



CHARACTERIZATION AND ASSESSMENT OF THE CRANBURY BROOK WATERSHED

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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

INTRODUCTION

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 (characterization) and compares this to community goals and adopted standards in New Jersey (assessment). 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 Cranbury Brook Watershed was the third 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, and Rocky Brook Watershed was the second. The Cranbury Brook Watershed is located within the southeastern 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 Cranbury Brook area, it will be referred to as a watershed.

This report is intended to relay the past and present status of the Cranbury 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 Cranbury 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 Cranbury 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.

INTRODUCTION

LANDSCAPE

A foundation for the Cranbury 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.

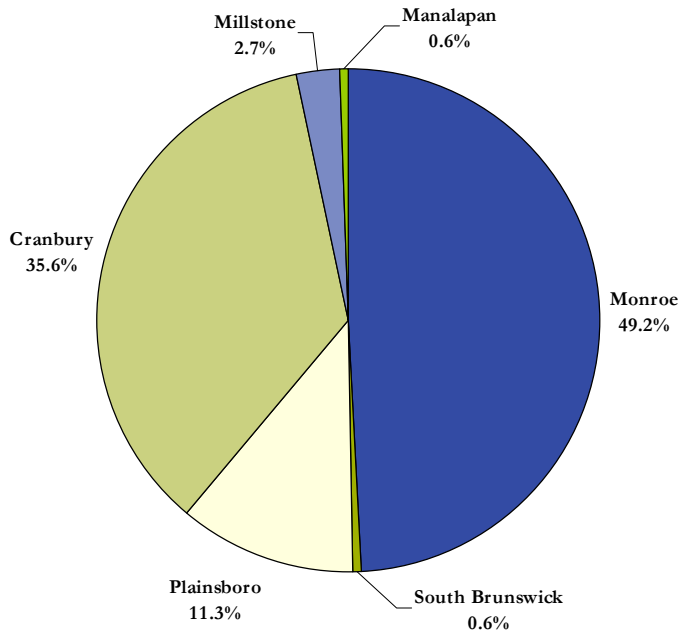
SETTING

The Cranbury Brook Watershed covers over 14,200 acres (approximately 22 square miles) that lie in parts of Cranbury, Monroe, Plainsboro and South Brunswick Townships (all in Middlesex County), and Manalapan and Millstone Townships (both in Monmouth County) (Table 1, Graph 1 and Figure 2). Within the watershed, the majority of the land is located in two municipalities. Almost half (49.2%) of the area lies within Monroe Township (Table 1 and Graph 1). Of the remaining watershed area, 35.6% lies within Cranbury Township, and the rest of the municipalities comprise the final 15.2% (Table 1 and Graph 1).

Table 1: Municipalities within the Cranbury Brook Watershed.

Municipality	County	Acres in the Cranbury Brook Watershed
Monroe Township	Middlesex	7,003
Cranbury Township	Middlesex	5,071
Plainsboro Township	Middlesex	1,608
Millstone Township	Monmouth	385
Manalapan Township	Middlesex	92
South Brunswick Township	Middlesex	81
TOTAL	---	14,240

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



Cranbury Brook has its headwaters in Millstone Township and flows approximately 13 miles through Monroe, Cranbury and Plainsboro Townships before meeting the Millstone River just north of the Plainsboro Pond (Figure 2). Cedar Brook is one of the major tributaries of Cranbury Brook, but there are also a few smaller tributaries draining into Cranbury Brook (Figure 2). Brainerd Lake and Plainsboro Pond are the two major lakes that Cranbury Brook flows through.

The Cranbury Brook Watershed is dotted with several golf courses, two in Monroe Township and one in Plainsboro. One of these, Concordia Golf Course in Monroe Township, is located on one of the tributaries to Cranbury Brook.

HISTORY

Applegarth, Dey Grove, Half Acre, Outcalt, Prospect Plains, and Union Valley are some of the hamlets located in Monroe Township. The earliest known inhabitants of the region were the Lenni Lenape. In 1746, Presbyterian missionary David Brainerd established a Native American mission called Bethel (translated as “House of God”) in Monroe. Under Brainerd’s direction, 160 Native Americans erected log houses, a church and a school and cultivated English wheat and Indian corn.

Initially, Monroe was part of the vast Piscataway region and later part of South Amboy Township. On February 23, 1838, Monroe Township (named after our fifth president) separated from South Amboy and was formed due

to increasing urbanization in the port area, with agriculture still dominating inland. Jamesburg, Helmetta and Spotswood, plus parts of Cranbury and East Brunswick Townships, lay within the original borders of Monroe.

Established in 1697, Cranbury is one of the oldest towns in New Jersey. The early history of the settlement indicates its location on a Native American trail, which later became an important stop on a main thoroughfare between the northern and southern colonies. The settlement probably grew around The Gristmill, built on Cranberry Brook in 1736, but the earliest written record of a land sale was in 1698. Maps from the 18th century refer to the town and stream as Cranberry, but the origin of this name is unclear. One theory is that cranberries might have grown in a marshy patch of land near the mill. In 1857 Reverend Joseph G. Symmes felt the name was incorrectly spelled and suggested it be changed to Cranbury. In Old English, the suffix “-bury” could be spelled either as “-bury”, “-bery”, or “-berry.” On March 7, 1872 Cranbury Township was officially created and organized as a separate political subdivision of Middlesex County consisting of the village of Cranbury and outlying areas, which were then parts of South Brunswick and Monroe Townships.

Historians differ as to how Plainsboro acquired its name. The oldest section of the community is the intersection of Plainsboro and Dey Roads. “Plane Tavern,” constructed in the early 1700’s, still stands today at this location. Some historians argue that the old bottles found by local residents give evidence that the Township was first called “Planesborough” after the tavern. Other researchers maintain that the area was first called the “Borough of the Plains” or simply “The Plains.” The first U.S. Post Office designated the area as “Plainsborough.” A subsequent Presidential decree in 1894 shortened the name to “Plainsboro.”

The Unami, a sub-tribe of the Lenni Lenape, were the first inhabitants of the Plainsboro area. The Dutch, migrating from the original settlement of Peter Minuet in New Amsterdam during the mid 1600’s, became the first European settlers. English settlers soon joined them. Given the region’s climate, good soils and available water, agriculture became the important economic focus. In 1897, the Walker-Gordon Laboratory Company selected Plainsboro as the site for its innovative certified dairy farm. Designed to produce clean, high quality milk and milk formulas for infant feeding at a time before pasteurization was a common practice, the farm grew to become the largest certified dairy farm in the world. The farm’s “Rotary Combine Milking System,” also known as the “Rotolactor,” a 50-stall merry-go-round milking facility, went into operation in 1930. The farm and its Rotolactor became a novel tourist attraction. The dairy operation ceased in 1971, about the same time that the community transformed from a small farm area into a more modern suburban area.

LANDSCAPE

POPULATION

People within a watershed have both direct and indirect impacts on water quality and therefore have opportunities to responsibly manage and improve water quality. Increasing populations within the Cranbury Brook Watershed are adding to the pressures of waste disposal and water treatment, an increased need for housing and increased water usage. Development pressure for growing populations increases, as the demand for additional infrastructure to support more residents rises.

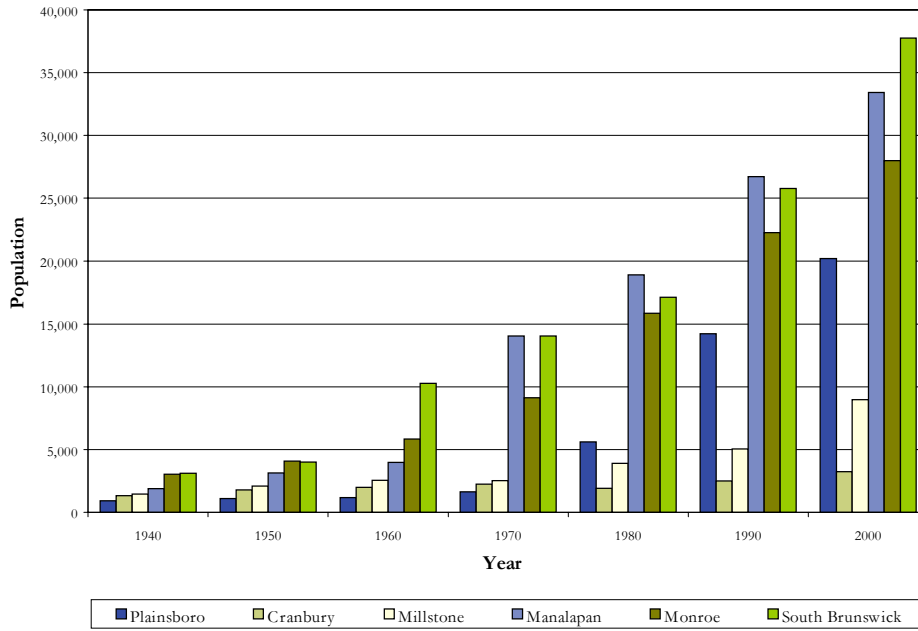
Population is increasing and development is progressing in the Cranbury Brook Watershed. The current trend is spreading large developed areas over the landscape, instead of clustering in hamlets, villages or town centers. People's dependence on the automobile and the lack of reliable public transportation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

The total population for the towns located within Cranbury Brook Watershed has increased more than ten-fold in 60 years, from 11,796 people in 1940 to 131,568 in 2000 (Graph 2 and Table 2). Total population increased at an average rate of 1,996 people per year. In comparison, the rate of increase between 1970 and 2000 was 2,930 people per year. Between 1940 and 2000, population changes for people living within the six municipalities found partially or fully within the Watershed show that growth occurred in each of the municipalities (Table 2 and Graph 2).

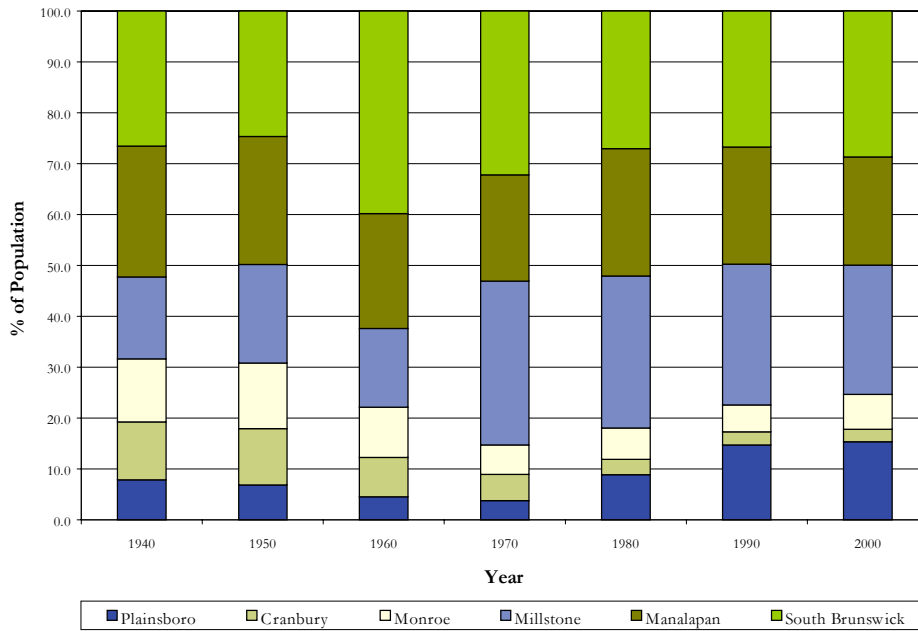
The largest population increase occurred in Plainsboro Township. Plainsboro experienced a 2,085% increase in residents between 1940 and 2000, as it went from 925 residents in 1940 to a population of 20,215 in 2000 (Table 2 and Graph 2). Plainsboro contributed a large percent of the 2000 population (15.4%) for the municipalities found all or part in the Cranbury Brook Watershed, while contributing to 11.3% of the entire watershed area (Graph 3 and Table 2). With such an increasing population in one municipality that constitutes a major portion of the Cranbury Brook Watershed, local governance needs to thoughtfully plan out the future direction of development within Plainsboro.

The smallest change in population was found in Cranbury Township with only a 140% increase in population over 60 years (Table 2 and Graph 2). In fact, over the last 30 years, Cranbury only gained 974 residents while the other municipalities gained between 6,435 and 23,676 residents in that same time period (Table 3). With the slow population growth rate and a small gain of residents over the past 30 years, Cranbury maintains the lowest density of residents in the Cranbury Brook Watershed with an average of 241 residents per square mile (New Jersey State Data Center 2001; Figure 3). Much of the density is distributed near major roadways like State Route 130 and the New Jersey Turnpike, where many businesses and direct connections to these roadways are located (Figure 3 and Figure 4).

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



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



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



The other municipalities within the Cranbury Brook Watershed have also increased their populations (Table 2). Monroe Township experienced the second highest population growth, with an increase of 823% of its residents over 60 years, as the residents increase from 3,034 in 1940 to 27,999 in 2000, and an increase of 206% over the last 30 years alone (Table 2 and Table 3).

Millstone Township contributes only 2.7% of the land in the Cranbury Brook Watershed. Millstone Township’s importance, however, lies in the fact that the headwaters for the Cranbury Brook are located there (Figure 2).

Manalapan Township (0.6% of the watershed area) and South Brunswick (0.6% of the watershed area) were excluded from analyses on population impacts to the region because of their small contribution to the Cranbury Brook Watershed. They are included for informational purposes only.

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

Municipality	1940 Population	2000 Population	% Population Change	% of Watershed Area
Plainsboro Township	925	20,215	+2,085%	11.3%
Cranbury Township	1,342	3,227	+140%	35.6%
Monroe Township	3,034	27,999	+823%	49.2%
Millstone Township	1,466	8,970	+512%	2.7%
Manalapan Township	1,900	33,423	+1,659%	0.6%
South Brunswick Township	3,129	37,734	+1,106%	0.6%
TOTAL	11,796	131,568	+1,015%	100%

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

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

Municipality	1970 Population	2000 Population	% Population Change	% of Watershed Area
Plainsboro Township	1,648	20,215	+1,127%	11.3%
Cranbury Township	2,253	3,227	+43%	35.6%
Monroe Township	9,138	27,999	+206%	49.2%
Millstone Township	2,535	8,970	+254%	2.7%
Manalapan Township	14,049	33,423	+138%	0.6%
South Brunswick Township	14,058	37,734	+168%	0.6%
TOTAL	43,681	131,568	+1,936%	100%

*The population figures listed are for the entire municipality and not just for the portion found in the Cranbury 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 materials they need to survive in our area (food, shelter and clean water.). Loss of animal species can be linked to loss in the 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 that may become endangered if conditions that harm them continue to accumulate.

