CHARACTERIZATION AND ASSESSMENT OF THE ROYCE BROOK WATERSHED

ACKNOWLEDGEMENTS

PRIMARY AUTHORS:

Steve Yergeau, Watershed Assessment Specialist
Priya Sankalia, GIS Specialist

CONTRIBUTING AUTHORS:

Andrew Rowan, Ph.D., Director, The GIS Center
Noelle MacKay, Deputy Director
Matthew J. Mulhall, P.G., M^2 Associates Inc.

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INTRODUCTION

Sprawl, according to Webster's New Collegiate Dictionary, is defined as: "to creep or clamber awkwardly; to spread or develop irregularly; to cause to spread out carelessly or awkwardly." *Awkward. Irregular. Careless.* These are not words that we want to associate with the planning and development of the towns where we live, work and play. And yet, in Central New Jersey the consequences of this careless development are clear: development is degrading our natural resources, most particularly putting the region's water quality and quantity at risk.

Across America, poor planning is allowing farmlands, forests, wetlands and viewsheds to be devoured at an astounding rate, changing forever the character of the places we call home. Countless acres of open space have become strip malls, roads and detention basins. This consumption of open space by haphazard growth is not merely aesthetically disturbing, but has severe environmental and quality of life costs.

Situated within the metropolitan corridor between New York and Philadelphia, Central New Jersey is on the front line in the battle to stop sprawl as development threatens to destroy our remaining open spaces. The consequences are clear: pollutants are elevated in many of our waterways, our wildlife populations are showing signs of distress due to exposure to high levels of pollutants, beautiful views are lost and our quality of life is diminished. Roadways and traffic congestion are eroding our sense of place and community.

Many streams in the 265-square-mile Stony-Brook Millstone Watershed (referred to from now on as the Millstone Watershed) have been designated as impaired by the New Jersey Department of Environmental Protection (NJDEP), which cites the pace of development and nonpoint-source pollution as the major causes. Additionally, 63% of the waterways in New Jersey are impaired for drinking, recreational or fishing uses and 39% of the waterways in the Nation are impaired (USEPA 2002). According to NJDEP data, nearly 11,000 acres of land were developed in the Millstone Watershed between 1986 and 1995/97, a rate of approximately 92 acres per month or over 92 football fields each month (one acre equals approximately one football field). During the years since 1995/97, this area has continued to experience extensive development, as 50 acres of land are lost to development each day in New Jersey.

In order to better identify the causes of declining environmental health, we need an understanding of our watershed and the changes that have occurred within its natural boundaries. The water that flows in a stream arrives there in part by flowing over the land or percolating through the soil. Thus, how we develop the land is reflected in the water quality of the streams.

Research indicates that the most effective management efforts are generally confined to subwatersheds on the order of 20-50 square miles (Center for Watershed Protection 1998). Such a localized approach allows personal contact with the community and fosters building relationships and trust. Most successful programs changing personal behavior have also cited one-to-one relationships as the key to success. Thus, this project was developed to address problems specific to a smaller subwatershed within the Millstone Watershed.

The first step in this project is to provide a characterization and assessment of an impaired subwatershed in order to understand the causes of the problems and identify appropriate solutions. This report identifies the current status of the environment (characterize) and compares this to community goals and adopted standards in New Jersey (assess). Information is collected on soil types, geology, land use changes, water quality, rare and/or endangered species, critical habitats and population changes. This information is analyzed individually and then integrated with other data from the watershed to pinpoint the potential causes of the water quality problems.

Once the subwatershed is identified and evaluated, the most effective watershed management tools are selected to restore, enhance or protect water quality. For example, if nonpoint-source pollution from residential lawns or a golf course is identified as a concern, the focus should be on implementing education programs for homeowners and golf courses in these areas. Visual assessments of local streams can also guide management actions. Areas in need of extensive streambank restoration can be identified, as can areas with high water quality that needs to be preserved. Stony Brook-Millstone Watershed Association (SBMWA), with 56 years of experience in water quality protection, has a large suite of tools that have been utilized successfully in the past to preserve our resources. These include:

- Extensive experience in education working with both adults and children;
- Streambank restoration, riparian buffer creation and reforestation;
- One-on-one education of residents, businesses and golf courses on best management practices for their properties in our River-Friendly Programs;
- StreamWatch, our successful, long-term water quality monitoring program;
- Working with municipalities to integrate the vision for the municipality into their zoning and ordinances; and
- Open space acquisition planning.

The Royce Brook Watershed was the fourth subwatershed chosen to undergo scrutiny, and this Characterization and Assessment Report is the result of our investigation. The Beden Brook Watershed was the first subwatershed to be thoroughly assessed, Rocky Brook Watershed was second and Cranbury Brook was third. The Royce Brook Watershed is located within the northern portion of the larger Millstone Watershed, in Central New Jersey (Figure 1). This report brings together information and links data to provide an understanding of why water quality in some areas is impaired. As SBMWA has done for many years, we are working with residents, municipal officials and businesses to understand their concerns and vision for their community, and we will work together to implement the best strategies for improving environmental quality. For this report, when discussing the entire Royce Brook area, it will be referred to as a watershed.

This report is intended to relay the past and present status of the Royce Brook Watershed and its environmental resources. The evaluation was used to set priority areas where SBMWA can utilize its effective watershed restoration tools. Goals of watershed restoration include improved water quality; local residents, businesses, and municipalities educated on nonpoint pollution reduction; and a measurable reduction in nonpoint-source pollution in Royce Brook and its tributaries.

SBMWA is not alone in our efforts. The United States Environmental Protection Agency (USEPA) has stated that nonpoint-source pollution, or pollution from runoff, is currently one of the leading causes of water quality degradation (USEPA 1996). This means that solutions, like recycling, involve everyone – our elected officials, business leaders, golf course superintendents and all residents. This report summarizes the causes of the problem. It is up to everyone who lives, works and plays in the Royce Brook Watershed to work together to provide a vision for this area and strive to protect the environment and quality of life that we value.

LANDSCAPE

A foundation for the Royce Brook Watershed needs to be laid in order to fully begin assessing the region. That foundation takes the form of understanding the townships that decide what happens within their borders and to the watershed, the waterways that meander through the landscape, the populations of residents that have an impact of the local environment everyday and the flora and fauna that inhabit the area and rely on it for survival. By simply describing these basic components within the watershed, protection and preservation practices can be formed for these particular resources.

SETTING

The Royce Brook Watershed covers over 10,550 acres (approximately 16.5 square miles) in parts of Hillsborough Township and Manville Borough (both in Somerset County; Figure 2, Table 1 and Graph 1). Within the watershed, the majority of the land (9,990.8 acres or 94.5%) is located in Hillsborough Township (Figure 2, Table 1, and Graph 1). The remaining watershed area (577.2 acres or 5.5%) lies within Manville Borough (Figure 2, Table 1, and Graph 1).

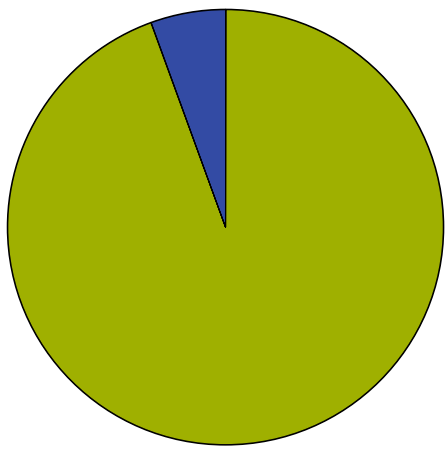
Table 1: Municipalities within the Royce Brook Watershed.

Municipality	County	Acres in the Royce Brook Watershed
Hillsborough Township	Somerset	9,990.8
Manville Borough	Somerset	577.2
TOTAL	- - -	10,568.0

Royce Brook has its headwaters in Hillsborough Township and flows approximately 9.2 miles east and north through Manville Borough before meeting the Millstone River just east of Route 533, right before the Millstone River joins the Raritan River (Figure 2). There are many unnamed tributaries of the Royce Brook.

The Royce Brook Watershed contains one golf course, the Royce Brook Golf Club in Hillsborough Township.

Graph 1: Percentage of the Royce Brook Watershed area within each municipality.



HISTORY

Because Clovis-type spear points have been found in Hillsborough, it is believed that early humans arrived at least ten or twelve thousand years ago when mammoth and mastodon still roamed the area. Artifacts of all of the archaeological periods are present indicating continuous occupation until historic times.

The Dutch first explored Hillsborough and the surrounding area in the middle 17th century. At that time the area was occupied by the Unami who were a part of the Lenapi Tribe. Because they spoke the Algonquin language they are considered part of the Algonquin Nation.

Records show that large tracts of land were patented to landowners in the area at around 1685. Some of the earliest land transactions found in the records of Hillsborough begin around 1700 and include the names John Royce, Peter DuMont, and Hendrik Beekman. Some of this land lies along what is now South Branch River Road. A short time later farms were carved out of a tract patented to Thomas Barker, whose land was along the Millstone River.

Hillsborough was known as Hillsbury and received its Charter on May 29, 1771, and officially became Hillsborough Township. Before that date it was known as the "Westering Precinct of Somerset County."

POPULATION

All people live in a watershed and have both direct and indirect impacts on water quality and therefore have opportunities to responsibly manage and improve water quality. Increasing populations in the Royce Brook Watershed are adding to the pressures of waste disposal and water treatment, an increased need for additional housing and increased water usage. Development pressure increases with growing populations as the infrastructure needed to support more residents needs to be in place.

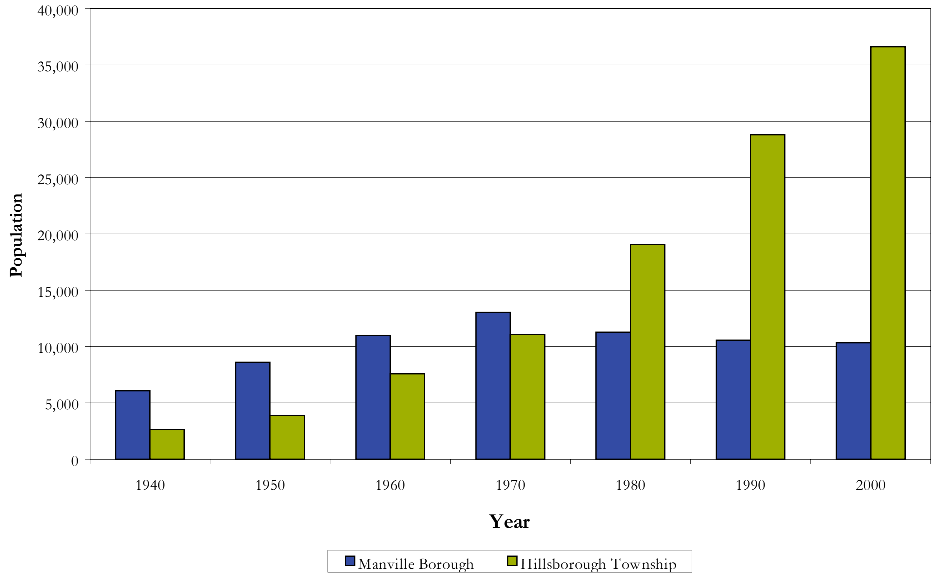
Population is increasing and development is progressing in the Royce Brook Watershed. The current trend is in spreading large developed areas over the landscape, instead of clustering in hamlets, villages, town centers, or boroughs. Dependence on automobiles and the lack of reliable public transportation have encouraged this pattern of development in the area and throughout New Jersey.

Within the municipalities that comprise the Royce Brook Watershed, the total population for the municipalities has increased more than five-fold over 60 years, from 8,710 people in 1940 to 46,977 in 2000 (Graph 2 and Table 2). This increase is at an average rate of 638 people per year. In the last 30 years alone (between 1970 and 2000), the population within the municipalities that constitute the Royce Brook Watershed increased at the rate of 763 people per year. Between 1940 and 2000, population changes for people living within the two municipalities found within the watershed show that overall growth occurred in both municipalities (Figure 3, Figure 4, Table 2, and Graph 2).

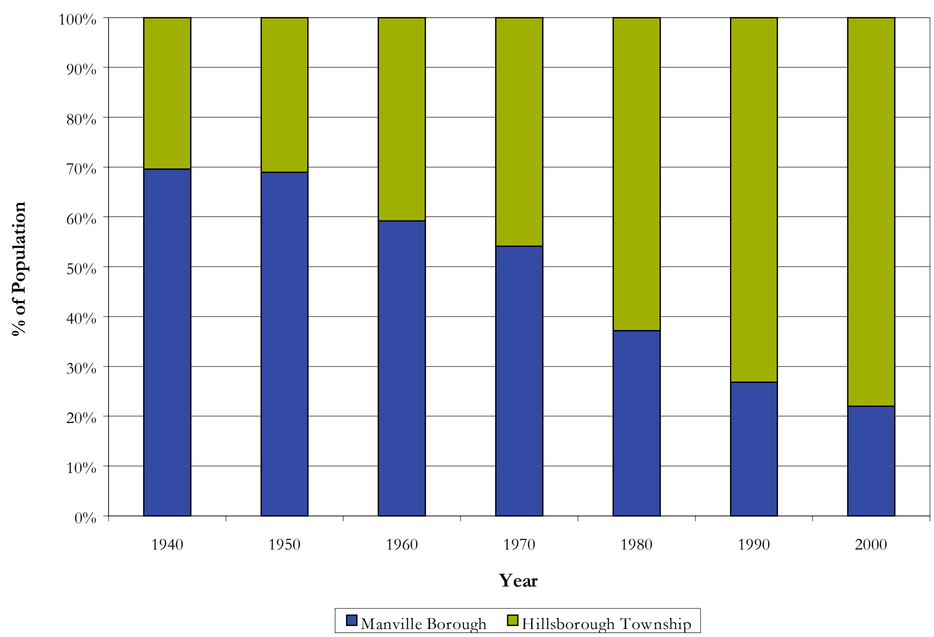
The largest population increase occurred in Hillsborough Township. Hillsborough experienced a 1,285% increase in residents between 1940 and 2000, as it went from 2,645 residents to a population of 36,634 in 2000 (Table 2). Hillsborough accounts for the largest portion of the Royce Brook Watershed (making up 94.5% of the overall watershed's area) and also contributed the largest percent of the population (78.0%) in the Royce Brook Watershed in 2000 (Graph 3). With such an increasing population in one municipality that constitutes a major portion of the Royce Brook Watershed, local governance needs to thoughtfully plan out the future direction of development within the borders of Hillsborough Township.

A much smaller change in population was found in Manville Borough with only a 71% increase in population over 60 years (Table 2 and Graph 2). In fact, over the last 30 years, Manville lost 2,686 residents while Hillsborough gained 25,573 residents in that same time period (Table 3). With the slow population growth rate and a large loss (21.0%) of residents over the past 30 years, Manville still maintains the highest density of residents in the Royce Brook Watershed with an average of 4,167.5 residents per square mile (New Jersey State Data Center 2001; Figure 3 and Figure 4). Hillsborough Township has only an average of 669.9 residents per square mile (New Jersey

Graph 2: Historical population of the Royce Brook Watershed by municipality. *



Graph 3: Percentage of total population of the Royce Brook Watershed by municipality. *



* The population figures listed are for the entire municipality and not just for the portion found in the Royce Brook Watershed.

State Data Center 2001; Figure 3 and Figure 4). Much of the density in Hillsborough is distributed near State Route 206 and County Road 514 (Figure 4). These numbers coincide with the fact that Manville Borough (like all boroughs in the state) was designed to cluster development and residents together and that Manville is nearly built out.

Table 2: Population changes in the municipalities that comprise the Royce Brook Watershed from 1940 - 2000. *

Municipality	1940 Population	2000 Population	% Population Change
Hillsborough Township	2,645	36,634	+1,285%
Manville Borough	6,065	10,343	+71%
TOTAL	8,710	46,977	+439%

Table 3: Population changes in the municipalities that comprise the Royce Brook Watershed from 1970 - 2000. *

Municipality	1970 Population	2000 Population	% Population Change
Hillsborough Township	11,061	36,634	+231%
Manville Borough	13,029	10,343	-21%
TOTAL	24,090	46,977	+95%

* The population figures listed are for the entire municipality and not just for the portion found in the Royce Brook Watershed.

CRITICAL HABITATS

NJDEP's Division of Fish and Wildlife has developed The Landscape Project, a planning tool to help land managers, planners and regulatory agencies integrate wildlife protection into their overall land use goals. The Landscape Project establishes "accurate boundaries around critical wildlife habitats and then comparatively ranks them to offer prioritization options for varying levels of conservation and management" (Niles et. al. no date). The ranking is based upon the presence or absence of animal species of concern, state threatened and endangered species, and federally threatened and endangered species.

Due to the loss of specific habitats, pollution, invasive plants and development, many species of plants and animals are losing the basic components they need to survive in our area (food, shelter and clean water.). Loss of animal species can be linked to a loss of resources that are necessary for survival of that species. Endangered species are those whose survival in New Jersey is in immediate danger. Threatened species are those who may become endangered if conditions that harm them continue to accumulate.

Somerset County supports a large diversity of endangered or threatened vertebrate, invertebrate and plant species (Table 4). Critical habitats for such species cover 37.0% (3,900 acres) of the Royce Brook Watershed (Figure 5). The portion of Hillsborough Township that is in the Royce Brook Watershed has 39.0% of its areas covered by critical habitats. Much of the critical habitats in Hillsborough Township are forested areas of importance to wildlife, ranging from Suitable Habitat (suitable for fulfilling the habitat requirements of species of concern, but no such species documented there) to areas with State Threatened Species (a patch of habitat where State-listed threatened species have been documented) (Figure 5). Smaller patches of grasslands are found in the western and southeastern portion of the watershed (Figure 5). Manville Borough is 7.0% covered by critical habitats within the watershed. These habitats contain wetland habitats providing Suitable Habitat for threatened or endangered species (Figure 5). Much of this critical habitat is located in the corridor along Royce Brook (Figure 5). The Royce Brook Watershed is home to one recorded state threatened species: the bobolink (*Dolichonyx oryzivorus*). Bobolinks prefer grasslands, especially low-intensity agricultural areas.

Table 4: Number of endangered/threatened species in the county that makes up the Royce Brook Watershed. *

County	Vertebrates	Invertebrates	Plants **
Somerset	16	3	20

* NJDEP's Natural Heritage Program gives the general area where the endangered or threatened species is located. This reduces the ability of people to pinpoint the location of the organism's habitat, and thus reduce the impact on that particular organism.
** All Plants recorded in the Royce Brook Watershed are listed as Endangered in New Jersey.

FLOODING

Flooding in the Millstone Watershed occurs as the result of intense thunderstorms, nor'easters, and hurricanes. These storms deposit large amounts of precipitation and produce significant runoff and headwater flooding of the low-lying and relatively flat floodplain. Headwater flooding is caused by drainage of rainfall from surrounding uplands into downstream areas. Coincident backwater flooding also occurs in association with the Raritan River. Backwater flooding results from downstream conditions such as channel restriction and/or high flow in a downstream confluence stream or river. The Borough of Manville, located at the confluence of the Millstone and the Raritan Rivers, is flooded by headwater and backwater events (U.S Army Corps of Engineers 2000).

The highly developed lands of the Royce Brook Watershed are increasing runoff potential and flood hazards. The Borough of Manville has experienced several major flooding events over the past century (U.S. Army Corps of Engineers 2000). In response to these floods, the U.S. Army Corps of Engineers (USACE) has been working to alleviate the impact of floods in the Millstone Watershed, and the area of Manville Borough in particular. Their work was initiated in 1999 and recommended non-structural and structural options to control flooding in the Borough.

Recommended non-structural options include (U.S. Army Corps of Engineers 2000):

- Acquisitions: The purchase, evacuation and removal of buildings from the floodplain.
- Raising: The elevation of a structure's lowest level to above the height of the floodplain.
- Ringwalls: Surrounding of a building with a barrier to stop floodwaters from entering the building.
- Floodproofing: Either wrapping or containing a structure within impermeable material or elevating the major utilities of a building to above potential floodwaters.

Recommended structural options include the construction of a levee wall surrounding the sections of Manville Borough that are most prone to flooding (U.S. Army Corps of Engineers 2000). Both the USACE and U.S. Geological Survey (USGS) are currently looking at which alternatives are appropriate to move forward in Manville.

<u>Assessment</u> –
The pattern of population growth found in Hillsborough Township has a more detrimental impact on water quality than clustering development in town centers. As agricultural lands, forested areas, and lands adjacent to wetlands are developed into residences and office buildings, they create residential and business destinations that attract more development (Center for Watershed Protection 1998). These developed areas tend to have a higher percentage of impervious cover, material that prevents water from percolating back into the ground. Among other things, this increase in impervious cover alters flooding patterns, heightens pollutant loads to streams, raises water temperatures and reduces baseflow in streams during drought (Center for Watershed Protection 1998; see Land Use section for

more information). Development that sprawls over the landscape makes systematic stormwater control extremely difficult, as well as fragmenting forests and other habitats thereby causing a decline in ecological health. Established centers, such as Manville Borough, that concentrate populations and impervious cover while maintaining surrounding open spaces (either in adjacent municipalities or within their own borders) minimize habitat fragmentation. In addition, infrastructure needs and costs increase as development occurs further away from established sewer and water systems. Municipalities need to manage the additional infrastructure and development patterns such that water quality is protected. If this population growth remains unchecked, environmental degradation is sure to follow. Proactive planning needs to be performed if this trend is to be curtailed.

Developing areas as planned unit developments is one way to reduce sprawl in New Jersey. Other innovative ways to plan developments include re-zoning (changing zoning classifications to permit development that is less dense), mixed-use development (projects that integrate different land uses, such as restaurants, residences, offices and parks), conservation design and town-center designation (centralized growth areas through incentives that allow for developing at higher densities and protecting surrounding open space). These alternatives need to be based on accurate scientific information about the carrying capacity of available water supplies, sewer systems and other infrastructure, and the goals and objectives of the municipality's Master Plan and decision-making committees. Municipalities must incorporate these alternatives into their Master Plans in order to balance development with the environment.

By providing alternatives to traditional development, municipalities will protect the environment and especially the sensitive habitats and the wildlife that lives within them. These critical habitats are being threatened by development. Municipalities need to incorporate information on the locations and inhabitants of critical habitats to assist in effectively planning out open space protection and where to place new developments. In addition to providing habitat for rare species, protecting important wildlife habitats will result in more open space for passive outdoor recreation, such as hiking, bird watching and canoeing. Open spaces provide places where people can escape the confines of urban and suburban living.

Flooding in Manville Borough will continue due to its location at the confluence of the Millstone and Raritan Rivers, unless progress is made to reduce floodwaters. The plans being put forth by the USACE to control flooding in Manville Borough need to be fully evaluated and implemented, if deemed feasible.

KNOWN CONTAMINATED SITES

Contaminated sites are generally the result of spills, leaks or careless practices with chemicals or other hazardous materials such as biological or radioactive wastes. It is important to be aware of these sites because the substances involved can be highly toxic and, therefore, can become hazards to human health as well as to the natural environment. Common contaminants found on these sites include metals, petroleum products and by-products, organic solvents and pesticides. Several different branches of the NJDEP regulate and oversee these sites once they are discovered and evaluated.

Note that the listing of contaminated sites gives the name of the current owner of each property. The current site owner and the potentially responsible party (PRP) for the contamination are not necessarily the same. Site managers at NJDEP are currently overseeing the investigation of listed sites found. Each site has a NJDEP case manager appointed to it, and the cleanup process can run several years depending on the severity of the contamination.

There are also many residential sites that contain underground storage tanks (USTs) that have not been described or mapped. This lack of information may prove risky as the status, whether leaking or intact, for these USTs is unknown, and therefore whether or not they are contaminating surrounding areas. For privacy and cost-benefit reasons, SBMWA has not made any effort to enumerate, locate or identify any USTs in this watershed.

In cases where there is ground water contamination, the Currently Known Extent (CKE) and Classification Exception Area (CEA) are determined. The CKE is a spatially defined area within which the local ground water resources can be compromised because the water quality exceeds drinking water and ground water quality standards for specific contaminants (NJDEP 2002). The CEA is a geographic area within which the New Jersey Ground Water Quality Standard (NJGWQS) for contaminants have been exceeded (NJDEP 2002). The determination of both these areas is useful to NJDEP, water purveyors and local officials in making decisions concerning appropriate treatment and/or replacement of contaminated drinking water supplies. They are also intended to provide information to the public about contaminated ground water areas and where well installation should be avoided, unless precautionary measures are taken to protect potable users.

Note that the list of contaminated sites and their remediation level is based on the 2001 information and supplemental GIS data available from the NJDEP's Site Remediation Program. This information and data are available for download from http://www.nj.gov/dep/srp/kcs-nj/ and as of publication of this report was last updated on October 1, 2002. *Any discrepancies in the information presented here should be brought to the NJDEP Site Remediation Program's attention at 1-800-253-5647 for reconciliation.*

There are currently 29 known contaminated sites (KCSs) in Royce Brook Watershed (Figure 6 and Table 5). Four are located in Manville Borough and the remaining 25 are in Hillsborough Township (Figure 6 and Table 5). Eleven of the 25 KCSs in Hillsborough are located along Route 206 (Table 5).

Two of the sites in Hillsborough Township are listed as Superfund sites: Nichols Engineering & Research Corporation and National Diagnostics (Figure 6 and Table 5). A federal trust fund (the "Superfund") was established by Congress by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, and is authorized for particularly large, extensive or dangerous contamination events. Superfund monies are available to remediate sites on the National Priority List, a ranking of sites that the U.S. Environmental Protection Agency (USEPA) has determined might represent long-term threats to public health and the environment.

The Nichols Engineering & Research Corporation site has ground water contamination due to volatile organic compounds and chlorinated solvents from an incident in 1985.

At National Diagnostics, trichloroethylene (TCE) and tetrachloroethylene (also known as perchloroethylene, or PCE) contaminated ground water wells, which resulted in a fine in 1986. This site is considered resolved and contaminants are being left to decrease by natural attenuation.

Assessment –
There are a large number of known contaminated sites in the Royce Brook Watershed (29 in a 16.5 square mile watershed). The PRPs need to stay vigilant of these sites by monitoring and perform remediation of any contamination present. This is especially true for those sites with certain or possible ground water contamination and more so for the Superfund sites: Nichols Engineering & Research Corporation and National Diagnostics. The Royce Brook Watershed has many areas with high recharge to ground water (see Water Supply section for more information). These areas not only allow for quick movement of water to ground water supplies but also any pollutants traveling with that water. By working to contain and clean up these potential sources of ground water contamination, the municipalities will ensure that drinking water supplies are safeguarded for their residents.

Table 5: Known Contaminated Sites in Royce Brook Watershed.

