	19.58	NA	9.2	NA	17.17	NA
% FINE SAND	0.43	NA	3.27	NA	2.86	NA
% SILT & CLAY	0.1	NA	0.12	NA	0.26	NA
Particle Size %						
on 3/8" screen	22.25	NA	47.44	NA	32.39	NA
on #4 screen	30.67	NA	24.53	NA	29.58	NA
on #10 screen	26.93	NA	15.4	NA	17.68	NA
on #40 screen	19.58	NA	9.2	NA	17.17	NA
on #200 screen	0.43	NA	3.27	NA	2.86	NA
% fines	0.1	NA	0.12	NA	0.26	NA

Appendix IV
Candidate Restoration Sites

Project Name: Finn Park Stormwater Improvements Rank: 1 Priority: High Map ID: 5	**Location/Ownership**: Perryville Road, Block 26 Lot 12

1. Identified Concerns

- Little effective stormwater management at site with poor quality and rate control
- Frequent flooding downstream at Perryville Road
- Potential source of various nutrients related to fertilizer applications and soil erosion

2. Mitigation Solutions

- Increase mowing height and reduce mowing frequency on non-playing surfaces
- Eliminate mowing of existing drainage swales
- 11 specific stormwater management recommendations (see map):
    1. Construct a bioretention basin for drainage area B
    2. Upsize existing 15” pipe with 24” pipe at Perryville Road drainage swale
    3. Convert existing swale for drainage area C to a vegetated swale
    4. Construct a bioretention cell for drainage area D
    5. Construct a sand filter or vegetated swale for drainage area 5
    6. Install a low berm around the lot to retain water and discharge through a small weir over amended soils
    7. Install a multi-chambered MTD at the southern entrance
    8. Install a bioretention feature at the small parking lot; this should discharge to a vegetated wet swale (9)
    9. Install a wet swale for drainage area F
    10. Install a series of catch basins along eastern end of the entrance drive off Finn Road
    11. Maintain roadside drainage swale along Finn Road near drainage swale

3. Benefits

- Maintaining longer grass on non-playing surfaces reduces generation of stormwater, reduces velocity, increases infiltration and evapotranspiration, limits erosion, and reduces maintenance
- 11 specific stormwater management recommendations benefits
    1. Reduction of stormwater volume and treatment for nutrients and solids
    2. Improves drainage to reduce flooding
    3. Vegetated swale will reduce stormwater velocity and improve solids removal
    4. Bioretention cell will decrease stormwater discharge rate from the parking lot
    5. Sand filter will reduce stormwater volume and soil loss as well as remove NPS pollutants
    6. The berm will direct stormwater runoff to a vegetated area to increase infiltration
    7. MTD will be sited to capture gravel from the driveway
    8. The berm directs stormwater to the wet swale
    9. The wet swale will reduce stormwater volume through infiltration, reduce velocity, and remove solids and nutrients
    10. The series of catch basins will again serve to manage road grit developed by the driveway and parking lots

<table>
<tr><td colspan="2">11. Swale maintenance or reconfiguration will improve drainage and decrease potential for flooding</td></tr>
<tr><td colspan="2">4. Implementation Concerns
• Few concerns at this site other than total scale of recommended projects</td></tr>
<tr><td>5. Task Description
• Construct bioretention basin
• Replace 15” pipe
• Conversion to vegetated swale
• Construct bioretention cell
• Construct a vegetated swale
• Install a low berm around parking lot with small weir and amended soils
• Install an MTD
• Construct a bioretention feature
• Install a wet swale
• Install a series of catch basins
• Swale maintenance</td><td>Projected Costs
• $60,000
• $5,000
• $15,000
• $30,000
• $15,000
• $40,000
• $75,000
• $10,000
• $15,000
• $20,000
• $5,000</td></tr>
</table>

<table>
<tr><td>Project Name: Sanctuary Stormwater Pond Modification
Rank: Tied-2 Priority: High Map ID: 4</td><td>Location/Ownership: Perryville Road, Block 27 Lot 12, potential drainage easement</td></tr>
<tr><td colspan="2">1. Identified Concerns
Sediment loading to the pond caused by erosion and poor stormwater management practices upstream
Downstream of the pond major erosion caused by inadequate detention and poor channel geometry
Flooding frequent downstream</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
The best option would be a reconfiguration of the basin to an infiltration design or a bioretention design or secondarily to a detention design
The spillway, if the basin remains in the current configuration, must be reworked to discharge into the channel at a reduced angle to decrease erosive forces
Secondly, the apron must incorporate a higher degree of roughness and flow dissipating features to decrease discharge velocity</td></tr>
<tr><td colspan="2">3. Benefits
Conversion to an infiltration system has two primary benefits: first, the vast majority of all water up to the design-storm, likely a one-year event, would be infiltrated into groundwater, greatly decreasing stormflow and increasing baseflow; second, these systems maintain as high or higher pollutant and nutrient removal capacity
Reduced discharge from the basin will lead to significantly reduced erosion and flooding downstream as well as decreased solids loads
A secondary benefit of this design is reduced stream temperature because heated impounded water will rarely be discharged and most water will leave the system as cool groundwater</td></tr>
<tr><td colspan="2">4. Implementation Concerns
Access to this site may be problematic, although a drainage easement may exist.</td></tr>
<tr><td>5. Task Description
Conversion to a bioretention system
Outlet reconfiguration</td><td>Projected Costs
$90,000
$15,000</td></tr>
</table>

<table>
<tr><td>Project Name: Union Township Public Works Yard Maintenance
Rank: Tied-2 Priority: High Map ID: 10</td><td>Location/Ownership: Main Street, Block 21 Lot 19</td></tr>
<tr><td colspan="2">1. Identified Concerns
Yard discharges directly to the stream which may be a vector for salts, petroleum products, and solids
Lack of buffer and vegetation is contributing to stream incision
Localized accumulations of debris in the channel and downstream (out of picture) a small diameter PVC pipe discharges to the stream</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
Cultural BMPs should be implemented at the yard to limit delivery of various pollutants; practices should focus on materials handling in particular and the possible installation of a containment pad for handling gasoline or other chemicals
The source of the PVC pipe downstream should be investigated and disconnected if necessary, particularly if related to the handling of wastewater
Channel clearing should conducted to remove all non-natural obstructions</td></tr>
<tr><td colspan="2">3. Benefits
Cultural BMPs will limit the discharge of toxic materials that negatively impact aquatic biota
Removal of debris in the channel will improve flow, reduce temperatures, and minimize flooding potential
Illicit discharges can be a major source of pollutant loading or E. coli to stream systems as gray water is frequently discharged in a similar manner</td></tr>
<tr><td colspan="2">4. Implementation Concerns
This is an ideal site and involves mostly instituting cultural practices.</td></tr>
<tr><td>5. Task Description
Channel clearing of debris
PVC pipe investigation</td><td>Projected Costs
$5,000
$5,000</td></tr>
</table>

<table>
<tr><td>Project Name: Main Street Obstruction Removal and Bank Stabilization
Rank: Tied-2 Priority: High Map ID: 11</td><td>Location/Ownership: Main Street, Block 21 Lot 19</td></tr>
<tr><td colspan="2">1. Identified Concerns
• Incised stream banks through area exacerbated by lack of riparian vegetation
• Old concrete dam causes flooding in the area
• The dam also acts as a barrier to fish passage and contributes to stream warming through unnecessary impoundment of the creek</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
• Dam removal
• Installation of a grade control device, likely a cross vane or engineered rock riffle to connect the stream beds across the hydraulic jump
• Implementation of a no-mow zone at a minimum or bank plantings to stabilize the reach</td></tr>
<tr><td colspan="2">3. Benefits
• Removal of the dam will result in improved hydraulics in the area with a greatly reduced chance of localized flooding
• Improved hydraulics will lead to increased oxygenation of the reach with turbulent flow and decreased temperature both benefitting macroinvertebrate utilization of the reach
• Allows for unimpeded fish passage
• The use of either grade control will create favorable habitat for aquatic biota
• Bank planting will increase bank stability and shading</td></tr>
<tr><td colspan="2">4. Implementation Concerns
• This is an ideal site for dam removal.</td></tr>
<tr><td>5. Task Description
• Dam removal
• Grade control installation</td><td>Projected Costs
• $25,000
• $25,000</td></tr>
</table>

Project Name: Sodres Farm Stormwater Management and Bank Stabilization Rank: Tied-2 Priority: High Map ID: 15	**Location/Ownership**: Block 25 Lot 37, private ownership

1. Identified Concerns

- Extreme erosion and bank incision
- *E. coli* loading to the stream from livestock and waterfowl
- NPS loading from agricultural fields
- Excessive erosion caused by poor riparian buffer in adjacent lands and excessive runoff from Cooks Cross Road upstream

2. Mitigation Solutions

- Bank stabilization including bank grading followed by riparian planting
- Installation of vegetated filter strips parallel to contours and grassed waterways perpendicular to grade
- Improved stormwater management of roadways upstream
- Agricultural BMPs such as nutrient and manure management

3. Benefits

- Bank stabilization efforts, particularly riparian planting, will limit further erosion on the stream and the continued loss of viable agricultural lands as well as provide shading to limit stream warming
- Vegetated filter strips and swales will decrease sheet flow velocity and reduce erosive forces on the stream
- Filter strips may reduce *E. coli* loading in the catchment by 50-70% and further increase efficacy by dissuading use of waterways by waterfowl
- Manure management techniques, including temporary storage and good handling practices, may reduce loading by up to 99%

4. Implementation Concerns

- Landowner participation and access is likely an issue at this site.

5. Task Description	Projected Costs
• Bank stabilization (1000 ft)	• $50,000
• Vegetated filter strip installation	• $30,000
• Stormwater BMP maintenance	• $10,000

<table>
<tr><td>Project Name: Race Street Tributary Restoration
Rank: 3 Priority: High Map ID: 12</td><td>Location/Ownership: Race Street, Block 25 Lot 2</td></tr>
<tr><td colspan="2">1. Identified Concerns
• Stream channel is completely degraded
• Extreme erosion, mass wasting, movement of very large particles
• Oxbow formation where stream is changing pattern and moving
• Culvert under is Race Street is severely scoured</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
• Control must be initiated upstream to limit the source generation of stormwater and better control structures to reduce velocity
• Many sections will need drastic reworking, but work will also be limited by steep grades and forested sections
• At risk infrastructure, such as the culvert, will need to be armored using gabions
• Grade control structures will be needed to limit headcut migration and to orient primary flow vectors in the center of the channel</td></tr>
<tr><td colspan="2">3. Benefits
• The main goal for work in this section will be to simply maintain the stream in the same course
• Bank stability will be aided through the use of hard armoring to absorb hydraulic impacts
• Armoring will reduce the generation of solids which are transported to Jutland Lake
• Infrastructure will be maintained</td></tr>
<tr><td colspan="2">4. Implementation Concerns
• The severity of the degradation, presence of trees, and steep slopes will make this a difficult implementation</td></tr>
<tr><td>5. Task Description
• Bank stabilization (2000 ft)
• Gabion installation
• Grade control installation</td><td>Projected Costs
• $100,000
• $30,000
• $50,000</td></tr>
</table>

Project Name: High View Court Bank Stabilization Rank: Tied-4 Priority: Medium Map ID: 3	**Location/Ownership**: Cooks Cross Road near High View Court, Block 27 Lot 3.02, potential drainage easement

1. Identified Concerns
- Major bank instability characterized by sloughing and mass wasting
- Sediment deposition
- Lack of riparian vegetation
- Eight stormsewer outfalls in the vicinity

2. Mitigation Solutions
- The major effort should focus first on the restoration of the stream banks
- Planting with shrubs and trees will be needed to stabilize the banks probably after grading; rip-rap and toe protection likely needed at certain locations
- If possible a regional bioretention basin should be created to receive and detain stormwater from the various basins prior to discharge to the stream
- If a bioretention basin is not feasible stormwater should be routed via vegetated swales of either dry or wet design

3. Benefits
- The primary goal of efforts in this area is to stabilize banks using to the greatest extent possible native vegetation and secondarily resorting to armoring techniques
- Bioretention basin would significantly reduce runoff velocity decreasing erosion and also providing solids capture and nutrient removal as an added benefit
- Bank stability will significantly decrease solids mobilization within the channel
- Increase plant density will limit stream warming within this reach

4. Implementation Concerns
- Siting a regional bioretention basin may be difficult and grading banks in residential lawns may prove unpopular.

5. Task Description	**Projected Costs**
• Bank stabilization (1000 ft)	• $50,000
• Limited toe protection installations	• $40,000
• Bioretention basin/vegetated swale installation	• $80,000

<table>
<tr><td>Project Name: Union Township Elementary School Stormwater Improvements
Rank: Tied-4 Priority: Medium Map ID: 8</td><td>Location/Ownership: Union Township Elementary School, Block 21 Lot 1</td></tr>
<tr><td colspan="2">1. Identified Concerns
Insufficient drainage and drainage treatment throughout campus
Basin discharge to sensitive wetlands</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
A variety of solutions can be employed at this site
All swales should be converted to vegetated swales to limit the formation of rills; at a minimum this may simply require no-mow zones
The corner of the parking lot would be an ideal location to install a rain garden
The basin should be converted to a bioretention system through the addition of plants to accelerate the natural processes of wetland species colonization</td></tr>
<tr><td colspan="2">3. Benefits
These solutions will provide increased treatment of stormwater, including solids removal in excess of 80%
Stormwater volume will be decreased in part through evapotranspiration
Plantings will stabilize the features and produce less erosion
Rain gardens and bioretention systems also have an educational benefit and can be used as a demonstration project for both the students and the community</td></tr>
<tr><td colspan="2">4. Implementation Concerns
An ideal site for relatively low intensity solutions.</td></tr>
<tr><td>5. Task Description
Conversion to vegetated swales
Rain garden installation
Conversion to bioretention basin</td><td>Projected Costs
$10,000
$10,000
$30,000</td></tr>
</table>

<table>
<tr><td>Project Name: Wood Hollow Road Detention Basin Upgrade
Rank: Tied-4 Priority: Medium Map ID: 14</td><td>Location/Ownership: Cooks Cross Road, Block 30 Lot 1.02, potential drainage easement</td></tr>
<tr><td colspan="2">1. Identified Concerns
Insufficient detention
Downstream flooding and erosion of roadside swale and adjacent properties
Older style basin with low-flow channel and inadequate treatment of first-flush</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
Modify basin by adding plantings and removing low-flow channel
Modify orifice to increase retention period
Reconfigure outlet swale
Regrade roadside swale</td></tr>
<tr><td colspan="2">3. Benefits
Increased retention period will yield improved capture of solids and phosphorus
Increased retention will also decrease discharge velocities and minimize erosion and flooding downstream
Vegetative component will increase NPS removal efficacy, limit maintenance, and decrease total volume through evapotranspiration and maintain lower temperatures in the basin
Regrading the roadside swale will limit generation of eroded solids in the swale and provide better channel geometry to improve conveyance</td></tr>
<tr><td colspan="2">4. Implementation Concerns
A relatively straightforward implementation project.</td></tr>
<tr><td>5. Task Description
Basin retrofits
Swale modifications</td><td>Projected Costs
$25,000
$20,000</td></tr>
</table>

Project Name: Wolf Farm Basin Maintenance and Buffer Restoration Rank: Tied-5 Priority: Medium Map ID: 9	**Location/Ownership**: Stonebridge Road, Block 21 Lot 29.12

1. Identified Concerns

- Lack of outfall maintenance manifested in erosion, sedimentation, and invasive species colonization
- Basin is showing high level of sedimentation
- Lack of any buffer upstream is leading to channel incision, solids mobilization, and direct sunlight on the stream contributing to warming

2. Mitigation Solutions

- Riparian bank plantings should be used to increase bank stability and shading
- Basin should be dredged to maintain solids capture efficacy

3. Benefits

- The addition of bank plantings will be extremely beneficial in limiting further erosion in this reach as well as reducing flood velocity as well as the uptake of nutrients and the filtering of solids
- Riparian vegetation will also limit warming in this section by providing shade
- The dredging of the basin is a required periodic maintenance item that needs to be conducted to maintain high solids capture rate near 80%; the in-filling and establishment of cattails is evidence of high solids capture efficiency, but also of lax maintenance

4. Implementation Concerns

- A relatively straightforward implementation project although permitting for BMP maintenance may be complicated by its advanced state of infilling.

5. Task Description	Projected Costs
• Riparian plantings	• $15,000
• Basin maintenance	• $20,000

Project Name: Midvale Road Development Stormwater Management Rank: Tied-5 Priority: Medium Map ID: 13	**Location/Ownership**: Race Street, Block 22.02

1. Identified Concerns

- Excessive stormwater generation
- Source of generation is varied but includes large amount of impervious surface from roads, roofs, driveways, and compacted lawn as well as steep slopes
- Inadequate stormwater infrastructure
- Detention basin is probably by-passed by much of the runoff
- Extreme channel erosion downstream
- NPS generation from fertilizers, pets, and other sources

2. Mitigation Solutions

- The basin must be reconfigured to remove the low flow channel, increase detention, or switch to an infiltration design to drastically reduce volume
- All homes should install dry wells or rain barrels to limit roof runoff
- Cultural BMPs, such as limiting irrigation, need to be implemented community wide
- Grass needs to be maintained at longer lengths to curb volume
- Vegetated filter strips should be installed to reduce sheet flow velocity and reduce pollutant loads
- Pervious pavement should be considered for driveways

3. Benefits

- The benefits will largely be realized downstream
- Bank stability will increase if runoff is significantly reduced
- Vegetated filter strips will minimize *E. coli* loading from pet waste and capture fertilizers and other solids
- Stream pattern can be maintained without major channel migration

4. Implementation Concerns

- A relatively straightforward implementation project although the modification of basin aesthetics may be problematic to surround homeowners

5. Task Description	**Projected Costs**
• Basin retrofits	• $25,000
• Rain barrel installation	• $300 per home
• Vegetated filter strip installation	• $30,000
• Pervious pavement installation	• $10 per square foot

Project Name: Race Street Flooding Alleviation Rank: Tied-5 Priority: Medium Map ID: 18	**Location/Ownership**: Race Street, Block 25 Lot 11

1. Identified Concerns
- Frequent flooding of roadway
- Formation of transverse gravel bars in mid-channel and other sedimentation
- Reduced buffer quality
- Minor erosion

2. Mitigation Solutions
- Limited channel cleaning to remove excessive accumulations of solids
- Riparian buffer planting to increase bank stability
- Roadway or bridge modification to promote drainage in floodway

3. Benefits
- Channel cleaning to remove accumulated gravel bars and other fine sediments that impede flow; avoid channel widening or deepening of the original channel to maintain floodplain connectivity
- Limited riparian plantings will stabilize the banks and provide shading; because this area is publically accessible for angling channel access must be maintained
- Bridge or roadway modification should raise bridge or install culverts on the floodplain to promote flow across floodplain and alleviate temporary impoundment behind the bridge; maintaining floodplain access will limit erosion in the channel

4. Implementation Concerns
- While identified above, major modification of the roadway is unlikely and the other offered solutions are more realistic

5. Task Description	**Projected Costs**
• Channel cleaning	• $25,000
• Riparian bank plantings	• $5,000


TOP LN

<table>
<tr><td>Project Name: Rt. 513 Public Access Improvements
Rank: Tied-5 Priority: Medium Map ID: 19</td><td>Location/Ownership: Race Street, Franklin Township, Block 3 Lot 1</td></tr>
<tr><td colspan="2">1. Identified Concerns
Unimproved access and facilities
Invasive species colonization</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
Invasive species removal followed by replacement with native vegetation
Access and use improvements including trail maintenance and provision of garbage cans</td></tr>
<tr><td colspan="2">3. Benefits
As one of the few publically accessible areas on the stream improvements to access would increase utilization consistent with use designations
Removal of invasive vegetation will improve access and enhanced native vegetation will provide shoreline stability and improved habitat quality</td></tr>
<tr><td colspan="2">4. Implementation Concerns
No concerns for this site.</td></tr>
<tr><td>5. Task Description
Invasive species removal
Riparian bank plantings
Site improvements</td><td>Projected Costs
$12,000
$8,000
$1,000</td></tr>
</table>

Project Name: Cooks Cross Road Runoff Management Rank: Tied-6 Priority: Low Map ID: 1	**Location/Ownership**: Cooks Cross Road near Woods Road, Block 28 Lot 25, potential drainage easement

1. Identified Concerns

- Excessive stormwater velocity causing bank incision and sedimentation
- Downstream ponds affected by extreme turbidity during storm events

2. Mitigation Solutions

- Regrade and modify road drainage swales and inlets
- Installation of a large MTD to capture road grit and eroded material from swales
- Construct a bioretention basin at the toe of slope to slow velocity and capture solids
- Consider linking these solutions
- Regular maintenance of the roadside drainage features and any constructed BMP is required

3. Benefits

- While the catchment at this location is small, less than 3.5 acres, steep slopes in this area exacerbate erosion and swales serve as the major loaders of solids
- Total anticipated solids load in this catchment combining road grit and eroded channel materials is approximately 15,000 lbs annually
- At 80% removal provided by either an MTD or bioretention basin, or in series, up to 12,000 lbs of solids could be captured
- Efficacy of the system would only be maintained under regular maintenance

4. Implementation Concerns

- Placing a bioretention facility may be difficult at this site. Efficacy of an MTD in this area would depend heavily on routine maintenance. Overall high costs and large footprint are concerns.

5. Task Description	Projected Costs
MTD installation	$100,000
Bioretention basin construction	$50,000
Modification of swales	$25,000

<table>
<tr><td>Project Name: Kenneth Place Detention Basin Outlet Repair
Rank: Tied-6 Priority: Low Map ID: 7</td><td>Location/Ownership: Kenneth Place, Block 28 Lot 13</td></tr>
<tr><td colspan="2">1. Identified Concerns
Outfall from detention basin is causing significant erosion in the channel through a tussock sedge wetland
Mowing encroaches on this wetland which may be potential habitat for T&E species</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
Repair outlet erosion by extending apron and laying rip-rap or convert to a vegetated swale
Channel should be slightly raised to allow the water to flood the wetland
Basin may be retrofitted to lower stage and provide more detention and increase detention period by resizing orifice
Provide a no-mow zone adjacent to the wetland</td></tr>
<tr><td colspan="2">3. Benefits
Modifying or retrofitting the outlet structure will decrease discharge velocity and limit erosion
Stabilizing the channel preferably through planting will limit erosion and provide roughness to further reduce velocity and limit deposition of sediment in the wetland
More regular flooding of the wetland will provide more natural hydrology
No-mow buffer will protect the wetland edge and provide a degree of water treatment</td></tr>
<tr><td colspan="2">4. Implementation Concerns
Permitting may be difficult because of the wetlands and potential T&E species issues.</td></tr>
<tr><td>5. Task Description
Rip-rap installation/conversion to vegetated swale
Basin retrofits</td><td>Projected Costs
$20,000
$15,000</td></tr>
</table>

Project Name: Peaceful Valley Orchards Agricultural BMPs Rank: Tied-6 Priority: Low Map ID: 16	**Location/Ownership**: Block 25 Lot 35, private ownership

1. Identified Concerns

- General soil erosion in agricultural lands
- Streambank erosion
- NPS loading from agricultural fields
- Excessive turbidity of farm pond
- Outfall from road runoff is conveyed across agricultural lands and farm access lane

2. Mitigation Solutions

- Utilize vegetated swales to convey runoff
- Improve buffers on existing drainage features
- Install an improved agricultural stream crossing on the intermittent channel
- Continued use of agricultural BMPs such as residue management on fields

3. Benefits

- The use of vegetated swales captures many different pollutants, including nutrients, solids, and bacteria, and will limit erosion in the swale itself and points downstream
- Improving buffer width on existing drainage features will further add channel stability and limit the quantity of NPS pollutants discharged to the channel
- Adding an improved agricultural crossing on the access lane will significantly decrease localized erosion of the lane and limit solids loading to the swale
- Agricultural BMPs such as residue management, maintaining at least 30% ground coverage with crop residue, can decreased erosion of topsoil by up to 90% significantly reducing solids loading to the creek and maintaining organic rich soils in fields thus maintaining crop yields and decreasing the need for chemical fertilizers

4. Implementation Concerns

- Landowner buy-in is the primary concern at this site although certain agricultural BMPs are already in use

5. Task Description	Projected Costs
Vegetated swale installation	$40,000
Buffer improvements	$10,000
Construct improved agricultural crossing	$10,000

Project Name: Bank Stabilization upstream of Race Street near Hilltop Lane Rank: Tied-7 Priority: Low Map ID: 17	**Location/Ownership**: Race Street and Hilltop Lane, Block 25 Lot 11

1. Identified Concerns

- Significant bank erosion downstream of culvert under train tracks
- Formation of transverse gravel bars in mid-channel and other sedimentation
- High turbidity during stormflows indicative of TSS loading
- Some scour noted around culvert

2. Mitigation Solutions

- Limited channel cleaning to remove excessive accumulations of solids
- Classic location for installation of flow deflection devices, such as J-hooks, to minimize erosive forces on the stream bank
- Augment existing woody vegetation on stream banks with shrubs
- Inspection of infrastructure

3. Benefits

- Flow deflection devices will decrease erosive forces on outer bends and limit deposition of solids causing flooding downstream
- J-hooks also realign thalwegs to maintain flow in mid-channel, limit bar formation, and create fishery habitat
- Improved vegetation community will increase bank stability and provide shading
- Channel cleaning will remove accumulated materials, align flow in the center of the channel to prevent channel meander, provide better flow, and be less prone to flooding

4. Implementation Concerns

- Access through the forest and onto the land is a concern.