Critical habitats cover 59% (8,401 acres) of the Cranbury Brook Watershed (Figure 5). The portion of Monroe Township that is in the Cranbury Brook Watershed has 58% of its area covered by critical habitats. Many of the critical habitats in Monroe Township are grassland 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 of Special Concern (a patch of habitat where State species of special concern have been documented) (Figure 5). The portion of Cranbury Township in the Cranbury Brook Watershed is 72% covered by critical habitats, also containing mostly grassland habitats suitable for State-listed species of concern (Figure 5). Much of the critical habitat is located along stream corridors (Figure 5).

In the Cranbury Brook Watershed, one record of a state threatened species was found: the wood turtle (*Clemmys insculpta*). In the surrounding area (1/4 mile outside the boundary of the Cranbury Brook Watershed), the state threatened long-eared owl (*Asio otus*) was identified. The counties that comprise the Cranbury Brook Watershed support a large diversity of endangered or threatened vertebrates, invertebrates and plants (Table 4).

Table 4: Number of endangered/threatened species in the counties that make up the Cranbury Brook Watershed. *

County	Vertebrates	Invertebrates	Plants **
Middlesex	14	5	28
Monmouth	20	4	36

* 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 Cranbury Brook Watershed are listed as Endangered in New Jersey.

Assessment –

The pattern of population growth in the Cranbury Brook Watershed 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 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 into the ground. This increase in impervious cover alters flooding patterns, heightens pollutant loads to streams, raises water temperatures and also 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 fragments forests and other habitats, thereby causing a decline in ecological health. Established centers that concentrate populations and impervious cover while maintaining surrounding open spaces allow for more effective and efficient stormwater practices and 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.

In addition to providing habitat for the conservation of rare species and protecting ground water supplies, preserving important wildlife habitats will result in more open space for outdoor recreation. Open spaces provide places where people can escape the confines of urban and suburban living.

By providing alternatives to traditional development, municipalities will protect the environment and especially the sensitive habitats and the wildlife that live in them. These critical habitats are being threatened by development and municipalities need to incorporate this information on critical habitats in order to effectively slow sprawl, improve the environment and protect wildlife.

The headwaters for Cranbury Brook are contained in Monroe and Millstone Townships. Because of this, the residents in these townships need to be especially aware of their roles in impacting and improving water quality in Cranbury Brook Watershed.

LANDSCAPE

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 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 the 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 process of cleanup 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.

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 18 known contaminated sites (KCSs) in Cranbury Brook Watershed (Figure 6 and Table 5). Eleven KCSs are located in Cranbury Township, four are in Monroe Township, two are in Plainsboro Township and one is in Manalapan Township (Figure 6 and Table 5). Most of the KCSs in the Cranbury Brook watershed are commercial facilities; there are no residential contaminated sites listed. Twelve sites are listed at remediation level C2, which describes 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 (Table 5). One site, the Cranbury Township Landfill on Dey Road, is listed as C3. These sites are usually highly complex and threaten ground water resources with multiple contaminants; some at high concentrations with unknown sources, impacting soils, ground water and possibly surface waters and potable water sources (Table 5). The NJDEP oversees the installation and monitoring of wells

for monitoring ground water and for regularly sampling the surrounding soils to determine the extent of soil contamination at these sites.

Assessment –

There are a large number of known contaminated sites in the Cranbury Brook 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, where the contaminants can possibly reach drinking water supplies. The Cranbury Brook Watershed has many areas with high recharge to ground water (see Water Supply section). These areas not only allow for quick movement of water to ground water supplies, but also any pollutants traveling with that water.

Ground water contamination is a concern at one KCS: Plainsboro Township Sanitary Landfill (see Water Supply section and Figure 18 for more detail). This site is located within a half-mile of a public well in Plainsboro Township. Ground water impacts to this site have been rated as moderate by the NJDEP (Table 5). Special attention needs to be given to the continued monitoring of this site by the NJDEP to ensure that public safety is maintained.

Table 5: Known Contaminated Sites in Cranbury Brook Watershed.

Site Identification Number	Site Name	Address	Municipality	Remedial Level *
NJD097400345	General Foods Corporation	Prospect Plains Road	Cranbury Township	C2
NJD045782067	Jilco Equipment Leasing Company	19 Half Acre Road	Cranbury Township	C1
NJD002175313	Carter Wallace Incorporated	Half Acre Road	Cranbury Township	C2
NJL900000282	Cranbury Township Landfill	Dey Road	Cranbury Township	C3
NJD986611036	Amoco Service Station Cranbury Township	Rte 130 & Half Acre Road	Cranbury Township	C2
NJL000072512	Amoco Service Station Cranbury Township	Rte 130 & South River Road	Cranbury Township	C2
NJL600196174	Shell Service Station Cranbury Township	NJ Turnpike Molly Pitcher Service Area 7S	Cranbury Township	C2
NJD986586774	NJ Turnpike Molly Pitcher Service Area	NJ Turnpike MM 71.1	Cranbury Township	C2
NJL500048848	Lebanon Agricorp	150 Plainsboro Road	Cranbury Township	C2
NJL800317760	Protinick Farm	Prospect Plains Half Acre Road	Cranbury Township	N/A
NJL500052014	Hydro Med Sciences	8 Cedar Brook Dr.	Cranbury Township	N/A
NJL600186498	Local 9 Training Center	450 Rte 33 & Iron Ore Road	Manalapan Township	C2
NJD070406020	Kaiser Agricultural Chemicals	Prospect Plains - Half Acre Road	Monroe Township	C2
NJL800047797	Anderson Corporation	Hoffman Station Road	Monroe Township	B
NJL800245045	Middlesex Road Department Garage	Hoffman Station & Prospect Plains Roads	Monroe Township	N/A
NJL600236061	Princeton Meadows Golf Course	70 Hunters Glen Dr.	Plainsboro Township	C2
NJD980753610	Plainsboro Township Sanitary Landfill	Cranbury Neck Road	Plainsboro Township	C2
NJL600206304	C&H Diesel Service Incorporated	Rte 130	South Brunswick Township	C2

* 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 four permitted point source dischargers to surface water in the Cranbury Brook Watershed (Figure 7). The point source dischargers to surface water in the Cranbury Brook Watershed consist of the Princeton Meadows sewage treatment plant (STP) (NJPDES #NJ0024104), and three industrial dischargers, the Linpro Company (NJPDES #NJ0059838), Carter-Wallace, Inc. (NJPDES #NJ0002666), and Silvi Concrete of Englishtown, Inc. (NJPDES #NJ0106224) (Figure 7).

Both the Carter-Wallace and the Silvi Concrete of Englishtown sites have multiple discharges under their permits (Figure 7). Carter-Wallace has four discharges and Silvi Concrete has two (Figure 7).

All the surface water dischargers are listed as minor dischargers (Figure 7). All but the Princeton Meadows STP are listed as minor industrial dischargers (based on the amount of pollutant(s) in the effluent). The Princeton Meadows STP is listed as a municipal minor, sanitary discharge, which is defined as a publicly owned sewage treatment plant that discharges less than 1 million gallons per day (MGD).

It is important not to understate the impact of the sanitary discharges to Cranbury 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.

In some streams, however, the only flow during the summer months may be attributed to treatment facilities. By adding treated water to a completely dry system, treatment plants may help to sustain stream life.

PERMITTED DISCHARGERS TO GROUND WATER

There is one active permitted discharger to ground water in the Cranbury Brook Watershed: United Water Princeton Meadows (NJPDES #NJ0089711) (Figure 7). The site contains an infiltration pond that allows recharge into ground water. Infiltration ponds are lined with permeable soils that allow water be treated via percolation through the surrounding soils (NJDEP 2004a).

Assessment –

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

Infiltration ponds, such as the one at United Water Princeton Meadows, are one way to combine stormwater control with ground water recharge (see Water Supply section for more information on ground water recharge). Returning storm water to our ground water is one way to ensure that there are adequate supplies of treated drinking water available to future populations.

GEOLOGY

The Cranbury Brook Watershed lies along the western edge of the Coastal Plain Physiographic Province (Figure 8). The Coastal Plain in New Jersey is characterized by extensive sedimentary deposits of Cretaceous (<135 million years ago) to Pliocene (>5 million years ago) age. The deposits are mostly unconsolidated; that is, they have not been cemented into rock but rather are relatively loose sediments. Because of this, the material is easily eroded, and the present landscape of the Coastal Plain is largely the result of this erosion (Owen et al. 1998).

In cross-section, the unconsolidated sediments of the Coastal Plain lie in a wedge shape, thickening to the southeast. The wedge thins to nothing along the northwestern boundary of the Coastal Plain, giving way to the older, consolidated rocks of the Piedmont Physiographic Province. At its southernmost extent in New Jersey, under Cape May, the wedge of sediment reaches a thickness of over 6,000 feet (Vowinkel and Foster 1981). The sedimentary units are essentially undeformed, except for a moderate dip to the southeast. Several of the coarser-grained units in the sequence serve as major aquifers for the region. Over 75% of the fresh water supplies for the Coastal Plain comes from ground water, with high-capacity public supply wells commonly yielding over 500 gallons per minute (USGS 2001).

Five discrete major aquifers exist in the New Jersey Coastal Plain: the Potomac-Raritan-Magothy aquifer system, Englishtown aquifer, Wenonah-Mount Laurel aquifer, lower "800 foot" sand aquifer of the Kirkwood Formation, and the Kirkwood-Cohansey aquifer. All but the Kirkwood-Cohansey are confined aquifers for most of their extent, being overlain by relatively impermeable layers of fine sediment that impede the vertical movement of water between the aquifers (USEPA 1988). Because of the southeast dip of the formations, layers that are below the surface in the southeastern portion of the Coastal Plain crop out at the surface to the northwest. Since the lower formations are confined aquifers throughout most of their extent, their only source of recharge is infiltration through the surface soil and sediment in these areas of outcrop; very little water passes through the confining layers from one aquifer to another below it. Despite the small size of the Cranbury Brook Watershed, three of the five aquifers reach the surface within its extent. Most of the western (downstream) part of the watershed is immediately underlain by the Magothy Formation. An outcrop band of the Englishtown, approximately two miles wide, passes through the eastern-central part of the watershed; and the headwaters area is underlain by Wenonah and Mount Laurel sediments. In total, outcrops of these three aquifers underlie nearly 70% of the land area of the watershed. The watershed is therefore a crucial area in terms of recharge for these regionally important aquifer systems. Over 40% of the watershed lies in the outcrop area of the Magothy Formation, and the Potomac-Raritan-Magothy system is one of the most important Coastal Plain aquifers in terms of water supply. Impervious surfaces in the recharge areas within the watershed have an incremental negative effect on the water supply for the whole region, and contaminants

entering the ground water here have the potential of traveling great distances and impacting drinking water quality for large areas.

Following are brief descriptions of the geologic units occurring in the Cranbury Brook Watershed, listed in stratigraphic order from highest to lowest (from Owen et al. 1998; Figure 9).

Navesink Formation (Upper Cretaceous): A very small area in the uppermost headwaters of the watershed is underlain by the Navesink Formation, a medium-grained, glauconite sand with some clay and silt. It can contain large calcareous shells, and mica sand is abundant in some areas. The Navesink is 10-25 feet thick and, with the overlying Red Bank, represents a transgressive-regressive (advance and retreat of the sea) cycle of sedimentation. The contact between Navesink and Red Bank sediments is gradational. The basal sediments of the Navesink are quartz sand deposits formed by reworking of the underlying Mount Laurel Formation.

Mount Laurel Formation (Upper Cretaceous): The Mount Laurel is typically quartz sand with minor amounts of glauconite and feldspar, finer at the base and coarsening upward. Mica (both biotite and muscovite) is abundant near the base. Deposits are massive to crudely bedded, with interbedded thin layers of clay. Granules and gravel are abundant in the upper beds. This formation ranges from 15 to 33 feet thick and is gradational with the underlying Wenonah sands. Together, the Wenonah and Mount Laurel form a major aquifer in the region. Mount Laurel sediments underlie an area of approximately 200 acres in the uppermost part of the watershed in Manalapan and Millstone Townships, where Route 33 passes through the watershed.

Wenonah Formation (Upper Cretaceous): The Wenonah occurs in a 1½-mile wide band through the upper portion of the watershed. This unit is fine-grained, silty and clayey sand. It is composed of quartz, mica, and minor amounts of feldspar. Thickness ranges from 25 to 66 feet. The base of the Wenonah is a gradual transition over several feet into the underlying Marshalltown Formation, with the transition marked by a decrease in mica and an increase in glauconite.

Marshalltown Formation (Upper Cretaceous): The Marshalltown occurs in a narrow belt (approximately 1,000 feet) in the upper watershed. Deposits are fine- to medium-grained, silty and clayey sand composed primarily of glauconite and quartz. Glauconite concentration is very high at the base and decreases to approximately half in the upper portion. Other components are feldspar, mica, pyrite and phosphatic fragments. The Marshalltown and overlying Wenonah and Mount Laurel Formations together represent a transgressive-regressive sedimentation cycle similar to that of the Navesink and Red Bank.

GEOLOGY

Englishtown Formation (Upper Cretaceous): The Englishtown, which serves as one of the five major aquifers of the Coastal Plain, is exposed in the upper watershed in a band approximately two miles wide. Englishtown sediments are predominantly quartz, ranging in size from fine to coarse, gravel-like sand locally interbedded with thin to thick layers of dark clay. In some places carbonaceous matter is abundant, including large, lignitized logs. Feldspar, glauconite and muscovite are minor constituents in the sand, and pyrite occurs as well, especially in the carbonaceous deposits. The Formation ranges in thickness from 50 feet in the south to 150 feet in the central Coastal Plain. The basal contact is transitional, grading into the Woodbury Formation (or the Merchantville in some locations outside the watershed).