Site Identification Number	Site Name	Address	Municipality	Remedial Level*
NJL600178560	Hillsborough & Montgomery Telephone	306 Route 206	Hillsborough Township	B
NJL000060319	17 Scott Drive	17 Scott Drive	Hillsborough Township	C1
NJD982188468	Export Restoration Center (BP Gas)	401 South Main Street	Manville Borough	C1
NJL800499782	237 Hillsborough Road	237 Hillsborough Road	Hillsborough Township	C1
NJL800472821	272 Route 206	272 Route 206	Hillsborough Township	C1
NJL800500381	193 Valley Road	193 Valley Road	Hillsborough Township	C1
NJL000075861	35 North 15th Avenue	35 North 15th Avenue	Manville Borough	C1
NJL800596637	2227 Camplain Road	2227 Camplain Road	Hillsborough Township	C1
NJL800607491	244 Valley Road	244 Valley Road	Hillsborough Township	C1
NJL800301673	300 Valley Road	300 Valley Road	Hillsborough Township	C2
NJL000066563	Weidel Realty Company	302 Route 206	Hillsborough Township	C2
NJL500036025	Penn Color Incorporated	1501 Kennedy Boulevard	Manville Borough	C2
NJL600021109	Hillsborough Corner Store	400 Amwell Road	Hillsborough Township	C2
NJD986599405	Exxon Service Station - Hillsborough Township	296 Route 206 Triangle	Hillsborough Township	C2
NJD011418837	Sunoco Service Station - Manville Borough	710 Main Street	Manville Borough	C2
NJL600233449	Manville Borough Public Works Facility	1 William Street	Manville Borough	C2
NJL600203467	Texaco Service Station - Hillsborough Township	144 Route 206 South & Park Avenue	Hillsborough Township	C2
NJL800528077	Amoco Service Station - Hillsboroguh Township	426 Route 206	Hillsborough Township	C2
NJL800423733	Hillsborough Board of Education	Amwell Road & Route 206	Hillsborough Township	C2
NJL800545287	26 Scott Drive	26 Scott Drive	Hillsborough Township	C2
NJ4360010330	Veterans Administration Supply	152 Route 206 South	Hillsborough Township	C3
NJL000030254	Hillsborough Township Sanitary Landfill	Sunnymeade Road	Hillsborough Township	C3
NJL800531279	NJDOT Route 205 Section 15 N&J	137 Route 206	Hillsborough Township	C3
NJD006988455	Nichols Engineering & Research Corporation	Homestead & Willow Roads	Hillsborough Township	D
NJD085637379	National Diagnostics	198 Route 206	Hillsborough Township	D
NJD982181265	Old Camplain Road Well Ground Watershed Contamination	Old Camplain Road	Hillsborough Township	NA
NJ2360010332	General Services Administration Depot	152 Route 206 South	Hillsborough Township	Unknown
NJL800455685	913 5 Renate Drive	913 5 Renate Drive	Hillsborough Township	Unknown
NJL800537573	156 Opossum Road	156 Opossum Road	Hillsborough Township	Unknown

* Remedial Level: Level of site complexity to remediate the contamination, as outlined in Case Assignment Manual by the NJDEP's Site Remediation Program.
The intent of the remedial level is to reflect the overall degree of contamination at a site recognizing that different areas may involved varying levels of action.
A = Emergency or single-phase, short-term clean up.
B = Single phase clean up of soils only.
C1 = Single source/contaminant affecting both soils and groundwater.
C2 = Multiple sources/contaminants affecting soil/groudwater - moderate.
C3 = Multiple sources/contaminants affecting soil/groudwater - severe.
C4/D = Superfund site.
N/A = Known sites not adequately assessed to a rank.

KNOWN CONTAMINATED SITES

POINT SOURCE DISCHARGERS

Point source dischargers are facilities that discharge treated waste or cooling water directly to surface or ground water. These discharges can have powerful effects on the quality and quantity of water in a stream or aquifer. Because flow from these sources is independent of storm events, the quality of effluent in surface water discharges is crucial to habitat quality. The NJDEP regulates these facilities, and several federal and state laws govern their discharges. Each facility is assigned a case manager and is classified according to its type of discharge (i.e., land application, a pipe discharge to surface water, a percolation lagoon, a stormwater detention basin, etc.). Discharges may combine waters from more than one source (storm water and cooling water combinations are common). If this is done, then the permit is classified according to the major component of the discharge. Regular monitoring of the discharge is required for all permits.

Note that the information presented in this section was derived from the NJDEP Division of Water Quality's New Jersey Pollution Discharge Elimination System (NJPDES) database. This database is available for download from http://www.state.nj.us/dep/dwq/database.htm and as of publication of this report was updated on December 31, 2000. Supplemental information was obtained from the NJDEP's GIS layer for both surface water and ground water dischargers. *Any discrepancies in the information presented here should be brought to the NJDEP Division of Water Quality's attention at (609) 292-4543 for reconciliation.*

PERMITTED DISCHARGERS TO SURFACE WATER

There are currently eight permitted point source dischargers in the Royce Brook Watershed, all of which are located in Hillsborough Township (Figure 7). The point source dischargers to surface water in the Royce Brook Watershed consist of one sewage treatment plant (STP), the Valley Road Sewer Company-Fieldhedge Drive STP, and seven industrial dischargers (Figure 7). All of the industrial dischargers are classified as minor, except for Buckeye Pipeline Company, which is classified as a Petroleum Hydrocarbon Remediation (Figure 7).

Four of the industrial dischargers have multiple discharge points into local waterways (Figure 7). Glen-Gery Corporation (NJPDES #NJ0073652) has ten discharge points on the main stem of Royce Brook (Figure 7). Philips Concrete Incorporated (NJPDES #NJ0122432) and Industrial Tube Corporation (NJPDES #NJ0023019) have four discharge points each and are both located on the same tributary to Royce Brook (Figure 7). Defense Logistics Agency (NJPDES #NJ0102962) has two discharges on an unnamed tributary to Royce Brook (Figure 7).

It is important not to understate the impact of sanitary discharge to Royce Brook. Streams experience reduced flows after prolonged dry periods in the summer. The ratio of effluent water to baseflow, particularly in these summer months, may be a problem. Since the baseflow is lowered, the majority of the stream water can be treated effluent. If problems happen at the plant and treatment of the effluent does not take place, then water quality degradation may occur due to higher levels of contaminants in the effluent.

PERMITTED DISCHARGERS TO GROUND WATER

There are no active permitted discharges to ground water in the Royce Brook Watershed (Figure 7).

Assessment –
Point source discharges in the Royce Brook Watershed need to work within the guidelines of their active permits in order to maintain the health of Royce Brook.

With a large number of discharge points into the Royce Brook in Hillsborough (24 in all), the Township needs to be vigilant of these potential sources of pollution in this area to ensure that they do not become actual sources of pollution.

GEOLOGY

The Royce Brook Watershed lies in the Piedmont Physiographic Province (Figure 8). Bedrock formations within the Piedmont are of late Triassic and early Jurassic age (230 to 190 million years old) and are part of the Newark Supergroup. Only one geologic formation of the Newark Supergroup is present within the Royce Brook Watershed: the Passaic Formation of the Brunswick Group (Figure 9).

The Passaic Formation consists of reddish brown, thin-bedded to thick-bedded shale, siltstone, and very fine-grained to coarse-grained sandstone. In addition, some zones of dark gray siltstone are present, similar to those of the underlying Lockatong Formation (USGS, 1995b). The Passaic Formation is part of the Brunswick Group, which consists typically of red shale with local beds of fine-grained red sandstone, siltstone and black, gray or greenish shale. The Brunswick shale contains rare reptile footprints as well as fossil remains of plants and bony fishes (Hunter and Porter, 1990; Rogers, Golden and Halpern, 1995).

In some areas, contemporaneous gray lake deposits are distinct from other portions of the Passaic Formation and therefore, are mapped as a subunit of this formation as 'gray bed' (Figure 9). These gray lake deposits are comprised of gray to black silty mudstones, gray and greenish to purplish-gray argillaceous siltstones, black shale and gray argillaceous fine-grained sandstones (Mulhall 2004).

Beneath some portions of the Millstone Watershed, the thickness of the Passaic Formation may be as much as 6500 feet (Owens et al. 1998). Combined, the Passaic Formation and the subunit of gray lakebeds are encountered beneath approximately 124.4 square miles or nearly 44% of the Millstone Watershed making this the most common rock-type and most extensive groundwater resource within the watershed (Mulhall 2004).

The fine-grained sandstones, shales, and thin-bedded siltstones of the Passaic Formation serve as the primary water-bearing layers. Massive siltstone beds often confine these layers. In the Passaic Formation, vertical to near vertical joints may interconnect water-bearing layers. The NJGS ranks the Passaic Formation as a 'C' aquifer indicating that these rocks have moderate capacity to support major water-supply wells (Mulhall 2004).

Widmer (1965) indicates that the Passaic Formation is only slightly less yielding than the Stockton Formation in Mercer County. His results indicated that domestic well yields generally range from 0.5 to 60 gallons per minute with a median yield of 10 gallons per minute. Kasabach's (1966) study of Hunterdon County indicated a median yield of 15 gallons per minute for the Passaic Formation, which is only slightly less than the median yield calculated for the Stockton Formation beneath Hunterdon County. The USGS study of the Stony Brook, Beden Brook and Jacobs Creek drainage basins resulted in a compilation of data for 709 domestic wells and these data indicate that the

Passaic Formation has yields similar to the Stockton Formation. The data from the 709 wells indicate a median yield of 15 gallons per minute for both formations.

The USGS domestic well data indicate a median specific capacity for non-metamorphosed Passaic Formation rocks of 0.462 gallons per minute per foot (gpm/ft), which is very similar to the value determined for the Stockton Formation (Lewis-Brown 1995). The well data compiled by the USGS indicate that the Passaic Formation has a median specific capacity per foot of open hole of 0.00393 gpm/ft/ft, which is only slightly less than the value determined for the Stockton Formation (Lewis-Brown 1995). And similar to the Stockton Formation, the median specific capacity per foot of open hole for the Passaic Formation declined only one order of magnitude with depth. Unlike the Stockton Formation, the median yields and median specific capacities for the Passaic Formation are not significantly changed with depth. The results of the USGS assessment of median specific capacity per foot of open hole for the Passaic Formation indicate that drilling to depths greater than 200 feet most likely will not provide significant additional yield.

Assessment –
The geologic formations of the Royce Brook Watershed follow the nature of those found in the Piedmont physiographic province. Rock formations exert an influence on soils and therefore on vegetation and agriculture, drainage, water transportation, water supply and types of land use. Due to the variable resistance to erosion exhibited by the sedimentary rock formations in the Watershed, stream patterns and topography are controlled by outcrop patterns and the orientation of the underlying bedrock.

The well data compiled for Hunterdon and Mercer Counties indicate that the Passaic Formation has a median yield ranging from 10 to 15 gallons per minute. These data further indicate that the Passaic Formation has only slightly lower capacity to transmit water when compared to the Stockton Formation, but significantly greater capacity to transmit water than the Lockatong Formation. The USGS results indicate that a well completed in the Passaic Formation to a depth of 300 feet below ground surface will not have significantly greater yield than a well completed to depth of 100 feet below ground surface in this same formation.

SOILS

The soils that underlay a watershed exert an influence on the types of vegetation that grow, agriculture that can be performed, drainage patterns, water transportation, water supply and types of suitable land use.

The Royce Brook Watershed falls within the Passaic Formation of the Piedmont Physiographic Province, where sands, silts and some clay dominate the soil. Most of the soils are underlain by hard bedrock at a depth of 2 to 20 feet (USDA SCS, 1972). The dominant soil in the Royce Brook Watershed is the Penn series (New Jersey Water Supply Authority 2000). It consists of reddish-brown, moderately deep (20 to 40 inches to bedrock), well-drained soils formed in materials weathered from noncalcareous reddish shale, siltstone, and fine-grained sandstone normally of Triassic age (New Jersey Water Supply Authority 2000).

Soils are classified based upon their textures, composition and ability to drain water. Soil surveys that have been performed and mapped by the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS) found the soil associations that underlie the Royce Brook Watershed are the Penn-Reaville-Klinesville series (in northeastern portion of the watershed), the Penn-Bucks-Rowland series (in western portion of the watershed), the Downer-Sassafras-Hammonton series (in southern part of the watershed), and the Quakertown-Chalfont-Lehigh series (in southwestern portion of the watershed) (New Jersey Water Supply Authority 2000).

HYDROLOGIC SOIL GROUPS

Based upon their various compositions, soil series have varying degrees to which they can infiltrate water. Their ability to drain water, especially from precipitation, is evaluated and reported as the hydrologic soil group. Almost all of the Royce Brook Watershed is classified as hydrologic soil group C, covering 9,388.5 acres out of a total of 10,568.0 acres (88.8%) in the whole watershed (Figure 10). Hydrologic soil group C represents soils with a slow infiltration rate and is representative of the moderately coarse-textured soils seen in the Piedmont Physiographic Province. Most of this hydrologic soil group underlies the urban and developed areas in Hillsborough Township and Manville Borough (Figure 10 and Figure 12).

The second most common hydrologic soil group in the Royce Brook Watershed is group D, representing very slow infiltration rates (Figure 10). The hydrologic soils in group D are found primarily as streambeds in the Royce Brook Watershed (Figure 10). Most of these soil groups are located in headwater areas of tributaries to Royce Brook (Figure 10). Category D soil groups have very slow infiltration rates since most of these soils are clayey or are shallow to an underlying impervious layer (Figure 10). Runoff from soils in groups C and D will be moderate to rapid due to these moderately coarse-textured soils having slow to very slow infiltration rates.

SOIL ERODIBILITY

Soil erodibility defines the susceptibility of soil to erosion and largely depends on soil structure. Maintaining good soil structure will help to build healthy soils and reduce the detachability of soil particles via erosion. Maintaining this structure through soil management practices is an important component to prevent soil erosion, improve water management, encourage plant growth and improve water quality on farms and developed areas.

The erodibility is based upon the 'K-factor,' a measure of bare surface soil erosion. Different soils are given different K-factors based upon land use, an area's slope and distance to nearest stream (Maryland Department of Natural Resources 2001). The higher K-factor is of the soil, the higher the erodibility. Almost all of the soils in the Royce Brook Watershed are classified as having high erodibility (Figure 11). A few areas of moderately erodible soils are found in the central portion of the Watershed, in Hillsborough Township, adjacent to waterways (Figure 11).

SEPTIC SUITABILITY

Another aspect of soils is their ability to provide on-site septic systems to drain wastes: their septic suitability. Septic suitability determines whether or not septic systems are suitable for an area and which types of septic systems are appropriate, based upon the characteristics and properties of soils in an area. Each soil type is categorized by a "suitability class" delineated by the USDA. The suitability class is calculated by combining how severely the soil type restricts a septic system's functions with the depth where that soil type occurs (NJDEP 1999). The septic suitability needs to be considered when determining whether or not a septic system is a viable option for new residential areas. The major limiting factors of septic suitability are based on the fact that the underlying soil may percolate too slowly or not at all, which lowers the capacity of a residential septic system to perform properly (NJDEP 1999).

In order to function efficiently, a traditional septic system's tank collects wastewater from bathrooms, kitchens, and laundry rooms. Water is held in the tank so that solids can separate from the liquid portion of the wastewater. Anaerobic (not requiring oxygen) bacteria break down the sludge and turn it into liquid waste. This sludge eventually accumulates and fills up the tank, requiring a pump-out every two or three years, depending on how heavily the system is used (SBMWA 2002).

The liquid waste then flows out of the tank and into a drainfield where it flows through a gravel bed. As the water slowly trickles through the soil, the processes of filtration and biological degradation by organisms in the soil remove toxic substances, bacteria, viruses and other pollutants. The water then slowly makes its way to the ground water (SBMWA 2002).

In the Royce Brook Watershed, there are many areas that are considered unsuitable for the placement of traditional septic systems due to geology and soils (Figure 12). These areas are found throughout the watershed and are not concentrated in one particular area. Many areas within the Royce Brook Watershed are suitable for soil replacement or mound septic systems (Figure 12). Soil replacement septic systems work by installing the system in the ground and replacing the native soil with fill material (NJDEP 1999). Mound septic systems are tanks installed above ground, which are covered with fill (NJDEP 1999).

All but a small portion of the Royce Brook Watershed is designated for sewer service areas (Figure 12). Sewer service areas are those portions of a municipality that are designated for the installation of sewer lines and connections to a sewage treatment plant/facility. These areas are a key determinant to the amount, location and intensity of development.

Assessment –

The characteristics of the soils in the Royce Brook Watershed are aligned to their overall composition in the Piedmont (see Geology section for more detail). These soils are moderately coarse and infiltrate water into the subsurface at a slow rate. Because of this slow rate of water infiltration, much of the water that lands on the watershed enters the streams as runoff. Stormwater management in the Royce Brook Watershed should be looked at in order to deal with this runoff. Because municipalities rely on their local Soil Conservation Districts (SCDs) to enforce the sediment and soil management regulations, SCDs need to be aware of a site's soil characteristics when they review and enforce plans to control and manage soils during construction activities.

Almost all of the Royce Brook Watershed is categorized as having high erodibility. Highly erodible soils may increase sediment loads to streams during storm or flood events. In conjunction with the visual assessment data and observations during the biological assessments (see the Water Quality section for more details), this is already happening in the Royce Brook Watershed. Smothering of aquatic macroinvertebrate habitat and subsequent loss of biological diversity, clogging of fish gills and reducing plant productivity by reducing sunlight availability, are impacts to streams experiencing heavy sedimentation. Maintenance of soil integrity in areas with highly erodible soils can be done by encouraging environmentally friendly construction, properly implementing soil and erosion control BMPs and encouraging forested areas.

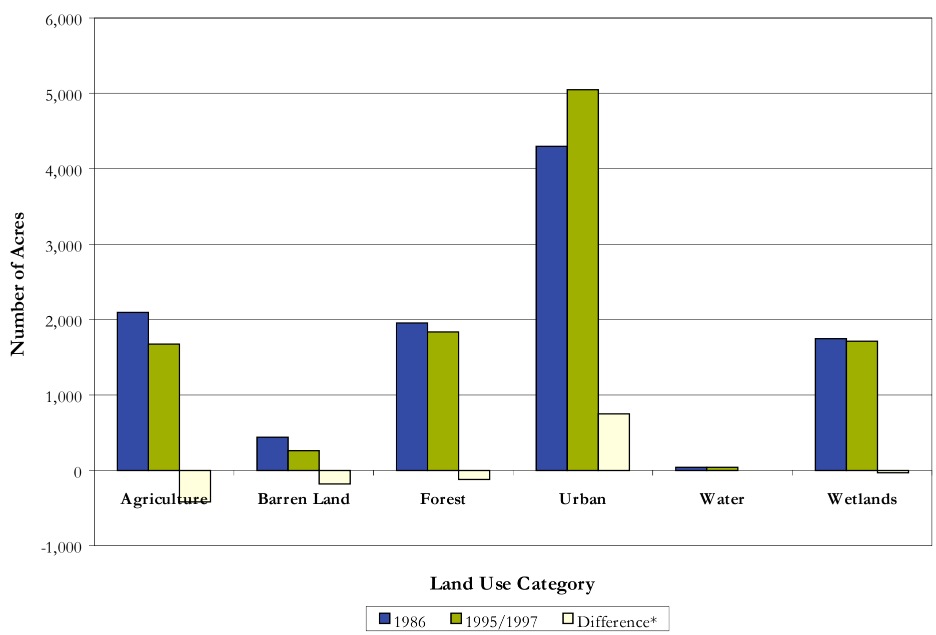
The extensive sewer service areas that cover the Royce Brook Watershed increase the potential for development to occur if it hasn't occurred already. Hillsborough Township and Manville Borough need to preserve lands in these sewer service areas, reducing development pressure. Preservation can occur via conservation easements, open space acquisitions and environmentally sensitive zoning.

LAND USE

The population of the Royce Brook Watershed is on the rise, and appropriate residential areas and necessary infrastructure continue to be built to accommodate this increasing population. These changes are reflected in the changing land use categories between 1986 and 1995 (Graph 4, Graph 5, Figure 13 and Figure 14). Land use was interpreted from photographs that were taken during flyovers of the State in 1986 and again in 1995.

The information for land use comes from the NJDEP land use/land cover data from 1986 and 1995, but development has occurred within the last ten years. Forests, agriculture, urban/developed land and wetlands will be discussed in more detail, as they account for the majority of land usage in this Watershed. The remainder of the land use in the watershed is made up of either water (41.0 acres, or 0.4% of the Royce Brook Watershed) in the form of streams, lakes, ponds, reservoirs and other waterbodies, or barren land (260.6 acres, or 2.5% of the Royce Brook Watershed) as developing land, quarries and mines (Graph 4 and Graph 5). Barren lands typically represent a temporary condition, as these areas are often due to clearing of land in the process of becoming part of the urban land use category.

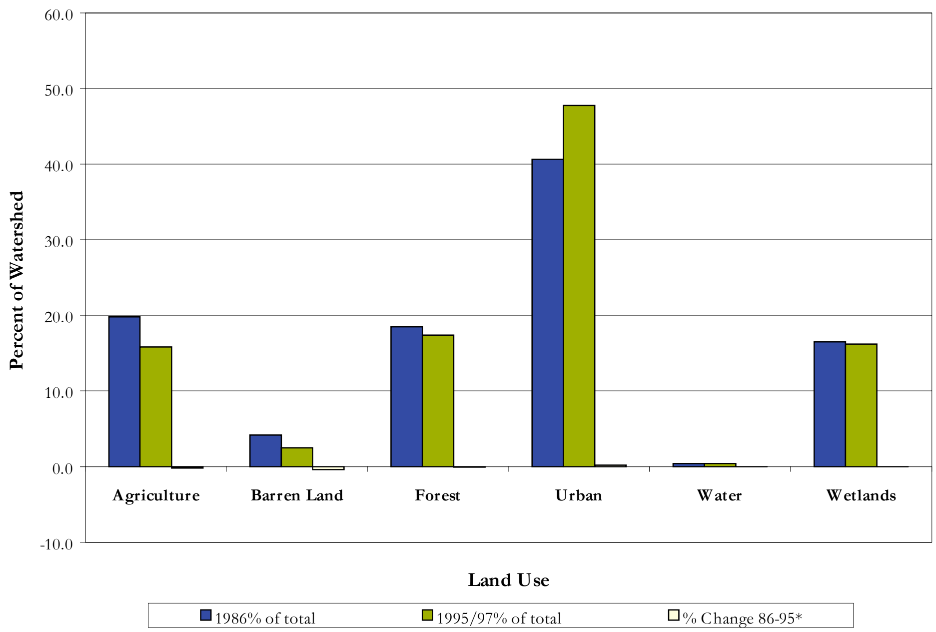
Graph 4: Changes in acreage of land uses in the Royce Brook Watershed from 1986 to 1995.



Source: NJDEP Land Use/Land Cover Data 1986 & 1995.
*Negative numbers represent a loss in acreage while positive numbers represent a gain in acreage.

In the Royce Brook Watershed, land use changed in the years between 1986 and 1995 (Graph4 and Graph 5). There has been a gain in urban areas (increased by 17.0%) and a loss of mostly agricultural lands (decreased by 20.0%; Graph 4 and Figure 14). Between 1986 and 1995, the lands that drain to Royce Brook have changed due to shifts in land use, as well as increases in population and local preservation efforts (Figure 13). To accommodate the increasing population, the agricultural lands are being developed to provide housing and services for new residents.

Graph 5: Changes in percent of total watershed area of land uses in the Royce Brook Watershed from 1986 to 1995.



Source: NJDEP Land Use/Land Cover Data 1986 & 1995.
*Negative percent changes represent a loss in acreage while positive numbers represent a gain in acreage.

FORESTS

Forests improve water quality by filtering pollutants, reduce flooding by slowing stormwater and provide habitat to a variety of plant and animal species. It has been shown that the best predictor of the presence of an unimpaired benthic macroinvertebrate community is the total area of forested land located upstream of a sampling site (USGS 1998).

Since 1986, there has been a slight loss in forested lands in the Royce Brook Watershed (Graph 5). Forested lands made up 18.5%, or 1954.9 acres, of the watershed in 1986, while in 1995, 17.4%, or 1,835.9 acres, was forest (Graph 4 and Graph 5). The woodlands were found scattered in small patches throughout the Royce Brook Watershed and in many headwaters areas (Figure 13).

AGRICULTURE

Between 1986 and 1995, a loss of 20% of the available agricultural lands located in mostly headwater areas of and tributaries to Royce Brook in Hillsborough Township (Graph 5 and Figure 14). In 1986, 19.8% of the Royce Brook Watershed, or 2,091.4 acres, was in agricultural use (Graph 4 and Graph 5). According to the 1995 data, there was approximately 15.8%, or 1,673.2 acres, of farmed lands in the Royce Brook Watershed.

All of the current agriculture is found in Hillsborough Township, most of which is located east of Route 206 (Figure 13). Almost all of the agriculture is located near the streams and wetlands found in the watershed, especially surrounding the tributaries that lead to the Royce Brook (Figure 13). In the past, these streams were used to irrigate crops or water livestock on many of the region's farms.

URBAN/DEVELOPED

In both 1986 and 1995, the largest land use category within the Royce Brook Watershed was in urban lands (Graph 4 and Graph 5). Approximately 47.7% of the watershed, or 5,045.4 acres, was developed into urban areas, which provide residential, recreational, commercial and industrial uses, in 1995 (Graph 4 and Graph 5). This was a gain of 17% from 1986, when there were 4,295.6 acres of urban land uses in the Royce Brook Watershed (Graph 4 and Graph 5). Currently, almost all of Manville Borough and much of western Hillsborough Township in the Royce Brook Watershed are developed (Figure 13 and Figure 15).

Hillsborough Township contains a mixture of urban land uses within the Royce Brook Watershed (Figure 15). Many of the commercial and industrial areas are located along Route 206 (Figure 15). Manville Borough contains mostly residential, single unit, medium density development (Figure 15). These areas are typified by residential neighborhoods with lots greater than $^1/_8$ acre in size and can be up to $^1/_2$ acre in size (USGS 1976). Impervious cover in these urban areas is generally around 30% - 35% (USGS 1976).

WETLANDS

Wetlands are those areas inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (U.S. Army Corps of Engineers 1987). Wetlands vary widely because of regional and geographic differences in soil types and climate and therefore, have a variety of essential functions and values associated with their roles in the environment. Water quality is improved as wetlands filter excessive nutrients, sediment and other pollutants through abundant plant life and help reduce flooding and storm surges by acting as natural retention basins. Wetlands are also excellent nurseries for a variety of wildlife, since wetlands process nutrients efficiently and retain those nutrients. These nutrients become essential building blocks for wildlife and vegetation.