5. Task Description	**Projected Costs**
Solids removal	$20,000
Flow deflection structure installation	$60,000
Bank stabilization and riparian enhancement	$20,000

Project Name: Sidney Road Bank Stabilization Rank: Tied-7 Priority: Low Map ID: 20	**Location/Ownership**: Sidney Road, Block 200 Lot 2.X
1. Identified Concerns • Minor buffer encroachment and fine solids accumulation • Limited erosion around bridge	
2. Mitigation Solutions • No-mow zone instituted on south bank with some plantings • Possible armoring with rip-rap or gabions near bridge	
3. Benefits • Improved bank stability by plantings to limit erosion and reduce solids • Decreased thermal impact • Decreased erosion around bridge to protect infrastructure	
4. Implementation Concerns • Landowner buy-in a concern.	
5. Task Description • Plantings • Gabion installation	**Projected Costs** • $2,000 • $60,000

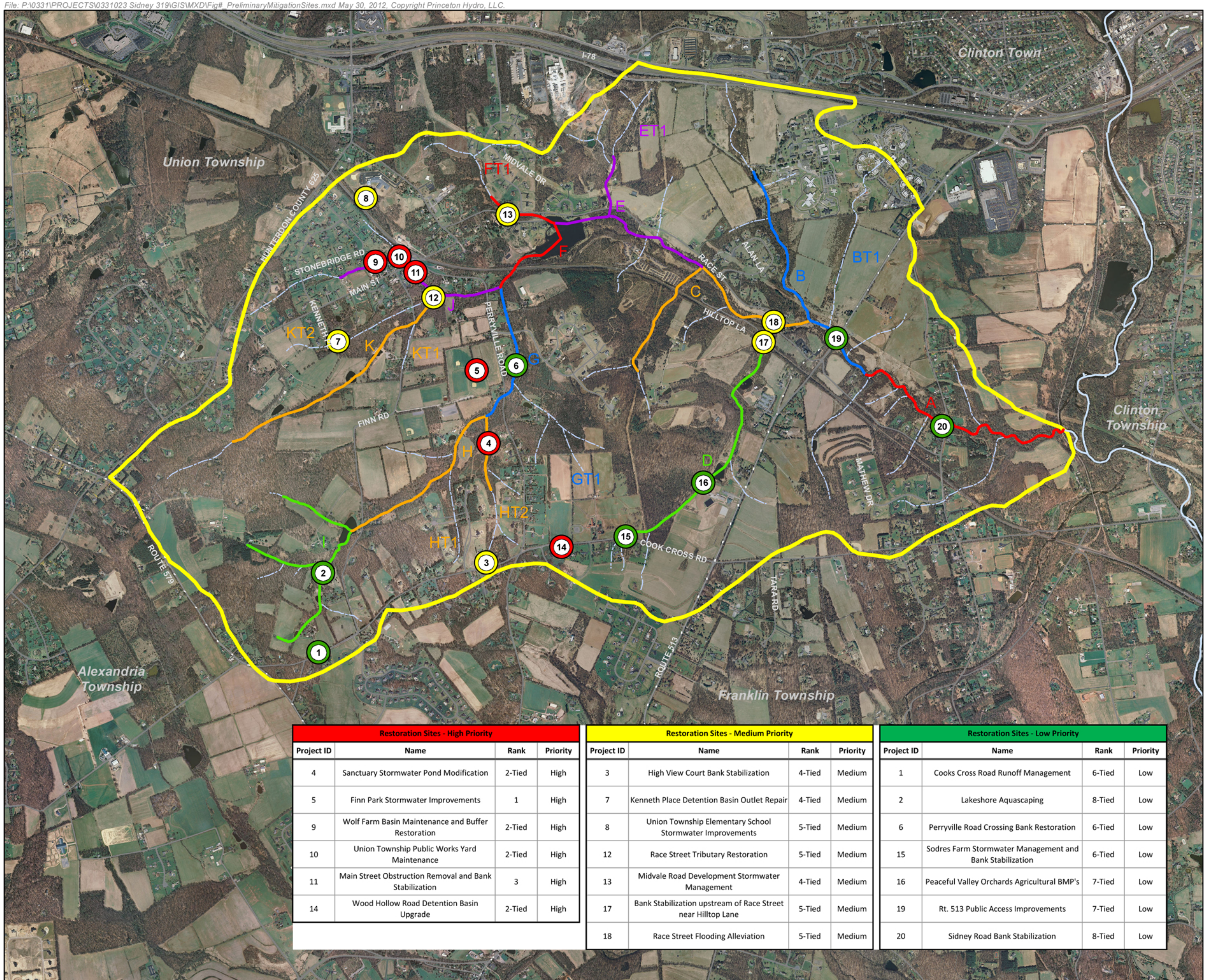
<table>
<tr><td>Project Name: Lakeshore Aquascaping

Rank: Tied-8 Priority: Low Map ID: 2</td><td>Location/Ownership: A general measure for ponds and lakes throughout the watershed, including Jutland Lake and the four identified ponds on reach I</td></tr>
<tr><td colspan="2">1. Identified Concerns
Bank instability
Unmitigated delivery of solids and nutrients in runoff
Increased temperatures including discharged waters to stream
Waterfowl access and pollutant loading</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
At a minimum establish a narrow no-mow zone around all lakeshores to limit goose access and provide filtration
Where acceptable establish multi-tiered planting or aquascaping plan including shallow emergents, herbaceous plants, and shrubs
Creative solutions can be used to maintain access and view including zig-zag paths through the plantings</td></tr>
<tr><td colspan="2">3. Benefits
The establishment of plants will foremost serve to mechanically filter runoff capturing much of the solids load as well as nutrients that contribute to infilling and algae blooms thereby reducing these issues with TP removal rates from runoff as high as 30%
Limits access for waterfowl such as geese; each goose kept off the lake decreases TP loading up to 0.5 lbs per year
In a lake setting planting may have a limited effect on decreasing temperatures, but still contributes positively
Increased value as wildlife habitat, especially important for species that rely on shrub or marsh habitats, such as Red-Winged Blackbird or Willow Flycatcher</td></tr>
<tr><td colspan="2">4. Implementation Concerns
Landowner buy-in a concern. While this is a low-rated project, it is also very easily implemented at minimum cost and thus should receive higher attention</td></tr>
<tr><td>5. Task Description
Shoreline aquascaping</td><td>Projected Costs
$2,000 to $20,000</td></tr>
</table>

<table>
<tr><td>Project Name: Perryville Road Crossing Bank Restoration
Rank: Tied-8 Priority: Low Map ID: 6</td><td>Location/Ownership: Perryville Road, Block 25 Lot 31</td></tr>
<tr><td colspan="2">1. Identified Concerns
Stream is incising near the road crossing
Lack of riparian vegetation upstream exacerbates problem</td></tr>
<tr><td colspan="2">2. Mitigation Solutions
Bank stabilization activities beginning with invasive vegetation removal followed by riparian planting
To minimize impacts to the adjacent forest grading activities and other disturbances should be limited
Bends should receive toe protection in the form of root wads or boulder toe
Upstream portions should focus on improving existing woody vegetation with the addition of woody shrubs</td></tr>
<tr><td colspan="2">3. Benefits
Initiating a planting plan focused on willows, dogwoods, and similar species will provide additional stability in this reach and limit in-channel erosion
Increased roughness along banks and in floodplain will reduce flood velocity further decreasing erosion
Vegetation community will be improved by the removal of invasive and replacement of natives providing increased shading, higher nutrient removal capacity, and better habitat value
Forested buffers are capable of providing up to 70% removal of solids in stormwater</td></tr>
<tr><td colspan="2">4. Implementation Concerns
Landowner buy-in a concern as well as the sensitivity of adjacent forest and wetland.</td></tr>
<tr><td>5. Task Description
Invasive vegetation removal and replanting
Toe protection installation</td><td>Projected Costs
$15,000
$25,000</td></tr>
</table>

Ranking Matrix									
Project Name	**Severity**	**Extent**	**Temporal Risk**	**Source Identification**	**Accessibility/ Land Use Setting**	**Benefit and Cost**	**Sum**	**Rank**	**Priority**
Finn Park Stormwater Improvements	2	3	2	3	3	3	16	1	High
Sanctuary Stormwater Pond	3	2	2	3	2	2	14	2-Tied	High
Union Township Public Works Yard Maintenance	2	1	2	3	3	3	14	2-Tied	High
Main Street Obstruction Removal and Bank Stabilization	2	1	2	3	3	3	14	2-Tied	High
Sodres Farm Stormwater Management and Bank Stabilization	3	3	3	2	1	2	14	2-Tied	High
Race Street Tributary Restoration	3	3	3	2	1	1	13	3	High
High View Court Bank Stabilization	2	2	2	2	2	2	12	4-Tied	Medium
Union Township Elementary School Stormwater Improvements	1	1	1	3	3	3	12	4-Tied	Medium
Wood Hollow Road Detention Basin Upgrade	2	2	2	2	2	2	12	4-Tied	Medium
Wolf Farm Basin Maintenance and Buffer Restoration	1	2	1	3	1	3	11	5-Tied	Medium
Midvale Road Development Stormwater Management	1	2	1	2	3	2	11	5-Tied	Medium
Race Street Flooding Alleviation	2	2	2	1	2	2	11	5-Tied	Medium
Rt. 513 Public Access	1	1	1	2	3	3	11	5-Tied	Medium
Cooks Cross Road Runoff	2	1	1	2	2	2	10	6-Tied	Low
Kenneth Place Detention Basin Outlet Repair	2	1	1	3	1	2	10	6-Tied	Low
Peaceful Valley Orchards Agricultural BMP's	1	2	1	1	2	3	10	6-Tied	Low
Bank Stabilization upstream of Race Street near Hilltop Lane	2	2	2	1	1	1	9	7-Tied	Low
Sidney Road Bank Stabilization	1	1	1	2	1	3	9	7-Tied	Low
Lakeshore Aquascaping	1	1	1	2	2	1	8	8-Tied	Low
Perryville Road Crossing Bank Restoration	2	2	1	1	1	1	8	8-Tied	Low

File: P:\0331\PROJECTS\0331023 Sidney 319\GIS\MXD\Fig#_PreliminaryMitigationSites.mxd May 30, 2012, Copyright Princeton Hydro, LLC.



Restoration Sites - High Priority

Project ID	Name	Rank	Priority
4	Sanctuary Stormwater Pond Modification	2-Tied	High
5	Finn Park Stormwater Improvements	1	High
9	Wolf Farm Basin Maintenance and Buffer Restoration	2-Tied	High
10	Union Township Public Works Yard Maintenance	2-Tied	High
11	Main Street Obstruction Removal and Bank Stabilization	3	High
14	Wood Hollow Road Detention Basin Upgrade	2-Tied	High

Restoration Sites - Medium Priority

Project ID	Name	Rank	Priority
3	High View Court Bank Stabilization	4-Tied	Medium
7	Kenneth Place Detention Basin Outlet Repair	4-Tied	Medium
8	Union Township Elementary School Stormwater Improvements	5-Tied	Medium
12	Race Street Tributary Restoration	5-Tied	Medium
13	Midvale Road Development Stormwater Management	4-Tied	Medium
17	Bank Stabilization upstream of Race Street near Hilltop Lane	5-Tied	Medium
18	Race Street Flooding Alleviation	5-Tied	Medium

Restoration Sites - Low Priority

Project ID	Name	Rank	Priority
1	Cooks Cross Road Runoff Management	6-Tied	Low
2	Lakeshore Aquascaping	8-Tied	Low
6	Perryville Road Crossing Bank Restoration	6-Tied	Low
15	Sodres Farm Stormwater Management and Bank Stabilization	6-Tied	Low
16	Peaceful Valley Orchards Agricultural BMP's	7-Tied	Low
19	Rt. 513 Public Access Improvements	7-Tied	Low
20	Sidney Road Bank Stabilization	8-Tied	Low

Princeton Hydro

NEW JERSEY COUNTY MAP

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

Feet
0 1,000 2,000
1 inch = 2,000 feet

SOURCES:

1. Streams as obtained from the NJDEP GIS website.
2. SCS streams heads-up digitzed from the Hunterdon County Soils Conservation Service handbook.
3. Roads obtained from NJDOT website.
4. 2007 aerial photographs obtained from NJGIN Information Warehouse.
5. Preliminary mitigation sites determined by Princeton Hydro, LLC through a visual assessment in March of 2008.

CANDIDATE RESTORATION SITES

SIDNEY BROOK PROTECTION PLAN
UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

Legend

- Roads
- SCS Streams
- Streams
- Study Area

Restoration Site Location & Priority Status

- High Priority
- Medium Priority
- Low Priority

Stream Segments

- A, F
- B, G
- C, H, K
- D, I
- E, J

Appendix V
New Jersey Water Supply Authority
Supporting Tasks and Restoration Sites

Appendix A
Road Crossing Protocol
and
Inventory

Road Crossing Protocol
NJ Water Supply Authority
March 2007

Notes:
- NJWSA is currently serving as data repository for all data collected through this effort.
- Please coordinate with NJWSA prior to starting an inventory to avoid duplication of effort.
- NJWSA will generate Steps 1 through 3 for any user.

1. **Overlay the following GIS layers**:
    - 2002 NJDEP Stream Coverage (note, the 2002 coverage does not include stream names)
    - 1995 NJDEP Stream Coverage (this coverage includes stream names but is not as accurate or complete as the 2002 line coverage)
    - Major Roads (Federal, State)
    - Local Roads (county, municipal)
    - Aerial photographs
    - Municipality boundaries

2. **Identify crossings**.
    - Download Hawth's Analysis Tools for ArcGIS 9 (from SpatialEcology.com website).
    - Vector Editing Tools – choose "intersect lines (make points)".
    - Choose appropriate shape files (roads and both stream coverages).
    - Create a "Stream Crossing" layer from the result.

3. **Assign each crossing a unique number.**
    Use the primary stream name (HUC-14 if possible, HUC-11 if not), followed by a number. For example, all crossings in the Lockatong Creek HUC-14s will be labeled Lockatong –#. All crossings in the Wickecheoke HUC-14s will be labeled Wickecheoke-#.

4. **At each crossing, document the following information, using the attached form:**
    - Road name
    - Stream name
    - Crossing number
    - Crossing type (culvert, bridge, etc.)
    - Adjacent land use – upstream and downstream, left bank and right bank
    - Adequacy of buffers – upstream and downstream, left bank and right bank
    - Stream alteration or channelization
    - Stream access to floodplain
    - Accessibility of stream for visual assessments – based on size of stream, vegetation, private property, fences, slopes, footing, etc. If the stream is too small or does not have a defined channel, is too large, is too overgrown for access, or cannot be safely accessed, note this.
    - Photograph numbers, locations & photo direction (upstream/downstream, left/right bank)
    - GPS file number (if applicable)

5. **Site Sketches**. If appropriate, sketch the stream and pertinent features – tributaries entering the stream, etc.

6. **Photographs**. At each crossing, take at least one photograph upstream and downstream that covers both banks and a depth of field at least five times the stream width (unless vegetation blocks the view). If the stream is too wide to capture both banks in one photograph, then take at least one of each bank in each direction. Also take photographs of any particular features of note, such as lack of buffer, animals with access to the stream, pipes discharging into the stream, etc. Be sure to log your photo numbers.

7. **New Locations**. If you locate a stream crossing that was not identified by the GIS stream crossing coverage, assign it a unique number and take a GPS point at that location. All points must use NAD 1983 State Plane New Jersey FIPS 2900 Feet. If no GPS unit is available, mark the location on an aerial photoquad using a fine point pen, for later location using GIS digitizing. Follow the protocol for documenting conditions at that location.

8. **Log all crossings and photographs using the Excel file provided to you by NJWSA.**

9. **Download photos to computer**. If you took photos in portrait orientation, please rotate them. Assign each photograph a unique file name and log it in the spreadsheet. Use the crossing identifier, followed by a unique photo number. For example, photographs at the crossing Lockatong 5 would be labeled:
   - Lockatong 5-1
   - Lockatong 5-2
   - Lockatong 5-3

10. **Scan your data sheets**, if possible.

11. **Send files** to NJWSA for central recordkeeping. Send:
   - Scanned data sheets
   - Completed Excel spreadsheet (electronic version)
   - Photographs
   - GPS files

to ranthes@raritanbasin.org.

Raritan Basin
Central to New Jersey

Road-Stream Crossing Inventory

Crossing #: *Date:* *Stream/River*:
Road: *Municipality:* *County:*

Observer:
GPS File # (if applicable): *Photo #'s:*

Crossing Type:
•Ford •Bridge •Open Bottom Arch •Single Cell Culvert •Multi-cell Culvert

Adjacent land use:
Upstream: *Notes/Photo #'s*

Land Use Category	**Left Bank[7]**	**Right Bank**
Forest		
Meadow/Field		
Pasture		
Cultivated Field		
Nursery		
Lawn		
Residential		
Commercial		
Industrial		
Other (specify)		

Downstream:

Land Use Category	**Left Bank**	**Right Bank**
Forest		
Meadow/Field		
Pasture		
Cultivated Field		
Nursery		
Lawn		
Residential		
Commercial		
Industrial		
Other (specify)		

Have the stream banks been altered or channelized (e.g. landscaping, paving, concrete, gabions, riprap)?

Upstream	Right Bank	Left Bank	Downstream	Right Bank	Left Bank
	Yes No	Yes No		Yes No	Yes No

Would this site benefit from riparian buffer improvements (e.g. revegetation)?

Upstream	Right Bank	Left Bank	Downstream	Right Bank	Left Bank
	Yes No	Yes No		Yes No	Yes No

Does the stream have ready access to its floodplain (i.e., stream is not heavily incised)?
Upstream Yes No *Downstream* Yes No

[7] Left bank and right bank are always identified while looking downstream.

Are there Outfall pipes/Drainage ditches draining to stream?
Upstream Yes No *Downstream* Yes No

Is this site accessible for visual assessments (consider size of stream, vegetation barriers and safety)?
Upstream Good OK Bad *Downstrea*m Good OK Bad

Sidney Brook Road Crossing Inventory - 3/22/2007										
Crossing #	**Id**	**Municipality**	**County**	**Road**	**File Photo Number**	**Photo Direction**	**Photo Description**	**Needs buffer work?**	**Notes**	**Crossing Type**
Sidneybrook1	1	Union Twp	Hunterdon	Finn Rd	SidneyBrook1-1	us				
Sidneybrook1		Union Twp	Hunterdon	Finn Rd	SidneyBrook1-2	ds			overgrown; good floodplain access	single cell culvert
Sidneybrook1		Union Twp	Hunterdon	Finn Rd	SidneyBrook1-3	rbk	road drainage			
Sidneybrook2	2	Union Twp	Hunterdon	Finn Rd	SidneyBrook2-1	us		yes	altered banks; pond big berm with outflow; lbk erosion from drainage	single cell culvert
Sidneybrook2		Union Twp	Hunterdon	Finn Rd	SidneyBrook2-2	side				
Sidneybrook2		Union Twp	Hunterdon	Finn Rd	SidneyBrook2-3	ds		maybe-rbk	little pond-not connected	
Sidneybrook3	3	Union Twp	Hunterdon	Finn Rd	SidneyBrook3-1	us		no	Ok buffer; road drainage both banks	
Sidneybrook3		Union Twp	Hunterdon	Finn Rd	SidneyBrook3-2	ds			small channel; scour pool below culvert	
Sidneybrook4	4	Clinton Twp	Hunterdon	Southgate Dr	Sidneybrook4-1	us		no	nice meanders, drainage off slope on lbk	
Sidneybrook4		Union Twp	Hunterdon	Southgate Dr	Sidneybrook4-2	ds		yes-lbk	some deposition at dns side of culvert; lacks understory	single cell culvert
Sidneybrook5	5	Clinton Twp	Hunterdon	Southgate Dr	Sidneybrook5-1	us		no		single cell culvert
Sidneybrook5		Clinton Twp	Hunterdon	Southgate Dr	Sidneybrook5-2	ds		no		
Sidneybrook6	6	Union Twp	Hunterdon	Main St	SidneyBrook6-1	us		yes	stream splits just above road-midchannel bar; storm culverts rbk&lbk	single cell culvert natural bottom
Sidneybrook6		Union Twp	Hunterdon	Main St	SidneyBrook6-2	us	pipe-lbk			
Sidneybrook6		Union Twp	Hunterdon	Main St	SidneyBrook6-3	us	pipe-rbk			
Sidneybrook6		Union Twp	Hunterdon	Main St	SidneyBrook6-4	ds		y-lbk; n-rbk	altered banks; checkdam; storm water culverts lbk%rbk	
Sidneybrook6		Union Twp	Hunterdon	Main St	SidneyBrook6-5	ds				
Sidneybrook7	7	Union Twp	Hunterdon	Race St	SidneyBrook7-1	us		no		open bottom arch

Sidneybrook7		Union Twp	Hunterdon	Race St	SidneyBrook7-2	ds		y-lbk; n-rbk	retaining wall below confluence	
Sidneybrook8	8	Union Twp	Hunterdon	Race St	SidneyBrook8-1	us			makes sharp right to go thru culvert crossing-NEEDS RESTORATION	
Sidneybrook8		Union Twp	Hunterdon	Race St	SidneyBrook8-2	us				
Sidneybrook8		Union Twp	Hunterdon	Race St	SidneyBrook8-3	us				
Sidneybrook8		Union Twp	Hunterdon	Race St	SidneyBrook8-4	ds			road ditch	
Sidneybrook9	9		Hunterdon	Race St				us-lbk-maybe	small and overgrown	single cell culvert
Sidneybrook10	10	Clinton Twp	Hunterdon	Amherst Ct	SidneyBrook10-1	us		maybe	stream buried-culvert through yard	
Sidneybrook10		Clinton Twp	Hunterdon	Amherst Ct	SidneyBrook10-2	ds		yes	overgrown; channel not well defined	
Sidneybrook11	11	Clinton Twp	Hunterdon	Dorchester	SidneyBrook11-1	us		?	stream banks altered-culvert thru yard; roof drains flow into stream thru pipe	
Sidneybrook11		Clinton Twp	Hunterdon	Dorchester	Sidney Brook11-2	ds		yes	retaining wall; stream straightened; lacks good buffer	
Sidneybrook12	12	Clinton Twp	Hunterdon	Farview Dr	SidneyBrook12-1	us		y-rbk	small channel; mowed to edge on rbk; pond	single cell culvert
Sidneybrook12		Clinton Twp	Hunterdon	Farview Dr	SidneyBrook12-2	us				
Sidneybrook12		Clinton Twp	Hunterdon	Farview Dr	SidneyBrook12-3	ds	ditch	y-rbk&lbk	no understory	
Sidneybrook12		Clinton Twp	Hunterdon	Farview Dr	SidneyBrook12-4	ds				
	13		Hunterdon	Hamden Rd					no access	
Sidneybrook14	14	Clinton Twp	Hunterdon	Oakridge Rd	Sidneybrook14-1	us		maybe	few trees-little understory	
Sidneybrook14	14	Clinton Twp	Hunterdon	Oakridge Rd	Sidneybrook14-2	ds		no	altered stream channel-appears to have been dug out	single cell culvert
	15		Hunterdon	78E					no access	
	16		Hunterdon	78E					no access	
	17		Hunterdon	78W					no access	
	18		Hunterdon	78W					no access	
	19		Hunterdon	West Main St					no access	
Sidneybrook20	20	Union Twp	Hunterdon	Perryville Rd	SidneyBrook20-1	us		n-both banks	road drainage LBK & RBK; overgrown	single cell culvert
Sidneybrook20	20	Union Twp	Hunterdon	Perryville Rd	SidneyBrook20-2	ds				
Sidneybrook21	21	Union Twp	Hunterdon	Perryville Rd	SidneyBrook21-1	us		yes	lbk steep, needs vegetation; rbk missing understory	
Sidneybrook21	21	Union Twp	Hunterdon	Perryville Rd	SidneyBrook21-2	ds		no	good floodplain access; road drainage rbk	
Sidneybrook22	22	Union Twp	Hunterdon	Fox Chase Turnpike	SidneyBrook22-1	us		n-both banks	altered channel-piped underground	single cell culvert

Sidneybrook23	23	Union Twp	Hunterdon	Hill & Dale Dr	SidneyBrook23-1	us		maybe	crestview estates; some deposition at culvert	
Sidneybrook23	23	Union Twp	Hunterdon	Hill & Dale Dr	SidneyBrook23-2	ds		no		
Sidneybrook24	24	Union Twp	Hunterdon	Hill & Dale Dr	SidneyBrook24-1	ds		no	not really a defined channel	single cell culvert
Sidneybrook24	24	Union Twp	Hunterdon	Hill & Dale Dr	SidneyBrook24-2	us		no		
	25		Hunterdon	173						
Sidneybrook26	26	Clinton Twp	Hunterdon	Regional Rd	Sidneybrook26-1	us		yes	comes out of Beaver Brook Golf Course; not aligned with culvert on us side; erosion at culvert;	single cell culvert
Sidneybrook26	26	Clinton Twp	Hunterdon	Regional Rd	Sidneybrook26-2	us	culvert			
Sidneybrook26	26	Clinton Twp	Hunterdon	Regional Rd	Sidneybrook26-3	ds		yes	storm drain rbk	
Sidneybrook27	27	Franklin Twp	Hunterdon	Sidney Rd/617	SildneyBrook27-1	ds		yes	buried	
Sidneybrook27	27	Franklin Twp	Hunterdon	Sidney Rd/617	SidneyBrook27-2	us		maybe	thru cow pasture, no defined channel	
Sidneybrook27	27	Franklin Twp	Hunterdon	Sidney Rd/617	SidneyBrook27-3	us				
Sidneybrook28	28		Hunterdon	Sidney Rd/617	SidneyBrook28-1	us		no		bridge
Sidneybrook28	28		Hunterdon	Sidney Rd/617	SidneyBrook28-2	ds		y-lbk; n-rbk	good floodplain access; eroding bank	
Sidneybrook28	28		Hunterdon	Sidney Rd/617	SidneyBrook28-3		road ditch			
Sidneybrook28	28		Hunterdon	Sidney Rd/617	SidneyBrook28-4		tree			
Sidneybrook29	29	Clinton Twp	Hunterdon	Wellington Dr	SidneyBrook29-1	us	storm water input	no	small undefined channel	multi-cell culvert
Sidneybrook29	29	Clinton Twp	Hunterdon	Wellington Dr	SidneyBrook29-2	us	stream			
Sidneybrook29	29	Clinton Twp	Hunterdon	Wellington Dr	SidneyBrook29-3	ds		yes	erosion at culvert; french drain on rbk	
Sidneybrook29	29	Clinton Twp	Hunterdon	Wellington Dr	SidneyBrook29-4	ds	erosion			
Sidneybrook29	29	Clinton Twp	Hunterdon	Wellington Dr	SidneyBrook29-5	ds	drain			
Sidneybrook30	30		Hunterdon	Hamden Rd/623	SidneyBrook30-1	us		maybe	stream banks altered w/ riprap on rbk; lbk little buffer; point bar at us side of culvert	
Sidneybrook30	30		Hunterdon	Hamden Rd/623	SidneyBrook30-2	ds		yes	buffer ok further ds	single cell culvert
Sidneybrook31	31		Hunterdon	Hamden Rd/623	SidneyBrook31-1	us		yes-rbk	storm culvert on lbk	open bottom box
Sidneybrook31	31		Hunterdon	Hamden Rd/623	SidneyBrook31-2	ds		no	gas pipeline easement-rbk	
Sidneybrook32	32		Hunterdon	Gephardt Farm La	SidneyBroook32-1	us		no	lakeside estates; runs into big man-made lake; minor erosion by road	
Sidneybrook32	32		Hunterdon	Gephardt Farm La	SidneyBrook32-2	ds		no	no channel	
Sidneybrook33	33		Hunterdon	Race St				y-us/lbk ;	small and overgrown	single cell culvert

								n-ds		
Sidneybrook34	34		Hunterdon	Pittstown-Clinton Rd/513	SidneyBrook34-1	us		maybe	old farm-lbk; ok floodplain access; island	
Sidneybrook34	34		Hunterdon	Pittstown-Clinton Rd/513	SidneyBrook34-2	ds		no	road ditch on lbk evidence of sediment input	
Sidneybrook34	34		Hunterdon	Pittstown-Clinton Rd/513	SidneyBrook34-3		road drainage			
Sidneybrook35	35		Hunterdon	Grandin Rd	Sidneybrook35-1	us			ok floodplain access	single cell culvert
Sidneybrook35	35		Hunterdon	Grandin Rd	Sidneybrook35-2	ds		yes-lbk		