Woodbury Formation (Upper Cretaceous): Downstream of the Englishtown at the surface, and below it in the stratigraphic sequence, Woodbury clays form a moderate band 1 to 1½ miles wide across the watershed. The unit is a dark gray clay-silt, weathering to brown and orange-pink. It contains mica throughout, and finely dispersed pyrite, carbonaceous matter and small pieces of carbonized wood. Thin layers of quartz sand occur near the base, and small amounts of glauconite are found locally near the top. Iron oxides are found in layers or filling fractures in the most weathered beds. The Woodbury Formation is generally about 50 feet thick over its entire extent. The Woodbury is notable for containing fossils of the dinosaur *Hadrosaurus foulkii* in an outcrop in Camden County.

Merchantville Formation (Upper Cretaceous): The Merchantville is a very clayey and silty, glauconite and glauconite-quartz sand. Deposits are massive to thickly bedded, grayish-green in color and weathering to brown or yellow-brown. Minor amounts of mica, feldspar and pyrite occur in the sand, except at the base, which is very micaceous. Iron incrustations can be extensive in weathered beds near the surface. The Formation ranges in thickness from 20 to 66 feet and occurs in the central portion of the watershed in a band approximately 1½ miles wide. The base of the Merchantville forms a sharp contact over an erosional surface at the top of the Magothy Formation, with a zone of reworked sediment 1-3 feet thick at the base of the Merchantville. The Merchantville and overlying Woodbury and Englishtown Formations together form a transgressive-regressive depositional cycle.

Magothy Formation (Upper Cretaceous): The Magothy Formation directly underlies the entire lower portion of the watershed except for a sliver at the western margin. The sands of the Magothy Formation, together with the contiguous Raritan and Potomac Formations, serve as an extensive and regionally very important aquifer system underlying nearly all of the New Jersey Coastal Plain and reaching 4,100 feet in thickness in southernmost New Jersey (USEPA 1988). The recharge area for the entire system occurs in a belt along the inner (western) edge of the Coastal Plain, where the formations reach the surface before thinning out and giving way to the Piedmont rocks to the northwest. The sediments of the Magothy are fine- to coarse-grained, locally gravelly, quartz sand, interbedded with thin layers of

clay or clay-silt, mostly at the top of the Formation. Minor amounts of muscovite and feldspar occur in the sand, and large wood fragments are found in the clay layers. The unit reaches a thickness of 260 feet near Raritan Bay, thinning to 80 feet or less to the south.

Stockton Formation (Upper Triassic): The Stockton Formation is a Piedmont Province formation that is unconformably overlain by Coastal Plain sediments at the margin between the Piedmont and Coastal Plain provinces. A narrow sliver of its outcrop area falls within the watershed at the farthest downstream (western) extent. Composition ranges from coarse-grained arkosic sandstone to mudstone, siltstone and shale. Maximum thickness of the formation is 4,000 feet.

Assessment –

The geology has a large influence on the water resources of the Cranbury Brook Watershed. The unconsolidated nature of the sediments has two major implications from the standpoint of water resources. First, streams and rivers of the Coastal Plain are typified by large amounts of alluvial sediment (considering their shallow gradients and relatively sluggish flows) because of the erodibility of the underlying deposits (see the Soils section for more information). This may result in water quality degradation through sedimentation of streams (see the Water Quality section for more information) and increased water treatment costs.

Second, the lack of cementation of the buried sediments means that the sandy units have a great deal of open pore space between the sand grains. Water moves more easily through these spaces, so the sediments serve as very productive aquifers. Increasing urbanization in the Cranbury Brook Watershed also increases the amount of impervious cover (see Land Use section for more details). This has the effect of decreasing the amount of water flowing into the aquifer by diverting precipitation over the landscape to streams and not downward into the soil. Placement of new development, and therefore impervious cover, out of areas that have high value for recharging the aquifers will help to maintain water levels for drinking, irrigation and industrial use (see Water Supply section for more details). Planning for and purchasing open spaces in areas of high ground water recharge will also ensure that these areas maintain their supplies of ground and drinking water.

With many formations containing deposits of glauconitic soils (Navesink, Mount Laurel, Marshalltown, Englishtown, Woodbury, and Merchantville Formations), use of septic systems in residential development is a concern in the Cranbury Brook Watershed. Glauconitic soils are easily compacted which makes them unsuitable for septic systems. The major limiting factor in determining the suitability of septic system placement is based on the fact that the underlying soils may percolate too slowly or not at all, which lowers the capacity of a residential septic system to perform properly. Easily compacted glauconitic soils may prevent proper percolation through the soil.

SOILS

The soils that underlie 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.

Soils are classified based upon their textures, composition and ability to drain water. Soil surveys have been performed and mapped by the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS). The Cranbury Brook Watershed falls in the Coastal Plain Physiographic Province where the soil is dominated by sands, silts, clays and gravel (New Jersey Water Supply Authority 2000a). The soil associations that underlie the Cranbury Brook Watershed are the Freehold-Connington-Adelphia series (in southeastern portion of the watershed), the Hammonton-Woodstown-Mullica series (in northeastern portion of the watershed), the Downer-Sassafras-Hammonton series (in southern part of the watershed), and the Atsion-Manahawkin-Berryland series (in western portion of the watershed) (New Jersey Water Supply Authority 2000a). All of these series consist of well-drained soils with a moderately coarse texture.

HYDROLOGIC SOIL GROUPS

Based upon their various compositions, soil series infiltrate water to varying degrees. Their ability to drain water, especially from precipitation, is evaluated and reported as the hydrologic soil group. Much of the Cranbury Brook is classified as hydrologic soil group B, covering 6,616.4 acres out of a total of 14,240.4 acres (46.5%) in the entire Watershed (Figure 10). Hydrologic soil group B represents soils with a moderate infiltration rate and is representative of the moderately coarse soils seen in the Coastal Plain Physiographic Province. Most of this hydrologic soil group underlies the agricultural areas in Monroe and Cranbury Townships and the developed areas in Plainsboro (Figure 10). The second most common hydrologic soil group in the Cranbury Brook Watershed is group C, representing slow infiltration rates and the fine to moderately fine soils in the area (Figure 10).

The hydrologic soils in group D are found primarily as streambeds in the Cranbury Brook Watershed (Figure 10). Category D soil groups have very slow infiltration rates since most of these soils are clayey or have an impervious layer near the surface (Figure 10).

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, reducing the detachability of soil particles and the susceptibility of soil crusting. Soil management is an important component in preventing soil erosion, encouraging plant growth and improving water quality on our farms and in our urban 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 (Renard, et al. no date). Almost all of the soils in the Cranbury Brook Watershed are classified as having medium to high erodibility (Figure 11). Very few areas have soils with low erodibility (Figure 11). Highly erodible soils are found in the western portion of the Watershed, in Monroe Township, along many of the headwater tributaries that feed Cranbury Brook (Figure 11).

Assessment –

The characteristics of the soils in the Cranbury Brook Watershed are aligned with those typical of the Coastal Plain (see Geology section for more detail). The geological character is mostly unconsolidated; that is, it is not cemented into rock, but rather is left relatively loose. These loosely aggregated soils allow for infiltration of varying rates, but are not a major impediment to subsurface water flow. 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.

Based on the relative unconsolidated nature of the soils, a large proportion of the Cranbury Brook Watershed is categorized as having medium or 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 Cranbury Brook Watershed. Smothering of aquatic macroinvertebrate habitat and subsequent loss of biological diversity, clogging of fish gills and reducing photosynthetic productivity by reducing sunlight penetration into water can impact waterways experiencing heavy sedimentation. Heightened sedimentation can increase water treatment costs as well. Maintenance of soil integrity in areas with medium to highly erodible soils can be accomplished by restricting earth moving activities, promoting and implementing soil and erosion control BMPs and encouraging forested areas.

Another aspect of soils is their septic suitability: their ability to host on-site septic systems with the capacity to drain wastes. Septic suitability needs to be considered when determining whether or not a septic system is a viable option for new residential areas in the Cranbury Brook Watershed. The major limiting factor of septic suitability is based on the fact that the underlying soils may percolate too slowly or not at all, which lowers the capacity of a residential septic system to perform properly. Soil data to determine septic suitability at the time of this report was reviewed and found to be limited in its ability to provide an accurate assessment. Future planning efforts should still consider septic systems as an option and review newer soils data for septic suitability as it becomes available.

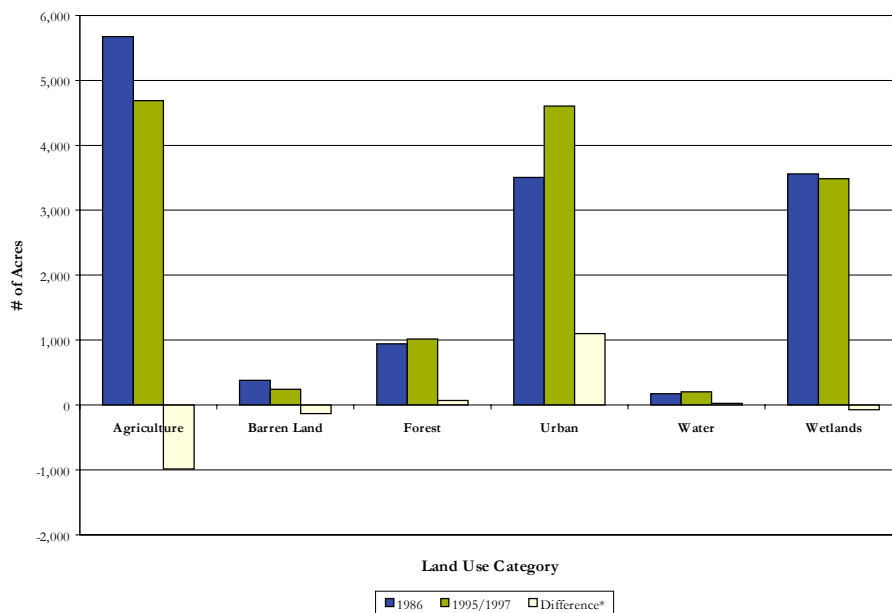
SOILS

LAND USE

The population of the Cranbury Brook Watershed is on the rise, and 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 1995/97 (Figure 12 and Figure 13). Land use was interpreted from photographs that were taken during flyovers of the state in 1986 and again in 1995/97.

The information for land use comes from the NJDEP land use/land use cover data from 1986 and 1995/97, but development has occurred over the last ten years. Forests, agriculture, urban/developed land and wetlands will be discussed in more detail, as they account for the majority (96.9%) of land usage in this watershed. The remainder of the land use in the watershed is made up of either water (200.9 acres, or 1.4% of the Cranbury Brook Watershed) in the form of streams, lakes, ponds, reservoirs and other waterbodies, or barren land (244.1 acres, or 1.7% of the Cranbury Brook Watershed) as developing land, quarries and mines (Graph 4 and Graph 5). Barren lands often represent a temporary condition, as many of these areas are in transition to developed lands.

Graph 4: Changes in acreage of land uses in the Cranbury Brook Watershed from 1986 to 1995/97.



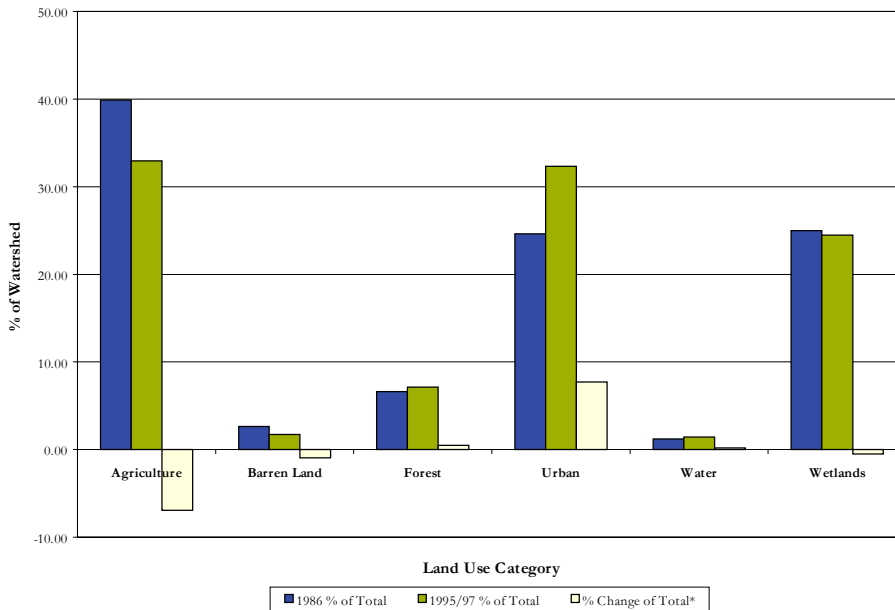
Source: NJDEP Land Use/Land Cover Data 1986 & 1995/97.

*Negative numbers represent a loss in acreage while positive numbers represent a gain in acreage.

In the Cranbury Brook Watershed, land use has changed dramatically in the years between 1986 and 1995/97, as there has been a gain in urban areas and a loss of primarily agricultural land. Between

1986 and 1995/97, the landscape draining to Cranbury Brook has 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, including commercial and industrial areas. The changes in land use were a loss of 986.0 acres, or 17.0%, of agricultural lands, and an increase of 1,098.0 acres, or 31.0%, in urban areas (Graph 4).

Graph 5: Changes in percent of total watershed area of land uses in the Cranbury Brook Watershed from 1986 to 1995/97.



Source: NJDEP Land Use/Land Cover Data 1986 & 1995/97.

*Negative percent changes represent a loss in acreage while positive numbers represent a gain in acreage.

FORESTS

Forests improve water quality by filtering pollutants, reducing floods by slowing stormwater and providing habitat to a variety of plant and animal species. It has been shown that the best predictor of the presence of an unimpaired aquatic insect community is the total area of forested land located upstream of a sampling site (USGS 1998). Unimpaired aquatic insect communities are indicators of clean waterways (see Water Quality section).