Of the total 10,568.0 acres in the Royce Brook Watershed, 1995 data shows 1,711.9 acres of wetlands, representing 16.2% of the entire Watershed area (Graph 4 and Graph 5). In 1986, there were 1,744.5 acres of wetlands. This represents a slight loss of 32.6 acres, or 2.0% of the wetland area over that time. A large tract of wetlands is found along Royce Brook north of Amwell Road before the Brook drains into Manville (Figure 13). Most of the wetlands found in the Royce Brook Watershed are deciduous wooded wetlands and modified agricultural wetlands. Deciduous wooded wetlands are common in the northeastern United States and provide habitat for many critically important species of wildlife. These wetlands are dominated by species of trees such as red maple (*Acer rubrum*), black willow (*Salix nigra*), swamp oak (*Quercus bicolor*) and sweetgum (*Liquidambar styrciflua*).

Modified agricultural wetlands are wetlands that have been modified to allow for cultivation of crops. In the Royce Brook Watershed, these wetlands are located adjacent to the agricultural areas in Hillsborough Township surrounding Royce Brook (Figure 13).

The majority of the wooded wetlands found in the Royce Brook Watershed are found in small patches in the upper reaches of Royce Brook in Hillsborough Township (Figure 13). The location of these areas is critical to maintaining healthy streams in the Watershed, as forested wetlands are important collection and treatment areas for polluted runoff. Many studies have determined the effectiveness of forested wetlands in improving water quality:

- A 50-meter wide riparian forest in an agricultural watershed of the Chesapeake Bay removed about 89% of the nitrogen that entered the forest from runoff (Peterjohn and Correll 1984).
- Riparian forests can reduce phosphate levels in runoff and floodwater by 50% (Gilliam 1994).
- A forested wetland overlaying permeable soil may infiltrate up to 100,000 gallons of water per acre per day (Anderson and Rockel 1991).

IMPERVIOUS COVER

Impervious cover is any surface that prohibits the movement of water from the land surface into the underlying soil. Buildings, paved surfaces (such as driveways, roofs, roads, airport tarmacs and cemented walkways), exposed bedrock and even severely compacted soils and lawns are considered impervious.

An increase in impervious surfaces in a watershed interferes with the natural flow of water into the aquifers and local waterbodies. Areas that are impervious prevent the percolation of water into the aquifer and impair local ground water resources due to decreased recharge. Impervious surfaces also increase the amount of stormwater runoff, which increases the frequency and intensity of local stream flooding. Because this stormwater runs directly into streams, often with no filtration through a streamside buffer, these floods can cause accelerated erosion. Since water does not have time to percolate into the soil naturally, harmful substances, such as oil, pesticides and fertilizers, carried by the runoff get deposited into streams and lakes and contribute to water quality degradation. Research has shown that stream ecosystems and water quality degrade as the amount of impervious surface within an area increases (Center for Watershed Protection 1998). The first limit to impervious areas appears at approximately 10% impervious cover, where sensitive elements are lost from the system. A second limit appears at approximately 25% impervious cover, where there is a shift to poor stream conditions that include diminished aquatic diversity, water quality and habitat function (Center for Watershed Protection 1998).

Royce Brook Watershed has an average impervious cover of 15.4% with specific areas covered in much higher amounts, suggesting some water quality degradation (Figure 16). In the Royce Brook Watershed, there are 1,623.6 acres of impervious cover. Many impervious areas are rated at 26% or higher for lands in this region (Figure 16). Manville Borough is almost entirely covered in impervious cover of 26% or more (Figure 16). This shows that these areas are highly developed and could be contributing to water quality problems as the Royce Brook flows into the Millstone River.

In Hillsborough Township, large patches of impervious cover above the 25% limit exist. These areas are adjacent to both Route 206 and County Road 514 and near their intersection (Figure 16).

The majority of the lands with a large amount of impervious cover are congregated close to tributaries to Royce Brook (Figure 16). This may be due to the conversion of agricultural lands, which are traditionally located near streams for crop irrigation, into residential developments.

It should be noted that NJDEP has identified several unnamed tributaries to Royce Brook as candidates for designation as Category 1 (C1) waterways (NJDEP 2004b). The basis for these nominations was that the lands surrounding them had less than 10% impervious cover. C1-designated waterways are afforded a higher level of protection from development. If the NJDEP accepts these nominations, the state anti-degradation policies and a proposed 300-foot buffer will protect these tributaries:

- The anti-degradation policies assure that water quality is maintained at a level necessary to protect the intended use of the waters, and establishes more protective criteria for any new or expanded discharges to these waters.

- NJDEP requires a 300-foot setback buffer on either side of the stream to protect C1 waters. This is included in the new Stormwater rules (NJAC7: 8-5.5h).

The 300-foot buffer along C1 waters will minimize impacts from stormwater runoff, and provide floodwater storage, erosion control, ground water recharge and maintain biological habitats and diversity.

RIPARIAN CORRIDORS

Of special note are riparian corridors, which are vegetated areas that lie along side streams. These areas are usually transitional zones between wetland and upland areas and are generally comprised of grasses, shrubs, trees, or a mix of vegetation types. Riparian corridors can be found in agricultural, forested, suburban and urban landscapes. In terms of nonpoint source pollution control, these are the last lines of defense for the streams they surround. When left as natural areas, riparian corridors provide erosion control by dense plant root growth, stormwater control by slowing water flow, and habitat for many species of plants and animals. Land use changes to these areas can have the most detrimental effects on water quality.

In the Royce Brook Watershed, the riparian area is based on the width of the 100-year flood prone areas, streamside hydric soils, streamside wetlands and associated transition areas, and a 150-foot or 300-foot wildlife passage corridor, depending on stream order (New Jersey Water Supply Authority 2000b). Some of these lands have undergone conversion from one land use category to another between 1986 and 1995 (Figure 17). Based on the above definition of riparian areas, historically Royce Brook Watershed had 3257.7 acres in this corridor. Of that amount, 281 acres (or 8.6%) have been converted to agricultural areas and 739.7 acres (or 22.7%) are urban areas (Figure 17). While most of this area is composed of wetlands (1764.7 acres or 70.9%), forested areas and water make up the rest (Figure 18).

PLANNING AREAS

The New Jersey State Development and Redevelopment Plan has established planning areas throughout the State designated for a variety of uses (New Jersey State Planning Commission 2001). Several of those planning areas (PAs) are aimed at limiting growth of development and preserving historical, cultural and environmental resources.

In the Royce Brook Watershed, PA4 (Rural), PA4b (Rural-Environmentally Sensitive), PA5 (Environmentally Sensitive) and PA8 (State Park) lands are found in small areas on the edge of the Watershed's boundary (Figure 19).

The majority of the lands in these PAs are wetlands and agricultural lands (Figure 19). Current, Federal and State regulations restrict development in wetlands. Agricultural areas have been more prone to development than other land uses within the Royce Brook Watershed (Graph 4 and Graph 5). Many agricultural areas in the Royce Brook Watershed are located within high ground water recharge areas (see Water Supply section) and contain critical habitats (Figure 5). Therefore, these areas become vital to protecting threatened and endangered species and potential drinking water supplies.

Assessment –
Land uses change to reflect the needs of municipalities. As more residents move into an area, more homes and infrastructure are needed to provide basic services to those residents. This is reflected in both the increasing population within the Royce Brook Watershed (see Landscape section for more detail) and the increasing acreage of developed areas between 1986 and 1995 (Figure 14). Many of the lands are being converted to developed areas. Due to the proximity of converted agricultural lands to waterways, water quality becomes a concern as impervious surfaces increase. Water quality would be better protected by decreasing the rate of conversion of farmlands in the Royce Brook Watershed to urban areas through participation in the State's farmland preservation programs, adopting and enforcing a stream corridor ordinance, or protecting riparian areas with conservation easements. This is important for Hillsborough as urban areas are being developed in the headwaters of the Royce Brook Watershed.

Urbanization of the Royce Brook Watershed has increased the amount of impervious cover in the region. This has the effect of decreasing biological diversity in nearby streams, increasing the frequency of flooding, and decreasing the amount of water recharging the ground water supply. Placement of new development, and therefore impervious cover, away from areas that have high value for recharging ground water supplies will help to maintain water levels for drinking, irrigation, and industrial use (see Water Supply section for more details). This strategy should be used in conjunction with water conservation education programs to proactively protect water supplies.

Studies show that limiting the amount of impervious cover alone will not benefit water quality. Maintenance of an adequate forest in conjunction with reduced impervious cover will help to keep aquatic biological populations healthy (USGS 1998). Maintaining impervious cover below 10% and forest cover at least at 65% has been shown to preserve water quality (Center for Watershed Protection 2003). With forest cover in the Royce Brook Watershed at 17.4% in 1995, efforts to reforest portions of the region should be considered.

Riparian corridors are being encroached upon slightly by developed areas in the Royce Brook Watershed (Figure 17). These areas are particularly sensitive to land use changes, as they are the natural buffers that protect the stream itself from a variety of pollution sources. Placement of new construction in the Royce Brook Watershed needs to be sensitive to or avoid altogether the riparian corridors in order to maintain ecological integrity. The good news is that most of the riparian corridor (70.9%) is made up of wetlands (Figure 18). These areas are already under development protection, but Hillsborough and Manville, if appropriate, should enact stream corridor protection ordinances to help control development in these areas. Acceptance by the NJDEP of the nomination of Royce Brook's tributaries as C1 waterways will aid in protecting these corridors. Hillsborough and Manville should support these C1 nominations.

Areas within the Royce Brook Watershed have been planned for limited growth (Figure 19). The areas contain mostly wetlands and agricultural lands. If these lands are currently not within farmland preservation programs, then they should be targeted as a high priority to be preserved. Preservation of these areas will benefit the habitats needed for threatened and endangered species as well as increase the amount of water reaching drinking water supplies (see Landscape and Water Supply sections).

WATER SUPPLY

Water is a necessary component for life on Earth. Aquatic ecosystems, however, are competing for the very resource that forms the basis of their existence. Multiple uses of water for irrigation for agriculture, recreation through fishing and boating, and commercial uses in industry have severely strained a resource that cannot be easily replenished. Less than 3% of all water on the planet as fresh water and less than 15% of that is available in surface and ground water (USGS 1999).

Watersheds are not comprised of surface water alone. The ground water present in the pore spaces of soil and rock is an important component of the watershed. Evaluating the health of one aspect alone presents a partial picture of the true quality of water in an area.

WELLHEAD PROTECTION AREAS

In order to retrieve water for use in everyday life, wells are drilled to a desired depth into an aquifer containing potable water. This water is pumped out of the wells for household, agricultural or commercial uses. There are different types of wells regulated by the State. Individual domestic wells are used for single homes for potable purposes. Public community wells (PCWs) supply water systems that service at least 15 connections used on a year-round basis or supply at least 25 year-round residents (New Jersey Geological Survey 2003). The source of a well and the structure built over it are referred to as the wellhead.

Protecting the wellhead from future and present contamination will protect the population from deleterious health effects. Wellhead protection areas (WHPAs) are delineated at the surface and represent the area that contributes water to a well in a defined time period (New Jersey Geological Survey 2003). The WHPA is divided into three tiers based upon the time of travel (TOT) that it takes for water at a given point to reach the well when pumped. TOTs are helpful in determining the risk of contamination to a well from ground water. A Tier 1 WHPA has a TOT of two years, Tier 2 has a TOT of five years, and Tier 3 has a TOT of 12 years (New Jersey Geological Survey 2003).

Within the Royce Brook Watershed, there is one defined WHPA: the Elizabethtown Water Company intake at the Millstone River in Manville (Figure 20). (Note that water traveling below the ground's surface can travel outside the surface-delineated watershed.) The WHPA overlaps a portion of the northeastern corner of the Royce Brook Watershed, in Manville Borough (Figure 20). The intake withdrew 117 million gallons per day (mg/d) in 1995 to be used as drinking water for much of the population of the Millstone Watershed (USDA Forest Service 2002).

There are no KCSs located within a WHPA in the watershed (Figure 20). The closest KCSs are the Manville Borough Public Works Facility and the Export Restoration Center (BP Gas) (Figure 6 and Figure 20). The Public Works Facility is categorized by the NJDEP as Remedial Level C2, indicating remedial levels associated with more complicated contaminant discharges, multiple site spills and discharges, more than one contaminant, and both soil and ground water impacted or threatened by the contaminants (Table 5). The Export Restoration Center is categorized at Remedial Level C1, which describes a single source or contaminant affecting both soils and groundwater (Table 5).

GROUND WATER RECHARGE

Ground water is not in endless supply. Water needs to enter the land's subsurface in order to recharge and reinvigorate ground water. Land use activities can disrupt the natural water cycle and the flow of water back into the soil and can diminish water supplies. As impervious cover increases with developed areas, water that would normally infiltrate back into ground water supplies is diverted as runoff. In an area preserved with natural cover (forests, fields and wetlands), studies estimate that approximately 50% of precipitation infiltrates into the ground, 10% flows over the land as runoff, and 40% is evaporated back into the atmosphere (Schueler and Holland 2000). The Royce Brook Watershed, with 15.4% impervious cover, may drop to 42% of precipitation infiltrating into the ground, 20% of the precipitation flowing away as runoff, and 38% evaporating into the atmosphere (Schueler and Holland 2000). This is common for areas with up to 20% impervious cover. For the whole Millstone Watershed with an average impervious cover of 8.8%, it has been estimated that 14.2% of precipitation infiltrates into the ground, 31.6% flows over the land as runoff, and 54.2% is evaporated back into the atmosphere (New Jersey Water Supply Authority 2000c).

Therefore, not all areas, even if left in their natural state, infiltrate water into the subsurface water equally. Different types of land use allow for different rates of infiltration. The underlying geology also plays a role in the capacity of water to percolate. In a developing watershed like the Royce Brook Watershed, the location of suburbanization and urbanization becomes important. Water quality also is an issue. Locating heavy development near areas that contain highly permeable soils can cause increased pollution of ground water from runoff.

In the Royce Brook Watershed, there are 5,127.65 acres (or 48.52% of the entire watershed area) found within areas classified as high ground water recharge (Figure 21). High ground water recharge is defined as that portion of the geologic formation where soil and land use allow for increased recharge of precipitation into the soil at the rate of greater than 10 inches per year.

Of the 5,127.65 acres classified as high ground water recharge areas, 1,477.8 acres (or 28.8%) were in agricultural lands in 1995, 2027.43 acres (or 39.5%) were in urban/developed areas, 1391.2 acres (or 27.1%) were forested, and the remaining acreage was water, wetlands, and barren land (Figure 21).

According to the New Jersey Water Supply Authority's report, *Ground Water in the Raritan Basin*, between 1986 and 1995, the Raritan Basin (of which both the Millstone Watershed and the Royce Brook Watershed are part) lost 5% of its recharge capability (New Jersey Water Supply Authority 2002). The Royce Brook Watershed exceeded this overall average, losing an average of 1.0 inch or 5.4% of its ground water recharge capability between 1986 and 1995 (New Jersey Water Supply Authority 2002).

The most likely reason for the loss of ground water recharge is the already existing urban/developed areas and an increase in developed/urban areas in high ground water recharge zones between 1986 and 1995 (see Land Use section for more information). Urban areas increased by 140.1 acres in areas of high ground water recharge. This increases impervious areas that prevent water from percolating back into the soil.

Assessment –
The wellhead protection area (WHPA) in Manville Borough is important to note, as it is a significant source of drinking water for the entire Millstone Watershed. Even though there are no known contaminated sites (KCSs) located within this WHPA, all adjacent KCSs need to have consistent monitoring by NJDEP to ensure that no contamination is documented in the vicinity of the WHPA.

There are many areas of the Royce Brook Watershed that contain high ground water recharge. These areas need to encourage regulations on the use of chemicals (especially harmful chemicals like pesticides) in the agricultural areas above ground water recharge zones to prevent contamination (Figure 21). If this is not possible, farms need to review and evaluate the many options available to reduce their pesticide use in such areas. For example, participation in the New Jersey Conservation Reserve Enhancement Program (CREP) to help farmers reduce impairment from agricultural water runoff sources in an effort to improve water quality along both impaired and unimpaired New Jersey streams through best management practices.

The loss of ground water recharge in the Royce Brook Watershed as reported by the Raritan Basin Watershed Management Project shows how poor planning can impact ground water recharge areas. Much needs to be done to increase efforts to protect high recharge areas. Municipalities should limit increases in impervious surfaces in the Watershed in order to prevent mitigation efforts to restore recharge areas in the future.

WATER QUALITY

Assessing water quality is an important way to gauge the response of streams and lakes to surrounding land uses, pollutant loadings, seasonal changes and community awareness on the importance of clean and healthy water.

Nonpoint-source pollution, associated with suburban development and activities, is of particular concern in this watershed. Nonpoint-source pollution comes from numerous, diverse, or widely scattered sources that together have an adverse effect on the environment. The USEPA has stated that nonpoint-source pollution, or pollution from runoff, is currently one of the leading causes of water quality degradation (USEPA 1996). Fertilizers and pesticides from yards, farms and golf courses, animal wastes (both farm animals, pets and wildlife), sediments from construction and erosion, detergents, and toxic chemicals from cars and household cleaning and yard care products are all examples of nonpoint pollution.

Under Sections 305(b) and 303(d) of the Clean Water Act, each state is required to monitor the health of its waterways, produce a list of waterways not meeting Surface Water Quality Standards, and report these to the USEPA. These lists are produced every two years and are used to establish the timeline in developing a total maximum daily load (TMDL) for the impaired waterways. A TMDL is the maximum quantity of a particular pollutant that can enter a waterway without affecting the designated use of that waterway (Jarrell 1999). Currently, the NJDEP produces a list that combines the waters assessed in the State (305(b) listings) and those assessed and not meeting State designated uses (303(d) listings) into one list, the Integrated List of Waterbodies (Integrated List).

Water quality data was gathered from a variety of sources (Figure 22 and Figure 23). The USEPA has incorporated biological monitoring at sites within the Royce Brook Watershed for inclusion on the State's Integrated List (NJDEP 2004c). The biological assessment data was gathered from the NJDEP's Ambient Biomonitoring Network (AMNET) 1994 and 1999 reports for the Raritan River drainage basin. Visual assessments were collected from reports performed by a Watershed Ambassador trained by SBMWA staff.

Visual assessments provide an overall sense of water quality through qualitative surveys. Biological assessments give information on long-term water quality as the organisms studied may have resided in a particular stream for months, but these do not reveal the source of impairments. Chemical assessments reveal detailed information on the quality of waterways. However, chemical assessments give a snapshot of a particular time and location, and only long-term monitoring is able to reveal significant trends.

VISUAL ASSESSMENTS

Visual assessments are a valuable tool in obtaining a gross evaluation of impacts on the health of the environment. Observational data can be difficult to compare between areas, however. An effort to quantify these observed characteristics was used, based upon visual assessment protocols used by the USDA's NRCS, the Upper Raritan Watershed Association (URWA), and the Maryland Department of Natural Resources (MDDNR) (USDA 1998; URWA 1997; MDDNR 2000). During the visual assessments, a score was given to each of ten parameters (i.e., water color, erosion, man-made structures, etc.) on a scale of 1 to 4. A score of 1 represents severe problems while a score of 4 represents pristine conditions. These ten parameters were then averaged to determine the overall value for the entire stream segment. It should be noted that the results be used with caution, since the data are based on qualitative judgments and observations.

Information presented for the visual assessments was developed from the collected reports of a trained Watershed Ambassador. Five navigable stream segments, referred to as "beats," are located in the Royce Brook Watershed along the main stem of the Royce Brook (Figure 22). All assessments were completed in December of 2003. The Watershed Ambassador walked the "beats" after being trained by SBMWA staff about what information to look for and how to assess water quality problems based on their observations. Notable or interesting sites or problems were photographed and recorded to aid in determining stream health.

It should be noted that the information gathered through the visual assessments is most directly applicable to the health of the riparian corridor. The overall health of these stream-buffering areas indirectly aids in determining water quality.

Note that the five "beats" within the Royce Brook Watershed have been given the designation of 'RCB', and are numbered sequentially starting with the most upstream "beat" (Figure 22).

The average score for all stream segments in the Royce Brook Watershed is 3.2 (Table 6). Through these assessments, the Royce Brook is rated as having overall good riparian corridor quality (Figure 22). The final visual assessment scores ranged from 3.4 along the segment of Royce Brook (RCB2) that stretches from Pleasant View Road to Route 206, to a score of 2.8 on the Royce Brook "beat" (RCB5) which stretches from Sunnymeade Road to the Royce Brook's confluence with the Millstone River (Table 6 and Figure 21). This segment is almost entirely contained in the highly developed Manville Borough (Figure 22).

The highest rated parameters addressed the riparian corridor and vegetation (Table 6). Scores for canopy cover, surrounding vegetation, aquatic vegetation and width of the riparian zone were high for the Royce Brook (either rated 3 or 4) showing that much of the area along the streams is buffered from surrounding land uses and impacts. The only exception to this was RCB5, which received a score of 1 on riparian zone width (Table 6). This indicates that there is significant disturbance due to residential or agricultural practices, roadways, or clear cutting of vegetation within 20 feet of the stream (SBMWA 2003).

The most common problems seen on the visual surveys were the result of urbanization. The lowest rated scores were for stream bottom, man-made structures and erosion (Table 6). Three out of the five stream segments surveyed rated each of these three measures as 2 (Table 6). For stream bottom a score of 2 shows that gravel, cobble and boulders present in the stream were at least 40% covered by sediment (SBMWA 2003). For man-made structures, a score of 2 indicates that man-made structures cover at least 50% of the stream reach (SBMWA 2003). Erosion scores rated as 2 indicate that the streambanks are moderately unstable and have between 30%-60% of their lengths showing signs of erosion (SBMWA 2003). Increased amounts of man-made structures close to the streams are most likely increasing flows into the stream due to imperviousness of these structures. Increased flows are heightening natural erosion along the Royce Brook, which results in sedimentation of the stream bottom. The sedimentation may also be due to the high erodibility of the soil types in the Royce Brook Watershed (see Soils section for more information). Advanced sedimentation of streams causes loss of habitat for aquatic macroinvertebrates (insect larvae, clams, crayfish, snails, etc.), clogs fish gills, and increases the concentration of metals and organic toxins, which easily combine with sediments (Center for Watershed Protection no date).

BIOLOGICAL ASSESSMENTS

The organisms that live within a stream system can convey much information about the health of the waterway. One such group of organisms is the aquatic macroinvertebrates. These are aquatic insects and their larvae, clams, snails, crayfish and other animals without a backbone that live in waterways. They are used as indicator organisms because of each species' varying sensitivities to pollution. For example, mayfly nymphs are very sensitive to pollution and are only abundant where water quality is good, while leeches and worms are tolerant to pollutants and can survive waters with poor water quality.

Biological data has been collected from NJDEP's AMNET monitoring program (Figure 23 and Table 7). At least 100 organisms are required from each sampling event for that event to be statistically valid for interpretation of results in this report. The organisms from these samples are identified to the family level and the data are entered into a database and rated in a scoring system to determine the level of stream impairment.

Streams are rated numerically and then categorized as "non-impaired," "moderately impaired," or "severely impaired" based on the following biological criteria:

- Pollution-tolerance of families collected;
- Number of different families collected;
- Number of pollution-intolerant ("sensitive") families collected;
- Percent of the sample composed of pollution-intolerant individuals; and
- Percent of the sample dominated by one family.

The three NJDEP sampling sites in the Royce Brook Watershed are (NJDEP 2000a) (Figure 23):

- Royce Brook at Route 206 at the Bloomingdale section of Hillsborough Township (AN0411).
- Royce Brook at Route 206 in Hillsborough Township (AN0412)
- Royce Brook at Route 533 in Manville Borough (AN0413).

According to the AMNET sampling events from 1993 and 1998, five of the six sampling events were rated as Moderately Impaired (Table 7 and Figure 23; NJDEP 1995; NJDEP 2000a).

Site AN0413 was rated Severely Impaired when sampled in 1998, possibly due to runoff from the adjacent roadway (Table 7; NJDEP 2000a). The site is located in the heavily developed Manville Borough and these conditions may be increasing the flows to the point that sediments carried by these flows are smothering habitat for aquatic macroinvertebrates or the habitats are getting washed out completely.

The Integrated List states that the Royce Brook site at Route 533 in Manville is impaired for supporting Aquatic Life (NJDEP 2004c). The other two biological assessment sites (at Route 206 in Hillsborough and at Route 206 at the Bloomingdale section of Hillsborough Township) were deemed to have insufficient information to determine whether or not they were supporting Aquatic Life (NJDEP 2004c). Currently, no TMDL is proposed for Royce Brook (NJDEP 2004c).

The NJDEP has also initiated a program in 2000 to evaluate fish communities to determine the health of waterways. Teams of NJDEP staff collect fish, identify and enumerate the species caught (NJDEP 2000b). During this collection the following metrics are determined:

- Total number of fish species
- Number of species that bottom dwelling fish that eat insects
- Number of trout and/or sunfish species
- Number of pollution-intolerant species
- Proportion of individuals as white suckers
- Proportion of individuals with broad habitat requirements

- Proportion of individuals as insect-eating members of the family *Cyprinidae*
- Proportion of individuals as trout or proportion of individuals as piscivores ("fish eaters")
- Number of individuals in the sample
- Proportion of individuals with disease or anomalies (excluding blackspot disease)

This data is combined into an index of biotic integrity (IBI) and will be used to develop biological criteria, prioritize sites for further studies, provide biological impact assessments, and assess status and trends of the state's freshwater fish assemblages (NJDEP 2000b).

One site along the Royce Brook is monitored as part of the NJDEP's fish IBI program:

- Royce Brook at Route 533 in Manville Borough (Figure 23). (Note that this site is the same as the AMNET site AN0413.)

The results from the survey performed in 2000 show that Royce Brook has an IBI of good and that the habitat was assessed as marginal (NJDEP 2000b). This indicates that the habitat present for fish species could improve and that the fish found in this habitat represent a balanced population (NJDEP 2000b).

The biological data follows a pattern similar to the visual assessments with the stream bottom undergoing sedimentation and smothering out habitat macroinvertebrates need to survive. During all sampling events in 1993 and 1998, it was noted that the stream bottom was mostly cobble, gravel and sand (NJDEP 1995, NJDEP 2000a). Also, the most recent Integrated List published by the NJDEP ranks the biological health of site AN0413 as non-supportive of aquatic life and ranks both sites AN0411 and AN0412 as having insufficient data to determine biological health (NJDEP 2004c).

CHEMICAL ASSESSMENTS

Data was downloaded from USEPA's Storage and Retrieval database (STORET) and reviewed. Data was downloaded from the STORET Legacy Data Center (data prior to 1999) and Modernized STORET (data 1999 to the present) (USEPA 2004). Data from the Legacy version of STORET was from 1960 to 1975. This data was not collected consistently over time or for any particular parameter. Modernized STORET data was only available from three days in 1999 and one day in 2000. Therefore, chemical assessments were not evaluated for the Royce Brook Watershed.