Appendix B

Potential Riparian Buffer Restoration Sites

Id	Block	Lot	Address	Owner	Notes	Priority Hi/Med/Lo	CCPI	Buffer Length	Buffer Width	Ac	Cost estimate
27	000040000	000030000	71 PITTSTOWN RD	SUNNY SLOPE REALTY COMPANY LP	mud pit through pasture (same pasture as 55) NO VEG mud swale could use some better pasture management. 27 flows to 58 through pasture, there appear to be 2 branches of the swale, once flows to 58, the other branches to south. Same recom as 55	High Site 1	med with some hi	about 1400 ft total RB & LB	25	1.61	$5,624
58	000040000	000030000	71 PITTSTOWN ROAD	SUNNY SLOPE REALTY COMPANY LP	banks stable, vegetated @ Sidney road Xing see 27	high Site 1	med and high				
55	000040000	000030000	71 PITTSTOWN ROAD	SUNNY SLOPE REALTY COMPANY LP	Private Ag Land. Minimal buffer, active pasture. Ditch through active pasture, same one as 27 flows through, not picked up on stream GIS layers, CCPI high along ditch, surrounded by medium. Great opp for restoration along the swale and RFF for farm. swale rather than a channel, good opportunity for pasture management	high Site 2	high	about 1200 ft RB & LB	25	1.38	$4,821
71	000220000	000200000	ROUTE 513 GRANDIN	MILLIGAN, JOSEPH BERTRAM & EMMA J	Mild erosion, some buffer, ag land adjacent, private property. see above, close to 1000 ft, LB and RB that would benefit from buffers US of 71 marker and down to 69 marker at confluence w/mainstem	high Site 3 Milligan	med	700 RB & LB	25	0.80	$2,812
69	000220000	000200000	ROUTE 513 GRANDIN	MILLIGAN, JOSEPH BERTRAM & EMMA J	Mild erosion, some buffer, trout stocked water, ag land adjacent, private property. Milligan, fishing area, partially owned by authority, deed restriction (see map) good buffer opportunity, ditch management needed across street at e'town gas	high Site 3 Milligan	high	1100 + 200	25	0.75	$2,611

6	000210000	000190000		UNION TWP	Stream adjacent to Historic Municipal Building. Very bad active erosion on LB. public land, lawn area next to historic building, garage/impervious area behind building, heavy bank erosion, could need more than buffer planting, upstream issues need to be addressed, culvert needs attention, Downstream: buffer opportunity on private property	highSite 4	mostly hi, some med	100	20	0.05	$161
91	0002220000	00044000	6 Race Street	Hartsell, Gene L. and Betty J.	intersection of Race & Hilltop, confluence of 2 branches of Sidney brook. Good opportunity, buffers needed on both sides and in middle area before total confluence	high site 5	med/high	270 RB & LB	20	0.12	$434
40	000280000	000120000	JUTLAND-MECHLIN CORNER	CHRISTOFF, GEORGE S & BARBARA T	no access for field recon. Adjacent pond also needs buffer	low	med	~500 ft LB, + ~750 lf pond shoreline	10	0.29	$1,004
35	000280000	000320000	653 COUNTY RD 579	GOECKLER, ADOLPH & GERTRUDE	outflow from pond, forested, limited view and access. N side of pond could use buffer	low	med and hi	325 lf shoreline	25	0.19	$653
39	000280000	000250000	COOKS CROSS RD	GOLDBERG, FRANK & AMY	outflow from pond, no field access. Pond could use some buffer	low	low	450 lf pond shoreline, 75 ft RB & Lb stream	15	0.21	$723
41	000280000	000210000	FINN ROAD	GEILER DOROTHY	Difficult to see from road. @ Road Xings, good buffers - tree and shrub layer. Online adjacent pond needs buffer	low	med	260 ft LB & RB ds of pond, 800 lf pond shoreline	25 and 10	0.48	$1,687
59	000100000	000040000	48 GRANDIN ROAD	VITALE MARIO & EMILY	low flow, good buffer by Grandin Rd Stream Xing. Mild erosion DS LB, pond could use some buffering	low	med and low	700 lf shoreline	10	0.16	$562

73	000220000	000180000	48 ROUTE 513	DEPT OF CORRECTIONS-STATE OF NJ	No access. RB US of marker appears to need buffer, ~300 ft	low	hi	200 ft RB & LB	25	0.23	$803
79	000250000	000020002	61 RACE ST	LEWIS, HENRY	inlet to pond, well vegetated. pond shoreline could have better buffer	low	med	1400 lf pond shoreline	10	0.32	$1,125
62	000250000	000350000	PITTS-CLINTON RD	FARMLAND LLC C/O ROBT. LECOMPTE	320 ft, RB could use buffer improvement	low/med	med	320 RB	20	0.15	$514
74	000220000	000180000	48 ROUTE 513	DEPT OF CORRECTIONS-STATE OF NJ	No access, appears to be unmapped stream. Needs buffer work. Mostly CCPI medium with some high and low. ~600 feet total, 200 ft US of marker looks like higher need	low/med	med	225 ft RB & LB US of marker, 225 DS of marker that might need improvement	20	0.41	$1,446
52	000220002	000110000	3 MIDVALE DRIVE	BROCHHAGEN, BRUCE P & KIRSTEN	basically a grass swale @ Race Rd. Stream Xing	med	med, low	400 ft RB & LB	20	0.37	$1,286
56	000050000	000060001	67 SIDNEY ROAD	SIRUSAS, GEORGE S	goes through res backyards, med and some hi CCPI. Might be good opp to work with homeowners	med	med and high	100 ft LB	15	0.03	$121
92	000040000	000030000	Sidney road (617)	SUNNY SLOPE REALTY COMPANY LP	main stem Sidney Brook flowing under Sidney road	med	high	250 RB	15	0.09	$301
93	280000	120000	FINN ROAD		outlet from pond DS of 41	med	med	250 LB & RB	25	0.29	$1,004
46	000280000	000120000	JUTLAND-MECHLIN CORNER	CHRISTOFF, GEORGE S & BARBARA T	Difficult to see from road. @ Road Xings, good buffers - tree and shrub layer. Pond and outlet need buffer, based on aerial, pond about 530 feet of shoreline, outlet ~100 ft RB & LB	med?	low/med	530 lf shoreline, 100 ft LB & RB	10	0.13	$442

70	000220000	000200000	ROUTE 513 GRANDIN	MILLIGAN, JOSEPH BERTRAM & EMMA J	Mild erosion, some buffer, ag land adjacent, private property. although buffer improvement could be beneficial, this area is within a gas pipeline easement and is therefore not a good location for restoration.	na	high and med				
36	000280000	000240000	3 FINN RD	STIGER, SANDRA E	Forested	na					
37	000280000	000240000	3 FINN RD	STIGER, SANDRA E	Underground pipe	na					
38	000270000	000090000	2 FINN ROAD	VIGLIANTI, ANDREW	Underground pipe	na					
42	000270000	000010000	22 FINN ROAD	TOWNSHIP OF UNION	buffered with trees, inactive pastures on both banks of segment. Trickle flow. In Finn Road Park	na	mostly low, some med				
51	000250000	000030000	71 RACE ST	CONRAIL C/O PAT TURSI	(upstream segment) Well buffered at road Xing (p'ville rd.) small area LB DS of bridge not well vegetated	na	na				
60	000100000	000060000	131 PITTSTOWN ROAD	CASSANO, WILLIAM J & HOPE M	could not locate, Underground pipe?	na	na				
61					could not locate, Underground pipe?	na	na				
63	000300000	000110000	6-8 GROVE FARM RD	ALDRICH, JOHN F	could not locate, Underground pipe?	na	na				
64	000300000	000010010	11 COOKS CROSS RD	RIDDLE, WILLIAM I & JANET L	could not locate, Underground pipe?	na	na				
65	000300000	000010004	21 COOKS CROSS RD	SOLED, STUART L	little flow, culvert under road, some rip-rap on RB DS of Xing. Well vegetated. Storm drain enters stream UG	na	na				
66	000300000	000010000	ROUTE 513/COOKS CRS RD	ROSSI, EDWARD J & PATRICIA S	little flow, culvert under road, some rip-rap on RB DS of Xing. Well vegetated. Storm drain enters stream UG	na	na				

75	000220000	000270000	RACE STREET	UNORSKI, JOHN & WALTER ETALS	Underground pipe	NA	NA					
76	000250000	000070000	RACE STREET	UNORSKI, JOHN & WALTER ETALS	Underground pipe	NA	NA					
82	000100000	000050013	7 MATHEW DRIVE	TOLBERT, MATTHEW B & HOLLY	Dry detention basin leads to dry stream bed that flows under Sidney Road,	NA						
80	000220000	000300000	5 ROUTE 173 E	RED HILLS INDUSTRIAL PARK	no access. SCS stream, 2 branches, aerial shows some veg	na - too low	na					
2	000280000	000230000		NOLTE, GEORGE & JEANNE	Stream flows from pond on private property approx 70feet under Finn road. Grass on banks. Head wall being washed out. too short, not a great opportunity	na - too low	low					
21				ROGER PRINCE &DIANE GUNSON	**Nice, interested homeowner. Grassy steep slope on private property.	na - too low						
33			42 RACE ST	JACQUELINE BURACHYNSKI	heavy shrub (multiflora). Roadside ditches enter. Sloped Ag field on right bank. ~5m buffer on each bank.	na - too low	low					
43	000270000	000030015			could not see from road, residential property, appears to need buffer improvement, low CCPI. can't confirm that there's a stream	na - too low	low					
44	000270000	000030015			could not see from road, residential property, appears to need buffer improvement, low CCPI. can't confirm that there's a stream	na - too low	low					
45	000250000	000320000	RT 635/PERRYVILLE RD	TALKA, JOEL	poor access, private property, trees and veg., aerial shows need for buffer. can't confirm that there's a stream	na - too low	low					

47	000210002	000320005	740 ROUTE 625	PERRYVILLE ESTATES, LLC	on unconnected segment of SCS stream, residential. can't confirm that there's a stream	na - too low	na				
48	000210000	000280000	217 MAIN STREET, JUT.	HUMMER, LEO R AND MARIE A	Some vegetation, residential area, private property. One fenced in pasture near stream. US of marker, residential yards, can't confirm stream exists, no field access.	na - too low					
50	000210000	000290013	19 STONEBRIDGE RD JUTLAND	GAWALIS, THOMAS J & VICTORIA S	behind house, some trees, residential area, along Railroad. can't confirm that there's a stream	na - too low	na				
53	000220000	000340000	PERRYVILLE ROAD	FALLONE PROPERTIES LLC	veg. OK. Limited access, low priority. can't confirm that there's a stream	na - too low	na				
54	000220002	000180000	17 MIDVALE DRIVE	CORCORAN, JOHN V & KATHLEEN A	veg. OK. Limited access, low priority. disconnected segment of SCS stream, can't confirm that stream exists	na - too low	na				
72	000220000	000180000	48 ROUTE 513	DEPT OF CORRECTIONS-STATE OF NJ	~400 ft of stream lacking buffer on aerial, no field access. SCS stream, can't confirm existence, no appearance on aerial	na - too low	low				
77	000250000	000060000	49 RACE ST	COZZE, RICHARD A	Cozze Bros. can't confirm that there's a stream	na - too low	NA				
78	000250000	000020008	61 RACE ST	LEWIS, HENRY	overflow from large pond. Appears Well vegetated on , private property	na - too low	low				
81	000220000	000300000	5 ROUTE 173 E	RED HILLS INDUSTRIAL PARK	no access. SCS stream, there may be a trib through woods, can't confirm	na - too low	na				
49	000210000	000260000	217 MAIN ST JUTLAND	HUMMER, LEO R & MARIE A	Some vegetation, residential area, private property. One fenced in pasture near stream. US of marker, buffer might be ok, DS to bend /property line might be ok, might be able to improve, can't tell and no field access	na can't confirm	US of marker RB med, LB high, DS of marker, RB high				

67	000250000	000370009	COOKS CROSS ROAD	MANZIONE, ANITA JANE	poor access, private property, trees and veg, appears to be a reach through field that could use buffer. No CCPI b/c SCS. can't confirm that there's a stream	na- too low	na				
68	000250000	000320000	RT 635/PERRYVILLE RD	TALKA, JOEL	poor access, private property, trees and veg, appears to be a reach through field that could use buffer. No CCPI b/c SCS. can't confirm that there's a stream	na- too low	na				

Appendix C

Planting Plans for Five Priority Riparian Buffer Restoration Sites

Planting Plans for Sidney Brook Watershed Restoration Plan

Site 69A, 69B, 69C, 69D: This site is located at Milligan Farms on Pittstown-Clinton Road in Union Township, New Jersey. There are several land uses upstream from this site including residential, agricultural and open space.

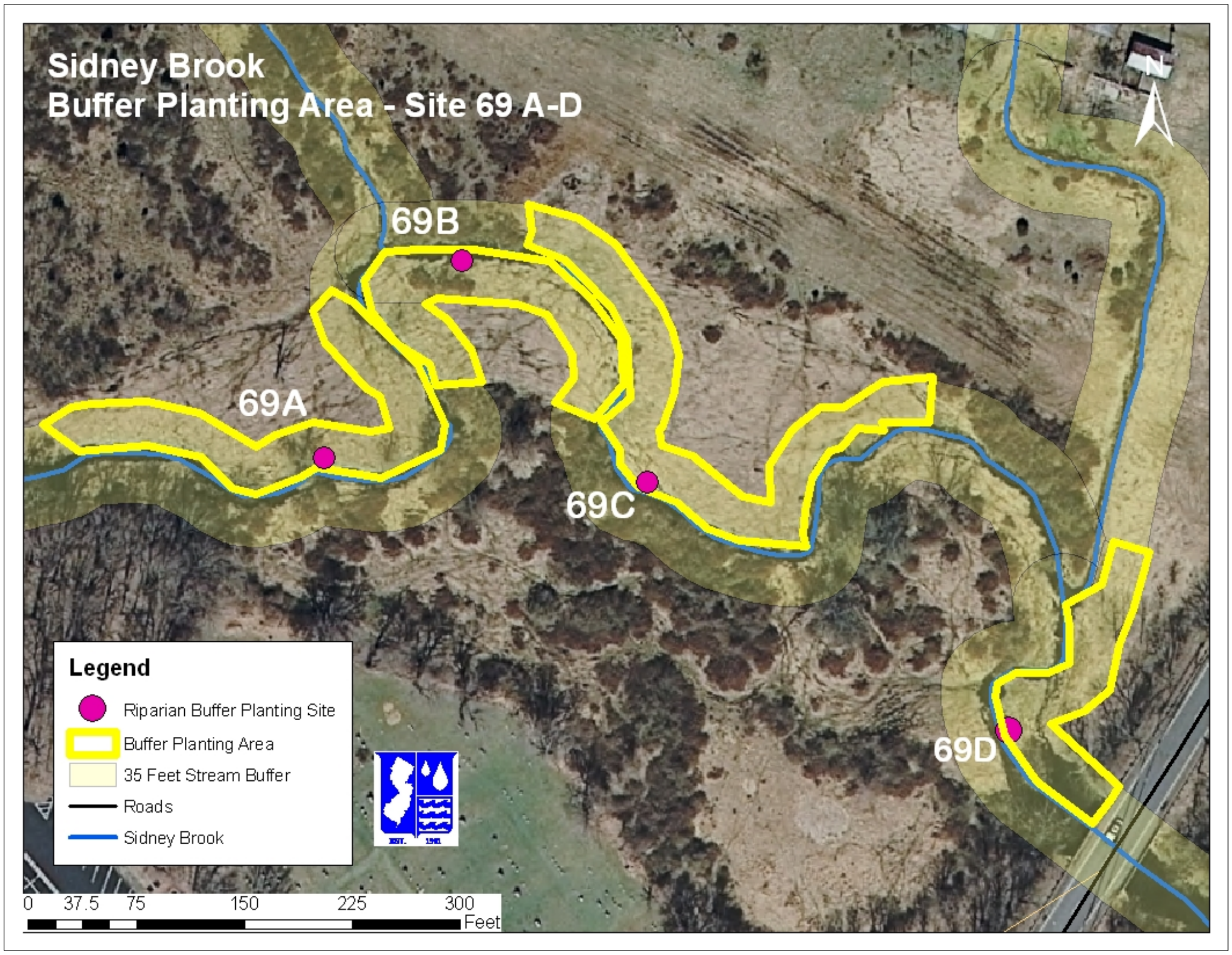


Figure 29. Buffer Site 69

Existing Conditions: There is very little canopy cover above the stream at this site. The stream banks are vegetated with grasses and the shrub layer is dominated by invasive species like multiflora rose and autumn olive. There is some fine material in the stream bed indicating some erosion and exposed banks in some areas. This site would be improved with the addition of several trees that have a high saturation tolerance due to the frequently wet conditions. The trees would provide canopy cover to help reduce temperature, stabilize the banks, crowd out the increasing amount of invasive species, and add plant material to the food web of the stream. Willows along the bank will help to stabilize areas exhibiting erosion.

Figure 30. Buffer Site 69

Soil Conditions: The soil in the wetland area adjacent to the stream is 85 percent Rowland silt loam and 15 percent minor components. The soil is frequently flooded and has a slope from 0-2 percent and is moderately well drained. Plant species selected for this area should be native species that are well adapted for wetlands and have a high tolerance for soil saturation.

Plant Species: Since canopy cover is needed at this site, and the soil is frequently saturated, tree species that are tolerant of "wet feet" will have the highest chance of survival as well as provide the most benefit to the stream. Listed below are species that fit this description.

Table 1. Plants appropriate for Buffer Sites 69A-D	
Plant Species	**Comments**
Atlantic White Cedar, *Chamaecyparis thyoides*	Does well in sandy or mucky soil
Eastern Cottonwood, *Populus deltoides*	Fast growth, high saturation tolerance
Pin Oak, *Quercus palustris*	Perpendicular branching habit
River Birch, *Betula nigra*	High saturation tolerance, mature height 80 ft.
Swamp White Oak, *Quercus bicolor*	High saturation tolerance, mature height 60 ft.
Willow, *Salix sp.*	Fast growth, high saturation tolerance
Silver Maple , *Acer saccharinum*	Fast growth, high saturation tolerance

Cost: The approximate size of this planting area is 1.04 acres, which can be broken down into four phases. Plant material is available in a variety of sizes and this will greatly affect overall costs. Container size "#1" are seven inches deep by six inches in diameter, container size "#2" are nine inches deep by eight inches in diameter, and container size "#3" is nine and three-quarters inches deep by eleven inches in diameter. These cost estimates are based on internet searches of local nurseries and can vary widely based on size, availability, shipping, whether ordered in bulk, the time of year and other variables. These cost estimates only account for plant material and assume that the planting will be completed by volunteer or in-kind labor. These estimates do not include the cost of maintenance, monitoring, other adaptive management techniques or other costs incurred during site preparation.

Design: The minimum width for this buffer design is 35 feet. Buffers at least 35 feet in width have the ability to stabilize banks, contribute to the aquatic food web, moderate temperature by shading as well as reduce the amount of nutrients reaching the stream. To achieve adequate plant density in the buffer, approximately 200 plants per acre should be planted initially, with the average spacing ranging from 14-18 feet. Containerized plants will be used. Due to the large size of this site, the planting of this buffer could be broken up into four phases. An additional consideration for this site will be the wetness of the site and the impact that will have on the ability to bring in heavy equipment for digging.

69A: This segment is the furthest upstream of this site. It is approximately 0.28 acres in size. A total of 86 plants will be needed to adequately buffer this area to achieve a density of at least 200 plants per acre, taking into account the willow and dogwood stakes will be planted in clusters.

Figure 31. Buffer Site 69A

Table 2. Plant Cost Estimate for Buffer Site 69A				
Plant Species	**Number of Plants**	**Container Size**	**Approximate Cost/Unit**	**Approximate Total Cost**
Salix nigra, Willow	30	stakes	$2.00	$60.00
Cornus sericea, Redosier Dogwood	30	stakes	$2.00	$60.00
Betula nigra, River Birch	6	#3	$16.25	$97.50
Quercus bicolor, Swamp White Oak	5	#2	$12.00	$60.00
Quercus palustris, Pin Oak	5	#3	$16.25	$97.50
Chamaecyparis thyoides, Atlantic White Cedar	5	#3	$16.25	$97.50
Acer saccharinum, Silver Maple	5	#2	$12.00	$60.00
TOTALS	**86**			**$532.50**

69B: This segment is along the upstream meander of the site and is approximately 0.23 acres in size. A buffer area of this size calls for 76 plants to reach an appropriate density at maturity, taking into account that the willow and dogwood stakes will be planted in clusters.

Figure 32. Buffer Site 69B and 69C

Table 3. Plant Cost Estimate for Buffer Site 69B				
Plant Species	**Number of Plants**	**Container Size**	**Approximate Cost/Unit**	**Approximate Total Cost**
Salix nigra, Willow	25	stakes	$2.00	$50.00
Cornus sericea, Redosier Dogwood	25	stakes	$2.00	$50.00
Betula nigra, River Birch	5	#3	$16.25	$81.25
Quercus bicolor, Swamp White Oak	6	#2	$12.00	$72.00
Quercus palustris, Pin Oak	5	#3	$16.25	$81.25
Chamaecyparis thyoides, Atlantic White Cedar	5	#3	$16.25	$81.25
Acer saccharinum, Silver Maple	5	#2	$12.00	$60.00
TOTALS	**76**			**$475.75**

69C: This area is approximately 0.33 acres. By multiplying the area by the rate of 200 plants per acre, the number of trees needed for this phase is 117 plants, taking into account that the willow and dogwood stakes will be planted in clusters. Listed below are the plants and a cost estimate.

Table 4. Plant Cost Estimate for Buffer Site 69C				
Plant Species	**Number of Plants**	**Container Size**	**Approximate Cost/Unit**	**Approximate Total Cost**
Salix nigra, Willow	40	stakes	$2.00	$80.00
Cornus sericea, Redosier Dogwood	40	stakes	$2.00	$80.00
Betula nigra, River Birch	7	#3	$16.25	$113.75
Quercus bicolor, Swamp White Oak	7	#2	$12.00	$84.00
Quercus palustris, Pin Oak	7	#3	$16.25	$113.75
Chamaecyparis thyoides, Atlantic White Cedar	7	#3	$16.25	$113.75
Acer saccharinum, Silver Maple	9	#2	$12.00	$108.00
TOTALS	**117**			**$693.25**

69D: This site is furthest downstream and closest to the road. The area for this site is just under 0.2 acres. Approximately 60 plants will be needed for this site.

Figure 33. Buffer Site 69D

Table 5. Plant Cost Estimate for Buffer Site 69D				
Plant Species	**Number of Plants**	**Container Size**	**Approximate Cost/Unit**	**Approximate Total Cost**
Salix nigra, Willow	40	stakes	$2.00	$80.00
Betula nigra, River Birch	5	#3	$16.25	$81.25
Quercus bicolor, Swamp White Oak	5	#2	$12.00	$60.00
Quercus palustris, Pin Oak	5	#3	$16.25	$81.25
Chamaecyparis thyoides, Atlantic White Cedar	5	#3	$16.25	$81.25
TOTALS	**60**			**$383.75**

Post Planting Maintenance: After planting is completed, there will have to be some ongoing maintenance to ensure plant survival and the effectiveness of the buffer. A large threat to plants will be feeding on the leaves by deer and feeding on the bark by mice. For the first several months after the planting, there should be routine examinations to make sure tree shelters and cages are in place. Watering may be necessary to assist the plants in establishing, especially during periods of drought. Checks should also be made after any major rain event where water may cause damage to the plants or cages. While the plants are being examined, opportunities for adaptive management should be considered. For example, if deer feeding pressure is heavy, more protective tree shelters or deer repellents may need to be used. Over time, as the plants are established, the routine checks can be reduced in frequency.

Site 6: This buffer site is located on public property next to the historic municipal building on Main Street in Union Township, New Jersey. Upstream from this site is a residential area as well as some small farm operations.

Figure 34. Buffer Site 6

Existing Conditions: The buffer planting area is approximately 0.10 acres in size and there is just over 100 feet of stream length. This site offers a highly visible opportunity to demonstrate how stream buffers can be implemented. There is severe erosion at this site. The left bank is incised and is approximately five feet above the stream. Fortifying this bank with some plant material will help to reduce erosion and bank failure, although a structural bank stabilization design may be needed to significantly improve conditions.

Figure 35. Buffer Site 6

Soil Conditions: The dominant soil type at this buffer site is Landsdowne silt loam. This soil has somewhat poor drainage.

Plant Species: On this particular site, the plants used will have to be able to root quickly, grow in partial shade and be tolerant of both wet and dry conditions. The goal of this planting is to stabilize the bank and the plant selection should reflect that need. Red-osier dogwood and willow stakes are commonly used to stabilize banks. Several species of trees are also acceptable to use above the bank to provide stability. This site also offers an opportunity to use more attractive plants that produce fruit and attract wildlife. Shrubs like Shadbush and Buttonbush will produce flowers, while River Birches have attractive exfoliating bark. The suggested number of plants for a buffer this size is approximately 20 plants, however, more will likely be needed to achieve the desired results. Listed below are native species that would suit this buffer site.

Table 6. Plants appropriate for Buffer Site 6

Plant Species	Comments
Red-osier Dogwood, *Cornus stolonifera*	Good for streambank stabilization
Willows, shrubs, *Salix sericea*	Fast growth
Shadbush, *Amelanchier canadensis*	Attractive flower in early spring
Buttonbush, *Cephalanthus occidentalis*	Medium shade tolerance
River Birch, *Betula nigra*	High saturation tolerance, mature height 80 ft.
Sweet Gum, *Liquidambar styraciflua*	Fast Growth, Red fall foliage
Rough Bluegrass, *Poa trivialis*, Fowl Bluegrass, *Poa palustris*, Virginia Wild Rye, *Elymus virginicus*	Grass seed mixture good for wet sites and shade
Black-eyed Susan, *Rudbeckia hirta*, Bee Balm, *Monarda didyma*, Purple Coneflower, *Echinacea purpurea*, Bush Clover, *Lespedeza capitata*	Coloful flowers, provides ground cover, low shade tolerance, adds wildlife value to grass mix

Cost: Plant material is available in a variety of sizes and this will greatly affect overall costs. Container size "#1" are seven inches deep by six inches in diameter, container size "#2" are nine inches deep by eight inches in diameter, and container size "#3" is nine and three-quarters inches deep by eleven inches in diameter.

Table 7. Plant Cost Estimate for Buffer Site 6				
Plant Species	**Number of Plants**	**Container Size**	**Approximate Cost/Unit**	**Approximate Total Cost**
Red-osier Dogwood, *Cornus stolonifera*	25	stakes	$2.00	$50.00
Willows, shrubs, *Salix sericea*	25	stakes	$2.00	$50.00
Shadbush, *Amelanchier canadensis*	3	#2	$12.00	$36.00
Buttonbush, *Cephalanthus occidentalis*	3	#1	$16.25	$48.75
River Birch, *Betula nigra*	3	#3	$16.25	$48.75
Sweet Gum, *Liquidambar styraciflua*	3	#2	$12.00	$36.00
Rough Bluegrass, *Poa trivialis*, Fowl Bluegrass, *Poa palustris*, Virginia Wild Rye, *Elymus virginicus*	14lbs/acre	1.4 lbs	$16.00/lb	$22.40
Black-eyed Susan, *Rudbeckia hirta*, Bee Balm, *Monarda didyma*, Purple Coneflower, *Echinacea purpurea*, Bush Clover, *Lespedeza capitata*	2 lbs/acre	0.2 lbs	16.00/lb	$3.20
TOTALS	**62 plus seed**			**$295.10**

Design: The willow stakes and red osier dogwood stakes should be densely planted along the bank to ensure stabilization of this bank. Bundles of five stakes planted every five feet will provide stabilization to the bank. Leaving room for the willows and dogwoods to grow, an additional twelve trees and shrubs could be planted in a staggered pattern ten to forty feet from top of bank. The shade-tolerant seed mix should be spread in the open areas between plants to offer further stabilization. Cages and tree shelters should be employed at this site to prevent herbivory. Signage delineating the riparian buffer area should be educational and will help prevent newly established plants from being mowed.