Since 1986, there has been a slight gain in forested lands in the Cranbury Brook Watershed (Graph 5). In 1986, 6.6% of the Watershed, or 944.7 acres, was forested (Graph 4 and Graph 5). In 1995/97, 7.1% of the Watershed, or 1,015.2 acres, was covered with forests (Graph 4 and Graph 5). The woodlands are found scattered in small patches throughout the Cranbury Brook Watershed (Figure 12).

AGRICULTURE

In both 1986 and 1995/97, the largest land use category within the Cranbury Brook Watershed was agriculture (Graph 4 and Graph 5). Up until the 1960s, there were many potato and dairy farms throughout Middlesex County. Today, Middlesex County has over 120 part and full time farmers, with most of the farmland concentrated in Cranbury, Monroe and Plainsboro Townships (Hlubik 2002; Figure 12). Farms currently specialize in intensive agriculture such as fruit and vegetable production. Almost all of the agriculture is located near the streams and wetlands found in the Watershed, especially surrounding the tributaries that lead to the Cranbury Brook (Figure 12). In the past, these streams were used to irrigate the crops or water the livestock on many of the region's farms.

In 1986, 39.9% of the Cranbury Brook Watershed, or 5,676.0 acres, was in agricultural use (Graph 4 and Graph 5). According to the 1995/97 data, there is approximately 32.9%, or 4,690.0 acres, of farmed lands in the Cranbury Brook Watershed. This represents a loss of 17% of the available agricultural lands to developed lands (Graph 5). This loss is particularly concentrated in Monroe and Plainsboro Townships (Figure 13).

URBAN/DEVELOPED

Approximately 32.3% of the Watershed, or 4,605.9 acres, was developed into urban areas, providing residential, recreational, commercial and industrial uses as of 1995/97 (Graph 4 and Graph 5). This is a gain of 31% from 1986, when there were 3,507.9 acres of urban land use in the Cranbury Brook Watershed (Graph 4 and Graph 5). The portion of Plainsboro Township in the watershed and the northwestern part of Monroe Township represent major areas of residential development, most of which was completed in the 1990s (Figure 12 and Figure 14).

In Plainsboro Township, the majority of the urban/developed lands are classified as residential, high density or multiple dwelling units (Figure 14). This classification contains either high-density single units or multiple dwelling units on $\frac{1}{8}$ or $\frac{1}{5}$ acre lots (USGS 1976). These areas are generally characterized by impervious cover of approximately 65% (USGS 1976; Figure 14).

The downtown area of Cranbury Township, just west of Route 130, is made up of mostly residential, low density, single unit developed areas (Figure 14). These areas are typified by residential neighborhoods with lots greater than $\frac{1}{2}$ acre and up to 1 acre in size (USGS 1976). Impervious cover at these urban areas is generally around 20%-25% (USGS 1976).

Monroe Township contains residential, high density or multiple dwelling units, mixed residential units and industrial development (Figure 14). All of this development is concentrated in the northern portion of the Cranbury

Brook Watershed in this municipality (Figure 14). Industrial developments are areas where the manufacturing, assembly and processing of materials takes place (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 14,240.4 acres in the Cranbury Brook Watershed, there are 3,484.3 acres of wetlands, representing 24.5% of the entire Watershed area in 1995/97 (Graph 4 and Graph 5). In 1986, there were 3,559.6 acres of wetlands. This represents a slight loss of 75.3 acres, or 2.0% of the wetland area, between those two years. Most of the wetlands surrounding Cranbury Brook and its tributaries today are deciduous wooded wetlands and modified agricultural wetlands. Deciduous wooded wetlands are found mostly in the upper reaches of the Cranbury Brook Watershed (Figure 12). Deciduous wooded wetlands are common in the northeastern United States and provide habitat for many critically important species of wildlife. Deciduous wooded wetlands are dominated by species of trees such as red maple (*Acer rubrum*), black willow (*Salix nigra*), swamp oak (*Quercus bicolor*) and sweetgum (*Liquidambar styraciflua*).

Modified agricultural wetlands are wetlands that have been modified to allow for cultivation of crops. In the Cranbury Brook Watershed, these wetlands are located adjacent to the agricultural areas in Cranbury Township surrounding Cedar Brook and Cranbury Brook (Figure 12).

The majority of the wooded wetlands found in the Cranbury Brook Watershed are found in the upper reaches of Cranbury Brook in Monroe Township, with a few located along Cedar Brook and Cranbury Brook in Cranbury Township (Figure 12). 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. The best predictor of the presence of a severely impaired aquatic insect community is the total area of urban land in close proximity to sampling sites (USGS 1998). Severely impaired aquatic insect communities are indicators of polluted waterways (see Water Quality section).

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 cover 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).

Cranbury Brook Watershed has an average impervious cover of 11.9% with some areas much higher, suggesting a likelihood of some water quality degradation (Figure 15). The highest percentages of impervious cover are found in Monroe and Plainsboro Townships. Much of that impervious cover in the Cranbury Brook Watershed is calculated at 26% or higher for these municipalities (Figure 15). This shows that these areas are becoming

heavily developed and could be contributing to water quality problems in the downstream portions of Cranbury Brook as it flows to the Millstone River.

Small patches of impervious cover above the 25% limit are located in Cranbury Township as well. These areas are adjacent to Route 130 and Brainerd Lake in the downtown section of this municipality (Figure 15). The majority of the lands with higher impervious cover are congregated close to streams (Figure 12; Figure 15). This may be due to the conversion of agricultural lands, which are traditionally located near streams for irrigation, into urban lands.

It should be noted that NJDEP has identified several unnamed tributaries to Cranbury 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 those vegetated areas that lie along the side of 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. These areas are the first and last lines of defense for the streams they surround in terms of nonpoint source pollution control. 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.

As defined by the Raritan Basin Watershed Management Project, 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 been converted from one land use category to another between 1986 and 1995/97 (Figure 16). Of the 14,240.4 acres in the Cranbury Brook Watershed, there are a total of 5,650.3 acres (39.7% of the Watershed) in the riparian corridor in 1995/97. Of that, 771.8 acres (or 13.7%) were converted to agricultural areas and 827.1 (or 14.6%) were changed to urban areas between 1986 and 1995/97 (Figure 16). There were only 28.2 acres (0.5%) of barren land within the riparian corridor. The remaining 4,023.2 acres of riparian corridor are made up of forested areas, water and wetlands (Figure 16). The majority (3,364.7 acres or 59.5% of the riparian corridor) consists exclusively of wetlands (Figure 16).

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 Cranbury Brook Watershed, PA4 (Rural), PA4b (Rural-Environmentally Sensitive), PA5 (Environmentally Sensitive) and PA8 (State Park) lands are found in two major areas: southeastern Monroe Township and western Cranbury Township (Figure 17).

In the southeastern portion of Monroe Township, the majority of the lands in these PAs are wetlands (Figure 17). Federal and State regulations currently restrict the development of wetlands. In western Cranbury Township, the majority of lands within the PAs with limited growth are in agriculture (Figure 17). Agricultural lands have been more prone to development than other land uses within the Cranbury Brook Watershed (Graph 4 and Graph 5).

Also, many agricultural areas in the Cranbury Brook Watershed are located within high ground water recharge areas (see Water Supply section) and contain critical habitats (Figure 5). 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 these residents. This is reflected in both the increasing population within the Cranbury Brook Watershed (see Landscape section for more detail) and the increase in developed areas (Figure 13). Many of the newly developed areas are being placed on former agricultural lands. Water quality becomes a concern for the urbanizing regions in the Cranbury Brook Watershed because of the proximity to streams and brooks of the agricultural lands being converted and the increase in impervious surfaces. Decreasing

the rate of conversion of farmlands in the Cranbury 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 would help to protect water quality. Farms in both Cranbury and Plainsboro Townships are already in preservation and many other lands are protected as open space. Of concern is Monroe Township, as the increasing urban areas in town between 1986 and 1995/97 are surrounding many of the tributaries that make up the headwaters of the Cranbury Brook Watershed.

Increasing urbanization in the Cranbury Brook Watershed also increases the amount of impervious cover. 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, out of areas that have high value for recharging ground water 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.

It has been shown that limiting the amount of impervious cover alone will not benefit water quality. Maintenance of an adequate forest and reduced impervious cover will 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 Cranbury Brook Watershed at 7.1% in 1995/97, efforts to reforest portions of the region should be considered.

Riparian corridors are being slightly encroached upon for developed areas in the Cranbury Brook Watershed (Figure 16). These areas are 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 Cranbury 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 (59.5%) is made up of wetlands. These areas are already under protection from future development, but municipalities should enact stream corridor protection ordinances to help control the influx of development into these areas. Acceptance of the nomination of Cranbury Brook's tributaries as C1 waterways will aid in protecting these corridors.

Many areas within the Cranbury Brook Watershed have been planned for limited growth (Figure 17). The areas within Cranbury Township are mostly in agriculture. 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).

LAND USE

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 alone only 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 that it takes for water at a given point to reach the well when pumped. Times of travel are helpful in determining the risk of contamination to a well from ground water. A Tier 1 WHPA has a time of travel of two years, Tier 2 has a time of travel of five years, and Tier 3 has a time of travel of 12 years (New Jersey Geological Survey 2003).

Within the Cranbury Brook Watershed, there are several WHPAs surrounding ten PCWs (Figure 18). (Note that water traveling below the ground's surface can travel outside the surface-delineated watershed.) Most of these PCWs and WHPAs are concentrated in the central part of the Cranbury Brook Watershed, at the border of Monroe and Cranbury Townships (Figure 18).

One well, located within Plainsboro Township, has one known contaminated site located within differing Tiers (Figure 18). The site is the Plainsboro Township Sanitary Landfill (Figure 18). The Landfill is categorized at 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). This site is detailed in the Known Contaminated Sites section of this report.

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 Cranbury Brook Watershed, with 11.9% impervious cover, is estimated to 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 shown 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 area like the Cranbury 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 Cranbury Brook Watershed, there are 4,568.2 acres (or 32.1% of the entire watershed area) found within areas of high ground water recharge (Figure 19). (High ground water recharge is defined as a rate of greater than 10 inches per year.)

Of the 4,568.2 acres of high ground water recharge areas, 2,966.2 acres (or 64.9%) are in agricultural lands, 904.7 acres (19.8%) are in urban/developed areas, 541.5 acres (11.9%) are forested, and the remaining acreage is water, wetlands, and barren land (Figure 19).

According to the New Jersey Water Supply Authority's report, *Ground Water in the Raritan Basin*, between 1986 and 1995/97, the Raritan Basin (of which both the Millstone Watershed and the Cranbury Brook Watershed are part)

WATER SUPPLY

lost 5% of its recharge capability (New Jersey Water Supply Authority 2002). The Cranbury Brook Watershed was above this overall average, losing an average of 7.9% of its ground water recharge capability between 1986 and 1995/97 (New Jersey Water Supply Authority 2002).

The most likely reason for the loss of ground water recharge is the increase in developed/urban areas in high ground water recharge zones between 1986 and 1995/97 (see Land Use section for more information). Urban areas increased by 124.1 acres in areas of high ground water recharge. This increases impervious areas that prevent water from percolating back into the soil.

AQUIFERS

Three distinct major aquifers have recharge areas (outcrops) in the Cranbury Brook Watershed: the Potomac-Raritan-Magothy, Englishtown and Mount Laurel -Wenonah systems (Figure 20).

The Potomac-Raritan-Magothy (PRM) aquifer system comes to the surface in the western part of the watershed in Cranbury and Plainsboro Townships (Figure 20). The PRM is an extensive aquifer that underlies a northeastern-southwestern band through central New Jersey along the Delaware River. This aquifer system extends from Perth Amboy and Woodbridge Townships in Middlesex County to Pennsville Township in Salem County. All aquifers in the state have been ranked according to their ability to yield ground water to high-capacity wells. The PRM has a ranking of A, meaning that the yield from high-capacity wells is in excess of 500 gallons per minute (Mulhall 2004). Some wells in the PRM in the northern Coastal Plain (of which Cranbury Brook Watershed is a part) have been shown to have yields ranging from 140 to 1,500 gallons per minute (Pucci 1989).

The Englishtown aquifer is found in the southeastern part of the Cranbury Brook Watershed, in Monroe Township (Figure 20). The Englishtown aquifer is the second most productive system in the Cranbury Brook Watershed, with a State ranking of B and yields of 251-500 gallons per minute (Mulhall 2004). The Mount Laurel-Wenonah (MLW) aquifer underlies the surficial soils in the southeastern portion of the watershed in Millstone and Manalapan Townships (Figure 20). The MLW is given a State ranking of C, with wells capable of yielding 100-250 gallons per minute (Mulhall 2004).

Two other aquifer systems are found in the Cranbury Brook Watershed: the Merchantville-Woodbury and Marshalltown-Wenonah aquifers (Figure 20). Both of these systems have been given a State ranking of E, meaning that wells are only capable of yielding less than 25 gallons per minute (Mulhall 2004).

WATER SUPPLY

Assessment –

The WHPA in Plainsboro Township is important to note, as there is the potential for ground water contamination due to its proximity to a known contaminated site (KCS) at the Plainsboro Township Sanitary Landfill. The landfill wells need consistent monitoring by the NJDEP to ensure that any contamination is noted quickly and clean-up efforts can be implemented immediately. This KCS also needs to be the top priority for remediation by NJDEP because of its proximity to the WHPA. In addition, all the towns in the Cranbury Brook Watershed should move forward with creating and implementing a wellhead protection ordinance in order to protect ground water resources from possible future contamination.

The Cranbury Brook Watershed contains many areas with high ground water recharge. These areas need to be protected by their respective municipalities (Cranbury and Monroe Townships, in particular) to prevent their development. Close attention needs to be paid to any increases in impervious surfaces in the Watershed, as possible mitigation efforts may need to be performed in order to prevent further decline of recharge areas. Both municipalities 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 19). 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 major aquifers in the Cranbury Brook Watershed (the PRM and Englishtown systems) represent potential drinking water supplies for not only residents in the towns located in this watershed, but also for many other municipalities throughout the State. It is critical that future plans for growth consider the high ground water recharge areas and underlying sources of drinking water during planning efforts.