POLLUTANT LOADINGS

Nonpoint-source loadings of nitrogen, phosphorus and total suspended solids (TSS) were modeled to calculate pounds per acre per year (lb/acre/yr) of each. A model from Princeton Hydro, LLC was used to estimate nonpoint-source pollutant loadings (specifically, nitrogen, phosphorus and total suspended sediments) based on land use types within that subwatershed as of 1995. Total acreage of a given land use type is calculated for each subwatershed; a coefficient estimates pounds per acre per year of pollutant runoff for each land use type; and total annual pollutant runoff is thus approximated for the subwatershed as a whole (Souza 2003 pers. comm.). The coefficients are based on studies of watersheds for which there was available monitoring information. Since these studies included watersheds with land use compositions similar to that of the Mid-Atlantic region, the coefficients – and thus the model – will only be valid in regions similar to that of the Mid-Atlantic. Note that the values presented here are estimates of loadings based upon nonpoint-source pollutants and are not actual field measurements.

The model generally scores agricultural lands high in phosphorus and TSS loadings, developed/urban areas high in all three loadings (nitrogen, phosphorus, and TSS), and other land uses (forest and wetlands) low in all three loadings. This is based upon the fact that impervious cover associated with urban areas increases nonpoint-source pollution loadings by preventing stormwater runoff from percolating back into the ground (see Land Use section for more information).

Several areas within the Royce Brook Watershed have high estimated loadings for nitrogen, phosphorus and TSS (Figure 24, Figure 25, and Figure 26). For phosphorus loadings, the highest levels estimated coincide with many of the agricultural lands in Hillsborough Township (Figure 13 and Figure 25). Much of these areas are considered to produce high levels (at or greater than 1.215 lb/acre/yr) of phosphorus (Figure 25). Nitrogen loading estimates for this model in the Royce Brook Watershed fall mostly within the lower part of the range (0.001-1.619 lb/acre/yr) (Figure 24). TSS loadings in the Royce Brook Watershed also fall mostly within the moderate range (at or greater than 202.4 lb/acre/yr) for this model (Figure 26).

Manville Borough, which is comprised of almost all urban/developed areas, has estimated pollutant loadings for nitrogen, phosphorus, and TSS that fall within the moderate range (Figure 13, Figure 24, Figure 25, and Figure 26).

The areas with the lowest estimated loadings in all three types of loadings (nitrogen, phosphorus, and TSS) coincide with the wetlands located in Hillsborough Township, north of Hamilton Road (Figure 13, Figure 24, Figure 25, and Figure 26).

Assessment –
To best assess water quality, trends in particular indicators need to be determined. Water quality information for the Royce Brook Watershed is very limited in terms of visual and biological assessment, and is virtually nonexistent for chemical assessments. This means that a long-term set of reliable data from one agency or group needs to be obtained. Measurements of the environment are highly valuable, but are very specific to the time and place where they were taken. A long-term (10-20 years) dataset helps to reduce this specificity and increase the likelihood that the measurements reflect the actual water quality conditions in the stream. Additional data will clarify if biological life is able to thrive in Royce Brook.

In general, Royce Brook does not fully support the breadth and diversity of aquatic life representative of a healthy stream ecosystem (Table 7). This means that there are one or many stressors that are suppressing the numbers and varieties of aquatic macroinvertebrate populations. These organisms form the food base for many other wildlife species, especially fish, frogs and some species of ducks.

The most likely stressor affecting the macroinvertebrate communities in Royce Brook is the heightened sedimentation seen in SBMWA's visual assessment (Table 6). The basis for this heightened sedimentation may be due to urbanization of lands and the soil composition and erodibility of the Royce Brook Watershed itself (see Land Use section, Geology section, and Soils section for more details). The majority of soils in the Watershed are classified as "high" in terms of their erodibility (Figure 11). This classification is based upon the "K-factor" and measures ability of bare soil to erode. This high erodibility combined with the large amount of developed lands seen in much of the watershed probably accounts for much of the sedimentation observed.

Nonpoint-source pollutant loadings for nitrogen, phosphorus, and TSS in the Royce Brook Watershed are found mostly within the moderate to high levels for the model used in this assessment (Figure 24, Figure 25, and Figure 26). Since the Royce Brook is already highly developed, the municipalities in this region need to incorporate stormwater management to help reduce the loadings of these nonpoint-source pollutants into the Brook. Of special note are the loadings for TSS, as the land use practices modeled in the Royce Brook Watershed are providing moderate levels of sediments to the streams in this region (Figure 26). This is important, as the soils in this area are already uncemented and therefore highly erodible (Figure 11; see Soils section). The municipalities in the Royce Brook Watershed (especially Hillsborough) need to enact sediment control ordinances to prevent materials from washing into streams and degrading habitat and water quality. Municipalities will also need to comply with the newly proposed stormwater management rules and develop plans to manage stormwater runoff.

Table 6: Visual assessment scores for Royce Brook 2003.

Visual Assessment "Beat"	Flooding Score	Water Odor Score	Water Color Score	Stream Bottom Score	Aquatic Vegetation Score	Surrounding Vegetation Score	Man-Made Structures Score	Erosion Score	Riparian Zone Width Score	Canopy Score	Overall Assessment Score
RCB1	2	4	3	2	4	4	3	3	4	4	3.3
RCB2	4	4	4	2	4	4	2	3	3	4	3.4
RCB3	3	4	3	3	4	3	2	2	4	4	3.2
RCB4	3	4	3	2	4	4	4	2	4	3	3.3
RCB5	3	4	4	3	4	2	2	2	1	3	2.8
											Average Stream Score = 3.2

WATER QUALITY

Table 7: Biological assessment data for Royce Brook Watershed 1993 and 1998 (NJDEP Data).

Site	Date	Number in Sample	FBI	Total Taxa Richness	EPT Richness	% EPT	% Dominance	Scoring for Stream Impairment Biological Assessment
AN0411	11/10/1993	100	5.0	12	1	11%	32%	Moderately Impaired
AN0411	11/12/1998	100	4.2	15	4	15%	51%	Moderately Impaired
AN0412	11/10/1993	18	7.9	7	0	0%	33%	Moderately Impaired
AN0412	11/12/1998	107	5.2	15	2	5%	59%	Moderately Impaired
AN0413	11/10/1993	100	5.6	11	1	12%	22%	Moderately Impaired
AN0413	11/12/1998	100	5.4	10	0	0%	64%	Severely Impaired

FBI = Family Biotic Index: Index of the average pollution-tolerance ("sensitivity") of individuals in the sample.

Total Taxa Richness: Number of different families in the sample

EPT Richness: Number of families in *Ephemeroptera, Plecoptera,* and *Tricoptera* Orders

% EPT: Percent of sample in the *Ephemeroptera, Plecoptera,* and *Tricoptera* Orders

% Dominance: Percent of sample composed of individuals from one family.

Samples should include at least 100 organisms for statistical evaluation. Samples with fewer than 100 were included in this table for interest, but would not be included in a rigorous evaluation of stream health. If sites consistently have fewer than 100 organisms that may indicate poor water quality or poor habitat for the macroinvertebrates.

FINDINGS & RECOMMENDATIONS

The results of this characterization and assessment represent an opportunity to properly plan the landscape of the Royce Brook Watershed in an environmentally responsible way and to work proactively to protect water quality. Overall, waterways are experiencing moderate degradation due to sedimentation in Royce Brook and stormwater is impacting the health of waterways. Sedimentation is partly due to the makeup of the underlying soils and geology. While this condition is natural, many other factors are amplifying this problem. Increases in populations in the Royce Brook Watershed, and associated land use changes, are adding to the amount of impervious surfaces, which augment the frequency and intensity of stormwater, flooding and erosion.

PLANNING FUTURE GROWTH

Finding: Populations in the Royce Brook Watershed, like the rest of New Jersey, are on the rise. The population went from 39,375 residents in 1990 to 46,977 in 2000, increasing by 19.3%. From 1986 to 1995, developed lands increased from 4,295.6 acres to 5,045.4 acres, a gain of 17.0%. Developed areas are on the increase at the expense of the remaining active agriculture in the watershed. (See Landscape section for more information.)

Recommendations:

- If not already completed, buildout analyses for each municipality should be conducted. This will allow for predictions of future growth and where current policies could lead. Regulations could be evaluated to determine if they are protective enough for preserving environmental quality.
- One way to balance the population growth with increased development is to plan for and maintain areas as town centers. These areas can be planned as mixed-use developments (projects that integrate different land uses, such as restaurants, residences, offices and parks), or low impact developments (ecologically friendly site development and stormwater management that aims to mitigate impacts to air, water and land) for maximum benefit.
- Royce Brook Watershed contains many critical habitats for a variety of threatened and endangered species. Critical habitats cover 37.0% (3,900 acres) of the Royce Brook Watershed. Many of these critical areas are adjacent to existing developments, putting them under development pressure. The municipalities that make up the watershed should review and reconsider their zoning to coincide with these environmentally important areas, restricting development and fragmentation of these habitats. Also, open space preservation can use critical habitat data as a tool to plan where efforts can be focused.

Finding: Much of the Royce Brook Watershed is developed and agricultural areas are converted to urban and developed land uses. Agricultural lands, once the basis for the area's economy, represent the rural character and a historical reference for towns. Many of the critical habitats for State threatened species within the watershed are grasslands that coincide with farmed areas in the watershed. (See Land Use section for more information.)

Recommendations:

- Hillsborough Township has prioritized suitable farms within its borders to preserve. Data on critical habitats and ground water recharge should also be reviewed in conjunction with soils data and factors that maintain and enhance agricultural viability when determining which farms to preserve. Farms that contain both of these environmentally sensitive features can be preserved and will not only preserve the rural character of the municipality, but will also protect threatened species and water supplies in the region (Figure 27).
- A few areas within the Royce Brook Watershed have been planned for limited growth and development. The planned areas within Hillsborough Township are mostly in agricultural lands. If these lands are currently not within State farmland preservation programs, then they should be high priority to be included in such, since a majority of agricultural lands are also being converted to urban land uses.
- Riparian corridors are being increasingly encroached upon for development in the Royce Brook Watershed. These areas are particularly sensitive to land use changes, as they are the natural buffers that protect the stream itself from a variety of pollution sources. Placing of new construction in the Royce Brook Watershed needs to be sensitive to or avoid altogether the riparian corridors in order to maintain ecological integrity. One way to ensure that riparian corridors are protected is to have the Royce Brook Watershed's municipalities and counties support the State recommendation of C1 protection for Royce Brook and its tributaries.
- Stream corridor ordinances will preserve the riparian corridor and prevent further development to these critical areas. The municipalities that do not have this protection for area streams should develop and implement such a strategy, if feasible.

Finding: Impervious cover prevents the movement of water into the soil. The Royce Brook Watershed is covered by 15.4% impervious cover. While this is below the 25% impervious cover limit where there is a shift to poor stream conditions that include diminished aquatic diversity, water quality, and habitat functioning, it is above the 10% impervious cover limit where sensitive elements are lost from the stream system. The municipalities need to be aware that much of the underlying soils in the Royce Brook Watershed are highly erodible and also have very slow infiltration rates, which increase the amount of runoff in this region. Water quality impacts have been noted due to the erodible nature of the soils in this region. (See Land Use section for more information.)

Recommendation:

- Increasing impervious cover will only exacerbate water quality problems by increasing the frequency and intensity of storm flows and flooding, a problem that has plagued Manville Borough over the past century. Municipalities need to incorporate innovative ways to plan developments including re-zoning (changing zoning classifications to permit development that is less dense or restrictive), mixed-use development (projects that integrate different land uses, such as restaurants, residences, offices and parks), conservation design and town-center designation (centralized growth areas through incentives and allows for developing at higher densities). Redeveloping existing urban land uses will also help to maintain current amounts of impervious cover in those areas.

MAINTAINING GROUNDWATER RESOURCES

Finding: There are 29 known contaminated sites (KCSs) in this 16.5 square mile watershed. Twenty-five sites are found within Hillsborough Township alone. This large number of KCSs in the Royce Brook Watershed warrants that the potentially responsible parties remediate any contamination present. (See Known Contaminated Sites section for more information.)

Recommendation:

- The wellhead protection area (WHPA) in Manville Borough is a significant source of drinking water for the entire Millstone Watershed. Even though there are no KCSs located within this WHPA, all adjacent KCSs need to have consistent monitoring by NJDEP to ensure that no contamination is documented in the vicinity of the WHPA.
- The creation and implementation of an ordinance to provide wellhead protection to the delineated WHPAs by the municipalities in the Royce Brook Watershed will ensure that groundwater is protected from possible contamination.

Finding: Much of the Royce Brook Watershed (83.1%) contains areas with high ground water recharge. These areas need to be protected by ordinances by their respective municipalities (Hillsborough Township, in particular) to restrict development in these areas. Reduced development in the high ground water recharge areas will aid in ensuring that plentiful supplies of water are available for the future. (See Water Supply section for more information.)

Recommendations:

- Since some of the high ground water recharge areas are located in agricultural areas in Hillsborough Township, this municipality needs to encourage regulations on the use of chemicals (especially harmful chemicals like pesticides) in the agricultural areas above ground water recharge zones to prevent possible contamination. If this is not possible, farms need to review and evaluate the many options available to reduce their pesticide use in such areas. For example, participation in the New Jersey Conservation Reserve Enhancement Program (CREP) to help farmers reduce impairment from agricultural water runoff sources in an effort to improve water quality along both impaired and unimpaired New Jersey streams through best management practices (BMPs).
- To ensure that ground water and aquifers maintain adequate water supply, municipalities can include the use of infiltration ponds and basins in new developments. These ponds are lined with permeable soils and materials that allow water to be slowly released back into the ground.

PROTECTING WATER QUALITY

Finding: The nature of Piedmont geology has a large influence on the water resources and environmental quality of the Royce Brook Watershed. Sandstones, siltstones and shales typify the Piedmont Physiographic Province. (See Geology section for more information.)

Recommendation:

- Due to the somewhat consolidated nature of the stones in the Piedmont Physiographic Province, infiltration rates for water entering the ground are slow to very slow. This has the potential to produce a high amount of runoff from storm events. This stormwater runoff needs to be controlled or managed by the municipalities, especially Manville Borough, which is almost completely developed, so that it does not degrade water quality or increase the potential for flooding.

Finding: Much of the Royce Brook Watershed is classified as having hydrologic soil group C, covering 9,388.5 acres out of a total of 10,568.0 acres (88.8%) in the entire watershed. Hydrologic soil group C represents soils with a slow infiltration rate, and is representative of the moderately consolidated soils seen in the Piedmont Physiographic Province. The second most common hydrologic soil group in the Royce Brook Watershed is group D, representing very slow infiltration rates. Most of these soil groups are located in headwater areas of tributaries to Royce Brook. Category D soil groups have very slow infiltration rates since most of these soils are clayey or are shallow to an underlying impervious layer. Runoff from these soils will be moderate to rapid due to these moderately coarse-textured soils having slow to very slow infiltration rates.

Based upon the visual assessment data and observations during the biological assessments, the most likely stressor affecting the macroinvertebrate communities in Royce Brook is heightened sedimentation. The basis for this heightened sedimentation may be due to the soil composition and high erodibility of the Royce Brook Watershed itself, which is exacerbated by the high amount of developed lands in the watershed. The nature of the Piedmont soils in the Royce Brook Watershed is an important factor impacting water quality of Royce Brook (especially macroinvertebrate communities and their habitats). (See Water Quality and Soils sections for more information.)

Recommendation:

- Because municipalities rely on their local Soil Conservation Districts (SCDs) to enforce the sediment and soil management regulations, SCDs need to be aware of the characteristics of a site's underlying soils when they review and enforce plans to control and manage soils during construction activities.
- To help alleviate any heightened sedimentation of waterways within the Royce Brook Watershed, municipalities that currently do not have sediment and soil erosion control ordinances should enact such an ordinance. It is especially critical to have these regulations in place during construction activities (as the region is undergoing increased development).

Agricultural activities (as much of this region is still farmland and many farms are located near streams) need to investigate the use of BMPs to help alleviate sediment loads into area streams.

Finding: The visual assessment information and biological data available shows that there are impacts to water quality, mostly stemming from the high amount of developed land in the Royce Brook Watershed. The Royce Brook is listed by the NJDEP as impaired due to non-support of aquatic life or as having insufficient data to determine the health of the waterways. (See Water Quality section for more information.)

Recommendations:

- In order to accurately assess the environmental health of Royce Brook, long-term trends in water quality need to be determined. Currently, there is a lack of reliable monitoring data (biological or chemical) on the water resources in this region, especially basic water quality information for many of the area's tributaries, which have an impact on the Royce Brook itself. Intensive monitoring needs to occur to determine the health of Royce Brook and its tributaries. Future monitoring could be performed by municipal environmental commissions through the State's Environmental Services Program Matching Grant, as has been done successfully by other towns.
- Point source discharges in the Royce Brook Watershed need to work within the guidelines of their active permits in order to maintain the health of Royce Brook.
- Nonpoint source pollutant loadings for nitrogen, phosphorus, and total suspended solids (TSS) in the Royce Brook Watershed are found mostly within the moderate to high levels for the model used in this assessment. Of special note are the loadings for TSS, as the land use practices modeled in the Royce Brook Watershed are providing moderate levels of sediments to the streams in this region. This is important, as the soils in this area are mostly uncemented and therefore highly erodible. Since the infiltration rates of the soils in the Royce Brook Watershed are slow to very slow, the potential for runoff in this region is high. Therefore the municipalities in the Royce Brook Watershed (especially Hillsborough Township) need to enact sediment control ordinances to prevent materials from washing into streams and degrading habitat and water quality.
- Since the Royce Brook Watershed is already highly developed, the municipalities in this region need to incorporate stormwater management to help reduce the loadings of nonpoint source pollutants into the Brook. Somerset County has moved this process forward and the municipalities within Royce Brook Watershed should cooperate to develop a regional stormwater management plan for Royce Brook and its tributaries.

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LIST OF ACRONYMS

AMNET	Ambient Biomonitoring Network
BMPs	Best Management Practices
C1	Category One Protection
CEA	Classification Exception Area
CKE	Currently Known Extent
EPT	Ephemeroptera Plecoptera Tricoptera
FBI	Family Biotic Index
GIS	Geographic Information System
IBI	Index of Biotic Integrity
KCS	Known Contaminated Site
MDDNR	Maryland Department of Natural Resources
MGD	Million Gallons per Day
ND	No Date
NJDEP	New Jersey Department of Environmental Protection
NJAC	New Jersey Administrative Code
NJGWQS	New Jersey Ground Water Quality Standard
NJPDES	New Jersey Pollution Discharge Elimination System
NJWSA	New Jersey Water Supply Authority
NRCS	Natural Resources Conservation Service
PA	Planning Area
PCE	Perchloroethylene
PCW	Public Community Well
PRP	Potentially Responsible Party
SBMWA	Stony Brook-Millstone Watershed Association
SCD	Soil Conservation District
SCS	Soil Conservation Service
STORET	Storage and Retrieval Database

STP	Sewage Treatment Plant
TCE	Trichloroethylene
TMDL	Total Maximum Daily Load
TOT	Time of Travel
TSS	Total Suspended Solids
URWA	Upper Raritan Watershed Association
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
WHPA	Wellhead Protection Area
WTP	Water Treatment Plant

GLOSSARY

alluvial: Relating to mud and/or sand deposited by flowing water.

aquifer: An underground geological formation, or group of formations, containing usable amounts of groundwater that can supply wells and springs.

baseflow: The sustained or fair-weather flow of a stream regardless of human-induced inputs.

benthic organism: Any of a diverse group of aquatic plants and animals that lives on the bottom of bodies of water; the presence or absence of certain benthic organisms is used as an indicator of water quality.

clay: A rock or mineral fragment or particle of decayed matter smaller than a very fine silt grain, having a diameter less than 1/256 of a millimeter.

confluence: A place of meeting of two or more streams; the point where a tributary joins the main stream.

deciduous: Describes a tree that loses its leaves during autumn.

detention basin: An impoundment or excavated basin for the short-term detention of stormwater runoff from an area.

dip direction: The vertical angle, measured at an observation point in surveying, between the plane of the true horizon and a line of sight to the apparent horizon.

dissolved oxygen: The volume of oxygen that is contained in water.

endangered species: Living organisms threatened with extinction by man made or natural changes in the environment.

erodibility: The tendency of soil to become detached and washed away during erosion.

erosion: The physical removal of rock or soil particles by a transport agent such as running water, wind, glacial ice, and gravity.

eutrophication: The slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears; during the later stages of eutrophication the water body is choked by abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorous; human activities can accelerate this process.

evapotranspiration: The loss of water from the soil both by evaporation and by transpiration from the plants growing in the soil.

floodplain: Area adjacent to a stream or river that is subject to flooding or inundation during severe storm events; often called a 100-year floodplain, it would include the area of flooding that occurs, on average, once every 100 years.

Geographic Information System (GIS): A computer system designed to manipulate, analyze, and display information that is tied to a geographic location.

gravel: An unconsolidated natural accumulation of rounded rock fragments resulting from erosion, consisting primarily of particles larger than sand grains.

ground water: The portion of water beneath the land surface that is below the water table and the pore spaces are filled with water.

habitat: The environment in which a plant or animal tends to live.

headwater stream / headwaters: The beginnings or sources for watercourses; typically, the point in the landscape where sufficient runoff collects in intermittent streams.

hydrology: The science that deals with water (both surface and ground water), its properties, circulation and distribution.

impervious cover / impervious surface: Any surface in the landscape that cannot effectively adsorb or infiltrate rainfall; usually associated with urban development; the amount of impervious surfaces has been used as an indicator to predict the severity of water quality impairments to local waterways.

infiltration: The movement of water into soil or porous rock.

infrastructure: The underlying system or network used for organization; most often refers to the road systems, sewer networks, school systems, etc. in a municipality.

macroinvertebrates: These are organisms that do not have a backbone and are visible to the naked eye (for example, certain insect larvae); they are most often used as indicator organisms in water bodies as they exhibit varying sensitivities to pollution.

Natural Heritage Database: a State database containing an inventory of all species of flora and fauna that are threatened or endangered.

nonpoint-source pollution: Any source of pollution not associated with a distinct discharge point; pollution from a diffuse source; includes sources such as rainwater runoff from agricultural lands, industrial sites, parking lots, and timber operations, as well as escaping gases from pipes and fittings.

nutrient: Any substance that is assimilated by organisms and promotes growth. Nitrogen and phosphorous are nutrients which promote the growth of algae. There are other essential and trace elements, which are also considered nutrients.

outcrop: The part of a geological formation or structure that appears at the surface of the Earth.

percolation: The slow movement of water through small openings within a porous material.

pervious surface: Any surface with the capacity for transmitting a fluid; also called permeable surface.

Physiographic Province: The distribution of land area in New Jersey into distinct divisions determined by New Jersey's geological history.

point-source pollution: A stationary location or fixed facility such as an industrial or municipal plant that discharges pollutants into air or surface water through pipes, ditches, lagoons, wells, or stacks; a single identifiable source of pollution such as a ship or mine.

porosity: The ratio of the volume of interstices of a material to the volume of its mass; the quality of being porous.

potable water: Raw or treated water that is considered safe to drink; also called drinking water.

recharge: The process of the absorption and addition of water to the zone of saturation or aquifer.

retention basin: A large depression built as a barrier to reduce flooding and storm surges.

riparian area: Land situated on or adjacent to a stream bank.

runoff: The portion of rainfall, melted snow or irrigation water that flows across the ground's surface and is eventually returned to streams; runoff can pick up pollutants from air or land and carry them to receiving waters; also called stormwater.

sand: A rock fragment or particle of detritus smaller than gravel but larger than silt.

sediment: Solid fragmented material that originates from weathering of rocks and is distributed by air, water or ice.

sedimentation: The act or process of forming or accumulating sediment in layers.

septic system: A system designed to treat waste and wastewater by the use of bacteria; most often associated with individual residences.

silt: A rock fragment or particle of detritus smaller than fine sand but larger than clay.

soil: The upper layer of the Earth's surface that may be dug up or plowed and in which vegetation grows.

species of special concern: A species that is not considered threatened nor endangered, but still monitored by Natural Heritage Database.

succession: The process of plant life maturation over a landscape.

surface water: All water found in rivers, streams, ponds, lakes, marshes, wetlands, as ice and snow, and transitional, coastal and marine waters.

threatened species: Species that may become endangered if conditions that harm them continue to accumulate.

total maximum daily load: The maximum quantity of a particular pollutant that can enter a waterway without affecting the designated use of that waterway.

turbidity: A measure of the ability of a suspended material to disturb or diminish the penetration of light through a fluid.

wastewater: Water that has been used for industrial, domestic, or agricultural practices and has not yet been treated.

watershed: A hydrologic unit in which all surface water runoff egresses through a single, natural hydrologic outlet, and as delineated in the statewide Water Quality Management Plan. Also, all the land area, which contributes runoff to a particular point along a waterway.

wellhead: The source of a well and the structure built over it.

wetlands: Areas that are soaked or flooded by surface or ground water frequently enough or for sufficient duration to support plants, birds, animals, and aquatic life. Wetlands generally include swamps, marshes, bogs, estuaries, and other inland and coastal areas, and are federally protected.