Post Planting Maintenance: Routine monitoring of a recently planted buffer is critical to the success of the buffer. For the first several months after planting, weekly checks for deer damage or out of place tree shelters will be beneficial to the establishment of the buffer. Watering may be necessary to assist the survival of the plants, especially during periods of drought. Checks should also be made after any major rain event where water may cause damage to the plants or cages. While the plants are being examined, opportunities for adaptive management should be considered. For example, if deer feeding pressure is heavy, more protective tree shelters or deer repellents may need to be used. Over time, as the plants are established, the routine checks can be reduced in frequency. Mowing should be reduced in buffer area to allow plants, especially the grass mix to establish and produce deep roots.

Site 91: This buffer site is located along Race Street near the intersection with Hilltop Lane in Union Township, New Jersey. It is located on private property and homeowner approval would be necessary before moving forward with this site. This site is just upstream from buffer site 69A-D.

Figure 36. Buffer Site 91

Existing Conditions: This buffer site is located at a confluence of a tributary and the main stem of the Sidney Brook. This site lacks a significant canopy and much of the riparian area is mowed lawn. By implementing a riparian buffer at this site, a canopy will provide shade and cool the water, shrubs and trees will stabilize the banks, and mowing needs will be reduced. This buffer site is 0.42 acres in size and includes 360 feet of stream length.

Figure 37. Buffer Site 91

Soil Conditions: Rowland silt loam is the predominant soil at this buffer site. This area is susceptible to water saturation and will be a major factor in selecting plants for the buffer.

Plant Species: Aesthetically pleasing plants will be important in the plant selection of this site due to the location on private property as well as the visibility from the road. Flowering shrubs like the Sweet Pepperbush and Buttonbush, as well as a fruit producing species like Highbush Blueberry will add aesthetic and wildlife value to this buffer. Planting the willows and dogwoods along the banks will help to stabilize the site.

Table 8. Plants appropriate for Buffer Site 91

Plant Species	Comments
Willows, shrubs, *Salix sericea*	Fast growth
Red-osier Dogwood, *Cornus stolonifera*	Good for streambank stabilization
Sweet Pepperbush, *Clethra alnifolia*	Summer flower
Highbush Blueberry, *Vaccinium corymbosum*	Fruit production
Buttonbush, *Cephalanthus occidentalis*	Unusual white flower
River Birch, *Betula nigra*	High saturation tolerance, Attractive exfoliating bark
Pin oak, *Quercus palustris*	Perpendicular branching habit
Sycamore, *Platanus occidentalis*	Fast Growth
Sweet Gum, *Liquidambar styraciflua*	Fast growth, red fall foliage
Rough Bluegrass, *Poa trivialis*, Fowl Bluegrass, *Poa palustris*, Virginia Wild Rye, *Elymus virginicus*	Grass seed mixture good for wet sites
Black-eyed Susan, *Rudbeckia hirta*, Bee Balm, *Monarda didyma*, Purple Coneflower, *Echinacea purpurea*, Bush Clover, *Lespedeza capitata*	Coloful flowers, provides ground cover, low shade tolerance, adds wildlife value to grass mix

Cost: Important considerations for estimating the total cost of implementing this buffer will be the availability of plant species and size, cost of labor, and tree cages and shelters. Plant material is available in a variety of sizes and this will greatly affect overall costs. Container size "#1" are seven inches deep by six inches in diameter, container size "#2" are nine inches deep by eight inches in diameter, and container size "#3" is nine and three-quarters inches deep by eleven inches in diameter. Below is a cost estimate for plant material, excluding labor and maintenance.

Table 9. Plant Cost Estimate for Buffer Site 91

Plant Species	Number of Plants	Container Size	Approximate Cost/Unit	Approximate Total Cost
Willows, shrubs, *Salix sericea*	25	stakes	$2.00	$50.00
Red-osier Dogwood, *Cornus stolonifera*	25	stakes	$2.00	$50.00
Sweet Pepperbush, *Clethra alnifolia*	7	#1	$7.00	$49.00
Highbush Blueberry, *Vaccinium corymbosum*	7	#3	$16.25	$113.75
Buttonbush, *Cephalanthus occidentalis*	7	#1	$7.00	$49.00
River Birch, *Betula nigra*	4	#3	$16.25	$65.00
Pin oak, *Quercus palustris*	3	#3	$16.25	$48.75
Sycamore, *Platanus occidentalis*	3	#2	$12.00	$36.00
Sweet Gum, *Liquidambar styraciflua*	3	#2	$12.00	$36.00
Rough Bluegrass, *Poa trivialis*, Fowl Bluegrass, *Poa palustris*, Virginia Wild Rye, *Elymus virginicus*	14 lbs/acre	6 lbs	$16.00/lb	$96.00
Black-eyed Susan, *Rudbeckia hirta*, Bee Balm, *Monarda didyma*, Purple Coneflower, *Echinacea purpurea*, Bush Clover, *Lespedeza capitata*	2 lbs/acre	1 lb	$16.00/lb	$16.00
TOTALS	**84 plus seed**			**$609.50**

Design: In order to reach a density of at least 200 plants per acre, approximately 84 plants will be needed. The majority of these plants will be the willows and dogwoods that will be used to line the top of the bank. Proper spacing between trees is important. Fourteen to eighteen feet between trees will account for the mature size of the trees. The riparian buffer seed mix should be spread to cover extent of buffer after the trees and shrubs are planted.

Post Planting Maintenance: Routine monitoring of a recently planted buffer is critical to the success of the buffer. For the first several months after planting, weekly checks for deer damage or movement of tree shelters will be beneficial to the function of the buffer. Watering may be necessary to assist the plants in establishing, especially during periods of drought. Checks should also be made after any major rain event where water may cause damage to the plants or cages. While the plants are being examined, opportunities for adaptive management should be considered. For example, if deer feeding pressure is heavy, more protective tree shelters or deer repellents may need to be used. Over time, as the plants are established, the routine checks can be reduced in frequency. Reduce or eliminate mowing in buffer area to allow herbaceous cover to establish and develop deep roots.

Site 27: Located on Sidney Road in Franklin Township, New Jersey, this buffer site is a swale through a pasture on a preserved farm that drains stormwater from Sidney Road and the northeastern section of the watershed. After flowing through the pasture, the swale reaches a wet area where there is a gas pipeline.

Figure 38. Buffer Site 27

Existing Conditions: This site is exhibiting some heavy erosion from stormwater as well as from heavy animal use. The section of the swale closest to the road is experiencing the most degradation since this area absorbs most of the force from stormwater. The water source this site provides, as well as the shade of one of the few trees in the pasture makes this site attractive to the cattle. There is also a pile of feed adjacent to this site, an indication of supplemental feeding. With a buffer of approximately 35 feet wide on each side of the swale, the total area is 1.25 acres.

Figure 39. Buffer Site 27

Soil Conditions: The major soil type at this site is Rowland Silt Loam. This soil type is commonly found in flood plains and is frequently flooded.

Plant Species: In order to maintain the area surrounding this site as viable pasture, trees will not be used for this buffer site. A combination of small shrubs and herbaceous ground cover will be used to stabilize the soil, provide some hydraulic roughness, and reduce erosion. A riparian buffer seed mixture will be used to achieve these benefits. In addition, several species of shrub will help to form a natural fence and will deter cows from entering the swale.

Table 10. Plants appropriate for Buffer Site 27	
Plant Species	**Comments**
Arrowwood, *Viburnum dentatum*	High avian wildlife value, late spring flower
Spicebush, *Lindera benzoin*	Mature height 20 ft.
Silky Dogwood, *Cornus amomum*	High avian wildlife value, fruit production in 2-3 years
Sweet Pepperbush, *Clethra alnifolia*	High avian wildlife value, summer flower
Big Bluestem, *Andropogon gerardii*, Indiangrass, *Sorghastrum nutans*, Switchgrass, *Panicum virgatum*, Bush Clover, *Lespedeza capitata*	Warm season grasses that act as filter strips, grows well on steep slopes
Creeping Red Fescue, *Festuca rubra* var. *rubra*	Provides erosion control while warm season grasses establish

Cost: The major cost incurred at this site will be fencing or some other exclosure to ensure the buffer is not grazed. This will allow plants and seeds to establish without heavy cow and deer pressure. An alternate source of water may need to be installed if the stream serves as the primary source of water in this pasture. In addition, a crossing must be provided for the cattle to access the section of pasture beyond the swale.

Plant material is available in a variety of sizes and this will greatly affect overall costs. Container size "#1" are seven inches deep by six inches in diameter, container size "#2" are nine inches deep by eight inches in diameter, and container size "#3" is nine and three-quarters inches deep by eleven inches in diameter. Listed below are cost estimates for plant material, excluding hay for the seed, labor and maintenance.

It should be noted that this site may be eligible for cost share programs offered through the various Farm Bill agencies, particularly through the Natural Resources Conservation Service.

Table 11. Plant Cost Estimate for Buffer Site 27

Plant Species	Number of Plants	Container Size	Approximate Cost/Unit	Approximate Total Cost
Arrowwood, *Viburnum dentatum*	10	#1	$7.00	$70.00
Spicebush, *Lindera benzoin*	10	#1	$7.00	$70.00
Silky Dogwood, *Cornus amomum*	10	#1	$7.00	$70.00
Sweet Pepperbush, *Clethra alnifolia*	10	#1	$7.00	$70.00
Big Bluestem, *Andropogon gerardii*, Indiangrass, *Sorghastrum nutans*, Switchgrass, *Panicum virgatum*, Bush Clover, *Lespedeza capitata*	12 lbs/acre	15 lbs	$16.00/lb	$240.00
Creeping Red Fescue, *Festuca rubra* var. *rubra*	15lbs/acre	18.75 lbs	$16.00/lb	$300.00
TOTALS	**40 shrubs plus seed**			**$820.00**

Design: The design of this buffer should be relatively basic, with the shrubs planted along the swale, and the seed mix planted in a 35-40 feet wide strip on each side. During seeding, materials such as hay or mulch may be used to assist in germination.

Post Planting Maintenance: The most important consideration after this buffer is planted to ensure that cattle do not have access to the planting area. This includes maintaining any fencing that is built around the buffer area. Routine monitoring of a recently planted buffer is critical to the success of the buffer. For the first several months after planting, weekly checks for deer damage or movement of tree shelters will be beneficial to the function of the buffer. Watering may be necessary to assist the plants in establishing, especially during periods of drought. Checks should also be made after any major rain event where water may cause damage to the plants or cages. While the plants are being examined, opportunities for adaptive management should be considered. For example, if deer feeding pressure is heavy, more protective tree shelters or deer repellents may need to be used. Over time, as the plants are established, the routine checks can be reduced in frequency.

During the first year of growth, the grasses and herbaceous cover should be mowed once to control weeds and to enhance competitive growth.

Site 55: This buffer site is a drainage swale in a pasture on a preserved farm located on Sidney Road in Franklin Township, New Jersey. It drains runoff from the upper sections of the pasture and from the hard and compacted surfaces surrounding the barn area. It drains to a wetland area where a gas line runs along the southern border of the parcel.

Figure 40. Buffer Site 55

Existing Conditions: This swale is an excellent opportunity for buffer implementation. The swale is vegetated, but it is grazed regularly by cattle. Livestock can compact as well as loosen soil that can easily be eroded when there is little vegetation. The steepness of the swale also contributes to the erosive power of stormwater flowing through the swale. By using a buffer guideline of at least 35 feet, this buffer totals 3.7 acres in size.

Soil Conditions: The soil in the area of this buffer is primarily made up of Pattenburg gravelly loam. The estimated grade on this site ranges from two to twelve percent.

Plant Species: In order to maintain the area surrounding this site as viable pasture, trees will not be used for this buffer site. A combination of small shrubs and herbaceous ground cover will be used to stabilize the soil, provide some hydraulic roughness, and reduce erosion. A riparian buffer grass seed mixture will be used to achieve these benefits. In addition, several species of shrub will help to form a natural fence and will deter cattle from entering the swale.

Table 12. Plants appropriate for Buffer Site 55	
Plant Species	**Comments**
Arrowwood, *Viburnum dentatum*	High avian wildlife value, late spring flower
Spicebush, *Lindera benzoin*	Mature height 20 ft.
Silky Dogwood, *Cornus amomum*	High avian wildlife value, fruit production in 2-3 years
Sweet Pepperbush, *Clethra alnifolia*	High avian wildlife value, summer flower
Big Bluestem, *Andropogon gerardii*, Indiangrass, *Sorghastrum nutans*, Switchgrass, *Panicum virgatum*, Bush Clover, *Lespedeza capitata*	Warm season grasses that act as filter strips, grows well on steep slopes
Creeping Red Fescue, *Festuca rubra* var. *rubra*	Provides erosion control while warm season grasses establish

Cost: The major cost incurred at this site will be fencing or some other exclosure to ensure the buffer is not grazed. This will allow plants and seeds to establish without heavy cattle and deer pressure. An alternate source of water may need to be installed if the stream serves as the primary source of water in this pasture. In addition, a crossing must be provided for the cattle to access the section of pasture beyond the swale.

Plant material is available in a variety of sizes and this will greatly affect overall costs. Container size "#1" are seven inches deep by six inches in diameter, container size "#2" are nine inches deep by eight inches in diameter, and container size "#3" is nine and three-quarters inches deep by eleven inches in diameter. Listed below are cost estimate for plant material, excluding hay for the seed, labor, maintenance and any fencing that will be necessary to exclude cattle from the buffer.

It should be noted that site may be eligible for cost share programs offered through the various Farm Bill agencies, particularly through the Natural Resources Conservation Service.

Table 13. Plant Cost Estimate for Buffer Site 55				
Plant Species	**Number of Plants**	**Container Size**	**Approximate Cost/Unit**	**Approximate Total Cost**
Arrowwood, *Viburnum dentatum*	20	#1	$7.00	$140.00
Spicebush, *Lindera benzoin*	20	#1	$7.00	$140.00
Silky Dogwood, *Cornus amomum*	20	#1	$7.00	$140.00
Sweet Pepperbush, *Clethra alnifolia*	20	#1	$7.00	$140.00
Big Bluestem, *Andropogon gerardii*, Indiangrass, *Sorghastrum nutans*, Switchgrass, *Panicum virgatum*, Bush Clover, *Lespedeza capitata*	12 lbs/acre	44.4 lbs	$16.00/lb	$710.40
Creeping Red Fescue, *Festuca rubra* var. *rubra*	15 lbs/acre	55.5 lbs	$16.00/lb	$888.00
TOTALS	**80 shrubs and seed**			**$2158.40**

Design: The design of this buffer should be relatively basic, with the shrubs planted along the swale, with the seed mix planted in a 35-40 feet wide strip on each side. Prior to planting the seed, the site may need to be prepared by removing some of the existing vegetation. The grass seed will need to be planted with a grass drill.

Post Planting Maintenance: Routine monitoring of a recently planted buffer is critical to the success of the buffer. For the first several months after planting, weekly checks for deer damage or movement of tree shelters will be beneficial to the function of the buffer. Watering may be necessary to assist the plants in establishing, especially during periods of drought. Checks should also be made after any major rain event where water may cause damage to the plants or cages. While the plants are being examined, opportunities for adaptive management should be considered. For example, if deer feeding pressure is heavy, more protective tree shelters or deer repellents may need to be used. Over time, as the plants are established, the routine checks can be reduced in frequency.

During the first year of growth, the grasses and herbaceous cover should be mowed once to control weeds and to enhance competitive growth.

Appendix D

Riparian Buffer Restoration Demonstration Site

Appendices

A - Freshwater Wetlands Permit

B - Species List

C - Site Photographs

Appendix A – Freshwater Wetlands Permit

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Land Use Regulation
Mail Code 501-02A
P.O. Box 420
Trenton, New Jersey 08625-0420
www.state.nj.us/dep/landuse

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

MAY 19 2011

Rick Anthes
NJWSA
74 E. Main Street
Somerville, NJ 08876

RE: Authorization for Freshwater Wetlands Statewide General Permit No. 16, Water Quality Certification, and Access Waiver for a General Permit
File No.: 1025-04-0003.1FWW110001
Applicant: Union Twp. EC/NJDEP Watershed Restoration 319
Project: Sidney Brook Watershed Protection Plan
Block: 22 Lot: 20
Union Township, Hunterdon County

Dear Mr. Anthes:

The Division of Land Use Regulation has reviewed the referenced application for a Statewide General Permit authorization pursuant to the requirements of the Freshwater Wetlands Protection Act Rules at N.J.A.C. 7:7A. The proposed activity is authorized by Statewide General Permit No. 16, which authorizes activities in freshwater wetlands and/or transition areas, necessary for the restoration, creation, or enhancement of the habitat and water quality functions and value of wetlands.

Limit of Authorized Disturbance

Based on plans entitled: **"SIDENY BROOK WATERSHED PROTECTION PLAN DEMONSTRATION RIPARIAN BUFFER IMPLEMENTATION WETLANDS DELINEATION AND PLANTING AREA UNION TOWNSHIP, NJ BLOCK 22, LOT 20"**, consisting of one plan sheet, dated January 2011, unrevised, and prepared by NJWSA.

The authorized activity involves the removal of invasive species (canary reed grass and multi flora rose) and the planting of 200 – 300 native trees (Atlantic white cedar, Eastern cottonwood, Pin oak, River birch, Swamp white oak, Black willow and Silver maple) along a section of Sidney Brook under a General Permit 16. Any additional disturbance of freshwater wetlands, State open waters or transition area shall be considered a violation of the Freshwater Wetlands Protection Act unless the activity is exempt or a permit is obtained prior to the start of the disturbance from the Division of Land Use Regulation.

Permit Conditions

The activities allowed by this authorization shall comply with the following conditions. Failure to comply with these conditions shall constitute a violation of the Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 *et seq.*).

Special Conditions

1. Prior to the commencement of site clearing, grading or construction, the permittee is responsible for having a silt fence erected at the limit of disturbance. This fence shall serve as both a siltation and debris barrier as well as a physical barrier protecting the remaining wetlands ands stream channel from encroachment by construction vehicles or activities. This fence shall be kept in place and maintained throughout the duration of construction, until such time that the site is stabilized.

2. In order to protect the warm water and trout maintenance fishery resource within Sidney Brook, any proposed grading or construction activities within the banks of this or any other water course on-site are prohibited between March 15 and July 31 of each year. In addition, any activity within the 100 year floodplain or flood hazard area of this watercourse which would introduce sediment into said stream or which could cause in the natural level of turbidity is also prohibited during this period. The Department reserves the right to suspend all regulated activities on-site should it be determined that the applicant has not taken proper precautions to ensure continuous compliance with this condition.

In addition to the above conditions and the conditions noted at N.J.A.C. 7:7A 4.3 and 5.16, the following general conditions must be met for the activity authorized under this Statewide General Permit:

General Conditions

1. All fill and other earth work on the lands encompassed within this permit authorization shall be stabilized in accordance with "Standards for Soil Erosion and Sediment Control in New Jersey" to prevent eroded soil from entering adjacent waterways or wetlands at any time during and subsequent to construction.

2. This permit is revocable in accordance with DEP regulations and State law.

3. The issuance of this permit shall not be deemed to affect in any way other actions by the Department on any future application.

4. The activities shown on the approved plans shall be constructed and/or executed in conformity with any notes and details on said plans and any conditions stipulated herein.

5. No change in plans or specifications shall be made except with the prior written permission of the Department.

6. The granting of this authorization shall not be construed to in any way affect the title or ownership of the property, and shall not make the Department or the State a party in any suit or question of ownership of the property.

7. This permit is not valid and no work shall be undertaken pursuant to this authorization until all other required federal, state, and local approvals, licenses and permits necessary for commencement of work onsite have been obtained.

8. A complete, legible copy of this permit shall be kept at the work site and shall be exhibited upon request of any person.

9. The permittee shall allow the Division the right to inspect the construction site and also shall provide the Bureau of Coastal and Land Enforcement, NJDEP with written notification 7 days prior to the start of the authorized work.

10. This authorization is valid for five years from the date of this letter unless more stringent standards are adopted by rule prior to this date.

Transition Area

The wetlands affected by this permit authorization are of Exceptional Resource Value and the standard transition area or buffer required adjacent to these wetlands is 150 feet. This General Permit includes a transition area waiver, which allows encroachment only in that portion of the transition area, which has been determined by the Department to be necessary to accomplish the regulated activities. Any additional regulated activities conducted within the standard transition area on-site shall require a separate transition area waiver from the Division. Regulated activities within a transition area are defined at N.J.A.C. 7:7A-2.6.

Appeal of Decision

In accordance with N.J.A.C. 7:7A-1.7, any person who is aggrieved by this decision may request a hearing within 30 days after notice of the decision is published in the DEP Bulletin by writing to: New Jersey Department of Environmental Protection, Office of Legal Affairs, Attention: Adjudicatory Hearing Requests, 401 East State Street, P.O. Box 402, Trenton, NJ 08625-0402. This request must include a completed copy of the Administrative Hearing Request Checklist. If a person submits the hearing request after this time, the Department shall deny the request. The DEP bulletin is available through the Department's website at www.state.nj.us/dep.

Please contact Tina Wolff of our staff at (609) 777-0454 or e-mail at Tina.Wolff@dep.state.nj.us should you have any questions regarding this letter. Be sure to indicate the Division's file number in all communication.

Sincerely,

Daniel Bello

Daniel Bello, Supervising Environmental Specialist
Central Region
Bureau of Inland Regulation

c. Union Township Municipal Construction Official w/ plan
Union Township Municipal Clerk
Dave McPartland, NJWSA

ADJUDICATORY HEARING REQUEST CHECKLIST
AND TRACKING FORM

I. Permit Decision or Other Department Decision Being Appealed:

____

____

Issuance Date of Decision Document   Document Number (if any)

II.

______________________________   ______________________________
Name of Person Requesting Hearing   Name of Attorney (if applicable)

______________________________   ______________________________

______________________________   ______________________________
Address   Address

______________________________   ______________________________
Telephone No.   Telephone No.

III. If you are the applicant or permittee, please include the following information with your hearing request:

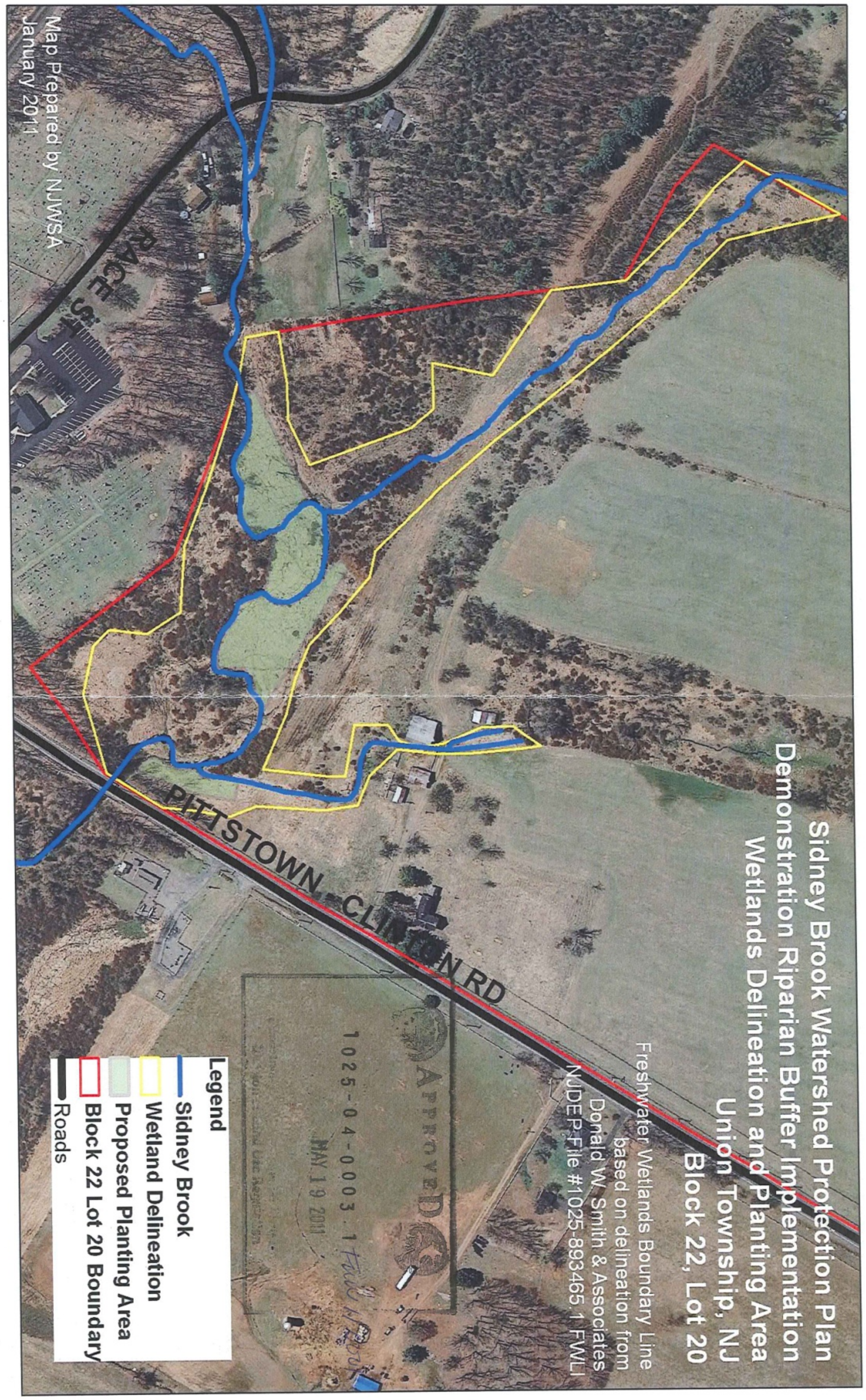
A. The date you received the permit decision or other decision which you are appealing;
B. A copy of the decision document;
C. The findings of fact and conclusions of law you are appealing;
D. A statement as to whether or not you raised each legal and factual issue during the permit application process;
E. Suggested revised or alternative permit conditions;
F. An estimate of the time required for the hearing;
G. A request, if necessary, for a barrier-free hearing location for physically disabled persons;
H. A clear indication of any willingness to negotiate a settlement with the Department prior to the Department's processing of your hearing request to the Office of Administrative Law; and
I. This form, completed, signed and dated with all of the information listed above, including attachment, to:

1. New Jersey Department of Environmental Protection
Office of Legal Affairs
Attention: Adjudicatory Hearing Requests
401 E. State Street
P.O. Box 402
Trenton, NJ 08625-0402;

with a copy to:

2. New Jersey Department of Environmental Protection
Land Use Regulation Program
Attention: Director
501 E. State Street
P.O. Box 439
Trenton, NJ 08625-0439

Signature:______________________________ Date:____________



Sidney Brook Watershed Protection Plan
Demonstration Riparian Buffer Implementation
Wetlands Delineation and Planting Area
Union Township, NJ
Block 22, Lot 20
Freshwater Wetlands Boundary Line
based on delineation from
Donald W. Smith & Associates
NJDEP File #1025-893465.1 FWLI
RACE ST
PITTSTOWN - CLINTON RD
APPROVED
1025-04-0003.1
MAY 19 2011
Legend
Sidney Brook
Wetland Delineation
Proposed Planting Area
Block 22 Lot 20 Boundary
Roads
Map Prepared by NJWSA
January 2011

Sidr

Appendix B – Species List

Pinelands Nursery
323 Island Road
Columbus, NJ 08022
Phone:(609) 291-9486 Fax:(609) 298-8939
Email:sales@pinelandsnursery.com

Pinelands
Nursery & Supply

Packing Slip

ORDER NUMBER:	3412
CUSTOMER NO:	7184
REPRINT DATE:	06/16/2011
PAGE NUMBER:	1 of 1
PO#:	PO #111010D

Bill To:
NJ WATER SUPPLY AUTHORITY
74 EAST MAIN STREET
SOMERVILLE, NJ 08876-2312

Ship To:
NJ WATER SUPPLY AUTHORITY
88 PITTSTOWN
ANNANDALE, NJ 08801

PHONE 908/685-0315
PHONE
FAX: 908/685-0195

CONTACT RICHARD ANTHES
TERMS: NET 30 DAYS
DATE ORDERED: 6/10/2011

REQUEST DATE 7:30 a.m.
SHIP METHOD Pinelands
SHIP ORDER: NO

Line	Quantity Ordered	Quantity Confirmed	Genus	Variety	Container / Plant Size	Unit Price	Line Total
1	19	19	ACER	SACCHARINUM	#2 NJ 5/6		
2	23	23	BETULA	NIGRA	#2 NJ 4/5		
3	23	23	CHAMAECYPARIS	THYOIDES	#2 NJ 4/5		
4	80	80	CORNUS	SERICEA	#2 NJ 18-24		
5	23	23	QUERCUS	BICOLOR	#2 NJ 4/5		
6	23	23	QUERCUS	PALUSTRIS	#2 NJ 3/4		
7	80	80	SALIX	NIGRA	#2 NJ 2/3		
8	1	1	Z S&H PINELANDS	PER LOAD (Rate valid for 30 days)	00 00		

272 ITEMS TOTAL

THANK YOU FOR YOUR ORDER

Approved By

Accepted By

All Claims To Be Made Within 10 Day

NO: 11001164 JANUARY 1, 2011

NEW JERSEY DEPARTMENT OF AGRICULTURE
PO BOX 330, TRENTON, NEW JERSEY 08625-0330
NURSERY CERTIFICATE

This certifies that the stock actually in the nursery when examined was apparently free from injurious plant pests.