WATER SUPPLY

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 of 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 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). 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-source pollution.

Water quality data was gathered from a variety of sources (Figure 21, Figure 22, and Figure 23). The USEPA and NJDEP have compiled assessments, and Cranbury Township and SBMWA have conducted chemical monitoring at various sites within the Cranbury Brook Watershed. The biological assessment data was gathered from the NJDEP's Ambient Biomonitoring Network (AMNET) 1994 and 1999 data 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. Note that the results should 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. Six navigable stream segments, called “beats,” are located in the Cranbury Brook Watershed along the main stem of the Cranbury Brook (Figure 21). All assessments were completed in November and December 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 six “beats” within the Cranbury Brook Watershed were designated “UMR,” which stands for Upper Millstone River, and numbered sequentially starting with the most upstream “beat.”

The average score for all stream segments in the Cranbury Brook Watershed is 3.2 (Table 6). Through these assessments, the Cranbury Brook is rated as having overall good riparian corridor quality (Figure 21). The final visual assessment scores ranged from 3.0 along the segment of Cranbury Brook (UMR14) that flows from Main Road to George Davison Road to a score of 3.6 on the Cranbury Brook “beat” (UMR13) that stretches from Applegarth Road to Main Road downstream of the Plainsboro Pond (Table 6).

The highest-rated parameters dealt with assessment of 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 Cranbury Brook (either rated 3 or 4), showing that much of the area along the streams is buffered from surrounding land uses and impacts.

The most common problems seen on the visual surveys were the result of sedimentation. The lowest-rated parameter was for the stream bottom. Two out of the six stream segments surveyed rated stream bottom as 1, indicating that gravel, cobble and boulders present in the stream were at least 40% covered by sediment (SBMWA 2003). At the same time, erosion scores on the visual assessments were rated 2 at these same “beats” (UMR10 and UMR11), indicating that the streambanks are moderately unstable and have between 30%-60% of their lengths showing signs of erosion (Table 6; SBMWA 2003). Most of the sedimentation may be due to the nature of the Coastal Plain geology and associated soil types (see Soils section and Geology section for more information). The physical characteristics of the Coastal

WATER QUALITY

Plain formations lead to higher soil erodibility than in other parts of the Millstone Watershed. 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 22). 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 two NJDEP sampling sites in the Cranbury Brook Watershed are (NJDEP 2000) (Figure 22):

- Cranbury Brook at Applegarth Road in Monroe Township (AN0385).
- Cranbury Brook at Edgemere Avenue in Plainsboro Township (AN0386).

According to the AMNET sampling events from 1990 and 1999, two of the four sampling events were rated moderately impaired (Table 7; NJDEP 1995; NJDEP 2000). Note that site AN0386 was not sampled in 1999 due to construction of the bridge at Cranbury Brook (Table 7; NJDEP 2000).

The Applegarth Road site (AN0385) was rated severely impaired when sampled in 1999, possibly due to runoff from the adjacent roadway (NJDEP 2000). Upstream of this site, it was noted in 1999 that the right bank had storm sewers and that the left bank was reinforced with concrete (NJDEP 2000). 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 (see Visual Assessment section above).

The biological data follows a pattern similar to the visual assessments with the stream bottom undergoing sedimentation and smothering out habitat for macroinvertebrates to properly survive. During both the sampling events in 1990 and 1999 at AN0385, it was noted that the stream bottom was mostly gravel and sand (NJDEP 1995, NJDEP 2000).

The most recent Integrated List (see below for more information) published by the NJDEP ranks the biological health of Cranbury Brook as non-supportive of aquatic life (NJDEP 2004c). Brainerd Lake is listed as being supportive of aquatic life (NJDEP 2004c).

CHEMICAL ASSESSMENTS

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 U.S. Environmental Protection Agency. 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).

The Integrated List states that the Cranbury Brook site at Prospect Plains is impaired for fecal coliform and pH (NJDEP 2004c). A TMDL for fecal coliform for the length of Cranbury Brook upstream of its confluence with Cedar Brook was proposed in April of 2003 (NJDEP 2003). The site at Prospect Plains was also listed on the Integrated List as meeting the water quality standards for phosphorus, temperature, dissolved oxygen, nitrate, dissolved solids, total suspended solids, and unionized ammonia (NJDEP 2004c).

SBMWA's chemical action teams (CATs) monitor one chemical monitoring site in the Cranbury Brook Watershed (Figure 23). Chemical monitoring is conducted every other weekend throughout the year. Volunteers monitor six parameters: dissolved oxygen (DO), pH, nitrate-nitrogen, orthophosphates,

water temperature and turbidity. For this assessment, water quality was determined for all six parameters, but three in particular are important to nonpoint-source pollution control: DO, nitrate-nitrogen and orthophosphates. These three are excellent indicators of nonpoint pollution and eutrophication in waterways.

The site in the Cranbury Brook Watershed currently monitored by SBMWA's volunteers is (Figure 23):

- Cranbury Brook at Maple Avenue just downstream of Plainsboro Pond (CB1).

Site CB1 has been monitored since the summer of 1992. Data was analyzed by annually averaging the value for each parameter monitored (Graph 6). The results show that Cranbury Brook is maintaining good water quality, as many of the parameters meet or exceed the State Water Quality Standard (Graph 6). A parameter of concern is pH (Graph 6). Nine out of the past 12 years of sampling have an annual average pH that is at or below the State Water Quality Standard (6.5-8.5 standard units). These pH values show that the waters of Cranbury Brook are mildly acidic and that these values are in a trend to become more so (Graph 6). In fact, 36% of all pH measurements taken between 1992 and 2003 are below the State Water Quality Standard.

The Cranbury Township Environmental Commission (EC) received an Environmental Services Program (ESP) matching grant to perform baseline water quality monitoring of streams within their municipality and the Cranbury Brook Watershed (Township of Cranbury EC 2003). Six sites were selected for assessment (Figure 23 and Table 8).

- BL-01: Brainerd Lake near Route 130
- BL-02: Brainerd Lake near Main Street
- AR-03: Cranbury Brook upstream of Brainerd Lake, at Applegarth Road
- MS-04: Cranbury Brook downstream of Brainerd Lake, behind the firehouse
- CB-05: Cedar Brook at Plainsboro Road
- MR-06: Millstone River at Old Trenton Road

After sampling was performed in July 2002, October 2002 and April 2003, the results were acceptable in meeting the State Water Quality Standards for most of the measurements taken (Township of Cranbury EC 2003). The Cedar Brook monitoring site (CB-05) did violate the standards for biological oxygen demand, total suspended solids and total phosphorus (Township of Cranbury EC 2003). It should also be noted that pH values did violate the State Water Quality Standard at least once at each of the six monitoring sites during the study (Table 8). This was noted as due to equipment problems (Township of Cranbury EC 2003).

WATER QUALITY

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 pollutant loadings based on land use types within a watershed as of 1995/97. Total acreage of a given land use type is calculated for each watershed; 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 watershed 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 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 Cranbury Brook Watershed have high 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 Cranbury and Monroe Townships (Figure 12 and Figure 25). Much of the area is 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 Cranbury Brook Watershed fall mostly within the moderate range (1.620-3.035 lb/acre/yr) (Figure 24). TSS loadings also fall mostly within the moderate range (at or greater than 202.4 lb/acre/yr) for this model (Figure 26).

The areas with the lowest loadings in all three types of loadings (nitrogen, phosphorus, and TSS) coincide with the wetlands located in both Cranbury and Monroe Townships (Figure 12, Figure 24, Figure 25, and Figure 26).

Assessment –

Water quality information for the Cranbury Brook Watershed is limited in terms of visual, biological and chemical assessments; a long-term set of reliable data is needed. Measurements of the environment can be highly valuable, yet very specific to the time and place where the measurements were taken. A long-term (10-20 years) dataset helps to reduce this specificity and increase the likelihood that the measurements are reflecting the actual water quality conditions in the stream.

The chemical data available shows that there is very little impacting water quality of Cranbury Brook (Graph 6, Table 6, Table 7 and Table 8). However, pH levels are trending towards acidity (Graph 6). One possible explanation is that during excavation activities one or more soil layers may generate acidity when exposed to the surface and washed into nearby waterways. With the increasing amount of development happening in the Cranbury Brook Watershed, efforts will need to be made to control sediment during construction activities to help alleviate this potential problem. Increasing the sampling effort in Cranbury Brook and its tributaries will help to clarify the impacts affecting its acidity. By increasing the number and frequency at which samples are taken, the actual nature of the chemical constituents in the stream can be reliably assessed.

In general, Cranbury 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 and creating opportunities for pollution-tolerant varieties of macroinvertebrates to thrive.

The most likely stressor affecting the macroinvertebrate communities in Cranbury Brook is the sedimentation seen in SBMWA's visual assessments (Table 6). The basis for this sedimentation may be due to the soil composition and erodibility of the Cranbury Brook Watershed itself (see Geology section and Soils section for more details). The majority of soils in the Watershed are classified as medium to 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 moderate erodibility combined with the sandy geology of the southeastern portion of the watershed probably accounts for much of the observed sedimentation.

In addition to this "natural" sedimentation, the land use practices occurring in the Cranbury Brook have only helped to accelerate the sedimentation process seen in local streams. Nonpoint-source pollutant loadings for nitrogen, phosphorus and TSS in the Cranbury Brook Watershed are found mostly within the moderate to high levels for the model used in this report (Figure 24, Figure 25 and Figure 26). Of special note are the loadings for TSS, as the land use practices modeled in the Cranbury Brook Watershed are providing moderate levels of sediments to the streams in this region (Figure 26). Therefore, the municipalities in the Cranbury Brook Watershed (especially Cranbury and Monroe) need to enact sediment control ordinances to prevent materials from washing into streams and degrading habitat and water quality.

Table 6: Visual assessment scores for Cranbury 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
UMR10	2	4	4	1	4	4	3	2	4	3	3.1
UMR11	2	4	4	1	4	4	3	2	4	3	3.1
UMR12	2	4	4	2	4	4	3	2	3	3	3.1
UMR13	4	4	3	3	4	4	3	3	4	4	3.6
UMR14	2	4	2	3	3	3	4	3	2	4	3.0
UMR15	3	4	4	2	2	4	4	3	3	4	3.3
Average Stream Score = 3.2											

WATER QUALITY

Table 7: Biological assessment data for Cranbury Brook Watershed 1990 and 1999 (NJDEP Data).

Site	Date	Number in Sample	FBI	Total Taxa Richness	EPT Richness	% EPT	% Dominance	Scoring for Stream Impairment Biological Assessment
AN0385	7/25/1990	100	5.8	14	1	1%	28%	Moderately Impaired
AN0385	7/1/1999	100	7.1	7	0	0%	44%	Severely Impaired
AN0386	7/24/1990	100	6.8	12	1	1%	48%	Moderately Impaired
AN0386	7/13/1999*	N/A	N/A	N/A	N/A	N/A	N/A	No Rating

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.

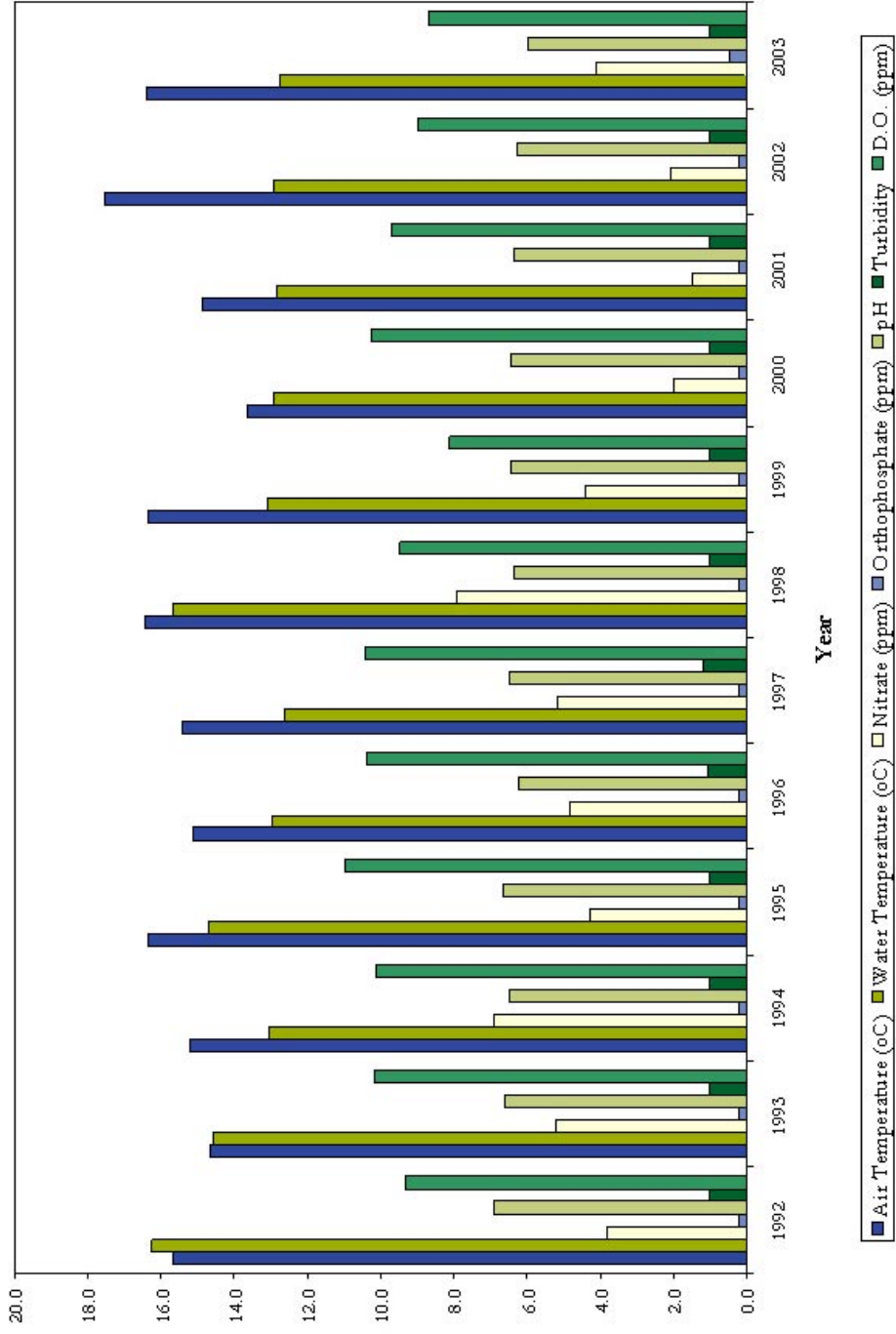
% Dominance: Percent of sample composed of individuals from one family.