FIGURES

Figure 1: Royce Brook Watershed & Millstone Watershed

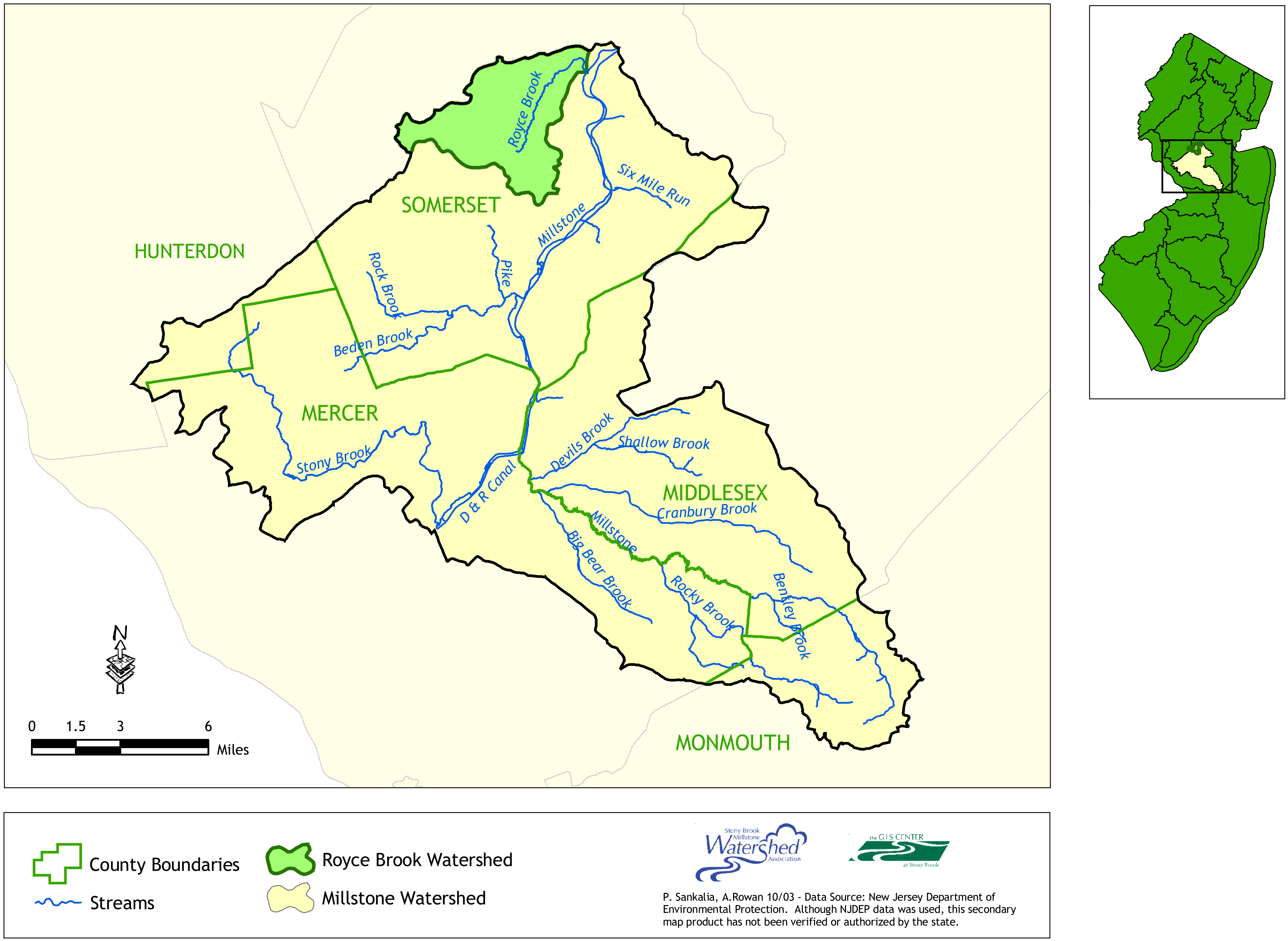
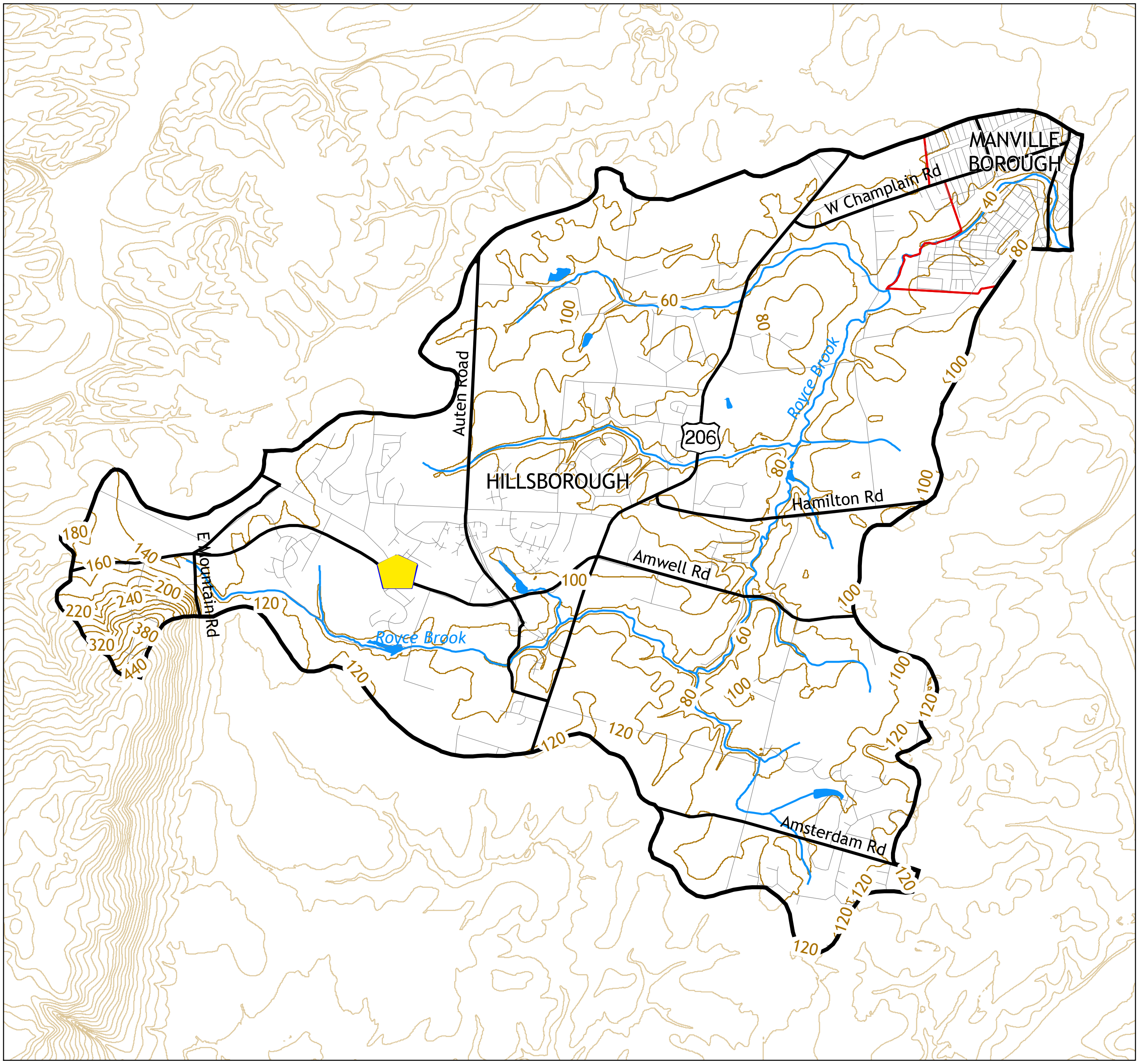


Figure 2: Royce Brook Watershed Topography



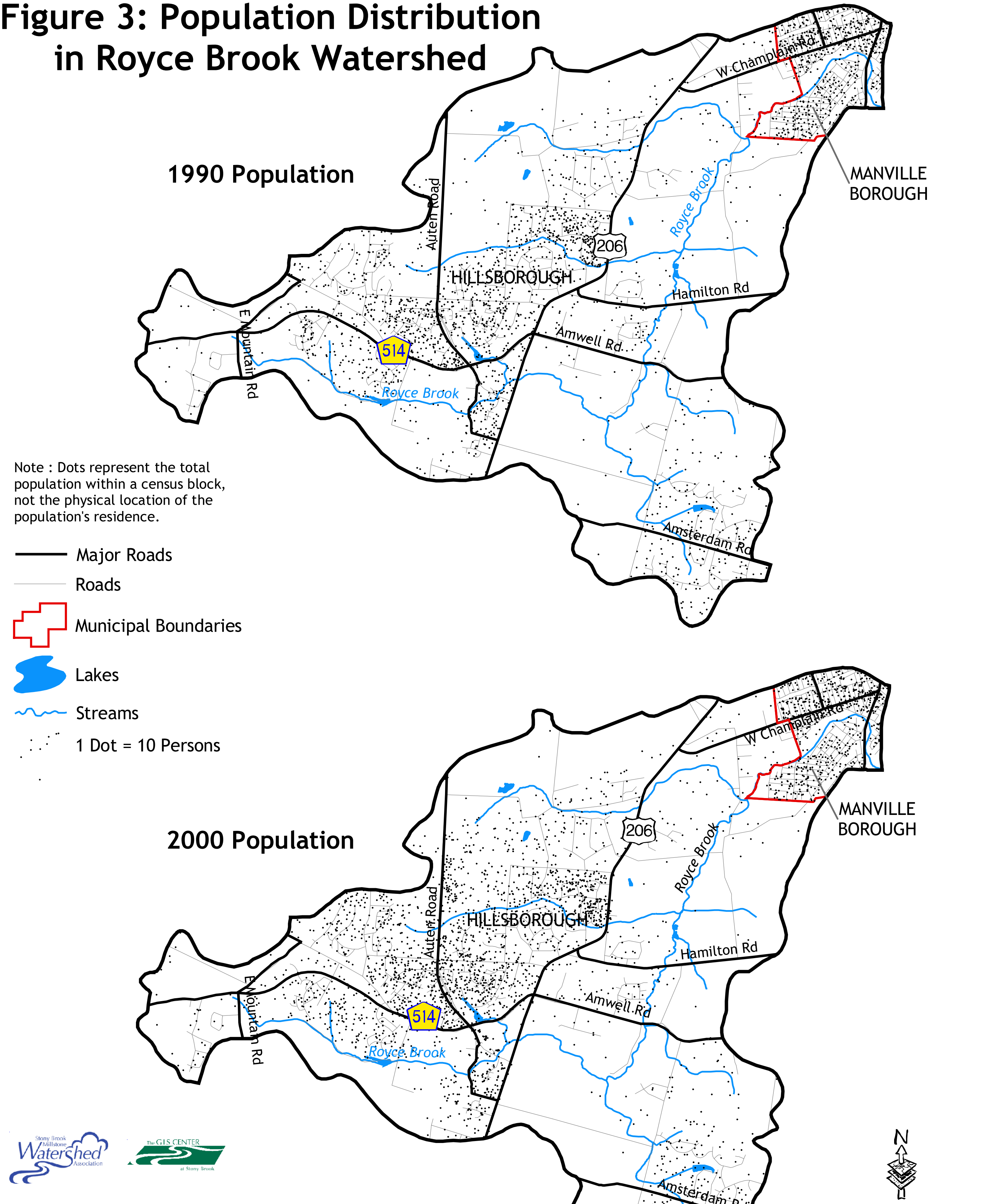
Major Roads
Municipal Boundaries
Lakes
Roads
Streams
Elevation Contours (20 foot intervals)

N

0 0.5 1 Miles

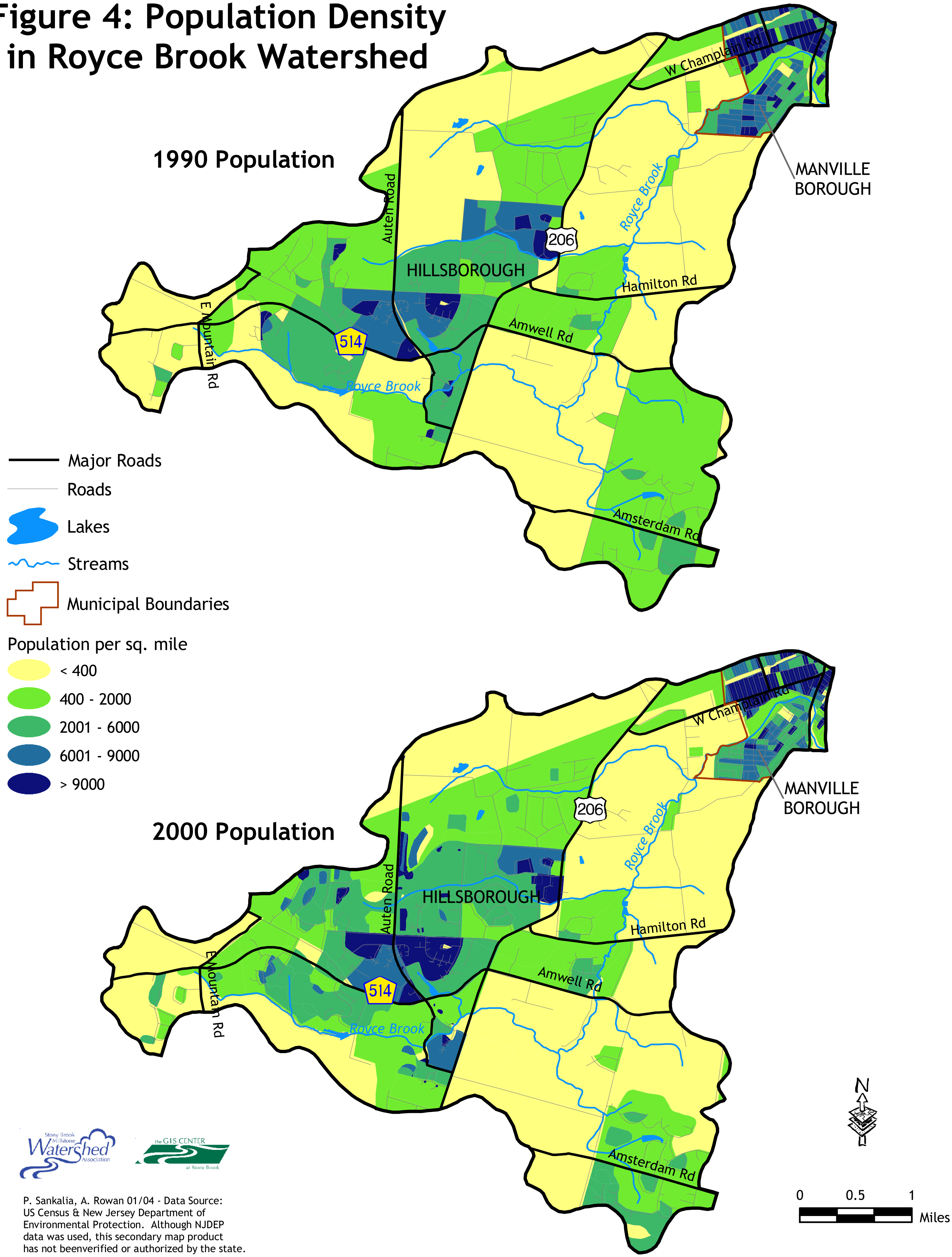
P. Sankalia, A. Rowan 11/03 - Data Source: New Jersey Department of Environmental Protection, US Census TIGER Files. Although NJDEP data was used, this secondary map product has not beenverified or authorized by the state.

Figure 3: Population Distribution in Royce Brook Watershed



P. Sankalia, A.Rowan 10/03 - Data Source: US Census & New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 4: Population Density in Royce Brook Watershed



P. Sankalia, A. Rowan 01/04 - Data Source: US Census & New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not beenverified or authorized by the state.

Figure 5: Critical Habitats in Royce Brook Watershed

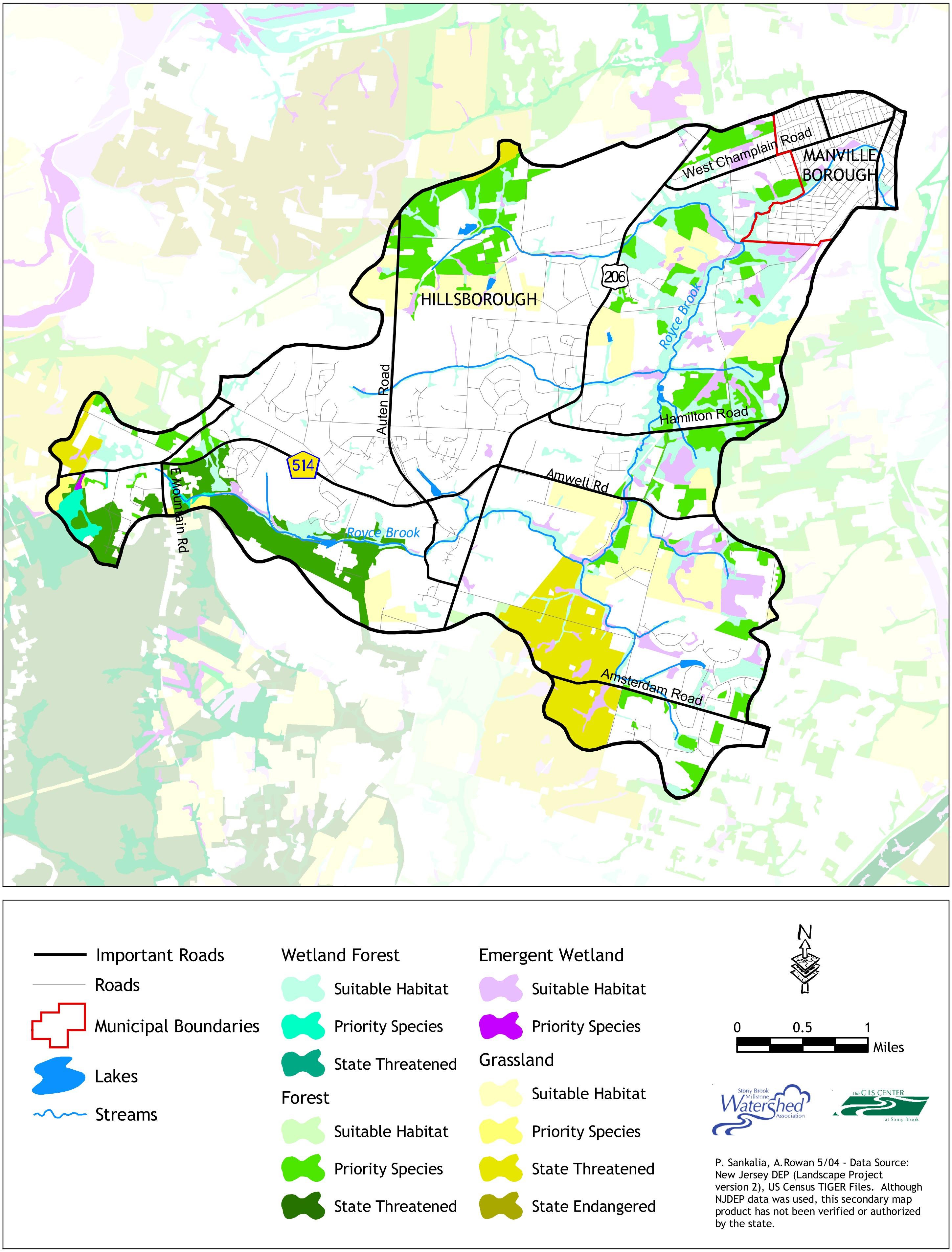
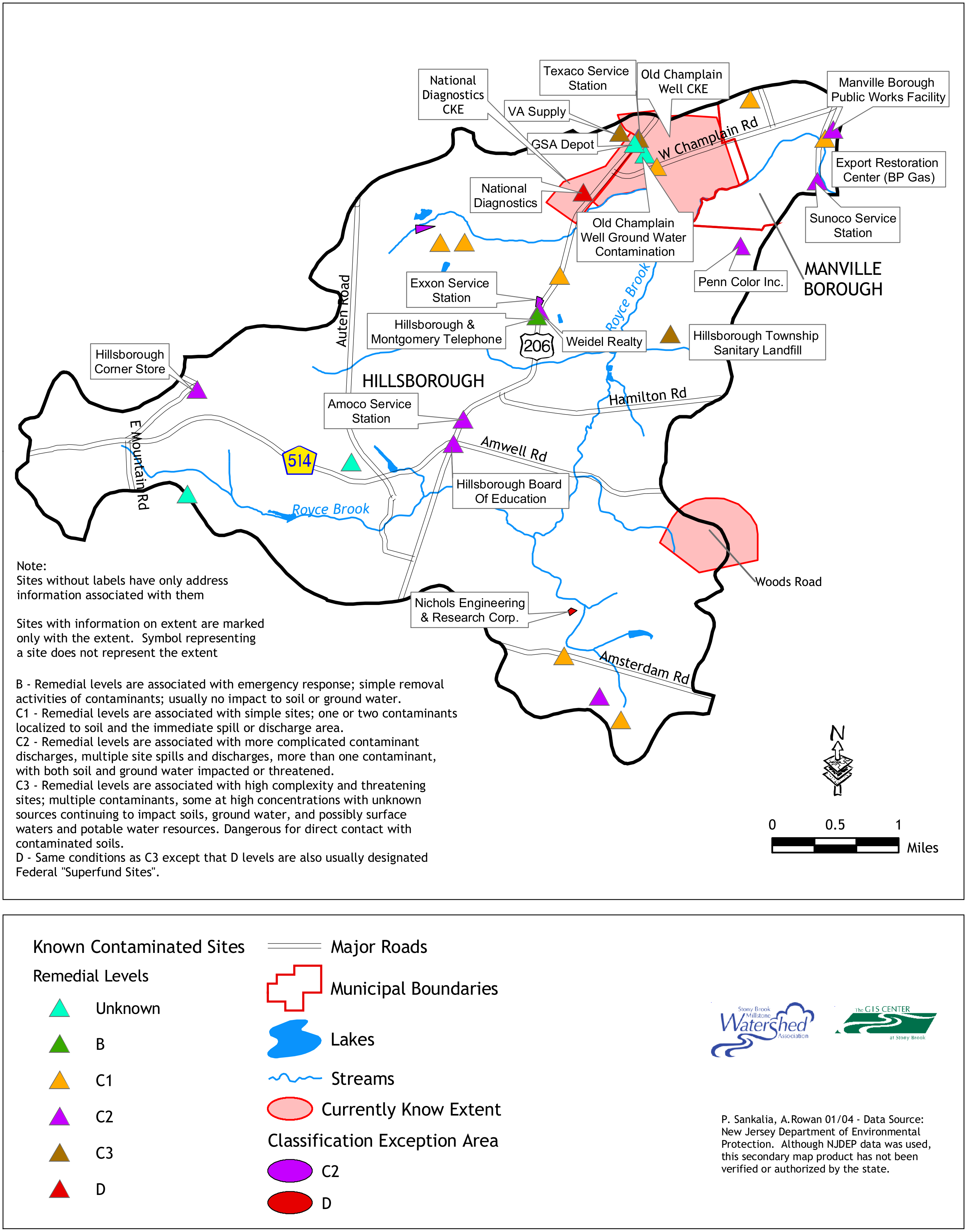


Figure 6: Known Contaminated Sites and Extent of Contamination in Royce Brook Watershed



Note:
Sites without labels have only address information associated with them

Sites with information on extent are marked only with the extent. Symbol representing a site does not represent the extent

B - Remedial levels are associated with emergency response; simple removal activities of contaminants; usually no impact to soil or ground water.
C1 - Remedial levels are associated with simple sites; one or two contaminants localized to soil and the immediate spill or discharge area.
C2 - Remedial levels are associated with more complicated contaminant discharges, multiple site spills and discharges, more than one contaminant, with both soil and ground water impacted or threatened.
C3 - Remedial levels are associated with high complexity and threatening sites; multiple contaminants, some at high concentrations with unknown sources continuing to impact soils, ground water, and possibly surface waters and potable water resources. Dangerous for direct contact with contaminated soils.
D - Same conditions as C3 except that D levels are also usually designated Federal "Superfund Sites".