Furthermore, this certificate is conditioned upon the nursery receiving or distributing only stock which is accompanied by an official valid certificate of inspection indicating that the nursery stock was inspected and certified to be apparently free of dangerously injurious insects and plant diseases.

This certificate shall be valid until December 31, 2011, or until subsequent inspection finds infestation of dangerously injurious insects and plant diseases.

PINELANDS NURSERY
323 ISLAND RD.
COLUMBUS, NJ 08022

Carl P. Schulze, Jr.
Director, Division of Plant Industry

Thursday, June 16, 2011

Page 1 of 1

Appendix C – Site Photographs

Figure 1: Sidney Brook riparian buffer planting at Milligan Farm

Figure 2: Sidney Brook riparian buffer planting at Milligan Farm

Figure 3: Sidney Brook riparian buffer planting at Milligan Farm

Appendix E

Properties Identified Through Critical Area Criteria

Open Space Acquisition - Critical Area Worksheet												
Block	Lot	Street Location	Acres	Number of Critical Area Overlap	Habitat	Riparian	Wetlands	Wetland Buffer	Groundwater Recharge	Erodible Soil	Dense Forest	Comments
00005	00007	81 SIDNEY ROAD	80.11	less than 1/4 acre of 3 CA								>1/2 in study area, farm, stream flows through corner of parcel
00025	00018 06	HILLTOP LN	49.75	3, 4	4a, 3b, 3c	4a, 3b			all		4a, 3a, 3c	>50% w/ CA, Forest & Farm
00025	00035 01	140 PITTSTOWN RD	5.71	3	3a	3a	3a					
00010	00030	115 PITTSTOWN ROAD	3.39	less than 1/4 acre of 3 CA								
00025	00013	3 RACE ST	0.51	3, 4	3a, 4a	3a, 4a			4a		3a,4a	
00005	00021	93 SIDNEY ROAD	3.67	less than 1/4 acre of 3 CA								stream goes through parcel
00004	00007	25 GRANDIN ROAD	2.79	3	3a	3a			3a			
00010	00006	131 PITTSTOWN ROAD	38.85	3	3a	3a	3a					farm
00028	00012	JUTLAND-MECHLIN CORNER	60.10	3		3a,3b			3a,3b	3b	3a	
00025	00020	27 RACE ST	0.30	3, 4	3a,4a,4b	3a, 4a, 4b			3a, 4a, 4b	4a	4b	
00025	00009	25 RACE ST	0.60	3		3c	3a	3a, 3b	3a, 3b, 3c	3b, 3c		
00025	00022	45 RACE ST	1.20	less than 1/4 acre of 3 CA								
00025	00019	HILLTOP LN	0.07	3, 4	3a, 4a	4a			3a, 4a		3a, 4a	
00025	00017	5 RACE ST	0.60	3, 4	3a, 4a	3a, 4a			4a		3a, 4a	
00025	00006 01	RACE ST	9.38	3, 4	3a, 3b, 4a	3a, 3b, 4a			3a, 4a		3b, 4a	
00025	00010	23 RACE ST	5.80	3,4	3a, 3b, 4a	3a, 3b, 4a			3a, 4a	3b, 4a		
00025	00006	49 RACE ST	25.01	3	3b, 3c	3a, 3b, 3c			3a, 3b	3a, 3c		
00025	00018 05	118 PITTSTOWN RD	2.18	less than 1/4 acre of 3 CA								
00028	00035	619 COUNTY RD 579	12.83	3		3a			3a		3a	
00028	00036	COUNTY RD 579 ROW	3.46	3		3a			3a		3a	

00025	00011	RACE ST	10.30	less than 1/4 acre of 3 CA								stream flows along parcel boundary
00027	00010 02	16 FINN RD	4.31	3		3a			3a		3a	
00025	00035	PITTS-CLINTON RD	149.77	3, 4	3a, 3b, 4a	3b, 4a			3a, 3b, 4a		3a, 4a	
00027	00010 01	18 FINN RD	5.20	3		3a, 3b			3a, 3b	3b	3a	stream flows through property
00028	00021	FINN ROAD	57.45	less than 1/4 acre of 3 CA								stream flows along parcel boundary
00025	00027	RT 635/PERRYVILLE RD	27.95	less than 1/4 acre of 3 CA								farm; stream flows through parcel
00028	00033	647 COUNTY RD 579	73.25	3			3a	3a, 3b	3a, 3b	3b		farm
00025	00018 01	HILLTOP LN	30.98	3,4,5	3a, 3b, 4a, 5a	3a, 4a, 5a	4a, 5a		3a, 3b	5a	3b	
00009	00002	100 SIDNEY ROAD	6.65	3	3a				3a		3a	
00004	00010	96 SIDNEY ROAD	6.88	3	3a	3a			3a			stream flows through adjacent property
00025	00018 04	PITTSTOWN RD	36.29	3,4	3a, 3b, 3c, 4a	3b, 3c, 4a			3a,3b, 4a		3a, 3c, 4a	
00025	00018 03	PITTSTOWN-CLINTON ROAD	12.90	3, 4, 5	3a, 3b, 4a, 4b, 5a	3a, 3b, 4a, 4b, 5a			4a, 5a	3b, 5a, 4b	4a, 5a, 3b	contiguous with B25 CAs
00004	00012	27 GRANDIN ROAD	2.63	3	3a	3a			3a			
00005	00014	97 SIDNEY ROAD	3.15	3	3a	3a			3a			
00028	00045	21 FINN RD	5.94	3		3a			3a		3a	
00005	00017	107 SIDNEY ROAD	3.53	less than 1/4 acre of 3 CA								
00025	00002	61 RACE ST	47.95	less than 1/4 acre of 3 CA								stream flows through corner of property
00025	00002	61 RACE ST	47.95	less than 1/4 acre of 3 CA								large parcel along lake on Race St.
00004	00009	9 GRANDIN ROAD	1.13	less than 1/4 acre of 3 CA								stream flows through property
00022	00020	ROUTE 513 GRANDIN	102.22	3	3a	3a				3a		Milligan - owned by NJWSA
00005	00016	17 LOWER LANDSDOWN ROAD	105.82	3	3a, 3b, 3c	3a, 3c			3b, 3c	3a, 3b		large parcel at confl. Of Sidney and SB

00005	00014 01	95 SIDNEY ROAD	6.70	3	3a	3a			3a			stream runs through forested area on parcel
00010	00003	117 PITTSTOWN ROAD	4.25	3, 4	3a, 3b, 4a	3a, 4a	3a, 3b, 4a	3b, 4a				
00010	00008	67 HOGBACK ROAD	18.17	less than 1/4 acre of 3 CA								
00022	00030	5 ROUTE 173 E	63.71	3		3a			3a	3a		
00005	00019	99 SIDNEY ROAD	1.03	less than 1/4 acre of 3 CA								
00028	00024	3 FINN RD	56.74	less than 1/4 acre of 3 CA								headwaters flow through parcel
00025	00018 08	114 PITTSTOWN RD	9.32	less than 1/4 acre of 3 CA								stream runs through property
00004	00003	71 PITTSTOWN ROAD	120.60	3	3a, 3b	3a, 3b			3a	3b		buffer site 55, main stem goes through
00009	00001	PITTSTOWN ROAD	4.45	3	3a	3a	3a					
00025	00032	RT 635/PERRYVILLE RD	56.00	3		3a	3a, 3b, 3c	3b	3a, 3b, 3c		3c	
00025	00007	RACE STREET	28.30	3	3a, 3b	3a, 3b			3b	3a		~2,382 feet of stream length
00010	00002	107 PITTSTOWN ROAD	18.72	3,4	3a, 3b, 4a	3b, 4a	3a, 3b, 4a	3a, 4a				
00010	00004	48 GRANDIN ROAD	54.89	3	3a	3a	3a					large parcel, farm fields, pond, adj. to parcel with 4 CAs
00025	00021	47 RACE ST	47.10	3	3a		3b		3a, 3b		3a, 3b	forest
00005	00015	101 SIDNEY ROAD	5.52	3	3a				3a	3a		
00004	00006	29 GRANDIN ROAD	2.69	3	3a	3a			3a			CA combined with Hensler
00025	00018	HILLTOP LANE	12.18	3,4,5	4a, 4b, 5a	3a, 3b, 4b,5a	4b	5a	all		3a, 4a, 5a	contiguous with B25 CA

Appendix VI
Quality Assurance Project Plan

QUALITY ASSURANCE PROJECT PLAN (QAPP)
for the
SIDNEY BROOK WATERSHED PROTECTION PLAN

Union Township, Hunterdon County, New Jersey
319(h) Contract RP 07-003

Prepared by: Christine Altomari Date: March 17, 2009
Christine Altomari, Scientific Project Manager
Princeton Hydro, LLC

Reviewed by: Date: 3/17/09
Christopher Mikolajczyk, QA/QC Officer
Princeton Hydro, LLC

Reviewed by: Wm Harclerode Date: 4/14/09
William Harclerode
Union Township Environmental Commission
319(h) Grantee and Lead Planning Agency

Reviewed by: Date: 6-18-09
Nick Zripko, 319(h) Project Manager
NJDEP Bureau of Watershed Planning

~~Reviewed by: Date:~~
~~Robert Mancini, Section Chief~~
~~NJDEP Bureau of Watershed Planning~~

Approved by: Marc Ferko Date: 6/23/09
Marc Ferko, Quality Assurance Officer
NJDEP Office of Quality Assurance

QUALITY ASSURANCE PROJECT PLAN (QAPP)
for the
SIDNEY BROOK WATERSHED PROTECTION PLAN

UNION TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY

Submitted for the Section 319H NPS
Pollution Control and Management Implementation Grant:
Sidney Brook Watershed Protection Plan
02030105020070 South Branch of Raritan River (River Rd to Spruce Run)

Contract RP07-003

Submitted to:

New Jersey Department of Environmental Protection
Division of Watershed Management
P.O. Box 418
Trenton, New Jersey 08625-0418

Prepared by:

Princeton Hydro, LLC
P.O. Box 720
1108 Old York Road, Suite 1
Ringoes, New Jersey 08551

December 20, 2007
Revised May 2008
Revised March 2009

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PROJECT MANAGEMENT

Section 3: Distribution List

The following list (Table 1) identifies the key people involved with the Sidney Brook monitoring who will be included on all distributions for this Quality Assurance Project Plan (QAPP). All individuals included in this distribution list will be provided either an electronic or a paper copy of the QAPP prior to initiation of any field data collection. In addition, any formal revision to this QAPP will be provided to each individual in either paper or electronic form.

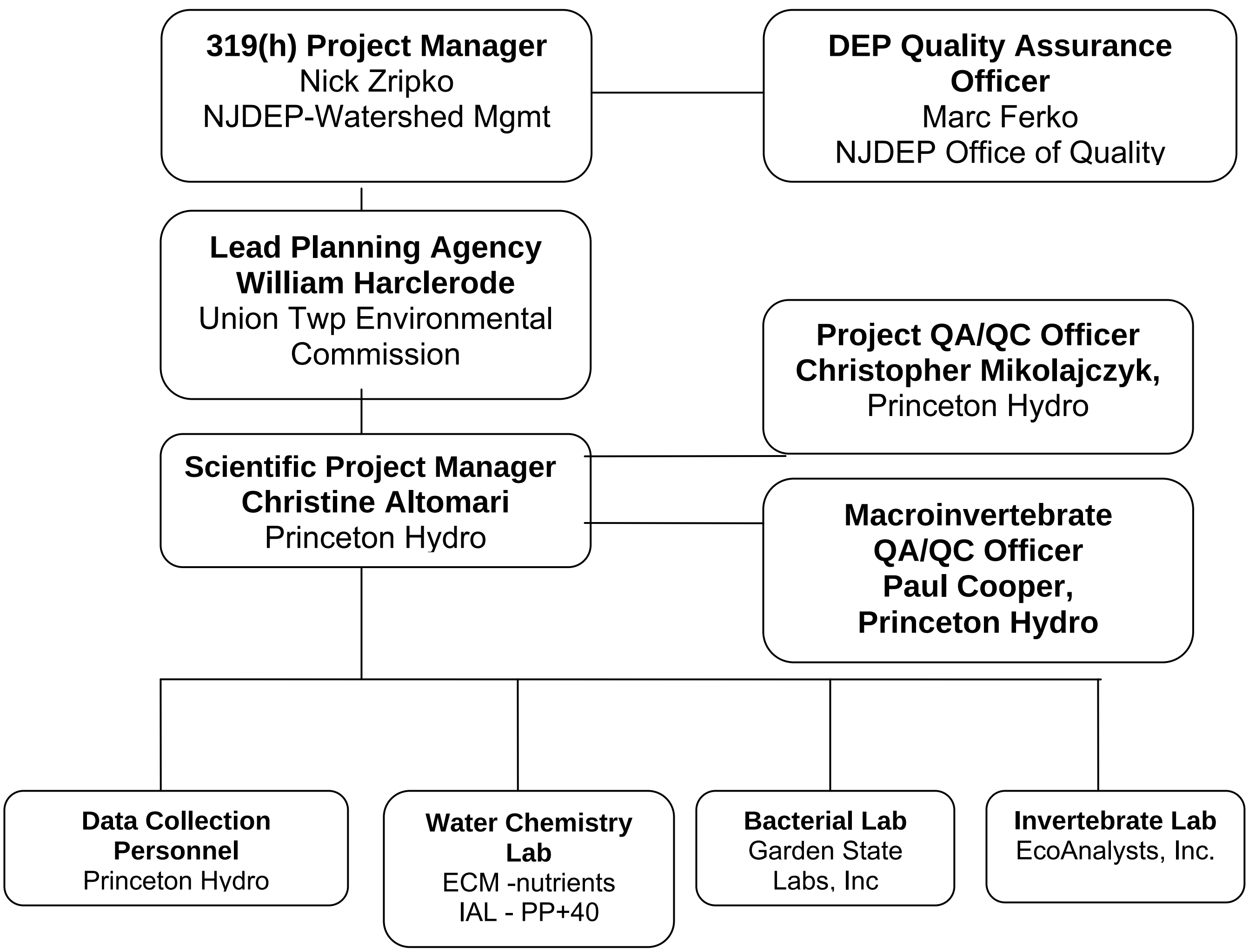
Table 1. Distribution List for QAPP and QAPP Revisions

Name	Organization	Address	e-mail
Christine Altomari, Scientific Project Manager	Princeton Hydro	P.O. Box 720 1108 Old York Road, Suite 1 Ringoes, New Jersey 08551	caltomari@princetonhydro.com
Christopher Mikolajczyk, QA/QC Officer	Princeton Hydro	P.O. Box 720 1108 Old York Road, Suite 1 Ringoes, New Jersey 08551	cmiko@princetonhydro.com
Paul Cooper, Staff Scientist	Princeton Hydro	P.O. Box 720 1108 Old York Road, Suite 1 Ringoes, New Jersey 08551	pcooper@princetonhydro.com
William Harclerode, Grantee	Union Twp Environmental Commission	140 Perryville Road Hampton, New Jersey 08827	**billharclerode@gmail.com**
Nick Zripko, 319(h) Project Manager	NJDEP – Division of Watershed Management	401 E. State Street P.O. Box 418 Trenton, NJ 08625-0418	nick.zripko@dep.state.nj.us
Marc Ferko, Quality Assurance Officer	NJDEP – Office of Quality Assurance	9 Ewing Street, 2nd Flr. PO Box 424 Trenton, NJ 08625-0424	marc.ferko@dep.state.nj.us

Section 4: Project Organization

The organizational structure for the Sidney Brook plan will be relatively simple (Figure 1), with the Union Township Environmental Commission serving as the Lead Planning Agency for all work. The NJDEP Division of Watershed Management will oversee the administration of the grant as well as compliance with the 319(h) nonpoint source funding goals, objectives, and project requirements. In addition, the NJDEP Office of Quality Assurance will provide general project oversight to ensure that the data collection efforts are of sufficient quality. The Scientific Project Manager will oversee all data collection efforts by contractual personnel at Princeton Hydro, IAL, Garden State Laboratory, and EcoAnalysts, Inc. and will report directly to Union Township. The Project Quality Assurance / Quality Control (QA/QC) Officer will provide detailed project oversight to ensure all data are collected in accordance with this Quality Assurance Project Plan and that these data meet the requirements set forth in this QAPP.

Figure 1. Organizational Chart for Data Collection on the Sidney Brook Watershed Protection Plan



Section 5: Problem Definition/Background

Water Quality Data

Sidney Brook is a 2nd order tributary to the South Branch of the Raritan River with a watershed drainage area of 5.5 square miles that spans much of southern Union Township and the northern portion of Franklin Township in Hunterdon County. Sidney Brook was adopted as a Category 1 stream in April 2003 by the NJDEP based on the populations of state-threatened wood turtles (*Glyptemys insculpta*) documented in Sidney Brook and the bog turtle (*Glyptemys muhlenbergii*) habitat within the watershed. In addition, initial biological and habitat surveys of Sidney Brook near the South Branch Raritan River confluence indicated diverse fish and invertebrate communities and high-quality stream habitat conditions, further motivating the change in designation from a Category 2 to a Category 1 waterbody. In May 2007, the NJDEP proposed to upgrade the upper segments of Sidney Brook to trout maintenance (TM) based on the recent documentation of young trout. The lower segment, south of Route 513 will remain designated as Non-trout (NT).

The Sidney Brook watershed currently contains a broad mix of human land uses, and based on the NJDEP 2002 land use GIS data, approximately 32.3% remains forest, 32.3% are farmlands, 9.0% are wetlands, and 26.0 % are developed lands. This can result in varied non-point source pollutants being introduced into Sidney Brook. The watershed is bordered by Interstate 78 and the Edna Mahan Correctional Facility for Women in the north. The western headwaters are dominated by a combination of older village residential and recent country residential areas interspersed with smaller forested tracts and limited agricultural lands. The southern and central portions of the watershed, however, primarily contain large forested and agricultural tracts of land with lower density residential. The watershed's landscape is being pressured with additional housing and commercial development in sensitive regions of the watershed. The watershed also spans the Highlands Preservation, the Highlands Planning, and non-Highlands areas, which may also increase the development pressures. This in turn could impact the existing water quality and potentially harm environmentally sensitive species using Sidney Brook, such as the state-threatened wood turtle.

The Sidney Brook Watershed lies within the NJDEP designated Watershed Management Area #8, hydrologic unit, HUC 02030105020070. Although the NJDEP recognized the sensitive and relatively high quality of Sidney Brook and the biological communities within the watershed, there remains limited water quality or biological survey data for this C1 stream and its watershed. In fact, Sidney Brook has not been included on the New Jersey 2006 and 2004 Integrated Water Quality Monitoring and Assessment Report (i.e., the 303(d) and 305(b) Integrated List), either under the name "Sidney Brook" as designated in N.J.A.C. 7:9B or under the name "Grandin Stream" as listed in the NJGS stream GIS layer. Thus, Sidney Brook effectively is included as part of Sublist 3 where insufficient information exists to determine if any designated use is attained.

NJDEP Amnet data was collected in 2001 from sample location AN0324A and received a Non-Impaired Rating. Additional macroinvertebrate sampling conducted by Princeton Hydro at three stations on Sidney Brook in August and November 2003 identified all three stations as Non-impaired (Race Street, Pittstown Rd and Sidney Rd). However, limited chemical sampling conducted by Princeton Hydro on Sidney Brook suggests that the stream may be experiencing some impacts from non-point source pollutants. Sampling conducted in November 2003 identified nitrate concentrations ranging from 1.7 to 2.4 mg/L at the stations downstream of the Race Street crossing, and fecal coliform was detected at 300 (CFU) at the Race Street station.

NJDEP Fish IBI data was collected in 2001 from sample location FIB1008 on Sidney Rd (Rte 617) in Franklin Township. The stream segment received an Optimal Habitat Assessment rating (score of 164) and the FIBI rating was excellent (score of 46). One Brook Trout was identified (with a length of 13 inches) and 15 Largemouth Bass were collected. The three most prevalent fish species included: Tesselated Darter (123); Blacknose Dace (112); and Longnose Dace (105). The presence of a Brook Trout in August is an indication of good water quality. In May 2007, the NJDEP proposed to upgrade the upper segment of Sidney Brook downstream to the Route 513 Bridge to a C1-Trout Maintenance designation. The segment downstream of Route 513 would remain C1 Non-trout. However, it should be noted that the brook trout identified by NJDEP in the sample FIB1008 was collected at Sidney Rd (Rte 617) downstream of Route 513. In August 2003, Princeton Hydro recorded finding a juvenile Brown Trout at the Race Street crossing just upstream of the Route 513 Bridge.

Section 6: Project/Task Description

The data collection efforts for the Sidney Brook consist of six separate tasks for measuring different components of stream health and quality:

1. Continuous Summer Water Temperature Monitoring
2. Physical and Chemical Water Quality
3. Priority Pollutants +40 (PP +40)
4. Bacterial Testing
5. Benthic Macroinvertebrates
6. Volumetric Stream Discharge

Originally, the project envisioned collecting data during separate field surveys over the course of a 12-month monitoring window; however, because of delays in the Stream Visual Assessment Program, the proposed stream monitoring data will be collected from April 2008 to November 2008. The following descriptions provide an overview of each task, the timing of data collection, and the number of data collection surveys. Detailed descriptions of the study design and methods can be found in Section 10 (Sampling Process Design) and Section 11 (Sampling Procedures and Requirements), and Table 2 presents a generalized project schedule. Additional collection of data for each of these tasks may occur on an as-needed basis during the project in response to site-specific events or conditions that cannot be foreseen. Any additional data collection will follow all protocols and requirements set forth in this Quality Assurance Project Plan.

Table 2. Field Sampling Schedule for Sidney Brook Data Collection

Tasks 2008		Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Task 1 - Temperature (continuous)										
Task 2 - Water Quality										
Task 3 – PP +40										
Task 4 - Bacterial										
Task 5 - Invertebrates										
Task 6 - Discharge										
Task 7 – Fish Survey										

Task 1: Continuous Temperature Loggers

Sidney Brook is proposed to be designated as a Category One-Trout Maintenance Stream (TM-C1), and the NJDEP identifies the Fish Index of Biotic Integrity for the upper reaches of Sidney Brook as "Excellent". However, one of the primary uncertainties regarding the existing conditions of Sidney Brook is the suitability of the stream to maintain a cold-water fishery resource (e.g., trout and other cold stenothermic species). Sidney Brook has been a yearly stocking location for brook and/or rainbow trout by the NJ Fish and Wildlife since records have been kept in 1986. However, the numerous small dams or road outfalls on the main stem as well as the tributaries to Sidney Brook, and the relatively narrow and immature riparian corridor along much of the stream, may lead to summer temperature regimes that are beyond the physiological tolerance of trout and other cold-water species. Limited sampling conducted by Princeton Hydro in August 2003 indicated that temperatures in the summer can exceed 20°C, and high storm flows can impact trout viability. The USGS sampling data from August 2006, identified water temperatures in the South Branch Raritan River at 28°C.

Princeton Hydro is a State-certified laboratory (#10006) for the *in situ* measurement of temperature, pH, specific conductivity, and dissolved oxygen. Princeton Hydro became State-certified for the collection of continuous water temperature monitoring in May 2007. Water temperature will be monitored at 7 stations on the Sidney Brook and its tributaries over the course of a nine month window (see Tables 9 and 10, Figure 2, Section 11, Task 1 for details and locations). Calibrated temperature loggers will be placed at each station during April and retrieved in October (Table 3). Limited trout stocking also occurs in some streams in the fall. The temperature loggers will be programmed to record water temperature at 15 minute intervals. Each logger will be inspected and field-calibrated during three intermediate surveys during the spring, summer and autumn deployment window, with each survey conducted under baseflow conditions to verify loggers remain submerged under low flows. During these intermediate surveys, data will be downloaded from the temperature loggers to a PDA computer without interruption of the logger program. Upon retrieval, data will likewise be downloaded from the temperature logger.

Task 2: Physical and Chemical Water Quality

Water quality monitoring will occur under both baseflow and stormflow conditions at 7 monitoring stations on the Sidney Brook (Table 9, Table 10, Figure 2, and Section 11, Task 2). Under baseflow conditions (see definition in Table 10), both direct measurements of water quality (temperature, dissolved oxygen, pH, conductivity) and discrete grab samples for water chemistry analysis (nitrate- nitrogen, total phosphorus, soluble reactive phosphorous (SRP or orthophosphate), total dissolved solids, total suspended solids) will be collected. Under stormflow conditions (see definition in Table 10), samples will be collected as a single integrated composite sample of stormwater conditions. These nutrient samples will be analyzed for the discrete water quality parameters (nitrate, total phosphorus, soluble reactive phosphorous (SRP), total dissolved solids, and total suspended solids) by Environmental Compliance Monitoring, Inc (ECM) (Hillsborough, NJ; NJ Certification # 18630).