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.

* Due to construction of the bridge at this site, a sample was not taken during this collection year.

WATER QUALITY

Graph 6: Chemical assessment data for Cranbury Brook Watershed 1992 to 2003 (SBMWA Data).



WATER QUALITY

Table 8: Water quality assessment of Cranbury Brook Watershed 2002 and 2003 (Cranbury Township Environmental Commission data).

Parameter	Sampling Date	Brainerd Lake 1	Brainerd Lake 2	Cranbury Brook Upstream	Cranbury Brook Downstream	Cedar Brook	Millstone River
Water Temperature (oC)	7/15/02	28	27	20	27	22	25
	10/23/02	12	12	10	12	9	11
	4/14/03	10	11	9	13	13	11
pH	7/15/02	7.3	7.3	7.3	5.0	5.1	5.2
	10/23/02	6.1	6.1	5.9	6.4	6.2	6.4
	4/14/03	6.8	6.8	5.2	6.8	6.8	6.8
Total Suspended Solids (mg/L)	7/15/02	< 4	14	< 4	11	81	10
	10/23/02	4	11	< 4	7	< 4	< 4
	4/14/03	6	6	5	6	< 4	< 4
Dissolved Oxygen (mg/L)	7/15/02	10.5	10.4	7.5	8.3	9.5	9.0
	10/23/02	8.9	9.0	9.7	9.3	7.5	9.9
	4/14/03	9.5	9.5	10.3	10.4	11.6	10.6
Nitrogen as Nitrate (mg/L)	7/15/02	0.15	0.15	2.9	0.14	5.7	3.4
	10/23/02	1.2	0.87	1.7	0.87	2.9	2.3
	4/14/03	0.67	0.71	0.63	0.62	1.1	1.2
Sulfate (mg/L)	7/15/02	< 20	< 20	< 20	< 20	< 20	28.4
	10/23/02	30.1	28.5	25.7	27.8	< 20	40.2
	4/14/03	20.9	21.9	22.7	20.8	< 20	22.6
Fecal Coliform (col/100mL)	7/15/02	105	125	No Data	No Data	No Data	No Data
	10/23/02	25	20	No Data	No Data	No Data	No Data
	4/14/03	< 2	< 2	No Data	No Data	No Data	No Data
Total Coliform (col/100mL)	7/15/02	320	190	No Data	No Data	No Data	No Data
	10/23/02	370	380	No Data	No Data	No Data	No Data
	4/14/03	170	150	No Data	No Data	No Data	No Data

WATER QUALITY

FINDINGS & RECOMMENDATIONS

This characterization and assessment represents an opportunity to properly plan the future landscape of the Cranbury 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 Cranbury Brook and stormwater is impacting the health of waterways. Increased sedimentation is attributed 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 Cranbury Brook Watershed, traditional construction practices 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 Cranbury Brook Watershed, like the rest of New Jersey, are on the rise. The population went from 70,753 residents in 1990 to 93,836 in 2000, increasing by 32.6%. From 1986 to 1995/97, developed lands increased from 3,507.9 acres to 4,605.9 acres, a gain of 31.3%. 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 such as the new town center in Plainsboro Township, and maintain villages such as Cranbury Township. 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.
- Cranbury Brook Watershed contains many critical habitats for a variety of threatened and endangered species. Many of these critical areas are adjacent to increasing development, putting them under pressure to be built upon. 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: Newly developed lands have been created in the Cranbury Brook Watershed. Much of the conversion was from agricultural areas to urban land uses. Agricultural lands maintain the rural character and history of towns that were founded upon a farming economy. Many of the critical habitats within the watershed are grasslands and coincide with farmed areas.

(See Land Use section for more information.)

Recommendations:

- Decreasing the rate of conversion of farmlands in the Cranbury 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 would help to protect water quality.
- Monroe Township needs to determine suitable areas to preserve farmlands if they have not done so already. Cranbury and Plainsboro Townships have a prioritization system for preserving farmlands in place. Data on critical habitats and ground water recharge should 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).
- Riparian corridors are being increasingly encroached upon for development in the Cranbury 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 Cranbury 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 Cranbury Brook Watershed municipalities and counties support the State recommendation of C1 protection for Cranbury 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 Cranbury Brook Watershed is covered by 11.9% 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 Cranbury Brook Watershed are moderately erodible. Water quality impacts have been noted due to the erodible nature of the soils in this region. (See Land Use section for more information.)

Recommendations:

- Increasing impervious cover will only exacerbate water quality problems by increasing the frequency and intensity of storm flows and flooding. Municipalities need to incorporate innovative ways to plan developments including 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 and allows for developing at higher densities).

- In order to maintain its 11.9% impervious cover, new developments in the Cranbury Brook Watershed should consider the use of porous pavement or other porous materials in the design of streets, walkways and other appropriate structures, if feasible. These materials allow for the infiltration of precipitation back into ground water supplies.

MAINTAINING GROUND WATER RESOURCES

Finding: There are 18 known contaminated sites (KCSs) in this 22 square mile watershed. Eleven sites are found within Cranbury Township alone. This large number of KCSs in the Cranbury Brook Watershed warrants the potentially responsible parties remediate any contamination present. (See Known Contaminated Sites section for more information.)

Recommendations:

- Ground water contamination is a concern at one particular KCS: Plainsboro Township Sanitary Landfill. This site is located within a half-mile of a public well in Plainsboro Township. Ground water impacts to this site have been rated as moderate by the NJDEP. Special attention needs to be given to the continued monitoring of this site by the NJDEP to ensure that public safety is maintained.
- The creation and implementation of an ordinance to provide wellhead protection to the delineated wellhead protection areas by the municipalities in the Cranbury Brook Watershed will ensure that public community wells are protected from possible contamination.

Finding: The nature of Coastal Plain geology has a large influence on the water resources of the Cranbury Brook Watershed. The unconsolidated nature of the sediments has two major implications from the standpoint of water resources. First, streams and rivers of the Coastal Plain are typified by large amounts of alluvial sediment because of the erodibility of the underlying deposits. The soils are easily eroded and carried to other areas of the watershed. Second, the lack of cementation of the buried sediments means that the sandy units retain a high porosity, making them very productive aquifers. (See Geology and Soils sections for more information.)

Much of the Cranbury Brook is classified as hydrologic soil group B, covering 6,616 acres out of a total of 14,240 acres (46.5%) in the entire watershed. Hydrologic soil group B represents soils with a moderate infiltration rate and is representative of the moderately coarse soils seen in the Coastal Plain Physiographic Province. This aids the extensive aquifers in the region by allowing for much ground water to be recharged to the soil. Most of this soil underlies the agricultural areas in Cranbury and Monroe

Townships and the developed areas of Plainsboro Township. (See Soils section for more information.)

Recommendation:

- Increasing urbanization in the Cranbury Brook Watershed also increases the amount of impervious cover. This has the effect of decreasing the amount of water flowing into the aquifer by diverting precipitation over the landscape to streams and not downward into the soil. Placement of new development, and therefore impervious cover, out of areas that have high value for recharging the aquifers will help to maintain water levels for drinking, irrigation and industrial use.

Finding: There are many portions of the Cranbury Brook Watershed that contain areas with high ground water recharge. These areas need to be protected by ordinances by their respective townships (Cranbury and Monroe, in particular) to restrict development. Reduced development in the high ground water recharge areas will ensure that there are plentiful supplies of water for many years to come. By working together to protect ground water supplies and aquifers, municipalities can coordinate preservation and protection efforts across town lines to look at areas regionally beyond the borders of the Cranbury Brook Watershed. (See Water Supply section for more information.)

Recommendation:

- Since the majority of high ground water recharge areas are located in agricultural areas in Cranbury and Monroe Townships, these municipalities 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 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: Based upon the visual assessment data and observations during the biological assessments, the most likely stressor affecting the macroinvertebrate communities in Cranbury Brook is heightened sedimentation. The cause of this heightened sedimentation may be due to the soil composition and erodibility of the Cranbury Brook Watershed itself. This moderate to high erodibility of its soils combined with the sandy geology seen in much of the southeastern portion of the Millstone

Watershed probably accounts for much of the sedimentation observed. Increasing the sampling effort in Cranbury Brook and its tributaries will help to clarify the impacts affecting its water quality. (See Water Quality section for more information.)

Recommendations:

- 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.
- 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.
- In order to accurately assess the environmental health of Cranbury Brook, long-term trends in water quality need to be determined. Currently, there is a lack of reliable monitoring data on the water resources in this region. Intensive monitoring needs to occur to determine the health of Cranbury Brook, its tributaries and its ponds and lakes. Future monitoring could be performed by municipal ECs through the State’s ESP Matching Grant program, as was done by Cranbury Township.
- Point source discharges in the Cranbury Brook Watershed need to work within the guidelines of their active permits in order to maintain the health of Cranbury Brook.
- Nonpoint-source pollutant loadings for nitrogen, phosphorus and total suspended solids (TSS) in the Cranbury Brook Watershed are found mostly within the moderate to high levels for the model used in this report. Of special note are the loadings for TSS, as the land use practices modeled in the Cranbury Brook Watershed are providing moderate levels of sediments to the streams in this region. This is important, as the soils in this area are already unconsolidated and therefore highly erodible. Therefore, municipalities in the Cranbury Brook Watershed (especially Cranbury and Monroe Townships) need to enact sediment control ordinances to prevent materials from washing into streams and degrading habitat and water quality.
- Middlesex County and municipalities within Cranbury Brook Watershed are already moving forward with developing a regional stormwater management plan for Cranbury Brook and also Cedar Brook, Devils Brook and Shallow Brook. This is a step in the right direction, as stormwater management needs to be addressed regionally in order to adequately handle the additional loads of nitrogen, phosphorus and TSS.

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AMNET	Ambient Biomonitoring Network
BMPs	Best Management Practices
C1	Category One
CAT	Chemical Action Team
DO	Dissolved Oxygen
EC	Environmental Commission
ESP	Environmental Services Program
EPT	Ephemeroptera-Plecoptera-Tricoptera
FBI	Family Biotic Index
GIS	Geographic Information System
KCS	Known Contaminated Site
MDDNR	Maryland Department of Natural Resources
MGD	Million Gallons per Day
MLW	Mount Laurel-Wenonah
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJGS	New Jersey Geological Survey
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
PCW	Public Community Well
PRM	Potomac-Raritan-Magothy

LIST OF ACRONYMS

PRP	Potentially Responsible Party
SCD	Soil Conservation District
SBMWA	Stony Brook-Millstone Watershed Association
STP	Sewage Treatment Plant
SWQS	Surface Water Quality Standard
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UMR	Upper Millstone River
URWA	Upper Raritan Watershed Association
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

LIST OF ACRONYMS

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

anaerobic: Describing an organism (especially a bacterium) that can survive in the absence of oxygen.

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.

biotite: A rock-forming mineral of the mica group.

calcareous: Containing calcium carbonate.

carbonaceous: Describes sediment that contains organic matter or is rich in carbon.

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.

Cretaceous: The last period of the Mesozoic era, covering 135 to 65 million years ago.

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: The angle that a geologic surface, such as a bedding plane or fault, makes with the horizontal.

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.

GLOSSARY

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.

feldspar: A group of rock-forming minerals that are the most widespread of any mineral group; usually white or nearly white and clear or translucent.

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.

glauconite: A dull-green earthy or granular mineral of the mica group.

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 where the spaces between soil/rock particles are filled with water.

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

Hadrosaurus foulkii: A duck-billed dinosaur discovered in New Jersey in 1858.

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 absorb or infiltrate rainfall; usually associated with urban

GLOSSARY

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.

mica: A mineral that is characterized by low hardness and the readily splitting into thin sheets; a prominent rock-forming constituent of igneous and metamorphic rock.

muscovite: A mineral of the mica group.

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

nitrate-nitrogen: The amount of nitrogen found in the form of nitrates.

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.

orthophosphate: Chemical parameter monitored for water quality assessment. A form of reactive phosphorus primarily found in fertilizer applied to agricultural and residential lands.

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.

GLOSSARY

phosphatic: Any rock or mineral containing phosphates or phosphoric acid.

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

Pliocene: A time period of Tertiary, between the Miocene and Pleistocene.

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 smoke 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.

pyrite: A common, pale-bronze or brass-yellow mineral that is an important ore of sulfur.

quartz: Crystalline silica; an important rock-forming mineral that forms the major proportion of sand.

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 the 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 that contributes runoff to a particular point along a waterway.