Figure 7: NJPDES Point Source Dischargers in Royce Brook Watershed

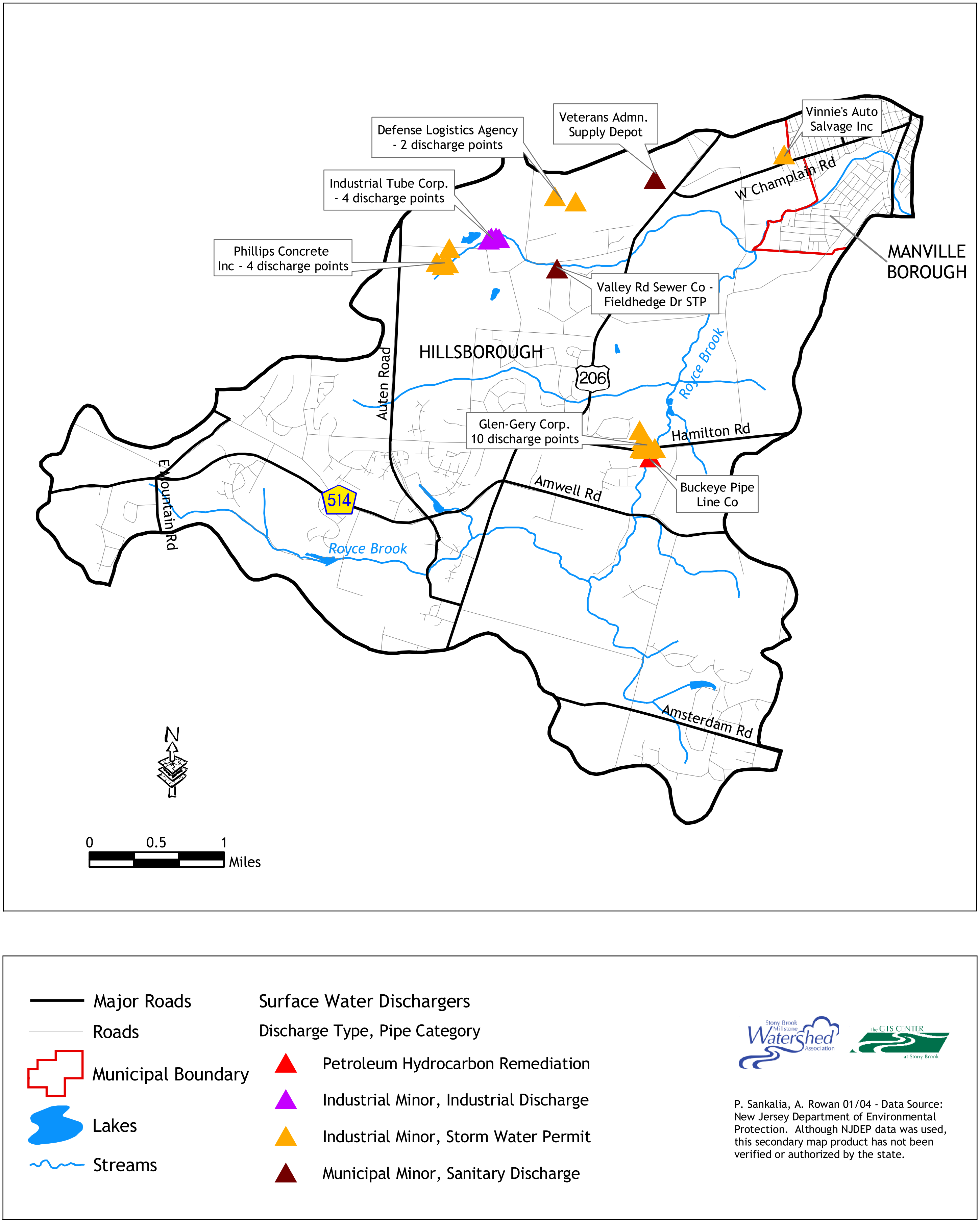
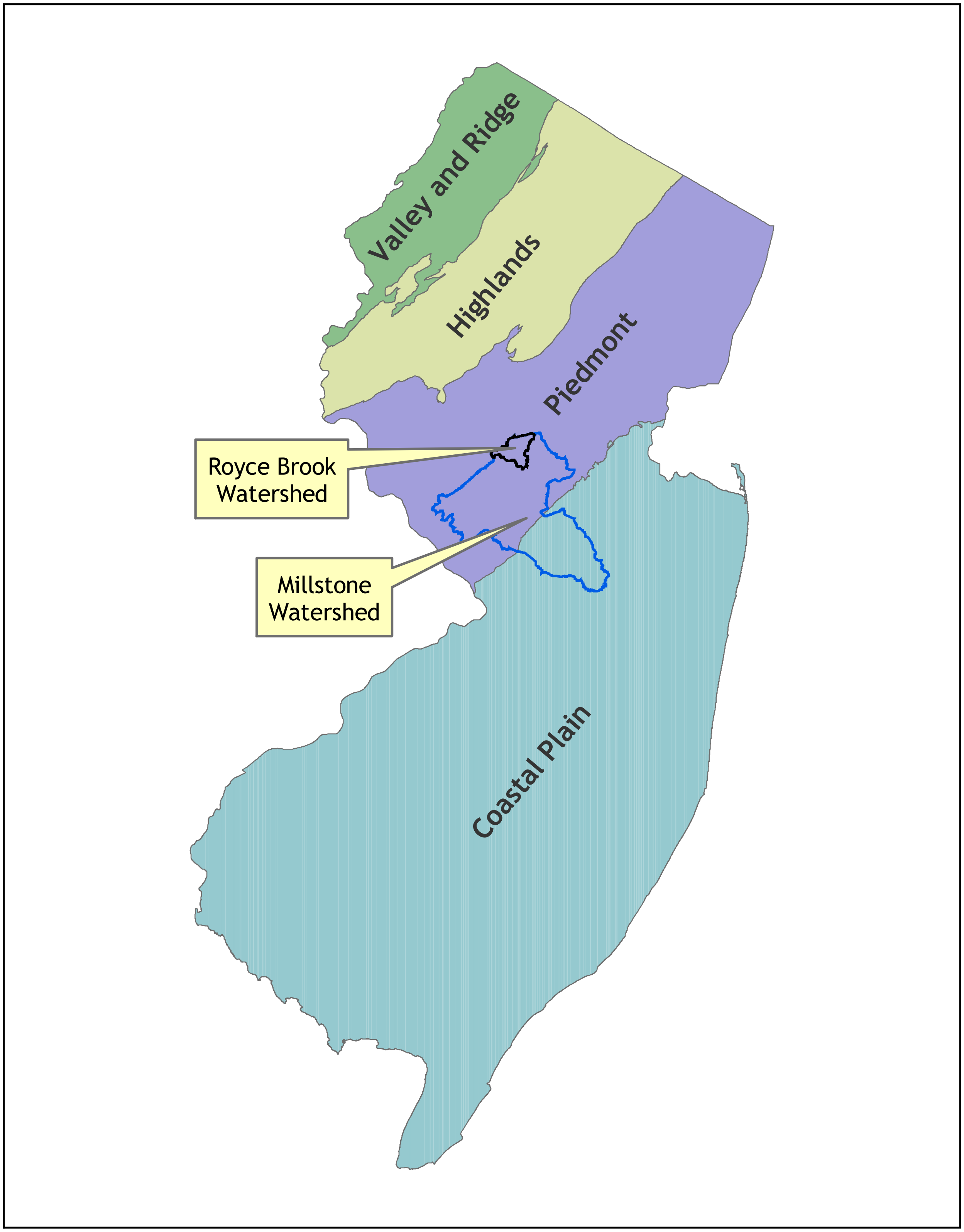


Figure 8: Physiographic Provinces of New Jersey



P. Sankalia, A.Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection, New Jersey Geological Survey & US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 9: Geology in Royce Brook Watershed

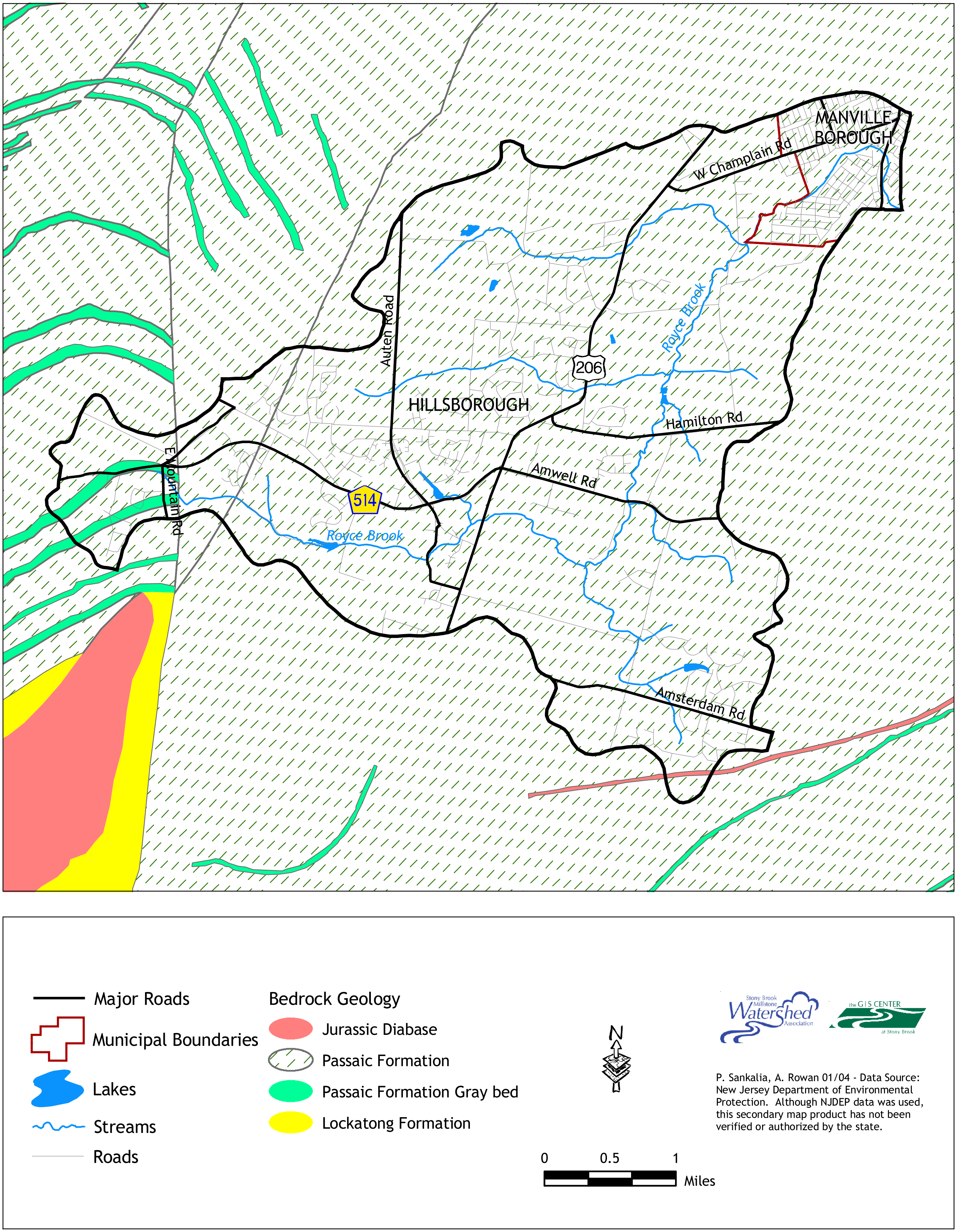


Figure 10: Hydrologic Soil Groups in Royce Brook Watershed

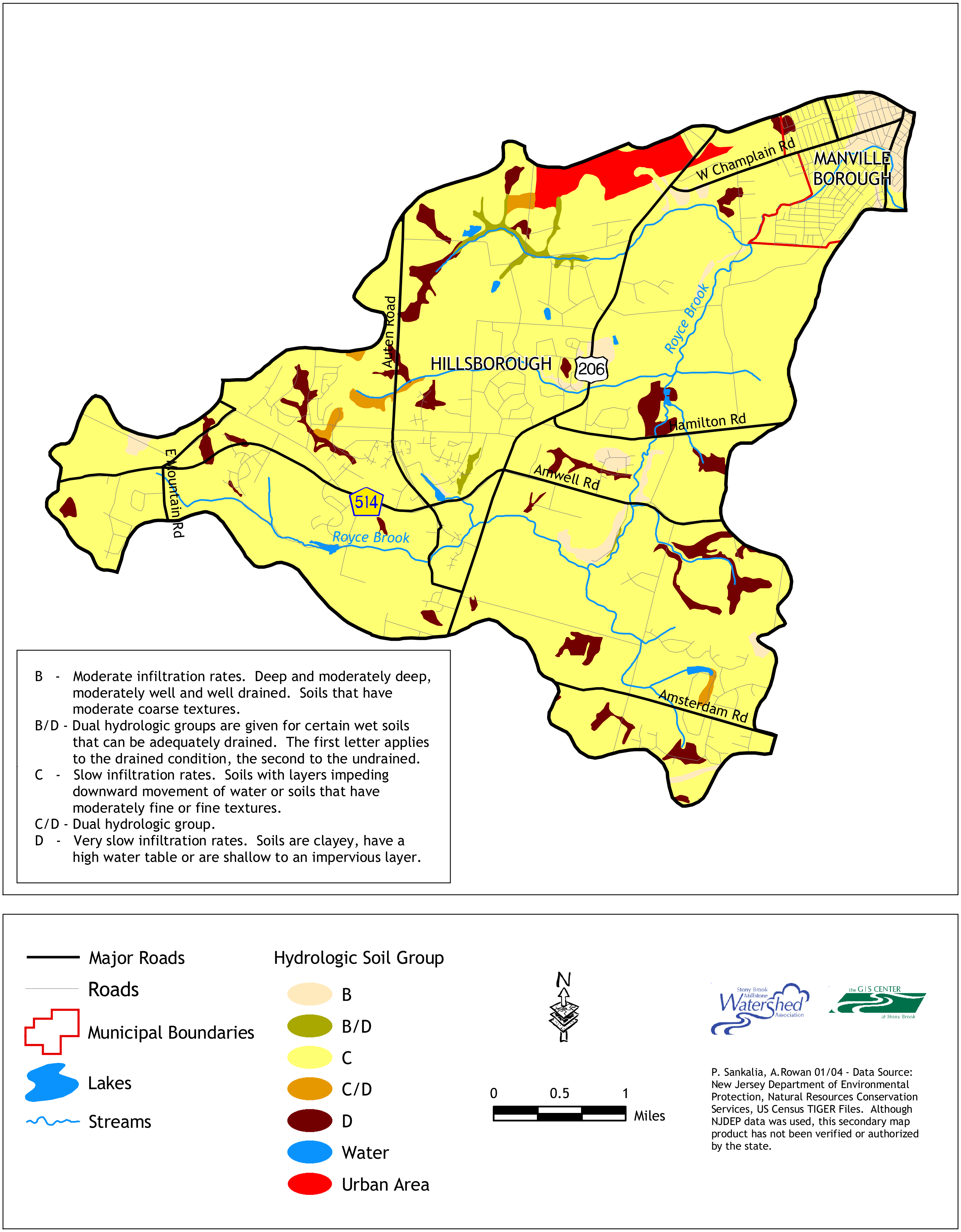


Figure 11: Soil Erodibility in Royce Brook Watershed

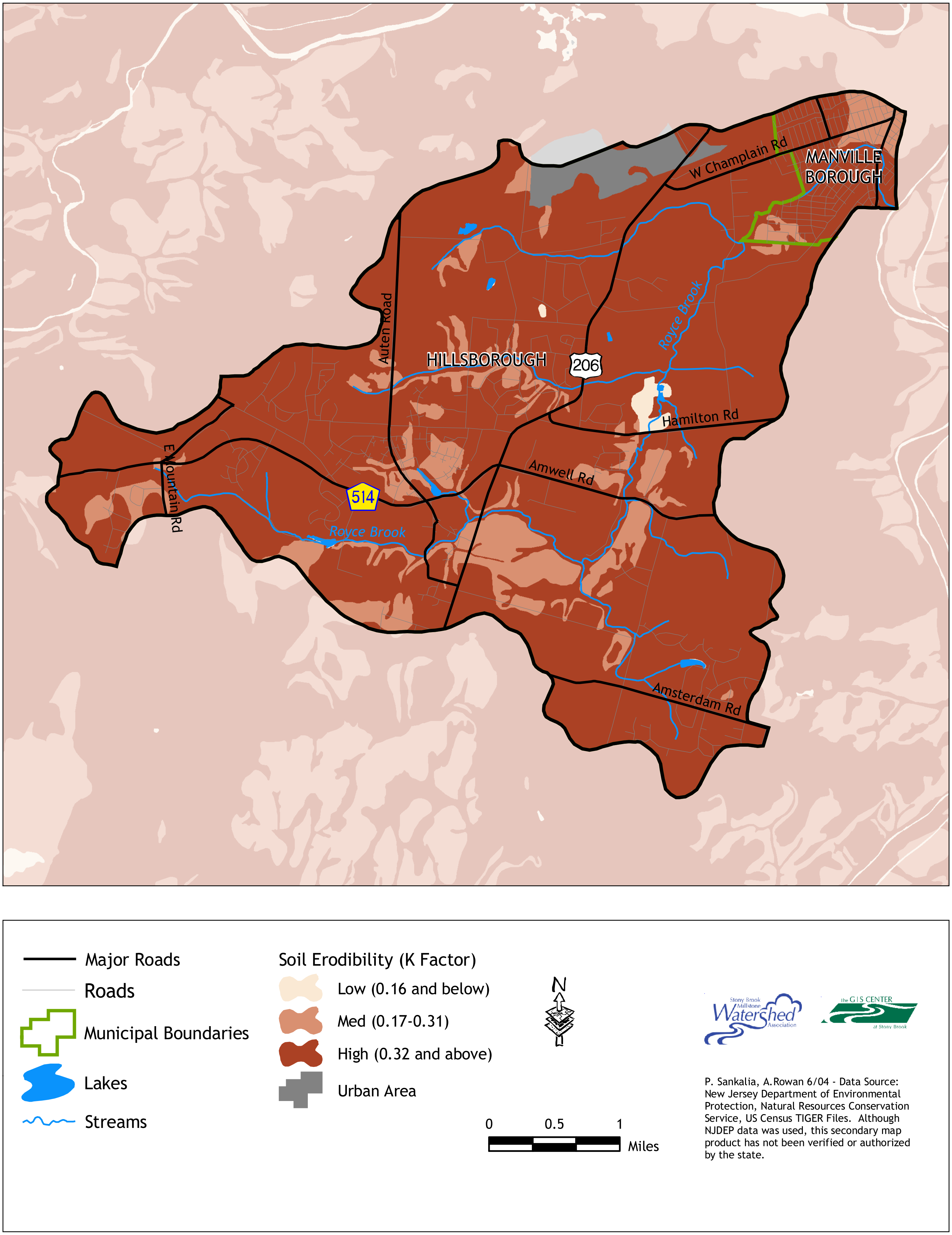


Figure 12: Septic Suitability in Royce Brook Watershed

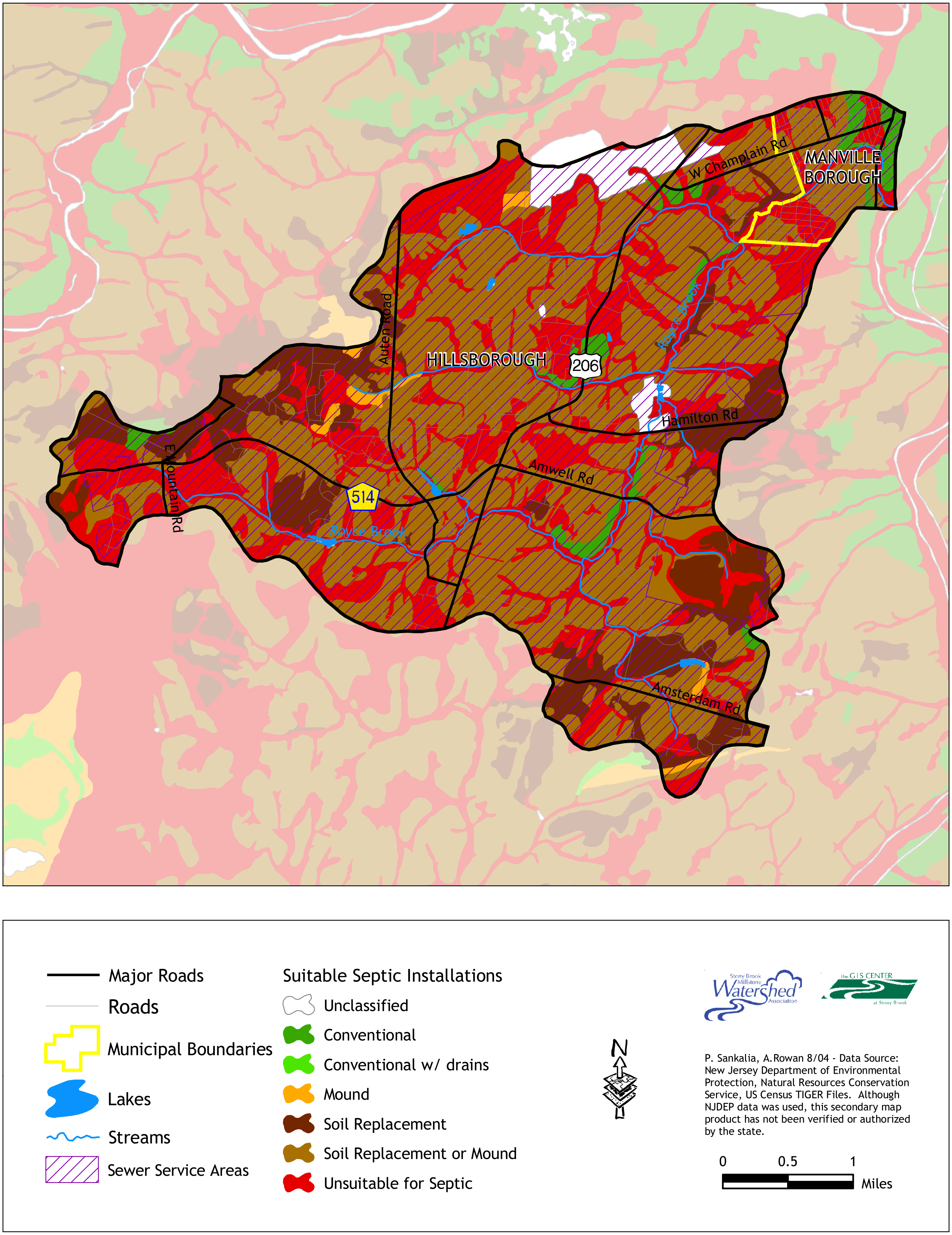


Figure 13: 1995 Land Use in Royce Brook Watershed

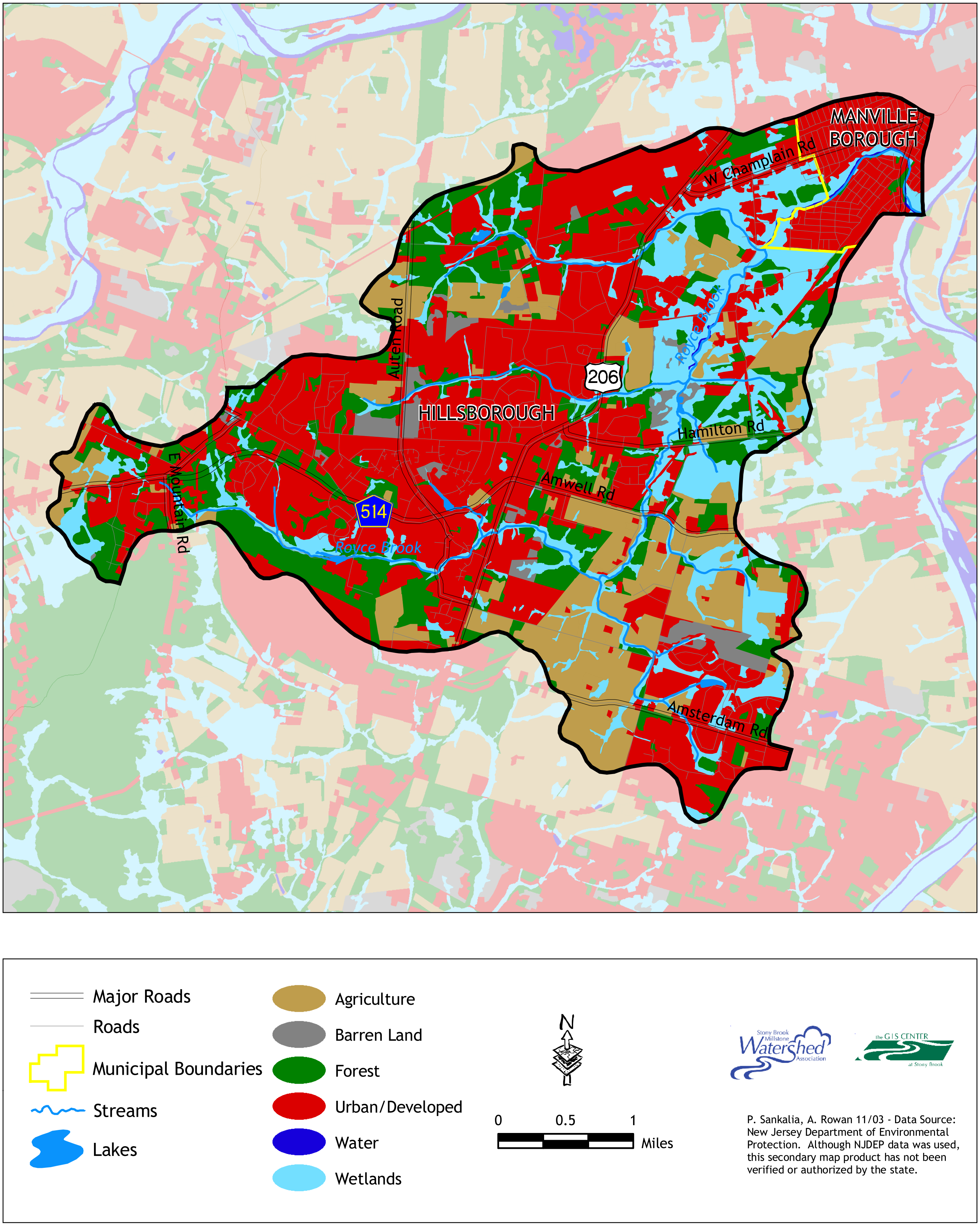
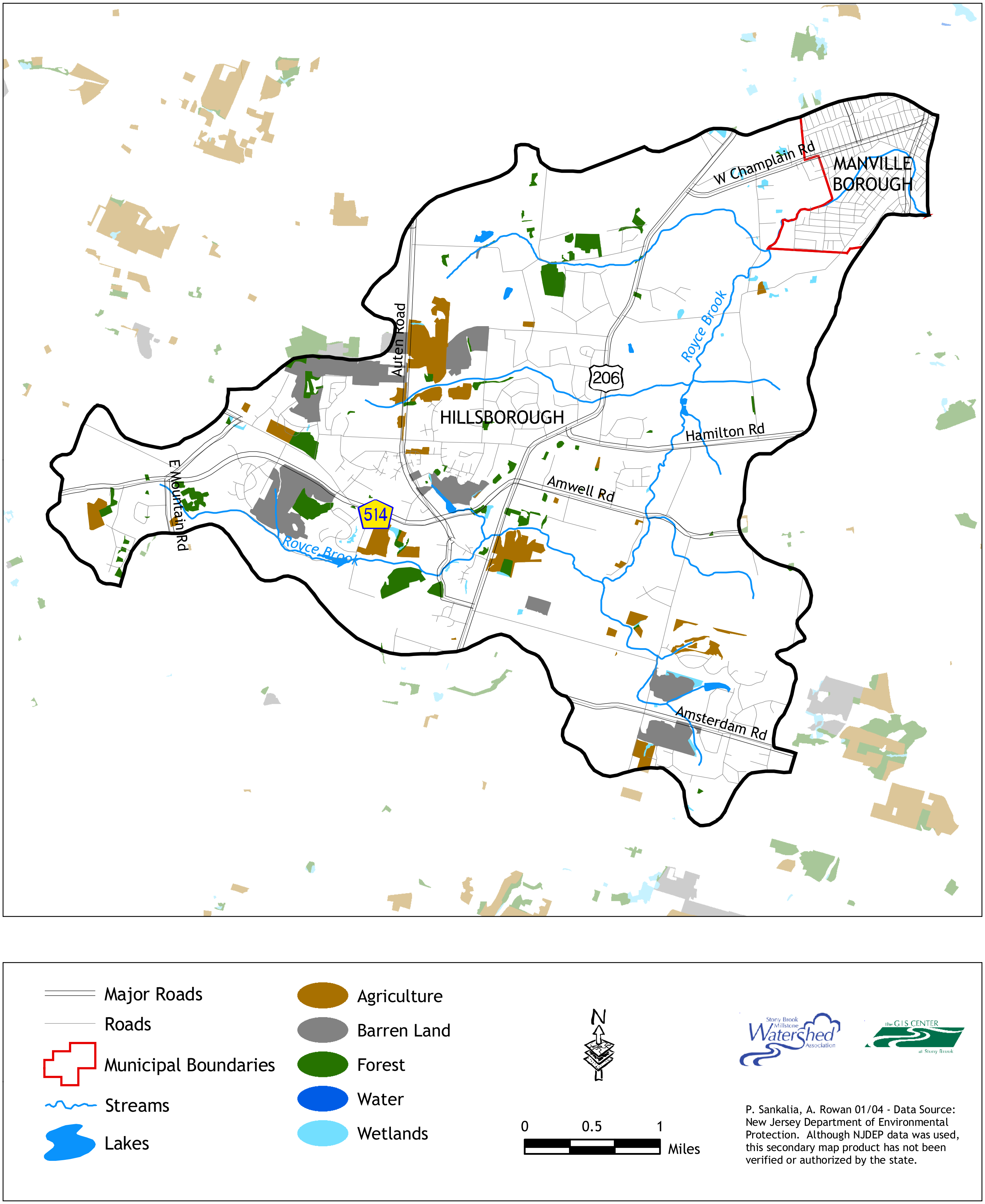


Figure 14: Land Use Changed to Urban/Developed between 1986 and 1995 in Royce Brook Watershed



P. Sankalia, A. Rowan 01/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 15: 1995 Urban/Developed Land Use in Royce Brook Watershed