Baseflow water quality monitoring will involve 1 monitoring survey during the spring, 2 surveys in the summer and 1 survey in the fall (Table 9, Table 10). Stormwater monitoring will likewise occur during these seasons, with a single storm event monitored in the Spring, Fall and Summer. Therefore, a total of 3 baseflow surveys and 3 stormwater surveys will be conducted over the course of the monitoring window.

Task 3: Priority Pollutant +40 (PP +40) Sampling of Stream and Sediments

A total of eight samples analyzed for priority pollutant analysis have been included in this scope of work. During one baseflow event a total of six samples will be collected, three aqueous samples and three sediment samples collected from stations #6, 7 and 10 on the main stem of Sidney Brook. The PP + 40 sampling stations are identified on Figure 2. The remaining two samples will be determined based on the preliminary results from this initial round of PP+40 analysis.

Specifically, these samples will be collected during one baseflow event and will be analyzed for the following parameters by Integrated Analytical Laboratories (IAL), a NJ State Certified analytical lab located in Randolph, NJ (NJDEP Certification IAL #14751): Volatile Organics, PCBs, Pesticides, Base Neutral / Acid Extractables, Cyanide, and Metals (Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Zinc) in order to comprehensively identify a broad suite of industrial, highway and human-derived pollutants.

Both aqueous and soil sampling is proposed because some of the parameters, such as the PCBs, Base Neutral compounds, Pesticides and Metals are more likely to be sequestered in sediment samples. In addition, limited sediment sampling conducted by the USGS on the South Branch Raritan River at the Stanton Station (01387000) identified several metals and PAH compounds at levels above the NJDEP Sediment Screening Criteria. This station is downstream from the confluence with Sidney Brook. A summary of this data is included in Appendix B. In addition, Union Township also provided limited sediment sampling data that identified the presence of PAHs in sediment in a tributary to Sidney Brook, just north of Pittstown Rd, or Route 513. Aqueous samples will also be collected to provide baseline data for the Category 1 stream. The collection of the two remaining PP+40 samples will be dependent upon the preliminary results, to assist in decisions for locations, parameters and the sample matrix.

Collecting sediment samples for Priority Pollutants + 40 will be limited to baseflow conditions and sampling stations # 6, 7 and 10 for the following reasons. First, the existing biological monitoring data from Sidney Brook suggest a relatively healthy community that would typically be found in locations without strong exposure to metals, organic compounds, or other anthropogenic pollutants. Therefore, the monitoring of these parameters in the central and lower sections of the watershed is intended primarily to document a potential chronic exposure of the stream community to any of these materials and to establish existing, baseline concentrations of these materials from which the Category 1 anti-degradation standards can be enforced. Second, the high costs for each sample precludes both greater numbers of sites and greater temporal replication without these analyses dominating the budget for the monitoring program. Again, because the existing data do not suggest heavy or chronic exposure to these contaminants, such broad sampling and high costs are not warranted at this time. Nevertheless, the mixture of industrial and urban development currently existing in the watershed, and the likelihood for moderate future expansion in these land uses, provides the rationale for a screening level monitoring program for these groups of contaminants.

Task 4: Bacterial Testing

Bacterial monitoring for E. coli bacteria will occur at 7 monitoring stations on the Sidney Brook (Table 9, Table 10, Figure 2, and Section 11, Task 3). A total of eleven (11) surveys will be conducted for bacterial concentrations. Three (3) seasonal baseflow events and three (3) stormflow events (one spring, one summer, one fall for both baseflow and stormflow) will occur along with the water quality monitoring of these **seven** sites during six events. In addition, to meet the data needs of the NJDEP, five (5) additional bacterial monitoring events will be scheduled during the summer monitoring events so that a total of five (5) bacterial measurements are taken at each station within a 30-day window between Memorial Day and Labor Day. This intensive 30-day monitoring will include both baseflow and elevated flow sampling events that reflect the ambient conditions in Sidney Brook during that 30-day window. The five sampling events will be spaced approximately evenly within the 30-day window. Samples for both baseflow and stormflow surveys of bacterial concentrations will be collected as single grab samples at the time of survey. The short holding times for bacterial samples precludes the use of extended composite sampling for these parameters. Bacteria samples will be analyzed by Garden State Laboratory, a NJ State Certified microbiological laboratory located in Hillside, NJ (NJDEP Certification #20044).

Task 5: Benthic Macroinvertebrates

Benthic macroinvertebrate samples will be collected at 8 monitoring stations on the Sidney Brook as a measure of the ecological integrity at these locations (Table 9, Table 10, Figure 2, and Section 11, Task 4). Each stream invertebrate sample will consist of a composite collection of 15 unit-area samples from a stream reach, spanning approximately 100 meters in length per each monitoring station according to NJDEP – Ambient Biological Monitoring (AMNET) protocols (NJDEP 2003). One survey of the benthic invertebrates will be conducted during the May-June survey. If an extended drought induces insufficient baseflow during the monitoring period, benthic macroinvertebrate sampling will occur in the fall if possible as per 2006 Integrated List Methodology. Stream flow conditions will be monitored as specified in Task **6**, and this information will be incorporated into our assessment of the macroinvertebrate data. In addition, 10% of the samples will be assessed by Princeton Hydro to ensure quality and reliance of the data. (See section 14)

Task 6: Volumetric Stream Discharge

Detailed discharge measurements will be collected at three (3) stations on Sidney Brook and its tributaries during the 12-month monitoring period (**Table 3**, Table 9, Table 10, Figure 2 and Section 11, Task 5. These three (3) stations are co-located with monitoring sites for water quality, bacterial concentration **and macroinvertebrate** monitoring sites (identified on the Sampling Stations map with red D-labeled dots). The discharge data will provide site-specific information on flow dynamics in the stream including storm hydrographs, volumes of flow passing each site, and changes in stream hydrology across the watershed. In addition, the site-specific discharge measurements will permit precise pollutant-loading estimates for different sections of the watershed.

Staff gauges and pressure transducers with data loggers will be installed at these three (3) stations to record depth measurement at established intervals (e.g., every 15 minutes) over the course of the monitoring window. Ratings curves will then be developed at each of these staff gauges to provide a means of computing discharge values based on the pressure transducer and staff gauge depth readings. To develop the ratings curves, discharge will be measured on a minimum of eight (8) occasions for each gauging station. Discharge will be measured using a USGS Price Type AA flow meter, with depth and flow measurements taken at 25 to 30 locations across the stream's cross section at each sampling station. The ratings curve will then be developed using USGS protocols for linear regression models based on log-transformed data.

The discharge estimates will be used to characterize the Sidney Brook hydrologic unit, HUC 0203015020070. Limited flow readings will also be collected during each sampling event at key locations in the watershed, for example, down gradient of the confluence of two major streams. This will be conducted at distinct times during the sampling (once in fall, spring and summer). These data will be used in concert with the computational modeling approach to estimate flow data to compute loading rates.

Section 7: Quality Assurance Objectives and Criteria

The project's data collection program seeks to collect environmental data from the Sidney Brook watershed that accurately represents the distribution of environmental conditions at the selected sampling sites. These data need to be of sufficient quality and quantity in order to distinguish important changes in these environmental conditions across sampling sites, with replication through time used to establish the consistency of any differences. To achieve these Data Quality Objectives (DQOs), acceptable limits for sampling and instrument variability will be established. Data that does not attain the Data Quality Objectives will either be discarded or will be flagged (minor non-compliance issues) for all future analyses and publications.

Summaries of all water quality parameters to be measured and analytical methods to be used are shown in Tables 5, 6 and 7. These tables were developed in coordination with the independent analytical laboratories; Environmental Compliance Monitoring, Inc. (ECM), and Integrated Analytical Laboratories, Inc. (IAL), who will follow the methods and protocols listed in these Tables. Information on project detection limits, precision and accuracy for discrete parameters of interest is listed in these tables. Princeton Hydro, LLC will also conduct all *in-situ* water quality monitoring, and the information on project detection limits, levels of interest, precision and accuracy for the *in-situ* parameters is listed in Table 4.

Precision - The precision of data collection procedures will be evaluated depending on the data collection task and the data parameter (see Tables 4 through 7 and Appendix C). When duplicate samples are analyzed the absolute differences will be evaluated.

Accuracy – Accuracy of all data sources will be attained through personnel training and various Quality Control procedures. Calibration and maintenance of laboratory equipment are critical components to ensuring accurate data (see Sections 15 and 16). In addition, based on field protocols and sampling frequencies a field duplicate is proposed to be collected and analyzed at a minimum basis of one for each daily sampling event to evaluate data accuracy.

Data Sensitivity – Certified laboratories, methods and equipment have been selected for this project which will provide detection limits at or below the value for which ecological changes and responses are typically observed. In addition, the methods and equipment used in this project will have sufficient sensitivity such that changes in the data parameters are clearly measured through the data collection procedures. The specific details on detection limits and sensitivity are provided in the Method Detection Limits (MDLs), in the accompanying Tables 4 through 7, and Appendix C.

Representative Data - Attaining data representative of the range of environmental conditions experienced throughout the Sidney Brook watershed requires an appropriate study design, sampling site determination, and project execution. The study design for each project task is described in Section 6 and again in Section 10. The central focus for the study design is to collect data under conditions representative of the variations seen throughout the year (e.g., seasonal samples under baseflow and stormflow conditions) and to include adequate temporal replication in order to narrowly define the central tendency of each data parameter. Sampling site location is likewise central to attaining representative data. Sites have been selected to span the range of stream sizes within the watershed, within budget and logistic limitations, and the specific location of each sampling site has been chosen in areas outside expected mixing zones for point or nonpoint source pollutants. Finally, the development and execution of the project according to this Quality Assurance Project Plan will ensure that the efforts spent designing the study and determining sampling sites will be matched with equal diligence and care. Specific training, documentation, and quality control elements within the QAPP will provide the vehicle for successfully executing these procedures as well as documenting the quality of the resulting data. Together, this suite of efforts will yield data that represents the environmental conditions, and the typical variability in these conditions, within the Sidney Brook watershed.

Data Comparability - Analytical data comparability will be achieved by following the analytical methodology, preservation practices and holding times described in Table 11 and 12. Each parameter will be analyzed using the referenced methodology and changes in analytical procedures will not take place from sample to sample. The same holds true for sample preservation, holding times and QA/QC practices.

The comparability of data collected during this project will be attained through the use of a series of efforts: qualified and trained personnel to collect and analyze samples; established and calibrated equipment for all measurements; standard operating procedures and quality control methodologies for all sample collection and measurement; and accepted sampling handling and holding procedures for any collected samples (see Sections 8, 11, 12, 16). Through these procedures, data for this project will be internally consistent and therefore directly comparable among sites and dates.

The project data will also attain broader comparability by utilizing procedures, equipment, and laboratories that have been accepted by authorities in the State of New Jersey. This comparability will be further ensured through the development and review of this Quality Assurance Project Plan by the New Jersey Department of Environmental Protection staff. By standardizing the methods, training, and equipment, and by following the quality assurance and quality control procedures set forth in this QAPP, the data collected during this project will be directly comparable to data collected by state and federal agencies measuring similar data parameters within New Jersey.

Data Completeness: The extent of complete data collection will be monitored for each of the 6 project tasks. Data will be considered complete and usable for decision-making when all results have been completed and submitted to the New Jersey Department of Environmental Protection, and the Union Township -Sidney Brook stakeholders, in accordance with the sampling and analytical methodology and the required QA/QC practices listed in this project plan. However, it is recognized that on occasion data loss may occur as a result of sampling equipment malfunction, losses during sample handling, or analysis outside of laboratory acceptance limits. Samples will be re-analyzed if results are outside of laboratory acceptance limits, providing that sufficient sample volume is available and that holding times for the affected parameters(s) have not been exceeded.

Spiking Protocol: The State certified laboratories will perform a laboratory matrix spike, at a frequency of one for every twenty samples analyzed. Standards will be checked by the laboratory daily or every twenty samples, whichever is less. A Standard Curve is generated once every three months, at a minimum.

Table 3. In Situ Field Analytical Procedures

Parameter	Organization or Laboratory	Analytical Method		Achievable Laboratory Limits*	
		Method / SOP	Modifications	Method Detection Limits	Method
Temperature (continuous)	Princeton Hydro SOPs IS-06.8, TD-06.8-cal	SM 18th Ed. 2550;	none	0º - 50º C	Manufacturer's specification and design
Temperature (*in situ*)	Princeton Hydro SOPs IS-06.8, TD-06.8-cal	SM 18th Ed. 2550;	none	-5º - 50º C	Manufacturer's specification and design
Specific Conductivity	Princeton Hydro SOPs IS-06.8, SC-06.8-cal	SM 18th Ed. 2510;	none	0.001 mS/cm	Manufacturer's specification and design
pH	Princeton Hydro SOPs IS-06.8, PH-06.8-cal	SM 18th Ed. 4500-H^+ B;	none	2.0 to 12.0 standard units	Manufacturer's specification and design
Dissolved Oxygen	Princeton Hydro SOPs IS-06.8, PH-06.8-cal	SM 18th Ed. 4500-O G;	none	0.2 mg/L	Manufacturer's specification and design
Volumetric Discharge**	Princeton Hydro	SOP QF-06.8	none	variable; depends on channel morphology	Manufacturer's specification on flow meter sensitivity (0.10 ft/sec) data on channel cross section

(na) = not applicable
SM 18th Ed. = Standard Methods for the Examination of Water and Wastewater, 18th Edition, 1992
EPA=Methods for Chemical Analysis of Water and Wastes, 1983
MDL = Minimum concentration of a substance that can be measured and reported with a 99% confidence level that the analyte concentration is greater than zero. (40CFR 136 Appendix B).

* Quality Control Procedures to assess performance include: temporal replicates, laboratory calibration and validation, and manufacturers performance specifications and QC.

** Volumetric Discharge Quality Control Procedures to assess performance include: Repeat field measurement, Discharge measurement at USGS gauging station, Manufacturer's specifications (0.10 ft/sec)

Table 4. *In Situ* Water Quality Parameters: Data Quality Objectives

Analytical Parameter	Analytical Method / SOP Reference[1]	QUALITY CRITERIA Precision	Accuracy	Sensitivity	QC Procedure to Assess Performance
Temperature	SM 18th Ed. 2550, Princeton Hydro SOPs IS-06.8, TD-06.8-cal	RPD<5%			Measurement replicate (temporal)
			± 0.2 ° C		Laboratory calibration and validation
			± 0.2 ° C		Manufacturer performance specification and QC
				0.01 ° C	Manufacturer performance specification and QC
Specific Conductivity	SM 18th Ed. 2510, Princeton Hydro SOPs IS-06.8, SC-06.8-cal	RPD<5%			Measurement replicate (temporal)
			± 0.010 mS/cm		Laboratory calibration and validation
			± 0.001 mS/cm plus ± 1% of reading		Manufacturer performance specification and QC
				0.001 mS/cm @ <1.000 mS/cm	Manufacturer performance specification and QC
pH	SM 18th Ed. EPA 4500-H^+ B, Princeton Hydro SOPs IS-06.8, PH-06.8-cal	Δ<0.20 standard units			Measurement replicate (temporal)
			± 0.2 units		Laboratory calibration and validation
			± 0.2 units		Manufacturer performance specification and QC
				0.01 units	Manufacturer performance specification and QC
Dissolved Oxygen	SM 18th Ed. EPA 4500-O G, Princeton Hydro SOPs IS-06.8, DO-06.8-cal	RPD<10%			Measurement replicate (temporal)
			± 0.5 mg/L		Laboratory calibration and validation
			± 0.2 mg/L		Manufacturer performance specification and QC
				0.01 mg/L	Manufacturer performance specification and QC

[1] - SM=Standard Methods for the Examination of Water and Wastewater, 18th Ed, 1992
[2] - EPA=Methods for Chemical Analysis of Water and Wastes, 1983
Δ = the absolute value of the difference between repeat measurements = $|x_1 - x_2|$
μ = the mean value of repeat measurements = $(x_1 + x_2) / 2$
RPD = relative percent difference (see Section 7.2.1)

Table 5. Nutrient and Pathogen Laboratory Analytical Procedures

Parameter	Laboratory	Method /SOP	Modifications	Method Detection Limit (MDL)
Nitrate-Nitrogen	ECM	EPA 353.3/ 4500 SM 18th Ed.	none	0.02 mg/L
Total Phosphorus	ECM	SM 18th Ed. EPA 365.2/365.3 4500-P B-5 & E	none	0.01 mg/L
Soluble Reactive Phosphorus (SRP)	ECM	SM 18th Ed. 4500-P B-5 & E	none	0.01 mg/L
Total Dissolved Solids	ECM	SM 18th Ed. 2540C	None	7 mg/L
Total Suspended Solids	ECM	SM 18th Ed. 2540D	none	2 mg/L
E coli	Garden State Lab	EPA Method 1603 SM 18th Ed. 9222 D Princeton Hydro SOP GB-06.8	none	≥1 CFU / 100 mL

(na) = not applicable
SM 18th Ed. = Standard Methods for the Examination of Water and Wastewater, 18th Edition, 1992
EPA=Methods for Chemical Analysis of Water and Wastes, 1983
MDL = Minimum concentration of a substance that can be measured and reported with a 99% confidence level that the analyte concentration is greater than zero. (40CFR 136 Appendix B).
ECM = Environmental Compliance Monitoring, Inc; NJDEP Certification # 18630
GSL = Garden State Laboratories; NJDEP Certification # 20044

* Quality Control Procedures to assess performance include: field duplicates, laboratory calibration and validation, laboratory matrix spikes, laboratory matrix spike duplicates, standard curves checked every 3 months, standards checked daily or every 20 samples, at a minimum, and manufacturers performance specifications and QC.

Princeton Hydro SOPs for Nitrate, Total Phosphorous and SRP are GS-06.8, CS-06.8

Table 6. Nutrient and Pathogen Discrete Water Quality Parameters: Data Quality Objectives

PARAMETER DETECTION LIMITS, QUANTITATION LIMITS, ACCURACY, AND PRECISION								
Parameter	Method Detection Limit - MDL	Instrument Detection Limit - IDL	Project Detection Limit - PDL	Practical Quantitation Limit - PQL	Accuracy (Mean % Recovery)	Precision (Mean-RPD)	Accuracy Protocol % Rec for LCL/UCL	Precision Protocol UCL %RR (Max. RPD)
Parameter								
Nitrate-N	**0.003 mg/L**	0.0015 mg/L	**0.007** mg/L	**0.007** mg/L	76 - 146	± 17	76 - 146	± 17
Total Phosphate-P	**0.02** mg/L	0.0008 mg/L	0.02 mg/L	0.02 mg/L	70 - 118	± 13	70 - 118	± 13
Soluble Reactive Phosphorous (SRP)	0.003 mg/L	0.0002 mg/L	NA	NA	69 - 131	± 13	69 - 131	± 13
Total Suspended Solids	3 mg/L	NA	**5.0** mg/L	**5.0** mg/L	NA	± 31	NA	± 31
Total Dissolved Solids	6 mg/L	NA	NA	NA	NA	± 17	NA	± 17

Note: **Information Provided by ECM**

N/A – Non Applicable

MDL – Minimum concentration of a substance that can be measured and reported with a 99% confidence level that the analyte concentration is greater than zero. (see 40CFR 136 Appendix B)

IDL – Based on five times the photometric noise times the factor sum from the analyte calibration curve.

PDL – Will generally be the same as the MDL; however, PDL may increase towards the PQL based on sample matrices.

PQL – Represents a practical and routinely achievable detection limit with a relatively high certainty that any reported value is reliable. The PQL is often 3 to 5 times the MDL. **For this project the PQL is equal to the PDL.**

*** The Integrated Analytical Laboratories (IAL) is the State certified laboratory that will be subcontracted by Princeton Hydro to perform the proposed analyses for priority pollutants in limited aqueous and sediment samples. IAL will report the concentrations found at or above the MDL as specified in the tables in Appendix C. For the priority pollutant analysis, the MDL will also serve as the PDL and PQL.**

Table 7. Laboratory Analytical Procedures for PP +40
Laboratory Analytical Procedures

Parameter	Organization or Laboratory	ANALYTICAL METHOD		
		Method / SOP	Modifications	Method
Volatile Organics +15 +MTBE	IAL	SM 18th Ed. EPA 624/8260B	None	Methodological limit specific to matrix and compound *
PCBs	IAL	SM 18th Ed. EPA 608/8082	None	Methodological limit specific to matrix and compound *
Pesticides	IAL	SM 18th Ed. EPA 608/8081A	None	Methodological limit specific to matrix and compound *
Base Neutral/ Acid Extractables +25	IAL	SM 18th Ed. EPA 625/8270C	None	Methodological limit specific to matrix and compound *
Cyanide	IAL	SM 18th Ed. EPA 335.2/ 9012A	None	Methodological limit specific to matrix and compound *
Metals (Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Silver, Thallium, Zinc)	IAL	SM 18th Ed. EPA 200.8/ 7000 series/ 6020	None	Methodological limit specific to matrix and compound *
Mercury	IAL	Mercury EPA245.1/ 7000 series	None	Methodological limit specific to matrix and compound *
Total Organic for Sediments (TOC)	IAL	EPA 415.1	None	Methodological limit specific to matrix and compound *
Grain Size Analysis for Sediments	IAL	ASTM C136-96A	None	Methodological limit specific to matrix and compound *

(na) = not applicable
SM 18th Ed. = Standard Methods for the Examination of Water and Wastewater, 18th Edition, 1992
EPA=Methods for Chemical Analysis of Water and Wastes, 1983
IAL = Integrated Analytical Laboratories (NJ Certification #14751)
*IAL Methodology Limits for each proposed analyte are presented in Appendix C

Table 8. Laboratory Analytical Procedures for Invertebrate Sampling Data Quality Objectives

Parameter	Organization or Laboratory	Analytical Method		Achievable Laboratory Limits*	
		Method / SOP	Modifications	Method Detection Limits	Method
Invertebrate Abundance	EcoAnalysts	Princeton Hydro SOPs BM-06.8, BL-06.8	none	0 indiv / m^2	Quality Control sorting checks on 10% of samples
Invertebrate Composition	EcoAnalysts	Princeton Hydro SOPs BM-06.8, BL-06.8	none	(na)	(na)

(na) = not applicable
* Additional Quality Control Procedures to assess performance include: field duplicates, Sorting efficiency check, Pattern in missed organisms detected in sorting check, Independent re-identification check, Pattern of misidentified organisms in re-identification check

Section 8: Training Requirements and Certification

Field sampling will be conducted by Princeton Hydro staff who are trained and experienced in the physical and chemical monitoring of streams, and who have reviewed and understand the specific requirements detailed in the project SOPs and this Quality Assurance Project Plan. In particular, as a New Jersey State Certified Lab for *in situ* measurements of water quality and continuous temperature monitoring, Princeton Hydro staff will have thorough training in the measurement and calibration procedures for these parameters (N.J. Certification #10006). The collection of macroinvertebrate and discharge measurements also requires additional specialized training. Macroinvertebrate collections will be conducted by personnel with multiple years of experience in composite sampling from high gradient streams in the mid-Atlantic and New England regions of the United States. Flow measurements will likewise be taken by staff with additional training and field experience in the USGS protocols for stream discharge measurements using flow meters.

Laboratory analyses of water quality samples will be conducted by the following New Jersey State Certified Laboratory:

- Nutrients - Environmental Compliance Monitoring Inc. (ECM) (Hillsborough, NJ; NJ Certification # 18630)
- PP+40 - Integrated Analytical Laboratories (Randolph, NJ; NJ Certification #14751)
- E coli - Garden State Laboratory (Hillside, NJ; NJ Certification # 20044)

Personnel at these laboratories have undergone extensive training in all analytical methods, and the laboratories maintain records of their personnel and their relevant training and experience.

Stream macroinvertebrate samples will be processed and identified in the laboratory by EcoAnalysts, Inc. (offices in Pennsylvania, Idaho, Montana, Missouri, and California; *www.ecoanalysts.com*). This company is a leader in aquatic macroinvertebrate production taxonomy for the United States, and the staff has undergone extensive training in both sorting and identification procedures. Among its accomplishments, EcoAnalysts conducts Quality Control checks for the NJDEP AMNET program, and serves in a lead role for Quality Assurance / Quality Control procedures for biological monitoring throughout the nation. Princeton Hydro, LLC will conduct 10% control checks of benthic macroinvertebrate samples to avoid systematic errors.

Section 9: Documentation and Records

All members of the project team will receive a final version of the QAPP once it has been approved by the reviewers. Project partners on the Distribution List (Section 3) will receive an electronic copy of the final QAPP, and Princeton Hydro staff working on the project will receive both electronic and paper copies. Any subsequent updates or revisions to the QAPP will likewise be circulated to partners on the Distribution List electronically, with both electronic and paper copies provided to Princeton Hydro staff working on the Sidney Brook project. In addition, each revision of the QAPP will be placed in a Sidney Brook project log book, with a summary sheet indicating the date of each QAPP revision, the date the QAPP revision was entered into the log book, and the person entering the revised QAPP.

The data collected for this project will serve as the foundation for a watershed characterization report. All final results from the data collection will be included in the characterization report, with both paper and electronic copies circulated to project partners. Supporting information for these data collection efforts will be kept on file at Princeton Hydro for a minimum of 3 years following completion of the characterization report, with both electronic and paper copies of each report included in the data archive. Examples of the records that will be kept on file but not included in the report will be calibration records, quality control results, field notes, and intermediate data products.

Quality Assurance Assessments (Sections 20) will be conducted and produced during the 12-month period of data collection. These assessments will be distributed to the Scientific Project Manager, and will be archived both in paper and electronic files for the project. A summary of these Quality Assurance Assessments will be included as a component of the watershed characterization report as a means of demonstrating and documenting the quality of the project data.

Figure 2 -Proposed Sampling Stations

MEASUREMENT/DATA ACQUISITION

Section 10: Sampling Design

The field data collection for the Sidney Brook project will complement the existing data for the watershed (see Section 18 for background information) with updated and more extensive information about the existing conditions, the health of the watershed's streams, and both the location and the source of ecological stressors (see Section 5 for expansion). The field work is divided into 6 data collection tasks (see Section 6):

1. Continuous Summer Water Temperature
2. Water Quality Monitoring
3. PP +40 Monitoring
4. Bacterial Testing – E coli
5. Benthic Macroinvertebrates
6. Volumetric Stream Discharge

These parameters were chosen by the project team in order to address known concerns in the watershed and to provide a broad assessment of ecological and water quality conditions throughout the watershed.

The study design targets specific locations within the watershed for measurements within each task. Such a targeted design (as opposed to a "probabilistic design") was chosen to account for field access opportunities, known transitions within the watershed, and the locations of potential problems and/or high-quality areas needing characterization. Sampling sites have been distributed throughout the watershed in order to document the transitions from headwaters to the main stem of the Sidney Brook. The parameters selected for sampling at each site were chosen to address potential issues or data gaps within the constraints of the logistical limitations and available budget.