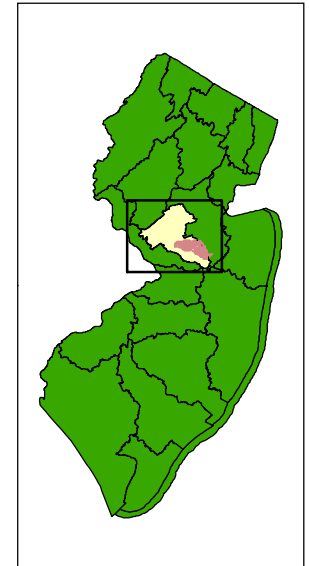
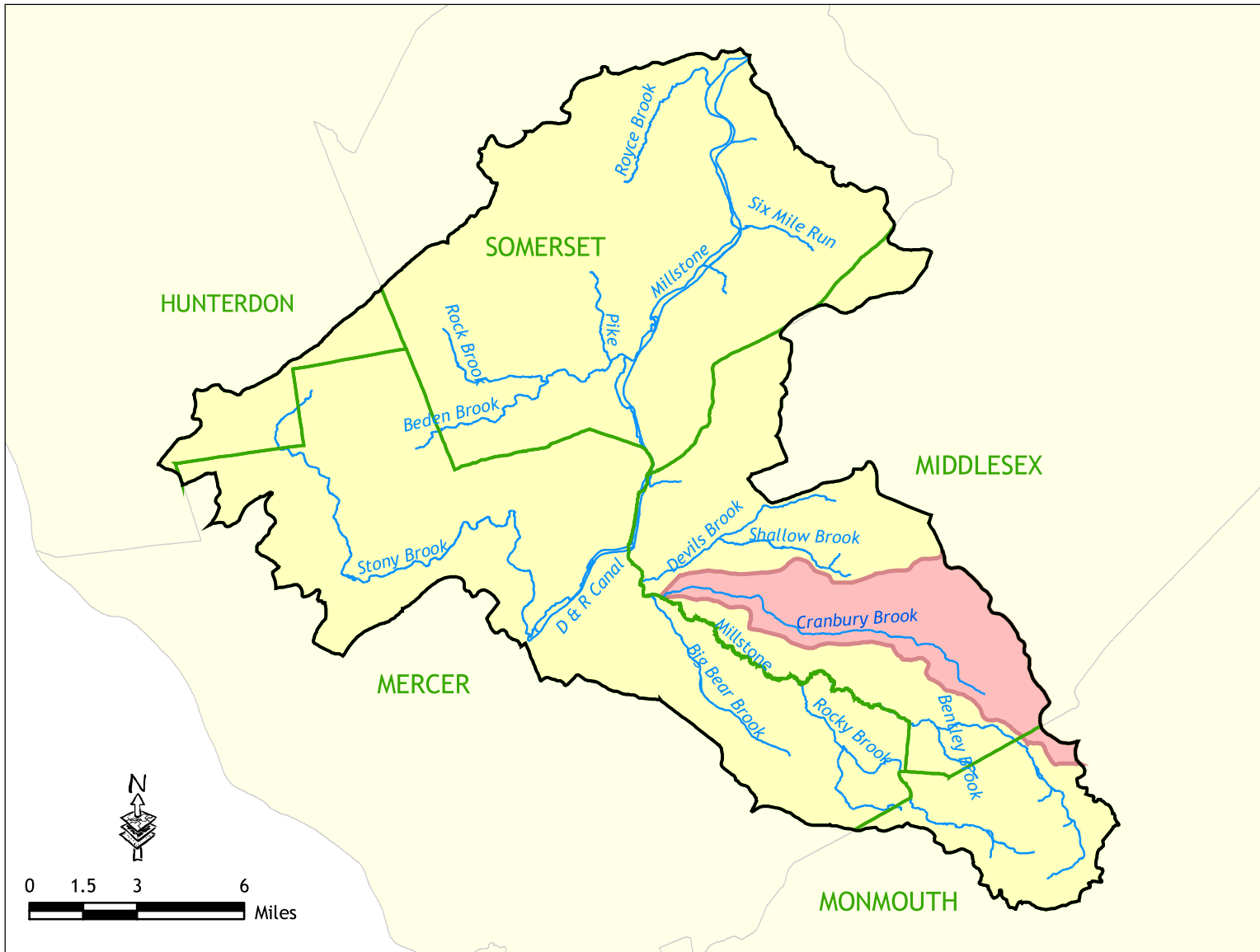
wellhead: The source of a well and the structure built over it.

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.

GLOSSARY

FIGURES

Figure 1: Cranbury Brook Watershed & Millstone Watershed









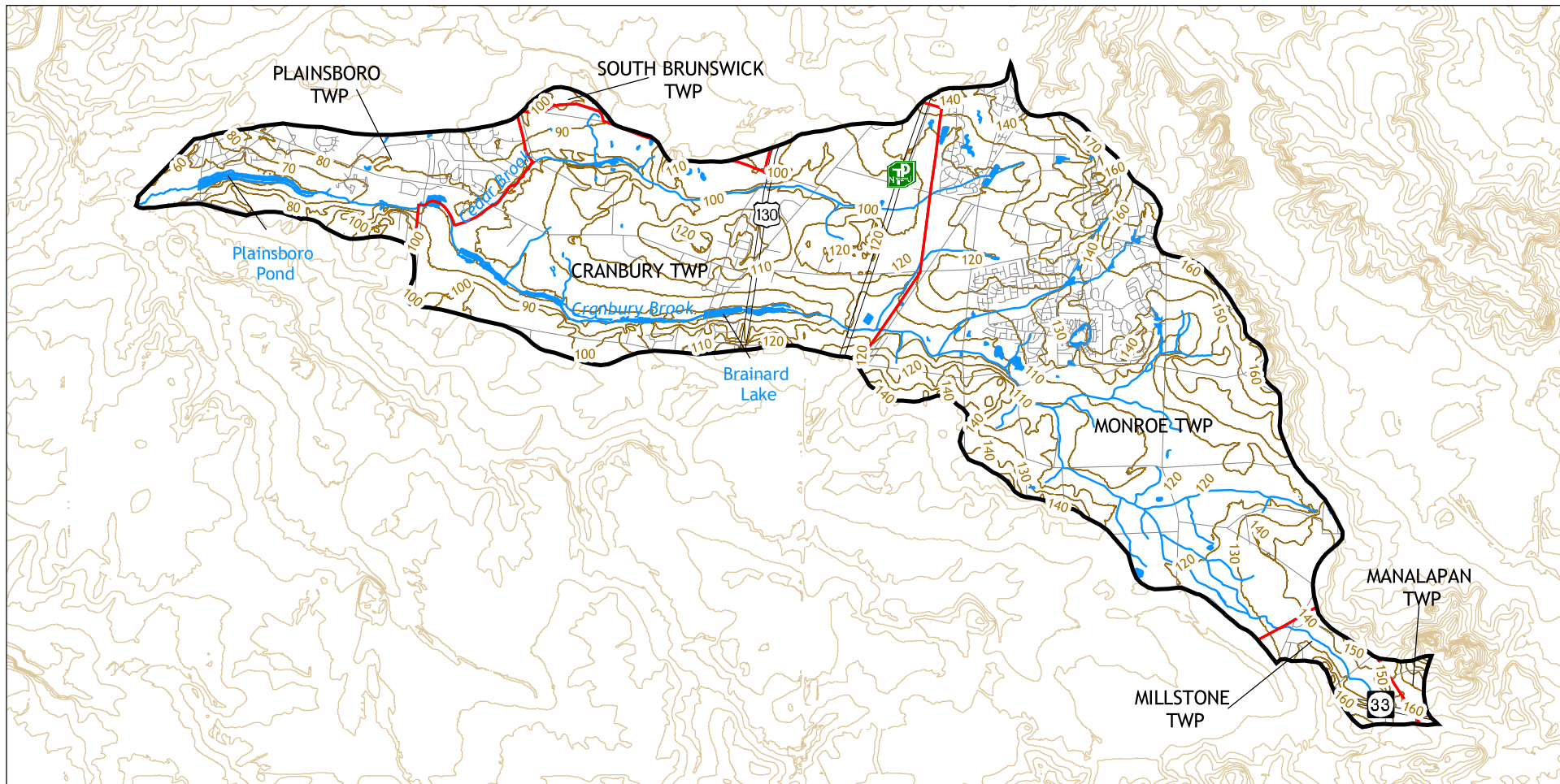







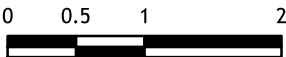
 Millstone Watershed	 County Boundaries		
 Cranbury Brook Watershed	 Streams	<p>P. Sankalia, A.Rowan 10/03 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.</p>	

Figure 2: Cranbury Brook Watershed Topography





	Municipal Boundaries		Major Roads
	Elevation Contours at 10 ft Intervals		Roads
	Lakes		Streams



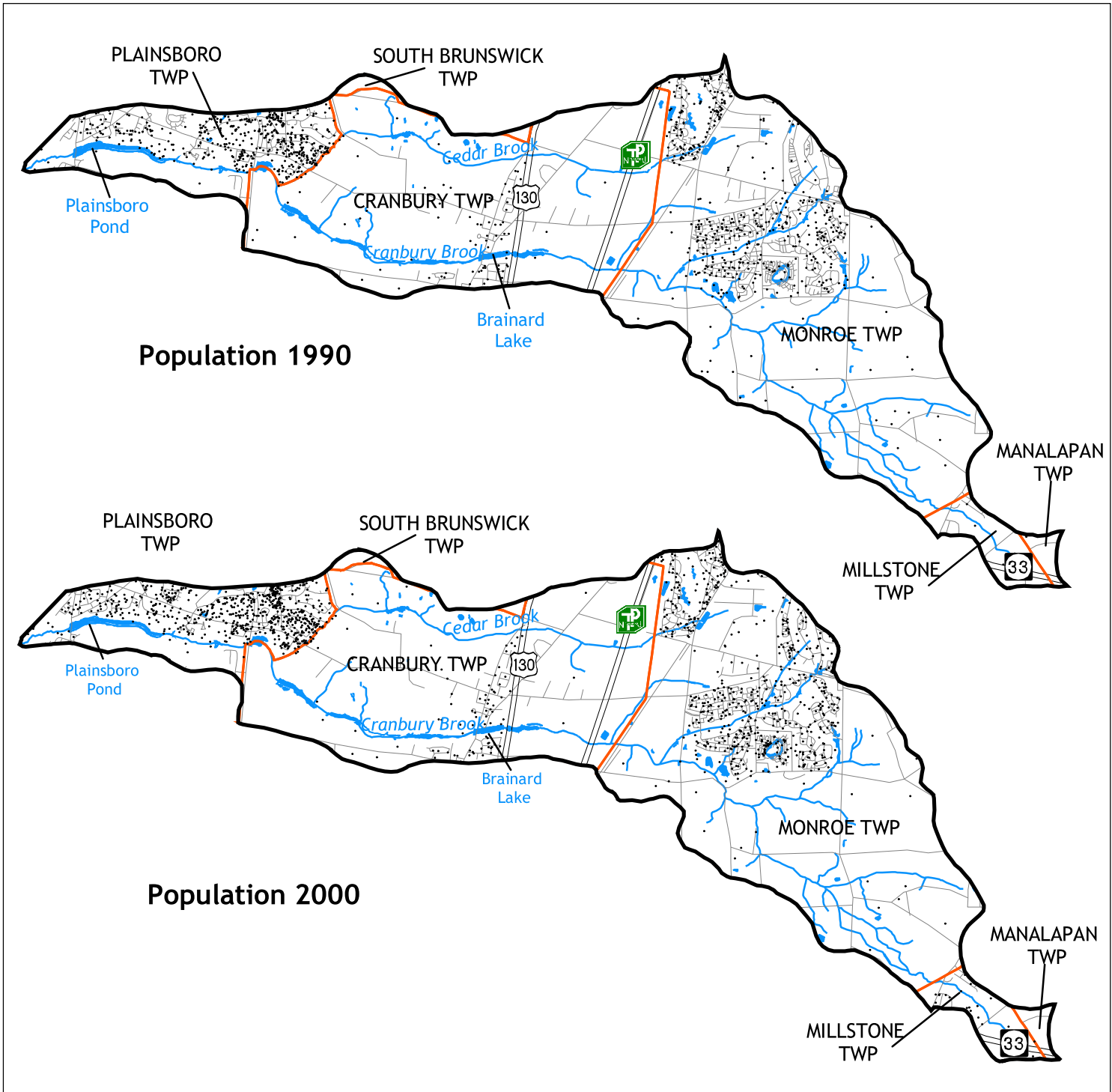


0 0.5 1 2 Miles

P. Sankalia, A. Rowan 7/04 - 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 3: Population Distribution in Cranbury Brook Watershed



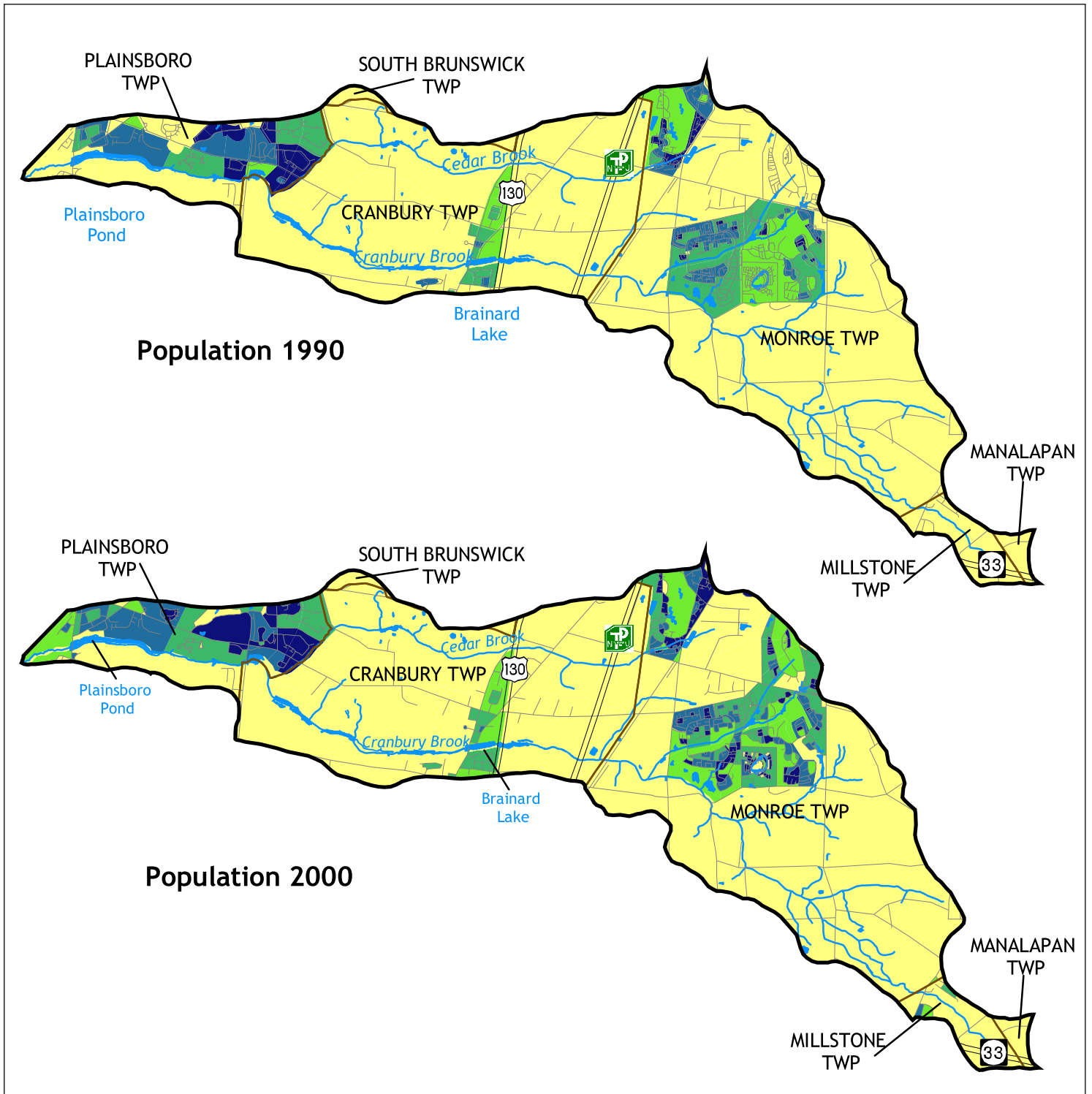
- Municipal Boundaries
- Major Roads
- Roads
- Streams
- Lakes
- Population Distribution**
- 1 Dot = 20 Persons

0 0.5 1 2
Miles

Note: Density of dots portrays population density. Within a census block, dots are randomly distributed. Locations of individual dots are not meant to portray exact locations of population.