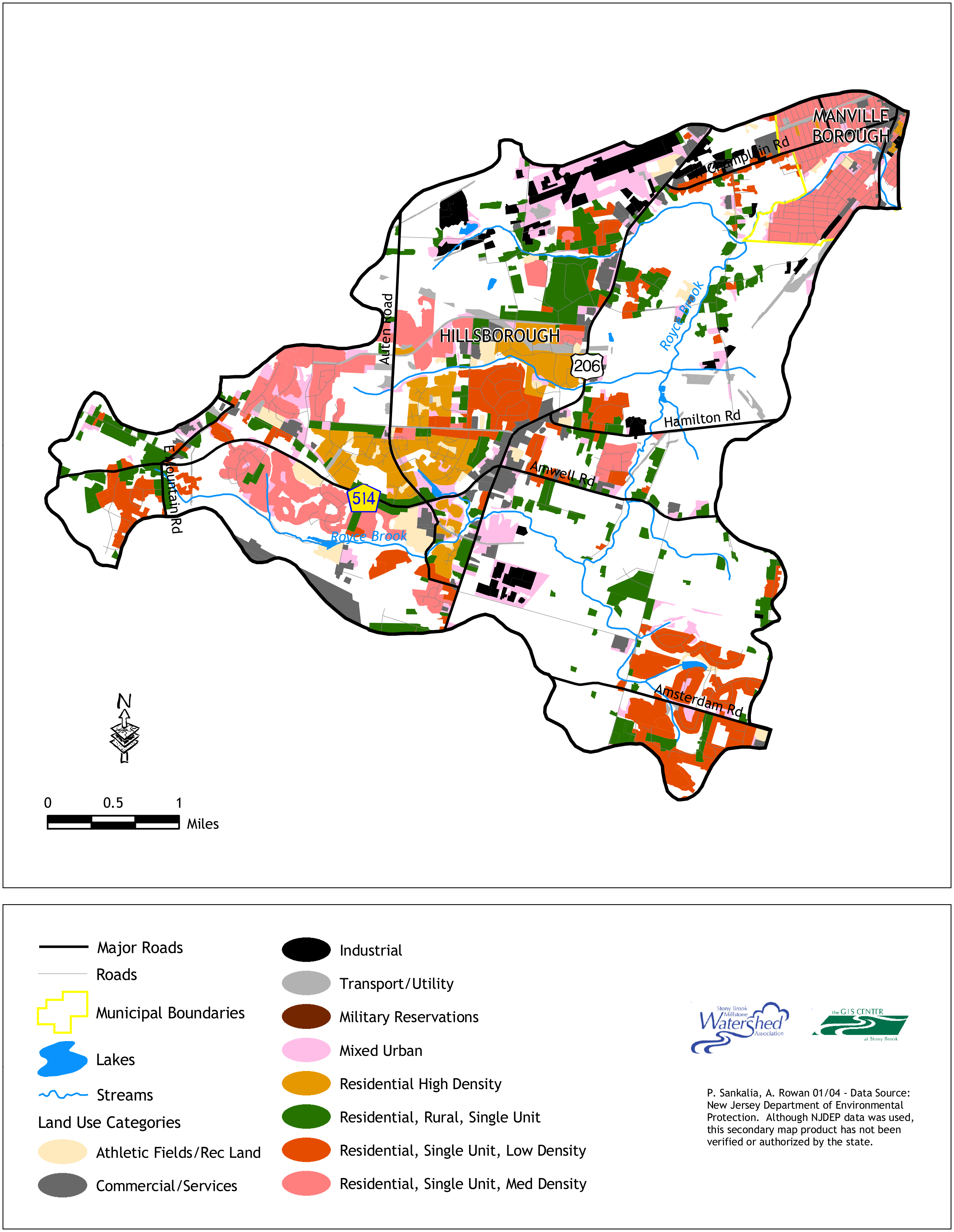
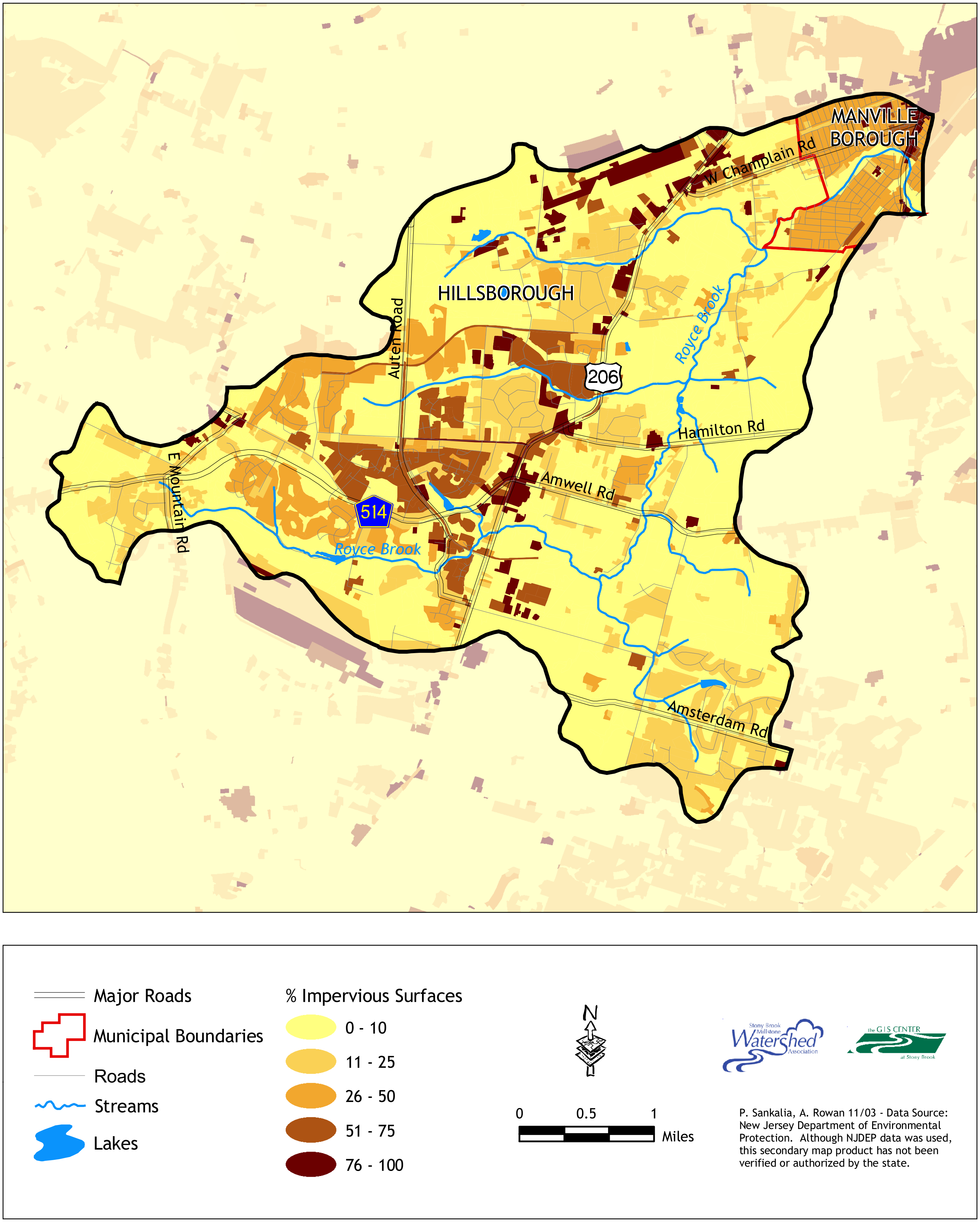
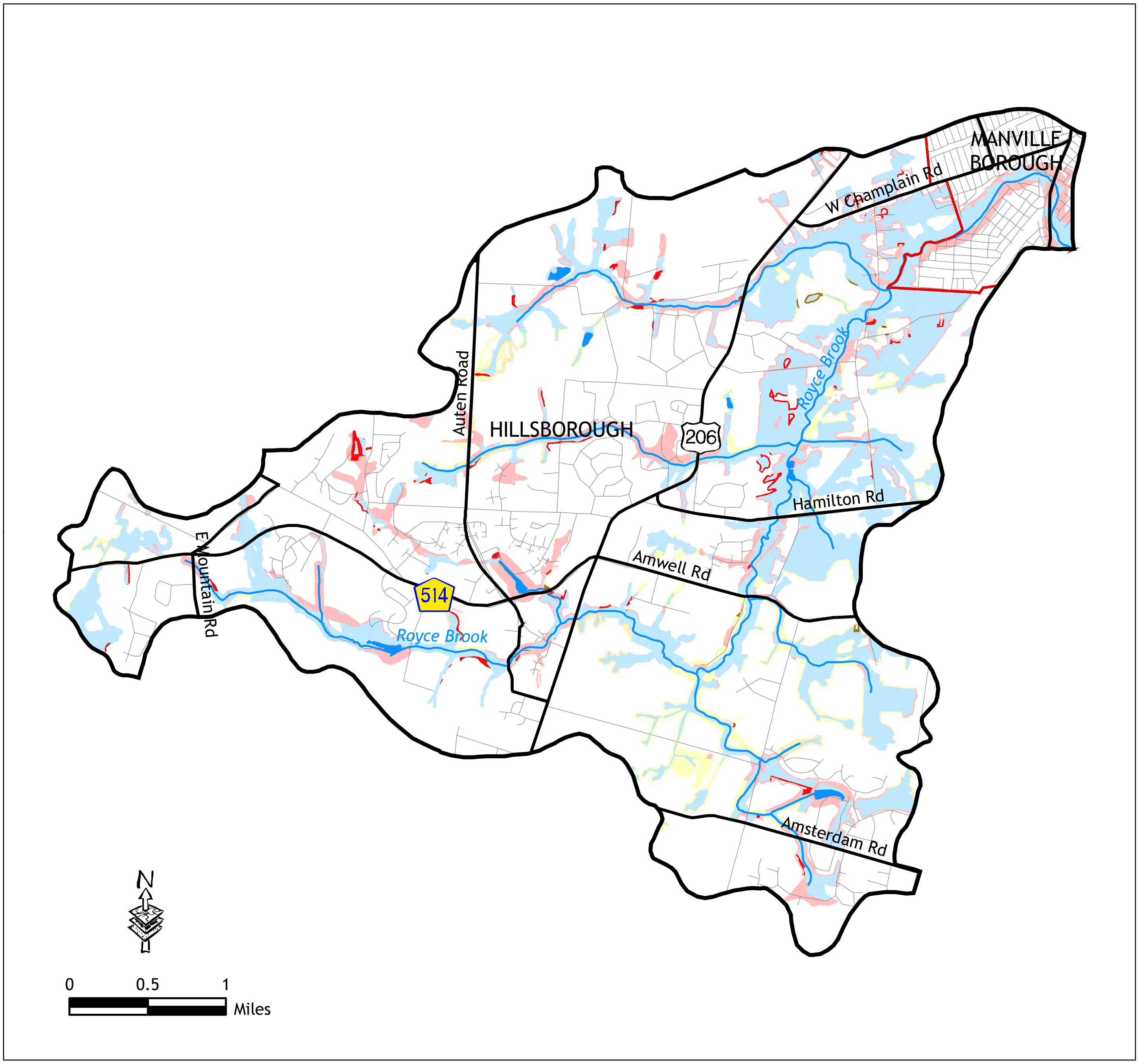


Figure 16: 1995 Impervious Surfaces in Royce Brook Watershed



P. Sankalia, A. Rowan 11/03 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 17: Riparian Land Cover Conversion in Royce Brook Watershed



Major Roads

Roads

Municipal Boundaries

Lakes

Streams

Riparian Areas

Agricultural Development before 1986

Agricultural Development 1986 to 1995

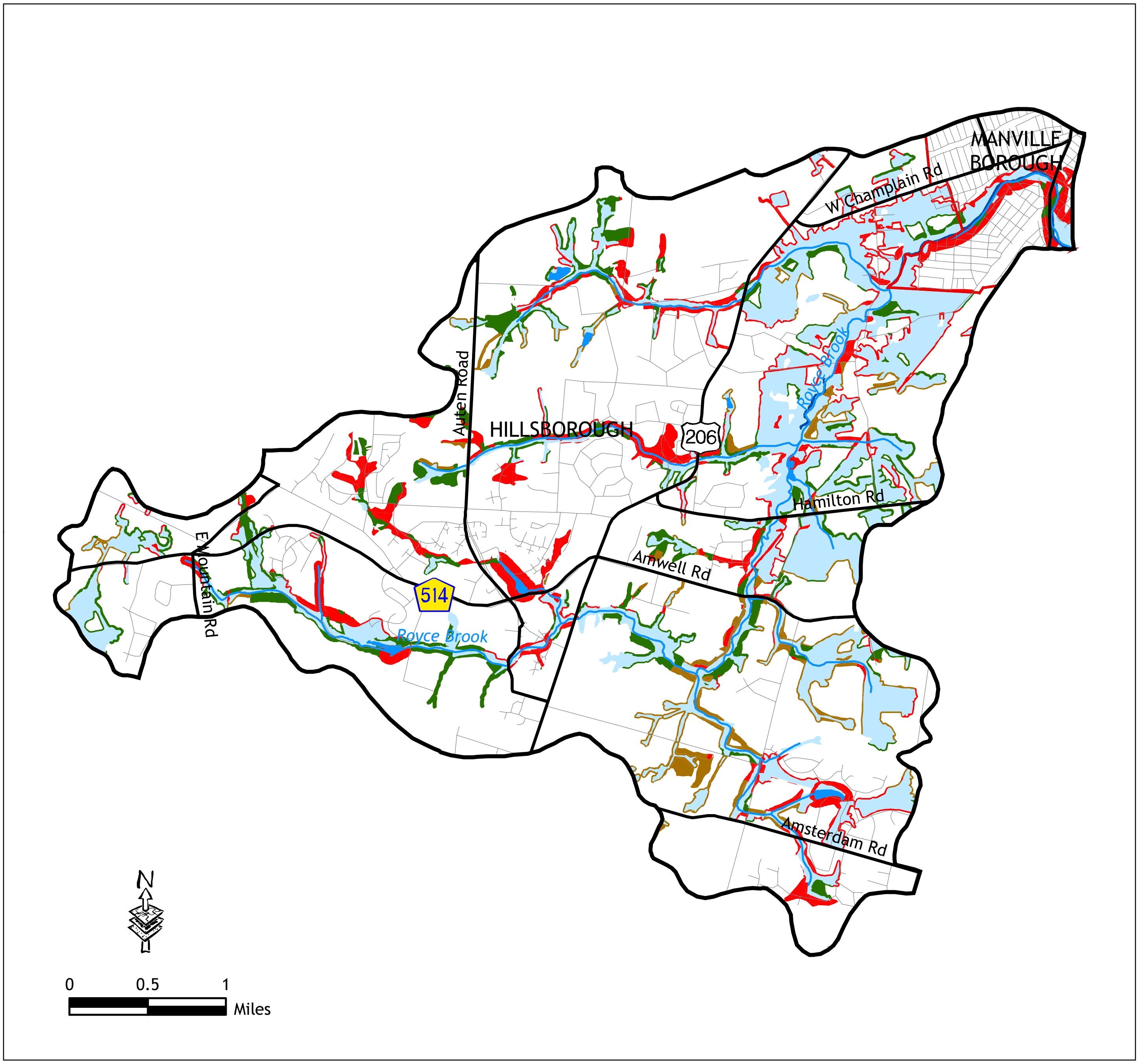
Urban Development before 1986

Urban Development 1986 to 1995

Remaining Riparian Area

P. Sankalia, A.Rowan 01/04 - Data Source: New Jersey Department of Environmental, Protection, Upper Raritan Watershed Association, US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 18: Riparian Land Cover in Royce Brook Watershed



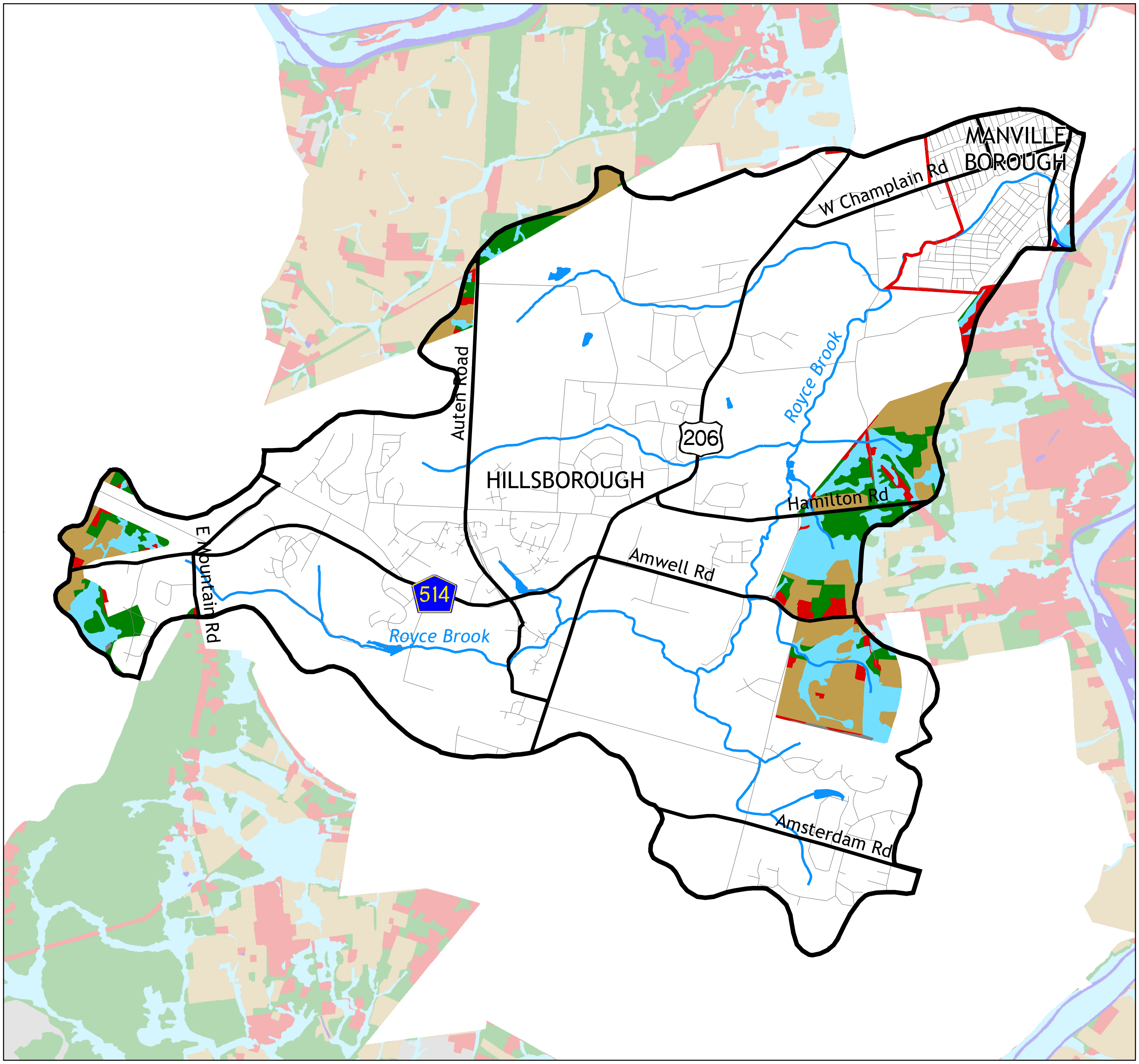
Major Roads
Roads
Municipal Boundaries
Lakes
Streams

Riparian Areas
Converted to Agriculture
Converted to Urban/Developed Land
Forest
Water
Wetlands

Stony Brook Millstone Watershed Association
the GIS CENTER at Stony Brook

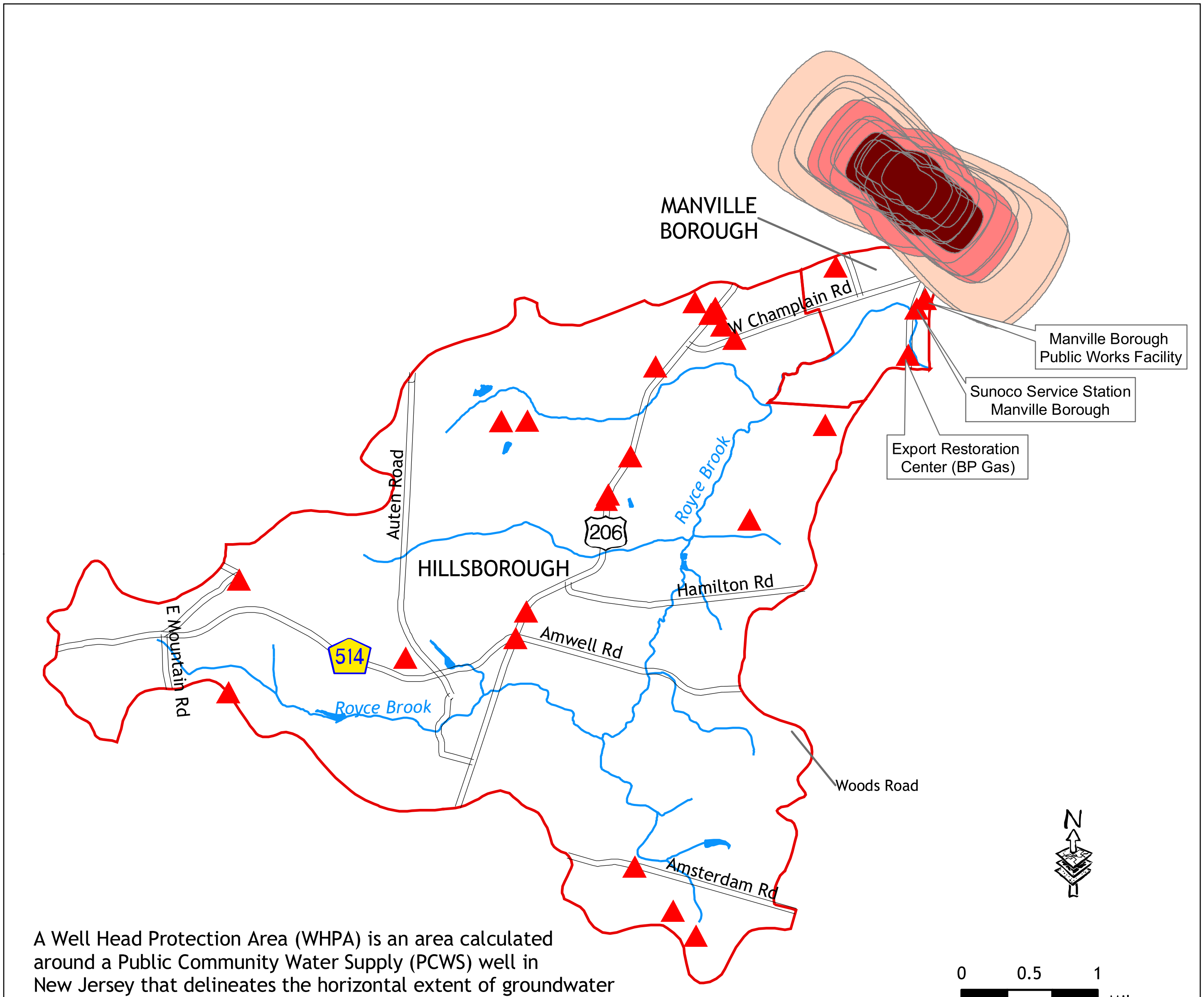
P. Sankalia, A.Rowan 01/04 - Data Source: New Jersey Department of Environmental, Protection, Upper Raritan Watershed Association, US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 19: 1995 Land Use in State Planning Areas PA 4, 4b, 5 & 8 in Royce Brook Watershed



P. Sankalia, A. Rowan 01/04 - Data Source: New Jersey Department of Environmental Protection, NJ Office of State Planning, US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 20: Known Contaminated Sites and Well Head Protection Areas in Royce Brook Watershed



A Well Head Protection Area (WHPA) is an area calculated around a Public Community Water Supply (PCWS) well in New Jersey that delineates the horizontal extent of groundwater captured by a well pumping at a specific rate over two- (tier one), five- (tier two), and twelve- (tier three) year periods of time for unconfined wells.