The detailed location of each sampling station is indicated below in Table 9 as well as in the sampling location maps (Figure 2). Overall, a total of 11 sites will be monitored for one or more parameters**.** The proposed sampling locations have been marked on the site map and during the initial sampling event, these sampling stations will be marked in the field with survey tape tied to either stakes or tree branches on each side of the stream and recorded with a field GPS unit. The GPS data will be recorded on GIS mapping to verify the station locations. During subsequent sampling events the sampling team will be provided specific directions on the sampling station, station features, and the flagging locations in order to ensure that the stations are maintained.

The frequency and types of sampling within each task are detailed in Table 9 and 10. The following is an overall summary of these tables and the study design (see Section 6 and Section 11 for additional details):

- temperature will be monitored continuously during a single summer at 7 stations;
- physical and chemical water quality will be measured during baseflow (3 events) and storms (3 events) during the sampling period (three seasons) at 7 stations;

- priority pollutants +40 (PP+40) will be sampled in aqueous and sediment samples at 3 stations during an initial baseflow event, and two remaining samples will be collected during a second event, but the location, matrix and parameters will be determined based on the preliminary PP+40 results;
- bacteria monitoring for E. coli analysis will occur at seven monitoring stations on the Sidney Brook for a total of eleven (11) surveys. Three (3) seasonal baseflow events and three (3) stormflow events (one spring, one summer, one fall for both baseflow and stormflow) will occur. In addition, five (5) additional bacterial monitoring events will be collected during a 30-day window between Memorial Day and Labor Day. This intensive 30-day monitoring will include both baseflow and elevated flow sampling events.
- benthic macroinvertebrates will be assessed once during a early summer sampling event at 8 stations;
- stream discharge will be measured throughout the year at 3 stations and flow will be measured over the course of the sampling program at key locations at distinct times during the sampling program (once in spring, summer and fall).

Obtaining quality-controlled data will be an integral part of data collection for each element. The detailed procedures for quality control and quality assurance are provided in Section 7, Section 14, Tables 3 to 8, and Tables 11 to 17. One element of the overall quality assurance/quality control will be field duplicates (see Section 14 and Tables 13, 14 and 15) for the water chemistry nutrient and bacteria parameters analyzed by a state-certified laboratory. A single field duplicate will be collected at one sampling station for each water quality monitoring event. The duplicates will be analyzed for all the nutrient and bacterial analytical parameters. Duplicates will not be collected for the priority pollutant samples.

Supplemental measurements and sampling for all data components may be conducted on an opportunistic basis in order to document individual problems, verify results, and more completely characterize the status of the watershed. Any additional sampling at the standard or supplemental sampling sites will be conducted in accordance with all methods and procedures outlined in this Quality Assurance Project Plan.

Princeton Hydro will notify the NJDEP, Division of Watershed Management Project Manger for the 319(h) grant at least three days prior to the sampling events, except for storm events which are scheduled dependent on daily weather conditions. The Project Manager will be called on the day of the sampling events.

Table 9. Sampling Locations for the Sidney Brook Project

Station	Location	Sampling Parameters: Temp	Water Quality	PP +40	Bact	Invert	Sampling Rationale
1	Northwest headwater tributary to Sidney Brook collecting runoff from the Wolf Farm and Main Street neighborhoods.	X	X		X		Upstream data, and potential runoff NPS in reach J.
2	Northwestern headwater tributary near Perryville Rd crossing, immediately upstream from the confluence with the southeastern headwater tributary		X		X	X	Data for reach J & K, and potential runoff NPS.
3	Forested headwater section of the southeastern headwater tributary, near driveway access road crossing the stream	X				X	Upstream data for reach I.
4**	Southeastern headwater tributary adjacent to Finn Road Park, approximately mid-way along this tributary's length		X		X	X	Data for reach G&H, down-stream of park and housing potential NPS.
5	Sidney Brook main stem immediately downstream from confluence between northwestern and southeastern primary headwater tributaries	X*					Data for reach F, upstream of Jutland lake.
6**	Sidney Brook main stem downstream of largest dam/reservoir within the watershed (known as Jutland Lake)	X		X	X	X	Data for reach E, downstream of Jutland lake and quarry.
7	Sidney Brook main stem in forested section upstream from Race St crossing, and downstream from the junkyard	X*	X	X	X		Data for reach C, downstream of potential junkyard NPS.
8	Headwater tributary to Sidney Brook which enters the main stem near the Race St crossing, with sampling occurring in forested section a short distance from Hilltop Lane					X	Data for reach D, and potential runoff NPS.
9	Sidney Brook main stem a short distance downstream of Race St crossing	X*				X	Downstream station for Union Twp.
10**	Sidney Brook main stem downstream of Rt 513 (Pittstown Rd) crossing within Franklin Township open space		X	X	X	X	Upstream station for Franklin Twp.
11	Sidney Brook main stem downstream of Rt 617 (Sidney Rd) crossing and	X*	X		X	X	Downstream of watershed

[1] - sampling parameters are: **Temp** = Continuous summer temperature; **WQ** = Water Quality- Chemical and physical; **PP+40=** Priority Pollutants +40; **Bact** = Bacteria; **Invert** = Benthic macroinvertebrate; Fish = Fish; **Discharge** = Discharge.
* Fish Sampling will also be conducted at these four stations.
** Stream discharge or flow measurements will be recorded at these stations.

Table 10. Sampling Parameters and Study Design, Sidney Brook Project

Parameter	Sampling Stations	Frequency	Sampling Window	Type of Sample	Stream Conditions
Water Temperature (continuous)	1, 3, 5, 6, 7, 9,11	Logged readings at 15-min intervals	May to October	In situ - stored to data logger	(no limitations)
Water Temperature (instantaneous)	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	In situ measurement	Baseflow conditions[1]
Conductivity	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	In situ measurement	Baseflow conditions[1]
pH	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	In situ measurement	Baseflow conditions[1]
Dissolved Oxygen	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	In situ measurement	Baseflow conditions[1]
Nitrate-Nitrogen	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	Discrete grab sample	Baseflow conditions[1]
		4 events	1 fall, 1 spring, 2 summer	Composite sample	Stormflow conditions[2]
Total Phosphorus	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	Discrete sample	Baseflow conditions[1]
		4 events	1 fall, 1 spring, 2 summer	Composite sample	Stormflow conditions[2]
Soluble Reactive Phosphorus (SRP)	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	Discrete sample	Baseflow conditions[1]
		4 events	1 fall, 1 spring, 2 summer	Composite sample	Stormflow conditions[2]
Total Dissolved Solids	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	Discrete sample	Baseflow conditions[1]
		4 events	1 fall, 1 spring, 2 summer	Composite sample	Stormflow conditions[2]
Total Suspended Solids	1,2, 4, 7, 10, 11	4 events	1 fall, 1 spring, 2 summer	Discrete sample	Baseflow conditions[1]
		4 events	1 fall, 1 spring, 2 summer	Composite sample	Stormflow conditions[2]
PP +40, TOC, Grain size	6,7,10	2 events	1 spring, 1 fall	Discrete grab sample	Baseflow conditions[1]
E. coli	1,2,4, 6, 7,10,11	5 events in 30 days	30-day window between Memorial and Labor Day	Discrete grab sample	Baseflow[1] and Stormflow[2]
		3 events	1 fall, 1 spring, 1 summer	Discrete grab sample	Baseflow Conditions[1]
		3 events	1 fall, 1 spring, 1 summer	Discrete grab sample	Stormflow Conditions[2]
Benthic macroinvertebrates	2,3,4,6,8,9, 10,11	1 early Summer	June	Semi -quantitative composite	No major floods in prior 3 weeks
Discharge	4,6,10	Continuous	Throughout sampling period	Direct measurement	Variable

[1] **Baseflow** is defined as conditions during which a minimum of 72 hours have elapsed since a storm event that has resulted in 0.1 inches or greater of precipitation (climate reference stations: NWS Coop station #283029 at Flemington)

[2] **Stormflow** is defined as a storm with a predicted rainfall total of over 0.5 inches in less than 12 hours (National Weather Service-Mount Holly), and during which the discharge (i.e., instantaneous volume of streamflow) at USGS reference stations (Spruce Run @ Clinton #01396800, South Branch Raritan @ High Bridge #01396500) increased by more than 100% (i.e., more than doubled) compared to pre-storm values.

Section 11: Sampling Procedures and Requirements

The methods and procedures for data collection on the Sidney Brook will involve a combination of generic procedures for data collection as well as site-specific requirements for the project. The following sub-sections provide the detailed procedures and requirements for each monitoring task as well as references to the applicable Standard Operating Procedures (SOPs) that will be used for this project (see Appendix B).

The proposed sampling locations have been marked on the site map and during the initial sampling event, these sampling stations will be marked in the field with survey tape tied to either stakes or tree branches on each side of the stream and recorded with a field GPS unit. The GPS data will be recorded on GIS mapping to verify the station locations. During subsequent sampling events the sampling team will be provided specific directions on the sampling station, station features, and the flagging locations in order to ensure that the stations are maintained.

Task 1: Continuous Temperature Loggers

Water-temperature loggers will be deployed at 7 stations on the Sidney Brook beginning in May and extending into September during one summer season (see Table 9, Figures 2, 3, and 4 for locations). Prior to deployment, each temperature logger will be placed in a room-temperature water bath (see SOP TC-06.8-cal in Appendix B). The logger will be activated to record water temperature for a minimum of 10 minutes, and an ANSI certified laboratory thermometer will be used to manually record the actual water temperature and to verify the calibration of each temperature logger.

At each station, the temperature loggers will be deployed in the deepest accessible portion of the channel (see SOP TC-06.8 in Appendix B). In areas with cobble and boulder-dominated substrates, probes will be secured to concrete block or paving stone, and the stone will be secured within the thalweg of the stream channel underneath the largest boulder that can readily be moved. In areas with a predominance of small substrates (gravels, sands, silts, clays), the temperature loggers will be secured to a stake or post driven into the deepest part of the channel.

Loggers will be deployed in May and retrieved in October. Loggers will be programmed to record water temperature at 15-minute intervals for the length of the deployment. Each logger will be manually inspected on two (2) intermediate dates during the deployment under baseflow conditions (see Table 10 for baseflow definition). If possible, these inspections will occur during periods of protracted low flow to verify that the temperature loggers remain submerged under low-flow conditions. During each inspection, a field verification of temperature will be conducted and the accumulated data will be retrieved. A field water quality meter, calibrated for temperature, will be used to record water temperature adjacent to the temperature logger. Field notes will be recorded with the field verification information, the approximate depth of the logger during the survey, the location of the logger relative to its deployment location, and the overall condition of the logger (e.g., sensor, casing, data port). Temperature data will then be downloaded from the logger without interruption of the logging program, and the logger will be re-deployed at the same location. Upon return to the office, all logger data will be stored to the project files and the simultaneous temperature measurements between the logger and the field meter will be compared. Loggers falling outside the Data Quality Objectives (see Table 3) will be retrieved, re-calibrated, and/or replaced with a new calibrated temperature probe.

Princeton Hydro obtained certification from the NJDEP Office of Quality Assurance in May 2007 to collect continuous temperature data.

Task 2: Discrete and *in situ* Water Quality Parameters

Princeton Hydro is a State-certified laboratory (#10006) for *in situ* measurement of temperature, pH, specific conductivity, and dissolved oxygen. A variety of water quality parameters will be measured during field surveys at 7 Sidney Brook stations (see Table 9). Some of these parameters will be measured directly in the field and are referred to as *in situ* measurements. These parameters are:

- water temperature
- specific conductance
- pH
- dissolved oxygen

Other parameters will require more detailed analysis at a state-certified laboratory. For these parameters, discrete water samples will be collected in sampling containers and transferred under chain-of-custody to the analytical lab for final determinations Integrated Analytical Laboratories (Randolph, NJ; NJ Certification #14751). These discrete parameters are:

- nitrate-nitrogen
- total phosphorus
- soluble reactive phosphorous
- total dissolved solids
- total suspended solids

The *in situ* measurements will be taken using a calibrated field sampling meter (see Section 16 for calibration details) during each of the three (3) baseflow monitoring events (see SOP IS-06.8 for methods in Appendix B). No *in situ* measurements will be taken during the stormflow periods. The probe will be placed on the stream bed away from the bank near the center of the stream channel in an area with relatively high flow rates. The meter will then be allowed to stabilize for at least 2 minutes, and measurements of each of the four water quality parameters will then be recorded a minimum of two times spaced at least 3 minutes apart. The time of each measurement will be recorded along with the value for each parameter.

Discrete water quality samples will be collected upstream from any prior sampling activity within the stream channel during each of the three (3) baseflow events (see SOP GS-06.8 in Appendix B). Samples will be collected in an unused, unpreserved 1000 mL bottle provided by the analytical lab. Prior to the collection of the first sample at each station, the sampling bottle will be triple-rinsed with stream water. Water samples will then be collected near the center of the stream at mid-depth within the water column. The sampling bottle will be inverted, placed underwater, and then filled completely prior to removal from the stream. The water sample will then be distributed into the appropriate final sample containers for the four analytical parameters (see Table 11). The process will be repeated until all final sample bottles for the station are filled. These samples will then be transferred to coolers containing wet ice, cooled to a temperature at or below 4ºC, and transported to the analytical laboratory. The same water collection bottle will then be used at subsequent stations for the same sampling date. Prior to re-use at a new station, the collection bottle will be triple-rinsed with stream water from the new sampling station. In addition, one replicate sample will be collected at a different station during each survey. This sample will be collected and processed using the same procedures.

During three (3) stormflow events (see definition in Table 10) the same discrete chemical parameters will be measured for a composite sample collected across the storm window (see SOP CS-06.8 in Appendix B). The composite samples will be collected manually at each station to account for the variability in weather patterns and precipitation events. At each station, the first sample volume will be collected at the expected start of the rainfall event. Subsequent samples of equal volume will be collected at regular intervals (0.50 to 1.0 hrs, depending on the storm event) for a time window projected to cover the full length of the storm event (up to 4 hours). Each sample volume collected at each interval will be directly added to a large sampling container dedicated for each station. Upon completion of the storm sampling event, the composite sample will be homogenized and then sub-sampled for each of the four sampling parameters. The sample bottles will then be placed in a cooler with wet ice, cooled to a temperature at or below 4ºC, and transported to the analytical laboratory. In addition, one replicate sample will be collected at a different station during each survey. This sample will be collected and processed using the same procedures, with the replicate sample taken from the same composite sample collected for that station.

Table 11. Discrete Water Quality and Bacteriological Sample Specifications

Parameter	Sample Container	Sample Volume	Initial Preservation[1]	Holding Time	Analytical Laboratory
Nitrate-Nitrogen (NO_3)	500 mL / pint bottle (combined sample for NO_3, TDS, TSS)	50 mL	Cool to ≤4ºC	48 hours	ECM
Total Phosphorus (TP)	1000 mL / quart bottle	50 mL	H_2SO_4 to pH<2.0; Cool to ≤4ºC	28 days	ECM
Soluble Reactive Phosphorus (SRP)	1000 mL / quart bottle	50 mL	Cool to ≤4ºC	48 hours	ECM
Total Dissolved Solids (TDS)	500 mL / pint bottle (combined sample for NO_3, TDS, TSS)	100 mL	Cool to ≤4ºC	7 days	ECM
Total Suspended Solids (TSS)	500 mL / pint bottle (combined sample for NO_3, TDS, TSS)	200 mL	Cool to ≤4ºC	7 days	ECM
E. coli	125 mL bottle	100 mL	Cool to ≤ 10ºC	6 hours	Garden State Labs

[1] The appropriate laboratory personnel at the specific laboratory are responsible for the addition of all preservatives to the appropriate sample containers prior to sample collection

Task 3: Priority Pollutants +40 (PP+40)

Discrete water quality samples will be collected upstream from any prior sampling activity within the stream channel during two (2) baseflow events for priority pollutant analysis (see SOP GS-06.8 in Appendix B). Aqueous samples will be collected in an unused, 1000 mL bottle provided by the analytical lab for each of the three stations. **Preservatives will be added to the bottles by the appropriate laboratory technicians in accordance with the analytical methods as indicated in Table 12.** Prior to the collection of the sample, the sampling bottle will be triple-rinsed with stream water. Water samples will then be collected near the center of the stream at mid-depth within the water column. The sampling bottle will be inverted, placed underwater, and then filled completely prior to removal from the stream. The water sample will then be distributed into the appropriate final sample containers for the analytical parameters (see Table 12). The process will be repeated until all final sample bottles for the station are filled. These samples will then be transferred to coolers containing wet ice, cooled to a temperature at or below 4ºC, and transported to the analytical laboratory. A new water collection bottle will then be used at each station. Elevated concentrations of contaminants in the water column are indicative of a higher degree of concern associated with contaminated sediments.

When sampling for both surface water and sediment at the same location, the surface water sample will be collected first. Replicate samples will not be collected for the priority pollutant samples.

The goals of the proposed sediment sampling are to determine ambient conditions and to identify areas of potential contamination and impacts. The NJDEP Field Sampling Manual notes that the areas of greatest contamination may occur in depositional areas in aquatic systems and the areas with a high percentage of silt content will be specifically targeted. Depositional areas are generally characterized by slower moving water where fine sediments tend to accumulate. It is important to note that sand and gravel sediments rarely reflect pollution loading. Sediment samples will be collected using a clean, dedicated **non-metal** trowel, with samples collected from the 0-6" interval (biotic zone) of the stream bottom. The sediment sample will then be distributed into the appropriate final sample containers for the analytical parameters (see Table 12). The process will be repeated until all final sample bottles for the station are filled. These samples will then be transferred to coolers containing wet ice, cooled to a temperature at or below 4ºC, and transported to the analytical laboratory. A new sediment collection trowel will be used at each station. While a sediment sample is usually expected to be a solid matrix, the NJDEP Field Sampling Manual notes that sampling personnel should avoid placing the sample in the bottle, and decanting off the excess liquid. Decantation promotes the loss of water-soluble compounds and volatile organics present in the sediment. If the sample is collected properly, any liquid that makes it into the bottle is representative of sediment conditions. Each bulk sediment sample will also be analyzed for total organic carbon (TOC), pH, and particle grain size, in addition to site specific analytical parameters, to fully characterize each sediment sample and to assess potential bioavailability of the contaminants.

Table 12. Discrete Sample Specifications for Priority Pollutant Analysis

Parameter	Sample Container	Sample Volume	Initial Preservation[1]	Holding Time	Analytical Laboratory
Volatile Organics	125 mL bottle	2 X 40 mL	HCL <2, Cool to ≤4ºC Zero head space	14 days	IAL
Base Neutral/ Acid Extractable Organics	2 X 1000 mL / quart bottle	2 X 950 mL	Cool to ≤4ºC	7 day extraction/ 40 days analysis	IAL
Pesticides	2 X 1000 mL / quart bottle	2 X 950 mL	Cool to ≤4ºC	7 day extraction/ 40 days analysis	IAL
PCBs	2 X 1000 mL / quart bottle	2 X 950 mL	Cool to ≤4ºC	7 day extraction/ 40 days analysis	IAL
Metals (except mercury)	500 mL / pint bottle	250 mL	HNO_3 Cool to ≤4ºC	180 days	IAL
Mercury	500 mL / pint bottle	250 mL	HNO_3 Cool to ≤4ºC	28 days	IAL
Cyanide, total	125 mL bottle	50 mL	NaOH >12, Cool to ≤4ºC Ascorbic Acid	14 days	IAL
Phenols	125 mL bottle	100 mL	H_2SO_4 <2 Cool to ≤4ºC	28 days	IAL
TOC / Grain Size	125 mL bottle	10 mL	H_2SO_4 <2 Cool to ≤4ºC	28 days	IAL

[1] The appropriate laboratory personnel at the specific laboratory are responsible for the addition of all preservatives to the appropriate sample containers prior to sample collection

Task 4: Bacterial Monitoring

Samples for bacterial concentrations will be collected during eleven (11) surveys at seven (7) Sidney Brook stations (see Tables 9 and 10; see SOP GB-06.8 in Appendix B). Two phases of bacterial monitoring will take place. First, five (5) surveys will take place under variable flow conditions within a 30-day window starting after Memorial Day through Labor Day. Samples will be collected during variable conditions including baseflow and elevated storm conditions. The second phase of bacterial monitoring will involve three (3) additional surveys conducted under true baseflow and three (3) stormflow conditions (see Table 10). During baseflow conditions, one sample will be collected in the spring, one sample will be collected in the summer and one sample will be collected in the fall. During stormflow conditions, one sample will be collected during each season- spring, summer and fall. At each station during the survey, a pre-labeled, sterilized 125 mL container will be used for each sample. The container will be placed underwater at approximately mid-depth with the lid in place, the lid will be removed and the container will fill with water, and the lid will be re-secured on the container prior to removal from the water. The sample will then be placed in a cooler with wet ice to cool the sample to below 10ºC. The process will be repeated at each of the remaining sampling stations, and the samples will be delivered to the analytical lab within 6 hours of collection of the first sample. In addition, one replicate sample will be collected at a different station during each microbiological survey. This sample will be collected and processed using the same procedures. Note: Two days prior to sampling, and on the day of sampling, the certified microbiological lab will be notified of the upcoming sampling survey in order to prepare for sample receipt and processing (Garden State Laboratories, NJ Certification # 20044).

Task 5: Benthic Macroinvertebrates

Benthic macroinvertebrates will be collected at eight (8) Sidney Brook stations (see Table 9) during early summer (see SOP BM-06.8 in Appendix B). This survey may occur in May–June. If an extended drought induces insufficient baseflow during the monitoring period, benthic macroinvertebrate sampling would occur later in the fall, or not at all as per 2006 Integrated List Methodology. In addition, stream flow data will be incorporated into our assessment of the macroinvertebrate data.

At each site, a single composite macroinvertebrate sample will be collected during each event using the NJDEP-AMNET protocols for high-gradient streams (NJDEP 2003). Each macroinvertebrate sample will consist of a quantitative composite of fifteen (15) unit area samplings of the stream benthos selected from the highest quality hard-substrate riffle and run habitats within a delineated 100-meter stream reach. Adequate riffle habitats should be available at all Sidney Brook stations to stratify the sampling strictly within these riffle habitats. Each 100-meter stream reach will be selected so that multiple riffles are available for sampling, and the invertebrate samples will be distributed across all riffle habitats within the 100-meter reach.

For the composite sample, each unit area sampling will entail placing a D-framed net (500 µm mesh) against the stream bottom and disturbing the benthos in a 1 foot square area upstream of the net by hand and foot for 30 seconds. Subsequent unit area samplings will be collected moving upstream, and the composite sample will be rinsed into a bucket after each of 5 unit areas have been sampled or when the net accumulates too much material for efficient sampling, whichever comes first. After a total of 15-unit area samplings, all material collected in the net will be washed into the bucket. Large stones and debris will be washed within the bucket, examined for any remaining invertebrates, and discarded after all invertebrates have been removed. All sample material will then be poured into the sampling net or into a #35 sieve (500 µm mesh), and the retained material will be preserved in sample bottles containing concentrated denatured ethanol. The sample bottle will be labeled using an alcohol-resistant pen with the stream, the station, the date of sampling, and the person collecting the sample. Field notes will document the number of samples collected for the composite, the habitats sampled, the net mesh size, the sieve mesh size, and the extent of the stream reach surveyed.

A qualitative visual habitat assessment will also be conducted at each site using NJDEP High Gradient Stream Habitat Assessment protocols (see Appendix D). This habitat assessment evaluates in-stream, stream bank, and riparian corridor conditions for their ability to provide a stable and functioning habitat template for the biota of the stream. Ten variables are evaluated on a 0-20 scale, and an overall Habitat Score is determined for the study reach as a simple sum across the ten variables. These Habitat Scores are then categorized based on observed thresholds for stream habitat conditions among different sites in New Jersey.

In the laboratory, samples will be rinsed through a 600 µm mesh sieve (standard No. 30) and transferred to a grid tray (see SOP BL-06.8 in Appendix B). Cells within the grid will be randomly selected for further processing and sorting under a dissecting microscope (minimum 10x magnification) to remove all invertebrates from the sample matrix. A minimum of 100 invertebrates will be sorted from each sample by sorting all invertebrates from a given cell and then selecting additional cells if less than 100 invertebrates have been collected. Once a grid cell is selected, all invertebrates from that cell will be sorted and included in the raw sample. Following NJDEP-AMNET protocols, all invertebrates will be identified to a minimum of family level with the exception that some groups of non-insect invertebrates and extremely immature insects will be identified to the lowest practical taxonomic level. Sub-sampled invertebrates and sorted detritus will then be preserved separately in 75% ethanol. Quality Control (QC) checks will be conducted by Princeton Hydro on the sorted detritus and on the invertebrate identifications for a random selection of 10% of the samples.

Task 6. Stream Discharge –

The determination of volumetric flows on the Sidney Brook will be made through a combination of discharge measurements at a single downstream station, observations of water level at that station during water quality surveys, and area-weighting of the discharge measurements for each water quality station.

Staff gauges and pressure transducers with data loggers will be installed at three (3) Sidney Brook stations (see Table 9, Figure 2). Following installation of the staff gauges, ratings curve will be developed over the course of the 9-month monitoring window using standard USGS protocols (Buchanan and Somers 1969). On a minimum of 8 surveys spanning the expected range of water levels and flows, paired water velocity and water depth measurements will be made across a stream cross section perpendicular to the stream flow (see SOP QF-06.8 in Appendix B). Discharge will be measured using a USGS Price Type AA flow meter, with depth and flow measurements taken at 25 to 30 locations across the stream's cross section at each sampling station. The resulting data on position, depth, and flow velocity will be entered into digital format, proofed for accuracy, and used to compute discharge for the observed gauge height on the staff gauge. A ratings curve for the Sidney Brook will then be developed using log-log regressions according to USGS protocols (Kennedy 1984)

To determine the discharge at three (3) Sidney Brook stations during baseflow events, the gauge height at each station will be recorded at the beginning and end of the day for water quality measurements. Discharge will be determined by the established ratings curve based on the average gauge height from the two readings (i.e., prior to surveys and following surveys), and discharge at the remaining stations will be estimated using drainage area weighting according to the following formula:

$$Q_x = Q_{1G} \cdot \frac{A_x}{A_{1G}}$$

where: Q_x = Discharge at Station X
Q_{1G} = Discharge at Station 1G
A_x = Drainage area at Station X
A_{1G} = Drainage area at Station 1G

Section 12: Sample Handling and Custody Procedures

For water quality samples (chemical, PP +40 and microbiological), the sampling containers, preservation, and holding times will follow the specifications of Table 11 and 12. Sample bottles and containers will be cleaned and provided by the State-certified laboratories. **The sample preservatives identified in Table 11 and 12 will be added by the laboratory technicians prior to sample collection.** Each container will be externally labeled with the stream name, date, site number, site name, and preservative used (if any) using a permanent marker (e.g., Sharpie). All samples will be transferred to an ice-filled cooler immediately following completion of sampling at a site and cooled to a temperature at or below 4ºC. Samples will be transported to the laboratory while on ice to maintain the 4°C temperature threshold. In order to meet holding times, samples will be delivered to the laboratory immediately following completion of daily sampling events. At the lab, samples will be handed directly to a laboratory analyst or technician, chain-of-custody forms will be signed over, and copies of the chains-of-custody will be retained in the project folder.

For stream invertebrate samples, samples will be transferred to wide-mouth plastic sampling bottles of varying size (typically 250 mL to 4000 mL) following all sampling activity at a station. Sample bottle size will be selected for each station such that the collected material fills no more than half of the sampling bottle. The invertebrate sample will then be preserved with 95% or 100% denatured ethyl alcohol, with the sample bottle completely filled with alcohol preservative to prevent damage to the sampled material. An internal label containing the stream name, station number and name, sampling date, and collector's name will be placed in the sample bottle, and the sample bottle will be sealed. Once sealed, the sample bottle will be gently inverted a minimum of 3 times to adequately distribute the alcohol preservative throughout the sample matrix. Samples will then be returned to the office. On the day samples are shipped to the contract laboratory, the alcohol will be poured off while covering the bottle opening with a 250 μm sieve, the collected material on the sieve will be washed back into the sample with tap water, and the sample will be re-wetted with tap water to prevent drying during shipping (the sample bottle will not be completely filled). The samples will then be shipped overnight, under chain-of-custody, on Monday, Tuesday, or Wednesday to ensure no long-term holding without alcohol preservative.

For direct measurements (*in situ* water quality and stream discharge), each field crew member will maintain a bound field notebook to record all data. Each page of the field notebook will be labeled with project name, sampling date, and sampling station. All measurements in the field will be recorded in the field notebook at the time of measurement. Upon completion of each day's field survey, two (2) copies of the field notebook pages will be made, with one copy retained by the field crew member and one copy archived in the project files. Data will then be transferred to digital format in the digital project files, with off-site digital archives kept of all project files.

Temperature logger data will be downloaded to a PDA computer (e.g., PalmPilot) in the field for each monitoring station. After completion of field sampling activities for each survey, all data will be off-loaded from the PDA to the digital project files. As with other digital data, off-site digital archives will be kept of the temperature logger data along with the remaining project files.

As described, chain-of-custody (COC) procedures will be utilized for all samples physically collected in the field. Personnel responsible for sampling operations will inform the analytical laboratory at least twenty-four (24) hours in advance of the date that stream monitoring samples will be delivered. The sample collector will be required to record the following information on the sampling container: stream name, station name and number, date of collection, preservative used, and collector's name. A COC form will be completed to identify the analyses requested and will be submitted to the laboratory at the time of sample delivery. The sample collector will deliver the samples to the laboratory, where laboratory personnel will visually inspect all sample containers to confirm the method of transportation, date of collection and preservation technique. Samples will not be accepted and fresh samples will be requested if for any reason the holding time was exceeded, proper preservation techniques were not followed, or transportation conditions were unsuitable.

Section 13: Analytical Methods Requirements

The field and laboratory monitoring will use EPA-approved analytical methods for all data collection (see Tables 3 to 8). For *in situ* field measurements, calibrated multi-probe water quality meters and temperature data loggers will be used for direct measurements of water quality parameters (see SOPs IS-06.8 and TC-06.8). Additional water chemistry and bacterial parameters will be measured through discrete water sample collection in the field (see SOPs GS-06.8 and GB-06.8). These discrete water samples will be analyzed by NJDEP-certified analytical laboratories using the methods outlined in Tables 5 through 8. Benthic macroinvertebrate samples will be collected by Princeton Hydro in the field, and will be analyzed in the lab by EcoAnalysts, Inc. (www.ecoanalysts.com) using NJDEP's Ambient Biomonitoring Network protocols (NJDEP 2003). No additional analytical methods are needed for volumetric discharge measurements collected in the field using USGS protocols.

Method Detection Limits are specified in Tables 5-7, pages 15-17, and will be low enough to provide useable data for the purposes of this study, which is to garner baseline data and /or supplement the existing database. Utilizing Project Action Limits for the Sidney Brook Watershed Protection Plan is not anticipated at this phase of the watershed assessment. Adherence to methodological requirements will be accomplished by using certified laboratories for field and lab water chemistry determinations, and by employing contractors for the invertebrate data collection with extensive experience in New Jersey and throughout the northeastern United States.

Section 14: Quality Control Requirements

Multiple quality control procedures will be implemented for the data collection and the data entry portions of the Sidney Brook project in order to ensure that data are collected according to established protocols, that all data have a known level of quality, and that digital data are an accurate record of field and lab measurements. In addition, all personnel performing data collection will be required to have detailed training and to fully understand the specific SOPs and/or methods they will be implementing for their aspect of the project (see Section 8). All Princeton Hydro staff conducting work on the project will also be required to have read this full Quality Assurance Project Plan in order to ensure adherence to all aspects of proper data collection.

The quality of field measurements will be verified and documented through equipment calibrations (Section 16), equipment maintenance (see Section 15), and repeat measurements as outlined in Table 13 and 14 to determine the frequency and location of repeat measurements. For repeat measurements, the multi-probe meter will be allowed to stabilize for a minimum of 5 minutes, and two sequential readings will be recorded at 5 minute intervals following stabilization. For continuous temperature monitoring, quality control will be attained through both lab and field calibrations (see Section 16).

Nutrients and Pathogens

Quality control procedures for discrete water quality samples (chemical and microbiological) will include field and laboratory blanks, spikes, and duplicates (see Table 13, Table 14). In the field, a field blank will be collected for each survey. Field blanks will be analyzed for Nitrate, TP, SRP, TDS, and TSS. A field duplicate or replicate sample will also be collected for all parameters (Nitrate, TP, SRP, TDS, TSS, and E. coli) at one station for each survey, with different stations selected for replication on different surveys. In the lab, one sample per sampling event will be analyzed for a matrix spike for Nitrate, and TP (SRP, TDS, TSS and E. coli spikes are not feasible). In addition, one split sample will be analyzed as a laboratory replicate for each sampling event for Nitrate, TP, SRP, TDS, TSS, and E. coli. Finally, calibration curves will be run for Nitrate, and TP (again, SRP, TDS, TSS and E. coli curves are not feasible), with spot checks on the standards curve performed daily or once per 20 sample (whichever is more frequent).

Priority Pollutant +40 (PP+40)
Quality control samples for the PP+40 analysis will be somewhat limited because this data is to provide baseline information only; is not intended for any enforcement or regulatory action; PP+40 analysis are not the focus of this study and are expensive. Three aqueous and three sediment samples will be collected during an initial baseflow event, and the analytical parameters of two remaining samples will be determined based on the preliminary results. One replicate aqueous sample will be collected for a volatile organic analysis only. Field blanks will NOT be collected for the aqueous or sediment samples.

Macroinvertebrates
Quality control procedures for laboratory processing of benthic macroinvertebrate samples will include sorting efficiency checks on 10% of the samples (1 for each seasonal survey) as well as re-identification of all sample organisms on 10% of the samples (1 for each seasonal survey; see Table 15). This 10% quality control check will be performed by state- certified Princeton Hydro, LLC.

Stream Discharge
For discharge measurements, two forms of quality control checks will be performed in addition to the standard maintenance and training procedures. First, for 10% of stream flow measurements (or for 1 measurement on each discharge transect, whichever is greater) the flow velocity will be re-measured immediately following the initial measurement, with both measurements recorded in the field notebook. Second, discharge measurements will be evaluated at a long-established USGS gauging station with continuous, real-time records of water stage and estimated discharge (South Branch Raritan River at Stanton, USGS #01397000). Comparisons will be made between Princeton Hydro's measurements of stream discharge and the USGS estimate of discharge at that station.

Data Entry
Quality control will also be an integral component of the data entry process for all collected data. At the end of each survey, or when laboratory results are received, the data will be entered into project spreadsheets for each monitoring parameter. Upon completion of data entry for a given survey, the digital data will be printed out for complete proofing of all data values. For each data point, a comparison will be made between a photocopy of the original data sheets (i.e., field notebook, laboratory report) and the printout of the digital data. Once all data are proofed, the original and the digital printout will be scanned for any data omissions or erroneous entries of data. Any original data entry errors will then be corrected in the digital data file.

Table 13. Field Quality Control Schedule for Water Quality and Microbial Parameters

Parameter	Number of Measurements based on Study Design	Rate of Sequential Repeat Measurements	Number of Sequential Repeat Measurements	Rate of Field Blank Samples	Number of Field Blank Samples	Rate of Field Duplicate Samples	Number of Field Duplicate Samples
Temperature (*in situ*)	**42**	1 station for each survey, no station repeated	6	-	-	-	-
Specific Conductivity	**42**	1 station for each survey, no station repeated	6	-	-	-	-
pH	**42**	1 station for each survey, no station repeated	6	-	-	-	-
Dissolved Oxygen	**42**	1 station for each survey, no station repeated	6	-	-	-	-
Nitrate-Nitrogen	**42**	-	-	1 for each survey	6	1 station for each survey, each station with at least 1 duplicate	6
Total Phosphorus	**42**	-	-	1 for each survey	6	1 station for each survey, each station with at least 1 duplicate	6
Soluble Reactive Phosphorus SRP	**42**	-	-	1 for each survey	6	1 station for each survey, each station with at least 1 duplicate	6
Total Dissolved Solids	**42**	-	-	1 for each survey	6	1 station for each survey, each station with at least 1 duplicate	6
Total Suspended Solids	**42**	-	-	1 for each survey	6	1 station for each survey, each station with at least 1 duplicate	6
E. coli	**77**	-	-	1 for each survey	11	1 station for each survey, no station repeated	11
Volatile Organics	8	-	-	-	-	1 aqueous sample for the project	-
Base Neutral/Acid Extractable	8	-	-		-	-	-
Metals	8	-	-		-	-	-
Pesticides	8	-	-		-	-	-
PCBs	8	-	-		-	-	-
Cyanide/ phenols	8	-	-		-	-	-

Table 14. Laboratory Quality Control Schedule for Discrete Water Quality and Microbial Parameters

Parameter	Number of Measurements based on Study Design	Rate of Matrix Spikes	Number of Matrix Spikes	Rate of Laboratory Duplicates	Number of Laboratory Duplicates	Standard Curves
Nitrate-Nitrogen	**48**	1 sample for each survey	6	1 sample for each survey	6	Completed once every 3 months; check-standards completed daily or after 20 samples (whichever more frequent)
Total Phosphorus	**48**	1 sample for each survey	6	1 for each survey	6	Completed once every 3 months; check-standards completed daily or after 20 samples (whichever more frequent)
Soluble Reactive Phosphorus	**48**	(na)	-	1 for each survey	-	(na)
Total Dissolved Solids	**48**	(na)	-	1 for each survey	-	(na)
Total Suspended Solids	**48**	(na)	-	1 for each survey	-	(na)
E. coli	**88**	(na)	-	1 for each survey	-	(na)
PP+40*	**8**	-	-	-	-	(na)

(na) - not applicable; not possible to run spikes or standard curve for SRP, suspended solids, E coli
* For the purposes of this project limited duplicates will be provided for the PP+40 analyses in order to address budget concerns.

Table 15. Quality Control Schedule for Invertebrate, Fish and Discharge Measurements

Parameter	Number of Measurements based on Study Design	Type of Quality Control Check	Rate of Quality Control Samples	Number of Quality Control Samples
Invertebrate Abundance	**8**	Sorting check for invertebrate processing	1 for each seasonal field survey	1
Invertebrate Composition	**8**	Re-identification of invertebrates in sample	1 for each seasonal field survey	1
Volumetric Discharge	**8**	Sequential repeats of flow measurements	1 for each 10 flow measurements, or 1 for each cross section, whichever is greater	approx. 24 (depends of field conditions)
		Discharge measurement at established USGS gauging station	1 for every 4 discharge measurements	2

Section 15: Instrument/Equipment Inspection, Calibration and Maintenance

All equipment used to collect and/or analyze data will be inspected and tested at regular intervals to ensure complete and accurate data collection, and in accordance with the NJDEP certification requirements for analytical labs. Table 16 provides an overall summary of these procedures. Multi probes will be inspected and calibrated prior to deployment to ensure that no defects exist and to verify calibrations (see Section 16). Damaged or inoperable probes will be replaced with new calibrated probes. Specific meters will also be sent to the manufacturer for scheduled maintenance as required.

The Price Type AA flow meter will also require a number of maintenance and inspection steps to ensure its accurate use in measuring flow rates. First, a spin test will be conducted prior to each survey to ensure that there is limited friction in the bucket-wheel assembly and that the bucket-wheel comes to a gradual stop, and the time and conditions of the spin test will be recorded (see Section 16 and SOP FM-06.8 for details). For transport of the Price meter to the field station, and for any travel between stations, the field crew will also position the raising nut so that no pressure is maintained on the unit's pivot. Following each use, the Price meter will be disassembled in the lab and allowed to dry for a minimum of 24 hours. Following drying, the pivot, bearing, and gears will be thoroughly oiled prior to re-assembly and storage.

Table 16. Summary of Equipment Testing, Inspection, and Maintenance Procedures

Sampling Task	Equipment	Maintenance, Testing, or Inspection Activity	Frequency	Responsible Person
Temperature (continuous)	Hobo Water Temp Pro sensors	1. Visual inspection of probe, sensor 2. Temperature verification	Prior to deployment; also during each data download	1. Field Crew 2. Field Crew
Water Quality	Multi-probe water quality meter (Eureka, Quanta, Horriba brands)	1. Visual inspection of DO membrane 2. Calibration for each parameter 3. Annual recommended maintenance	1. Prior to each survey 2. Prior to each survey 3. Once per year	1. Field Crew 2. Field Crew 3. Manufacturer
	Analytical lab equipment	Routine inspection and maintenance according to NJDEP certification	As required	Lab Personnel
PP +40	(none)	-	-	-
Bacterial	(none)	-	-	-
Invertebrate	500 µm D-frame net	Visual inspection of mesh	Prior to each survey	Field Crew
Discharge	50 m survey tape	Inspect prior to use	Prior to each survey	Field Crew
	Price Type AA flow meter	1. Spin Test 2. Raising nut extension 3. Drying and oiling	1. Prior to each survey 2. During all transport 3. End of each survey	1. Field Crew 2. Field Crew 3. Field Crew
	Pressure Transducer			

Section 16: Instrument/Equipment Calibration and Frequency

Regular calibrations of field and laboratory equipment will be used to verify and document the acceptable performance of this equipment prior to use for data collection. Table 17 summarizes the equipment calibration procedures and schedule for all equipment-based data collection, and the subsections below summarize the calibration methodologies. Calibration records will be kept for all procedures and stored in the laboratory with the equipment. Calibration information will include, but will not be limited to, dates of calibration, name of person performing calibration, problems encountered and, if so, how they were corrected. Princeton Hydro is a State-certified laboratory (#10006) for *in situ* measurement of temperature, pH, specific conductivity, and dissolved oxygen. Princeton Hydro became State-certified for the collection of continuous water temperature monitoring in May 2007.

Table 17. Equipment Calibration Schedule

Parameter	Equipment	Calibration Description	Frequency	Responsible Person	SOP Reference
Temperature (continuous)	Hobo Water Temp Pro sensors	1. Factory calibration 2. Lab calibration 3. Field verification	1. Single event at factory 2. Prior to deployment, and following retrieval 3. Each field download	1. Factory staff 2. Field Crew 3. Field Crew	TC-06.8-cal
Temperature (*in situ)*	Multi-probe water quality meter	Calibration against NIST thermometer	Every 3 months	Lab Manager or Field Crew	TD-06.8-cal
Dissolved Oxygen	Multi-probe water quality meter	Winkler titration	Each survey, day before or day of survey	Field Crew	DO-06.8-cal
pH	Multi-probe water quality meter	3-Point Calibration at pH=4.0, pH=7.0 and pH=10.0	Each survey, day of survey	Field Crew	PH-06.8-cal
Specific Conductivity	Multi-probe water quality meter	Calibration at 500 μS/cm	Each survey, day of survey	Field Crew	SC-06.8-cal
Volumetric Discharge	Price Type AA flow meter	Spin Test	Each survey, day of survey	Field Crew	FM-06.8-cal

Section 17: Inspection and Acceptance Requirements for Supplies

The primary supplies that will need routine inspection for the Sidney Brook project will be calibration standards for the multi-probe water quality meter and the sample containers for discrete water quality and bacterial samples. Calibration standards are obtained from reputable scientific supply companies and have expiration dates clearly marked on them. Prior to meter calibration, each standard will be inspected to ensure the expiration has not been exceeded. In addition, the Laboratory Manager for Princeton Hydro routinely checks the quantities and dates on all standards, and orders new standards in anticipation of future needs. Any expired standard will be discarded, and calibrations will be run on new standard materials that have not exceeded their expirations.

Sample containers will be prepared by each analytical laboratory and obtained prior to field surveys. Field crews will inspect all sample bottles the day before the survey to ensure the correct number, sizes, and preservatives have been prepared for a complete field survey (see Table 11 and 12 for specifications). Sample containers will also be inspected for integrity and leaks. Any container not meeting the requirements for volume, preservative, or condition will be discarded and replaced with an unused bottle obtained from the analytical laboratory.

Section 18: Data Acquisition Requirements

Multiple existing data sources will be accessed and utilized to characterize the current and past conditions of the Sidney Brook watershed, and thus to guide decisions on watershed planning, protection, and restoration. The primary external data source that will be utilized for this project is the NJDEP Ambient Biological Monitoring Network (AMNET) data for stream invertebrates and freshwater fishes. Princeton Hydro had also performed background water quality monitoring on Sidney Brook in 2003. The results were prepared for Franklin Township Environmental Commission as a report to assist in the Category 1 designation. The AMNET data have undergone extensive levels of quality control and quality assurance, and have been incorporated into the *Integrated Water Quality Monitoring and Assessment Reports* for the State of New Jersey. Because these data are known to have a high level of quality assurance, no further background on these data will be needed prior to incorporation of these data into the Sidney Brook plan. Furthermore, no qualifiers or flags will be needed when these data are presented because of their established high quality.

Published USGS maps for the watershed will also be utilized to understand and verify the historical development of the watershed. These USGS 1:24,000 quadrangle maps have varying levels of quality control for the original data and the revisions, but constitute the most accurate historical documentation of roads, buildings, and drainage networks currently available. These historic USGS maps will therefore be fully incorporated into the Sidney Brook plan, as needed, with no further review of the data and their sources. In addition, information obtained from these maps will be clearly sourced, but no additional qualification of the data will be given.

The NJDEP Division of Fish and Wildlife have also collected fisheries data on Sidney Brook, both in terms of existing communities of freshwater fishes as well as records of trout stocking for the Brook. The Fish and Wildlife data will be collated and referenced in a supporting role to assist in any decisions or recommendations.

Additional combined volunteer/professional efforts to collect benthic macroinvertebrate data from locations in the watershed are known to exist for the Sidney Brook watershed. These data will be collated and synthesized for the current project. In addition, any quality assurance and/or quality control information from these data collections will be accessed to determine whether rigorous standards were applied at the training, sample collection, and lab processing levels. Because these data were collected, in part, through volunteer efforts, it is expected that limited quality assurance was built into the data collection. If these data lack the level of quality assurance and quality control set forth in this Quality Assurance Project Plan for benthic macroinvertebrate collections, the data will be retained and utilized, but all tables of these data will highlight the unknown quality and uncertainty underlying these data. As a result, these data will be used as broad reference points to determine possible conditions at the time of collection, and will not be used as the primary source for any planning, protection, or restoration decisions or recommendations.

The Sidney Brook has not been monitored comprehensively for water chemistry by any local, state, or federal groups. The South Branch Watershed Association staff and volunteers, and the NJ Water Supply Authority may have collected limited water chemistry data for the stream. As stated above, if these data lack the level of quality assurance and quality control set forth in this Quality Assurance Project Plan, the data will be retained and utilized, but all tables of these data will highlight the unknown quality and uncertainty underlying these data. As a result, these data will be used as broad reference points to determine possible conditions at the time of collection, and will not be used as the primary source for any planning, protection, or restoration decisions or recommendations

Any additional data sources encountered or provided during the Sidney Brook project will be reviewed in a similar manner as the above examples. For data with strong quality control procedures and clear documentation of quality assurance, data will be directly incorporated into the project. For data with uncertain data quality, the data will be utilized as a possible reference point for comparisons and evaluations, but will not be the primary basis for decisions or recommendations of the plan.

Section 19: Data Management

Two general forms of data will be collected: (1) data recorded in field notes or in laboratory reports (e.g., discharge measurements); and (2) digital data recorded in data loggers (e.g., continuous water temperature). For data recorded in field notes or laboratory reports, photocopies will be produced and stored, and data entry into digital format will include 100% proofing of the data entry process (see Section 14). For digital data, backup copies of the digital files will be created and stored off-site.

Once data are compiled into a digital format, the original data products and files will be write-protected in order to ensure the integrity of these original data. Derivative data and analyses will draw on these original files by reference, but the original data files will not be modified once they are created and certified as accurate via proofing. Data analyses will use commercial software products (e.g., Microsoft Excel, **Microsoft Access**, Insightful S-Plus) for all subsequent steps. These programs will have established and documented routines for all calculations to ensure accurate calculations during data analysis steps. **The NJDEP will receive a digital copy of the data in a format that is not write-protected.**

The final reports for the Sidney Brook project will include raw data products as well as derived tables and figures that summarize the collected data. For raw data products, either original lab reports or fully proofed data tables will be presented. For data summaries, all values used in the tables and figures will be proofed for accuracy prior to general distribution of the reports to project team members. Each figure or table will be printed, and the printed product will be labeled with date and name of the person proofing the data. All data points will then be cross-validated against the original proofed data products, with clear marks indicating each proofed data value. For any errors encountered during this proofing process, the errors will be highlighted on the printed sheet, the correct value will be noted, and a note with date and initials for the person correcting the error will be placed next to each original mistake. These proofing records will be kept in the project folder for the duration of the project and will be archived for 3 years.

DATA VALIDATION and USABILITY

Section 20: Quality Assurance Assessment and Response Actions

The primary objective of the project (see Section 5) is the characterization of the existing quality of the Sidney Brook watershed. The collection of data meeting the Data Quality Objectives will provide a detailed characterization of the water quality, bacterial concentrations, thermal regime, and ecological integrity of the Sidney Brook at eleven locations throughout the watershed. Thus, the collection of quality-assured and quality-controlled data under the current Quality Assurance Project Plan will meet the primary objective of a detailed characterization of the Sidney Brook stream system. All data collected during the will be audited with respect to:

1. Data Quality Objectives
2. Compliance with sampling schedule set forth in Table 10
3. Sample specifications of Section 11 and Table 11, 12, 13 and 14
4. Calibrations of Section 16 and Table 17
5. Additional specifications established in this Quality Assurance Project Plan

The Quality Assurance assessments will utilize all procedures, requirements, and Data Quality Objectives outlined in this QAPP to objectively determine whether the collected data comply with the project's requirements. Any errors, deviations, or deficiencies identified in the data collection process will be addressed through a review of the type of deficiency, the options for correcting the deficiency, and ways to prevent any future issues. This review will be conducted jointly by the Scientific Project Manager and the QA/QC Officer using the QAPP and the specifications identified for how data will be handled. These assessments will provide detailed information about attainment of Data Quality Objectives, compliance with all Testing and Calibration procedures, data completeness, and deviations/deficiencies in the project data. These assessments will result in data-specific determinations of usability of data and any necessary qualifications of data. The determinations for each identified deviation/deficiency will lead to elimination of data not suitable for the project, flagging of data collected outside the project specifications, and supplemental data to ensure sufficient data for the Sidney Brook watershed characterization report as well as the recommendations in the Sidney Brook Watershed Protection Plan.

A summary of these assessments and any noted deficiencies will be prepared by the sampling crew and the Scientific Project Manager. Deficiencies will be highlighted in this report, with recommendation on both future prevention as well as corrective actions for the existing deficiencies. Determinations for corrective actions and/or qualification flags for existing data will be determined by the Scientific Project Manager and the QA/QC Officer based on the frequency, severity, and manner of the deficiencies. The final determinations will be summarized in an addendum to the Characterization and Assessment report. In addition, any actions required based on these reviews and assessments will be propagated through all existing data and broader project reports. All project participants will immediately report any deficiencies to the QA Officer. The QA Officer will recommend appropriate corrective action and determine the acceptability of affected data when deficiencies are noted. The QA Officer will notify the Project Officer of any unacceptable data to ensure that it is not included in evaluations of water quality for reporting purposes. Results of all corrective actions will be documented.

Section 21: Data Review, Verification and Validation

Data review, verification, and validation will occur throughout the Sidney Brook Watershed project through the multiple quality assurance steps outlined in this Quality Assurance Project Plan. The final determination of data validity will result from the Quality Assurance assessments (see Section 20) and the attainment of Data Quality Objectives, compliance with all Testing and Calibration procedures, data completeness, and deviations/deficiencies in the project data. These assessments will result in data-specific determinations of usability of data, necessary qualifications of data, and possible re-sampling to attain data completeness. The data-specific determinations for each identified deviation/deficiency will lead to elimination of data not suitable for the project or flagging of data collected outside the project specifications.

Section 22: Validation and Verification Methods

The Quality Assurance assessments (see Section 20) will utilize all procedures outlined in this QAPP to determine whether the collected data comply with the project's requirements. Because these procedures and objectives are generally quantifiable, the determination of compliance will generally be an objective determination of how the data meet the specifications in the QAPP. In a few instances (e.g., composition of invertebrates in the sorting checks, the manner of termination of the flow meter spin test), subjective criteria will be employed based on extensive experience and knowledge of the specifications for acceptable data.

As described in Section 20, any errors, deviations, or deficiencies identified in the data collection process will be addressed through a review of the type of deficiency, the options for correcting the deficiency, and ways to prevent any future issues. This review will be conducted jointly by the Scientific Project Manager and the QA/QC Officer using the QAPP and the specifications identified for how data will be handled. In general, data collected outside the specifications of the procedures, testing, and calibration identified in this QAPP will be flagged or eliminated from further use.

Section 23: Reconciliation with Data Quality Indicators and Measurement Quality Objectives

The project data will be reconciled with the Data Quality Objectives outlined in the QAPP (see Section 20), along with other required aspects of the data collection process, for each relevant data point collected as part of the Sidney Brook project. In this manner, full comparison of the data to the stated quality objectives will be attained.

The primary objective of the project (see Section 5) is the characterization of the existing quality of the streams in the Sidney Brook watershed. The collection of data will provide a detailed characterization of the water quality, bacterial concentrations, thermal regime, and ecological integrity of the Sidney Brook at eleven locations throughout the watershed. Thus, the collection of quality-assured and quality-controlled data under the current Quality Assurance Project Plan will meet the primary objective of a detailed characterization of the Sidney Brook watershed.

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Appendices

Appendix A - Scope of Work from Executed Contract

Appendix B - USGS Sediment Results for South Branch Raritan River Station 01397000

Appendix C- IAL Methodology for Priority Pollutant Analysis

Appendix D - Standard Operating Procedures (SOPs) for Sidney Brook Project

Appendix E - Habitat Assessment Form for High Gradient Streams

Appendix A

Attachment D (Scope of Work)

from Executed Contract

Appendix B

USGS Sediment Results for

South Branch Raritan River Station 01397000

Appendix C

IAL Methodology for

Priority Pollutant Analysis

Appendix D

Standard Operating Procedures (SOPs)

for Sidney Brook Project

Appendix E

Habitat Assessment Form

for High Gradient Streams