Known Contaminated Sites

Major Roads

Municipal Boundaries

Lakes

Streams

TIER

1 - Two Years

2 - Five Years

3 - Twelve Years

P. Sankalia, A.Rowan 01/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 21: Land Use in Areas of High Ground Water Recharge in Royce Brook Watershed

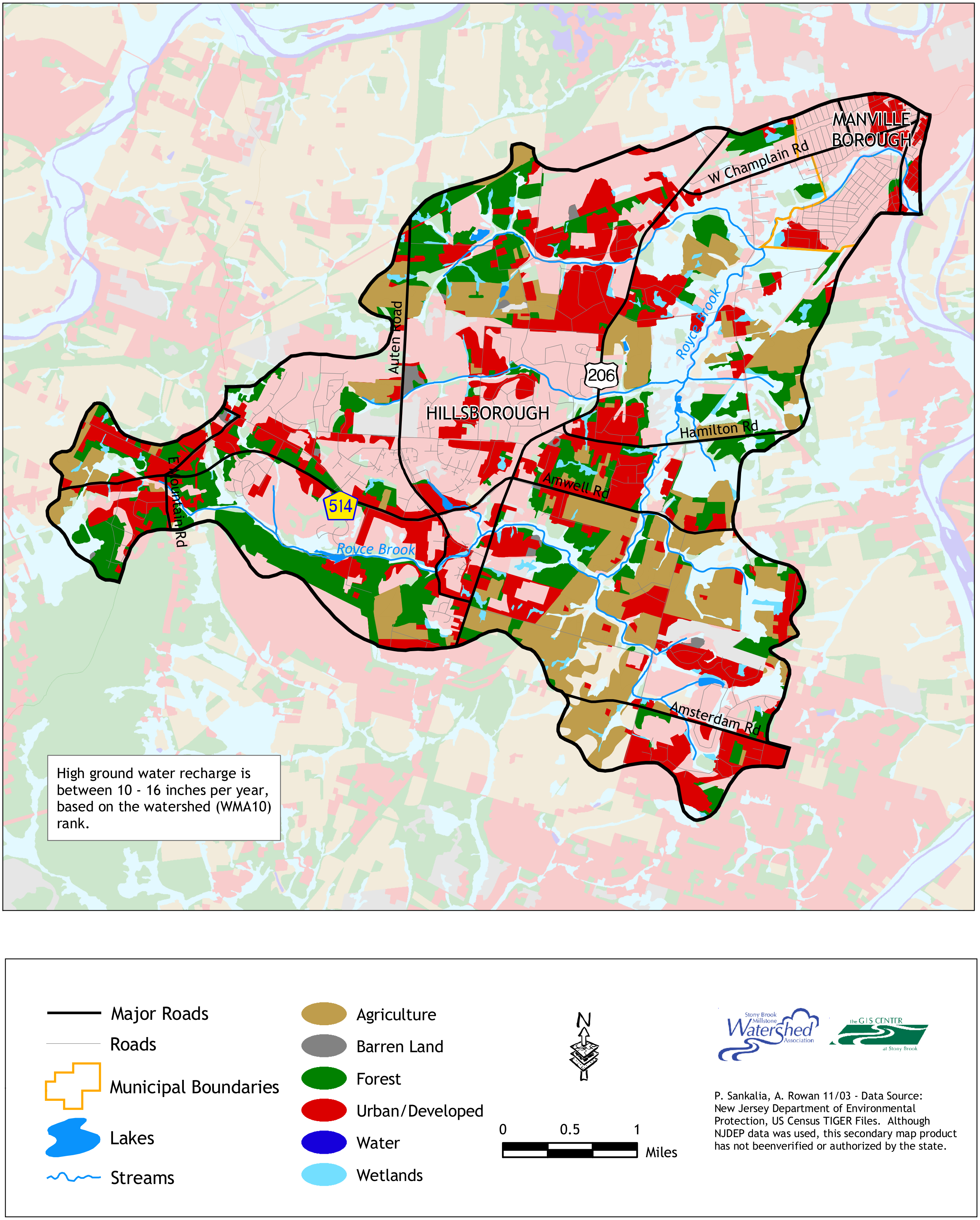
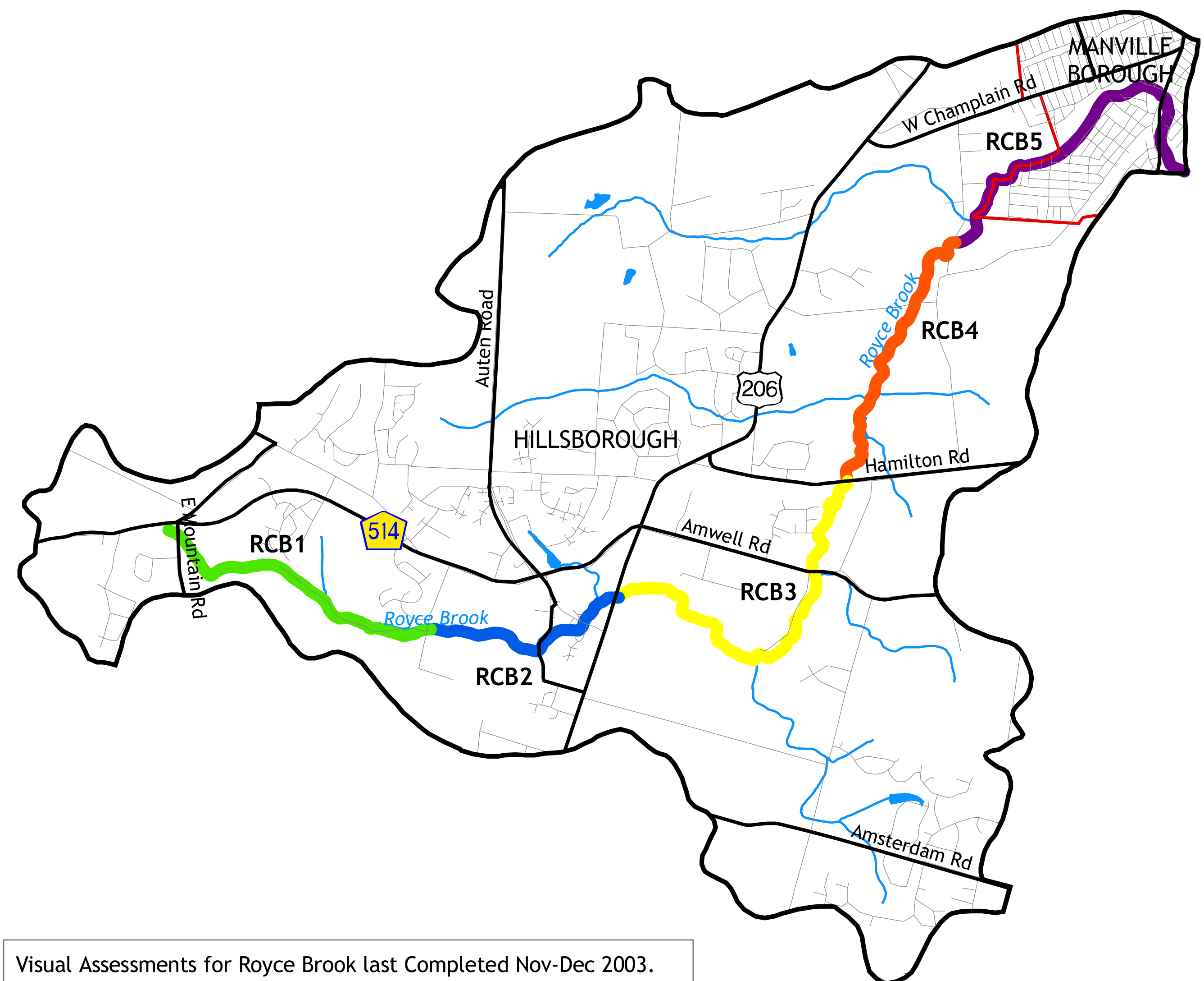
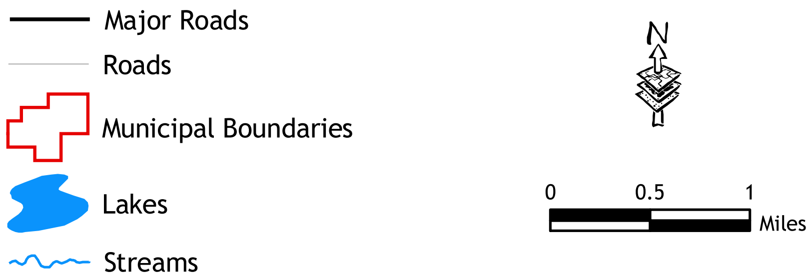


Figure 22: Visual Assessment Stream Segments in Royce Brook Watershed



Visual Assessments for Royce Brook last Completed Nov-Dec 2003.
All stream segments were rated Good and RCB2 was rated Excellent on a scale of Poor-Fair-Good-Excellent.



P. Sankalia, A. Rowan 01/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 23: AMNET Sites in Royce Brook Watershed

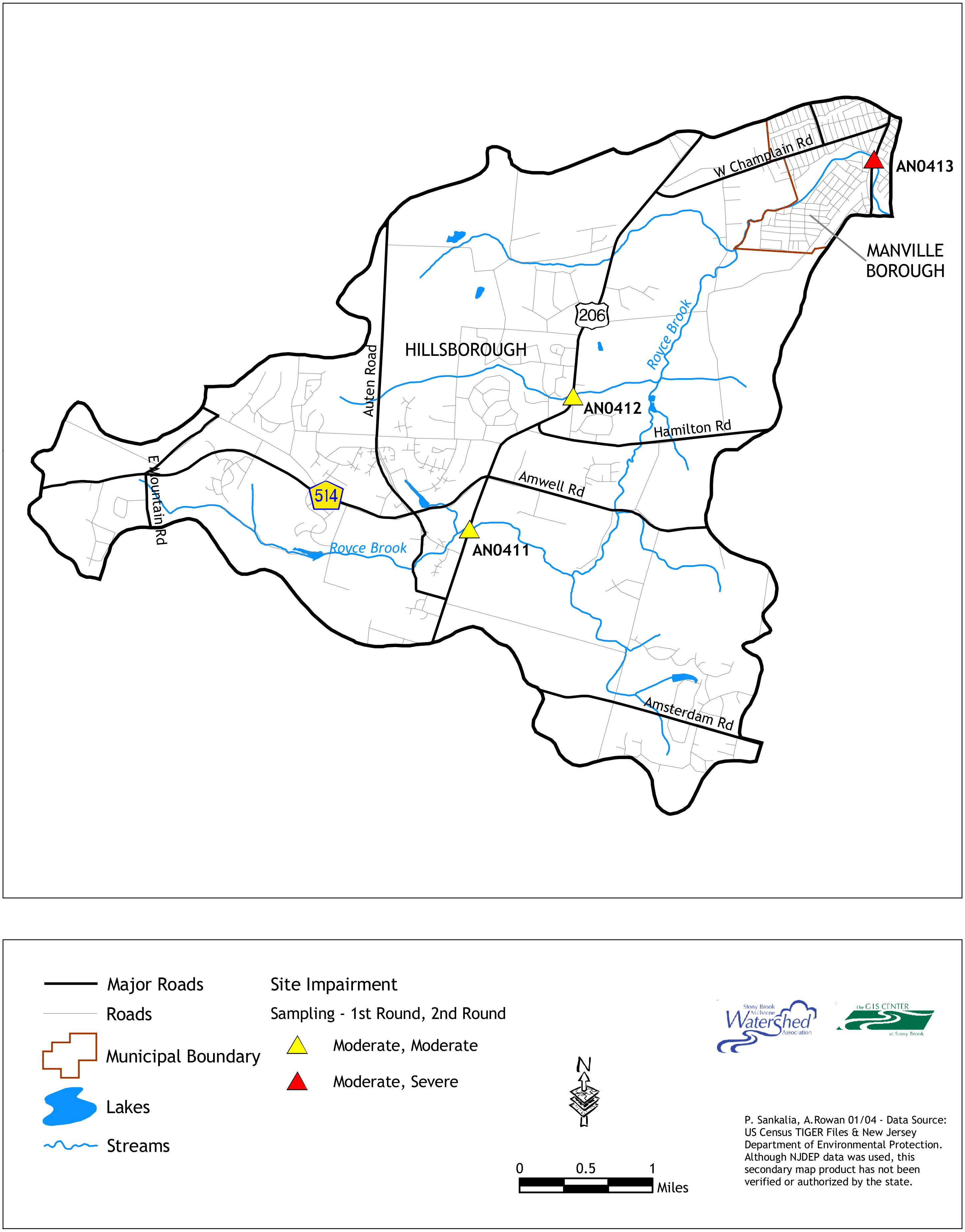
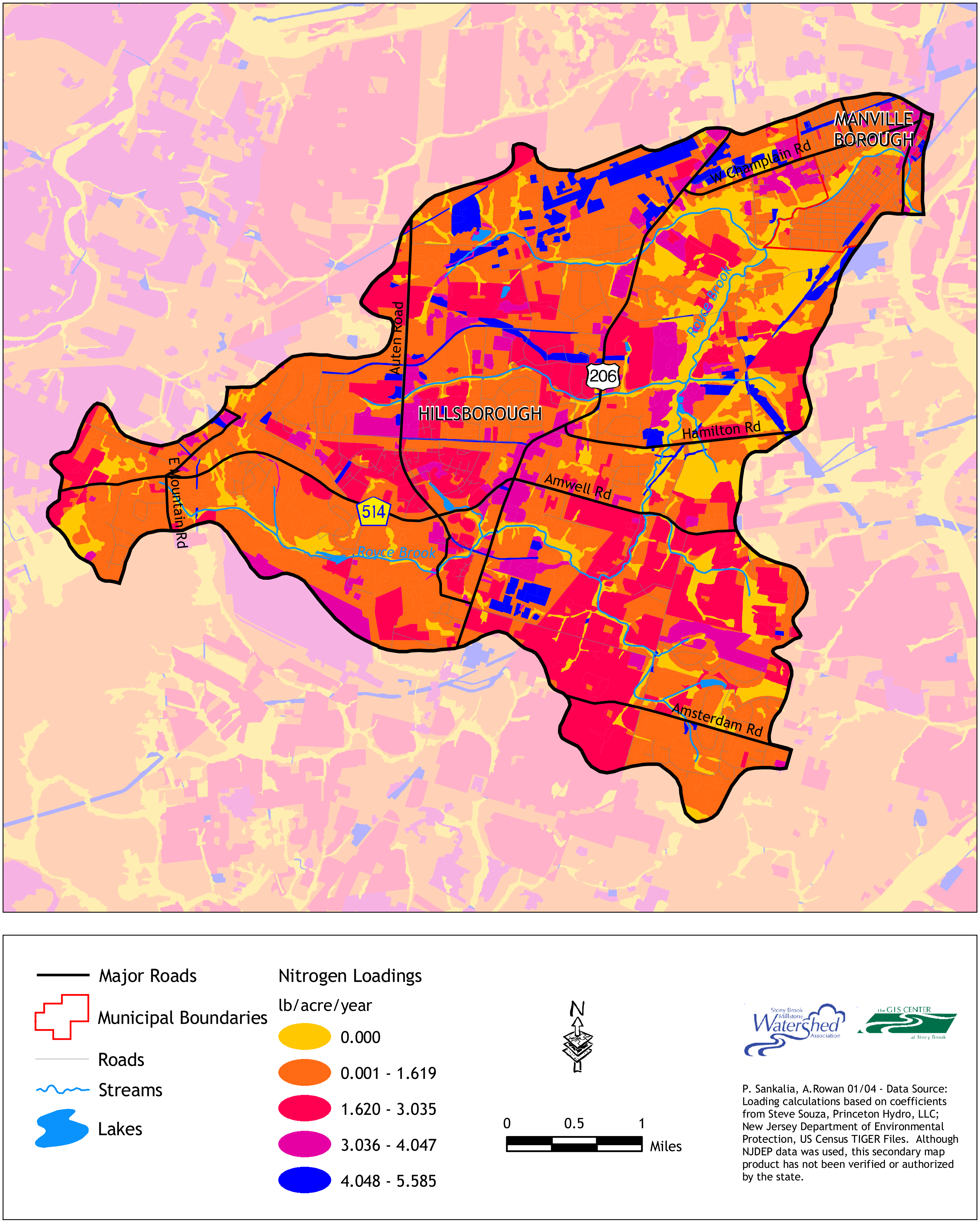
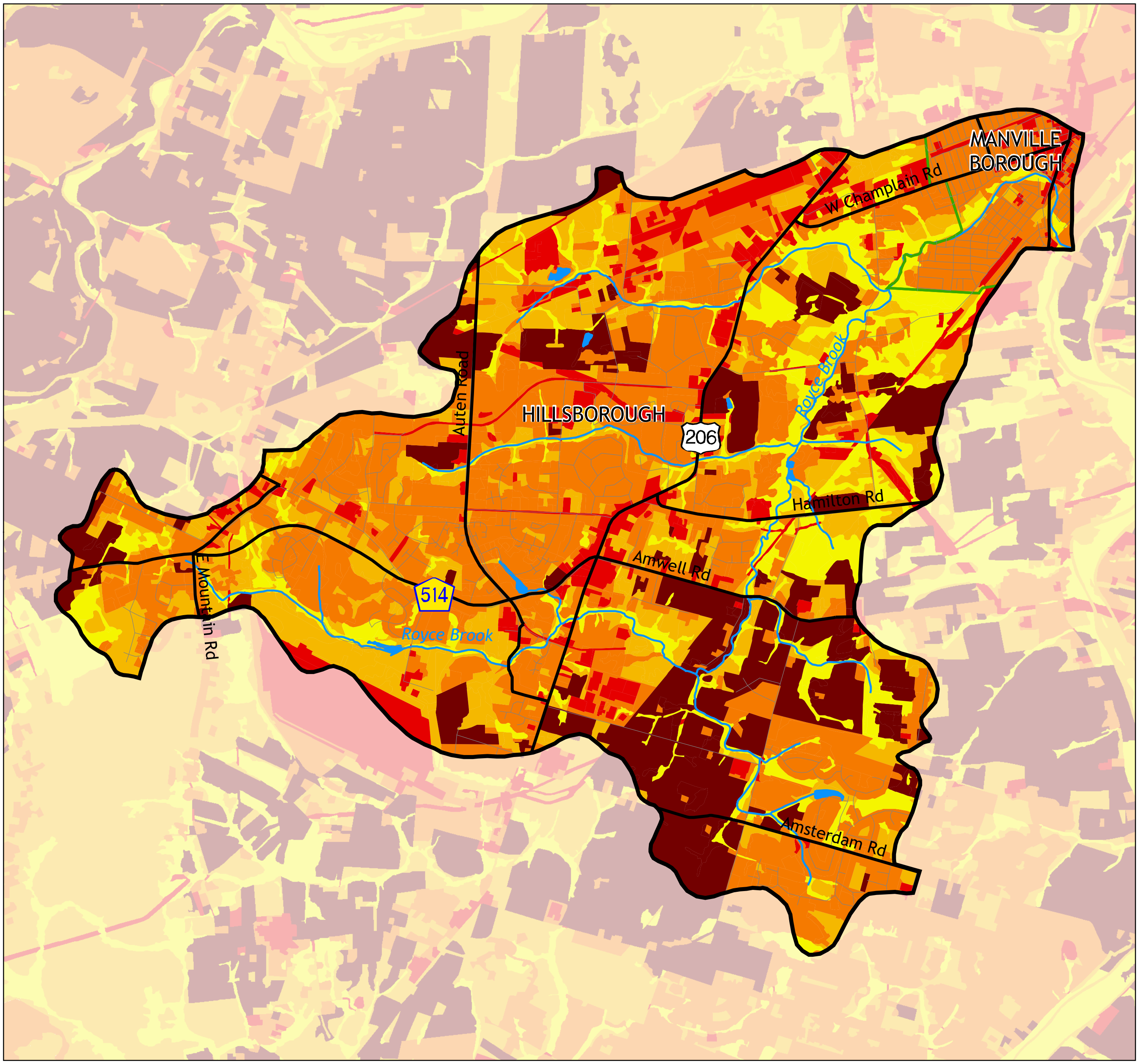


Figure 24: Nonpoint-Source Nitrogen Loadings in Royce Brook Watershed



P. Sankalia, A.Rowan 01/04 - Data Source: Loading calculations based on coefficients from Steve Souza, Princeton Hydro, LLC; New Jersey Department of Environmental Protection, US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 25: Nonpoint-Source Phosphorous Loadings in Royce Brook Watershed



Major Roads
Roads
Municipal Boundary
Lakes
Streams

Phosphorous Loadings
lb/acre/year
-0.101
-0.100 - 0.121
0.122 - 0.324
0.325 - 1.214
1.215 - 1.821

N

0 0.5 1 Miles

P. Sankalia, A.Rowan 01/04 - Data Source: Loading calculations based on coefficients from Steve Souza, Princeton Hydro, LLC; New Jersey Department of Environmental Protection, US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 26: Nonpoint-Source Total Suspended Sediment Loadings in Royce Brook Watershed

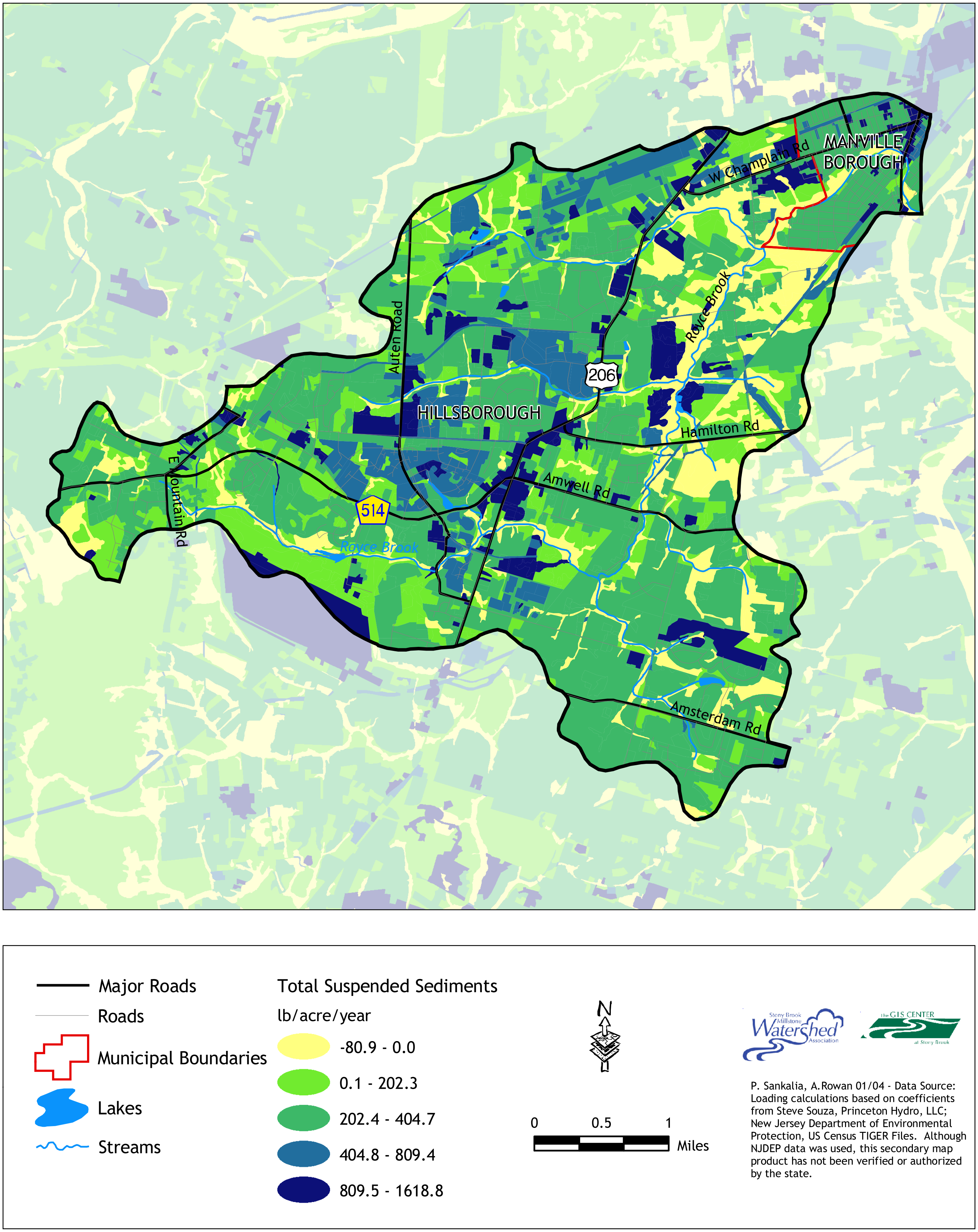
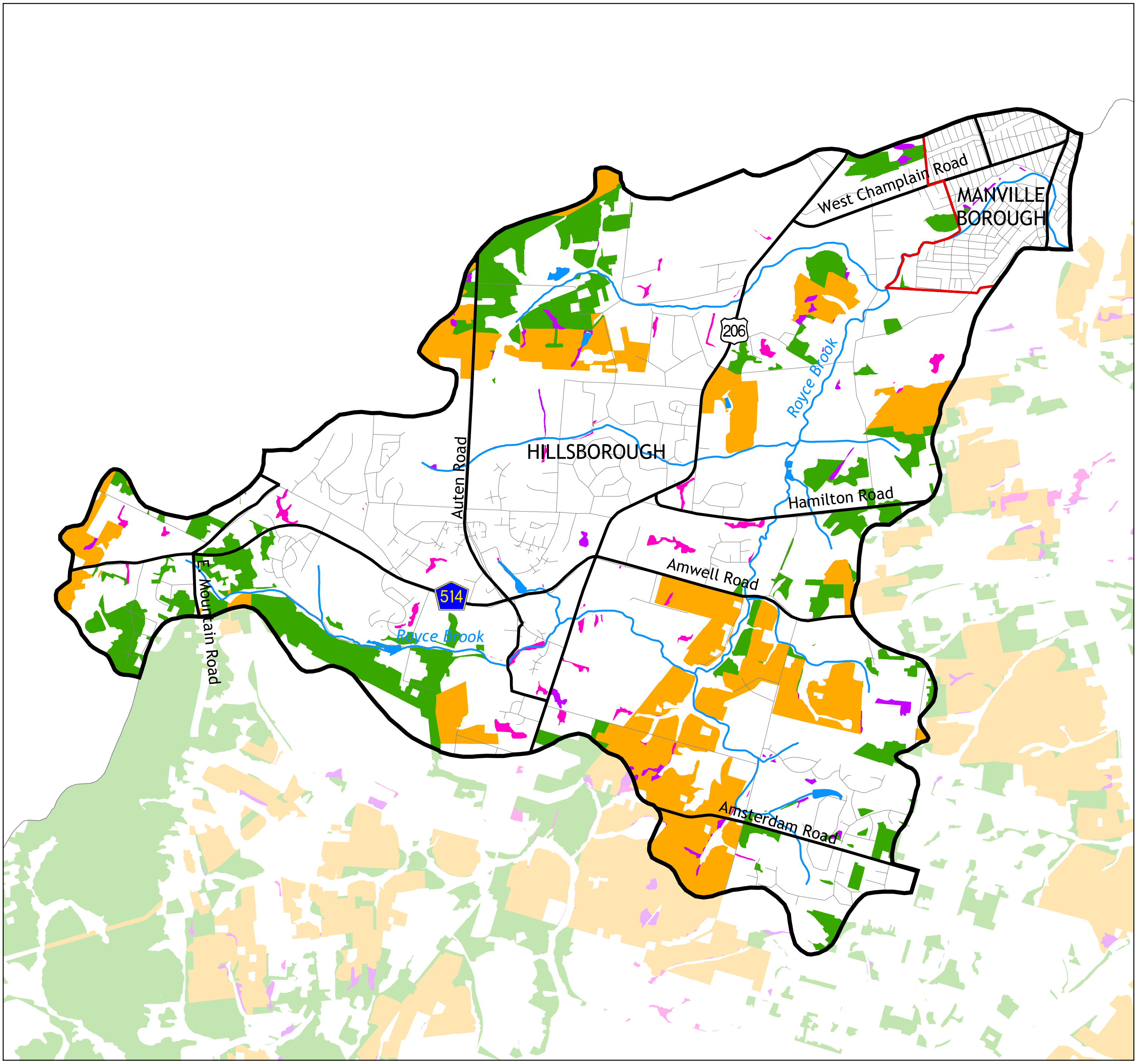


Figure 27: Areas with Critical Habitats and High Ground Water Recharge in Royce Brook Watershed



Major Roads
Roads
Streams
Municipal Boundaries
Lakes

Critical Habitats with High Ground Water Recharge

Grasslands
Forests
Wetland Forests
Emergent Wetlands

0 0.5 1 Miles

N

Stony Brook Millstone Watershed Association

The G.I.S. CENTER at Stony Brook

P. Sankalia, A.Rowan 5/04 - Data Source: New Jersey Department of Environmental Protection, US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Habitat data: Landscape Project version 2.
High recharge defined as 10 in/yr or greater.

Stony Brook Millstone Watershed Association
31 Titus Mill Road
Pennington, NJ 08534

PHONE: (609) 737-3735
FAX: (609) 737-3075
http://www.thewatershed.org