P. Sankalia, A. Rowan 7/04 - Data Sources: NJ Department of Environmental Protection, U.S. Census Bureau. This secondary map product has not been verified or authorized by those agencies.

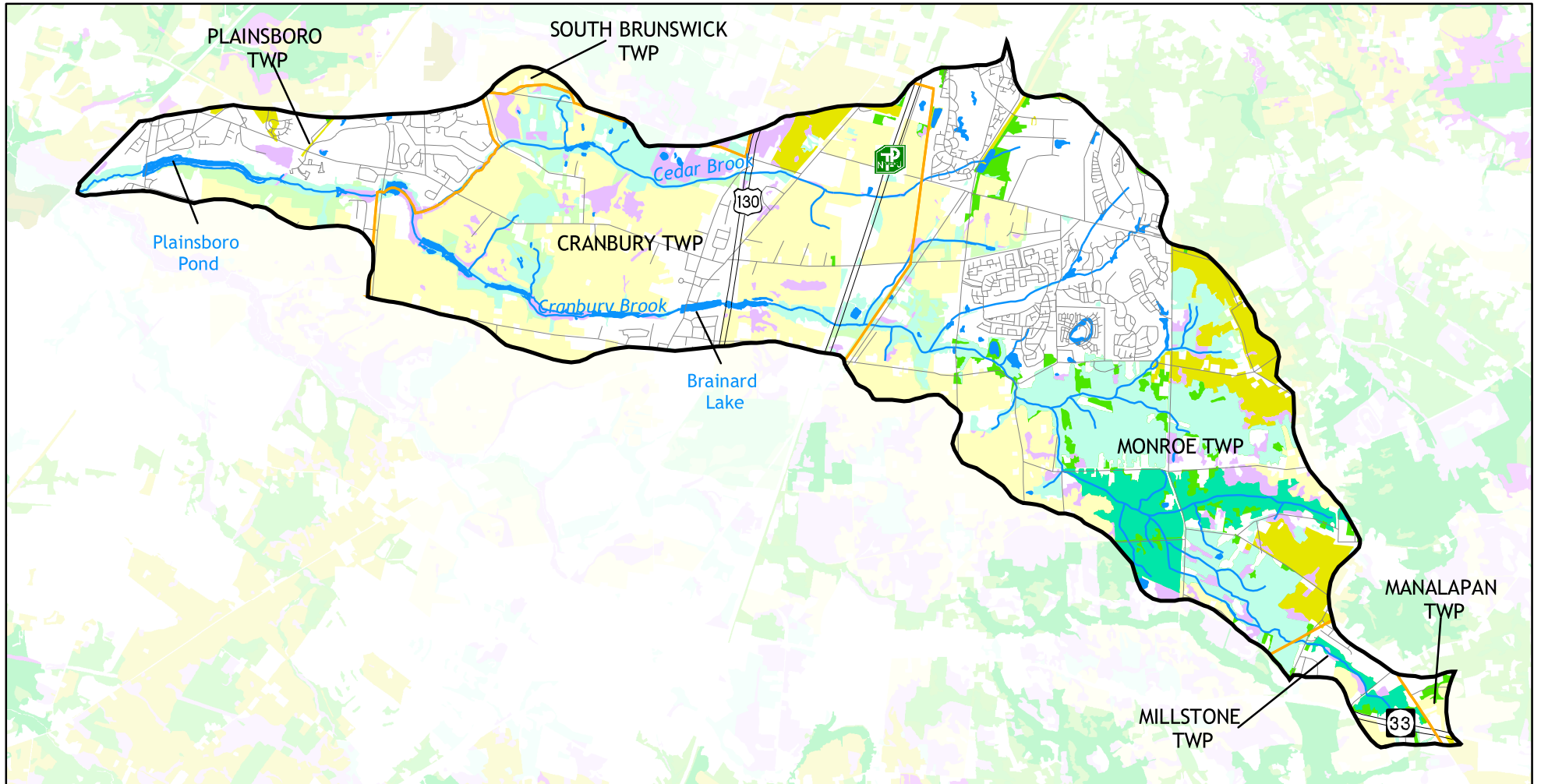
Figure 4: Population Density in Cranbury Brook Watershed



















<ul style="list-style-type: none"> Major Roads Municipal Boundaries Roads Streams Lakes 	<p>Population Density Persons/sq. mile</p> <ul style="list-style-type: none"> < 1000 1001 - 2000 2001 - 4000 4001 - 8000 > 8000 		<p>0 0.5 1 2 Miles</p>	
---	---	--	------------------------	--

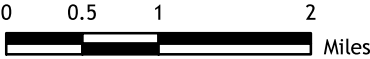
P. Sankalia, A. Rowan 7/04 - Data Sources: NJ Department of Environmental Protection, U.S. Census Bureau. This secondary map product has not been verified or authorized by those agencies.



Figure 5: Critical Habitats in Cranbury Brook Watershed



 Municipal Boundaries	 Wetland Forest Suitable Habitat	 Emergent Wetland Suitable Habitat
 Major Roads	 Wetland Forest Special Concern	 Emergent Wetland Special Concern
 Roads	Forest	Grassland
 Lakes	 Forest Suitable Habitat	 Grassland Suitable Habitat
 Streams	 Forest Priority Species	 Grassland Priority Species
	 Forest State Threatened	 Grassland State Threatened





P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection (Landscape Project version 2). Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 6: Known Contaminated Sites in Cranbury Brook Watershed

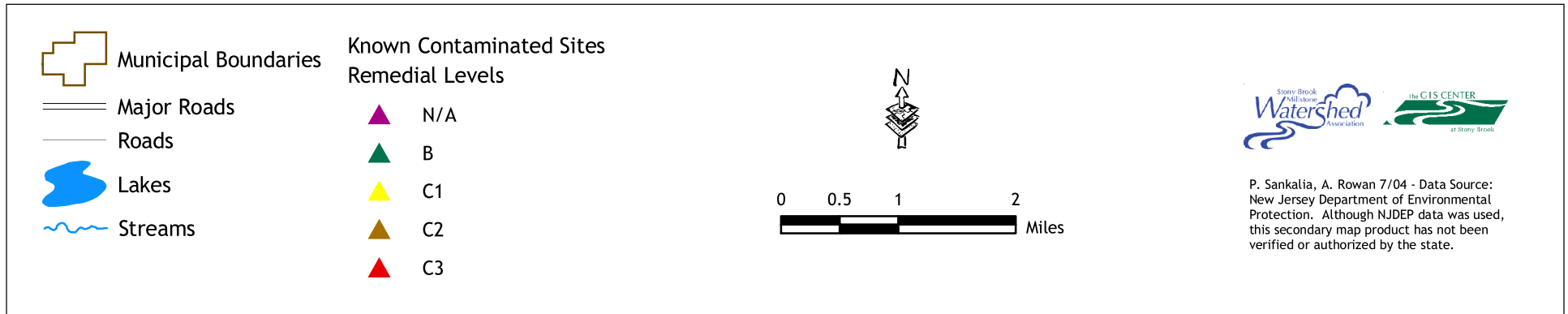
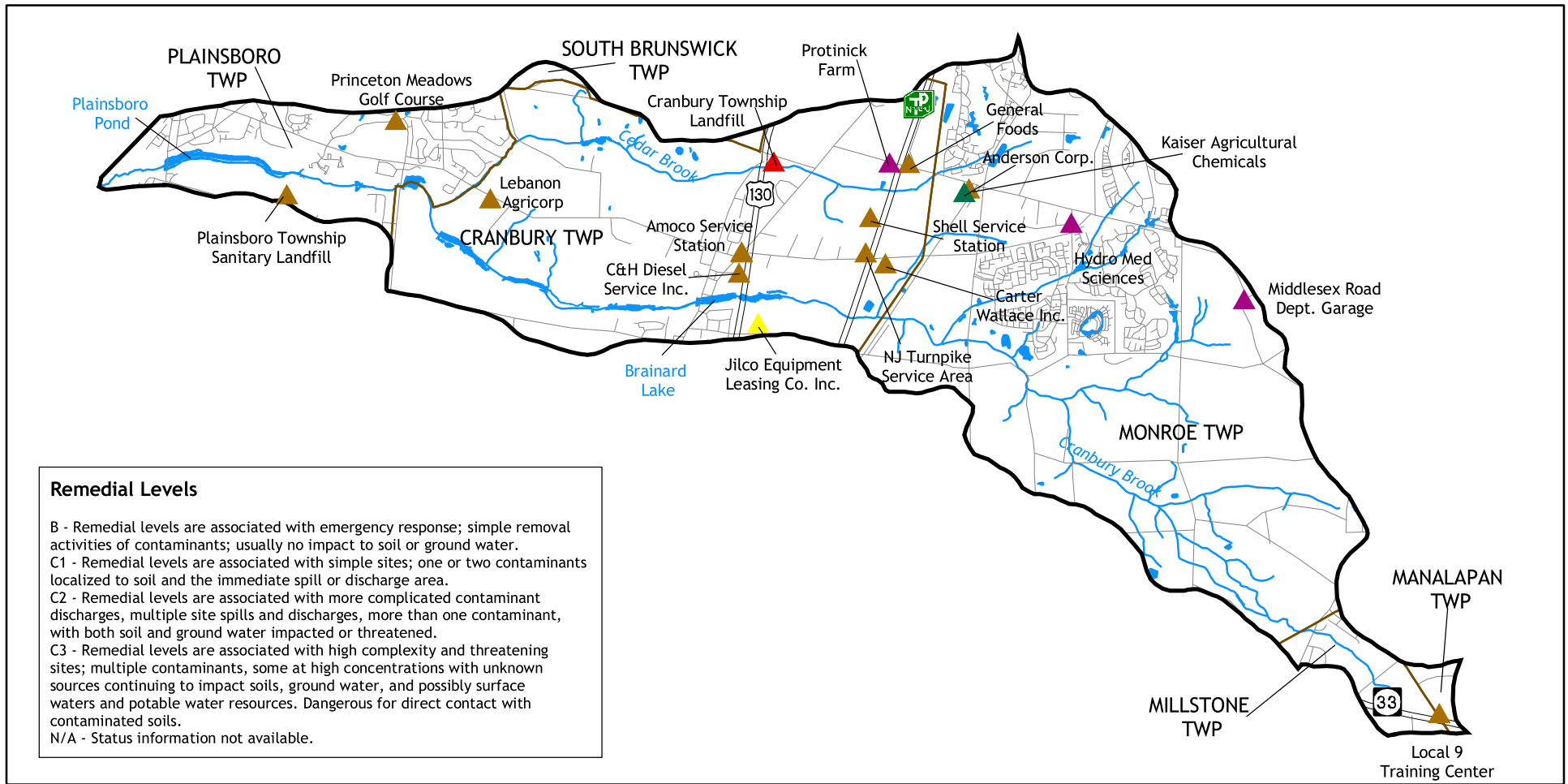


Figure 7: NJPDES Point Source Dischargers in Cranbury Brook Watershed

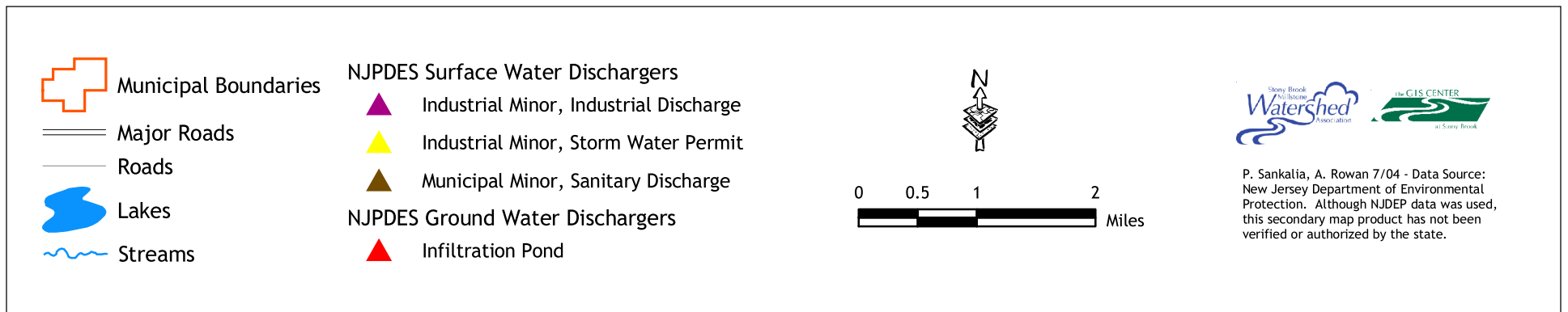
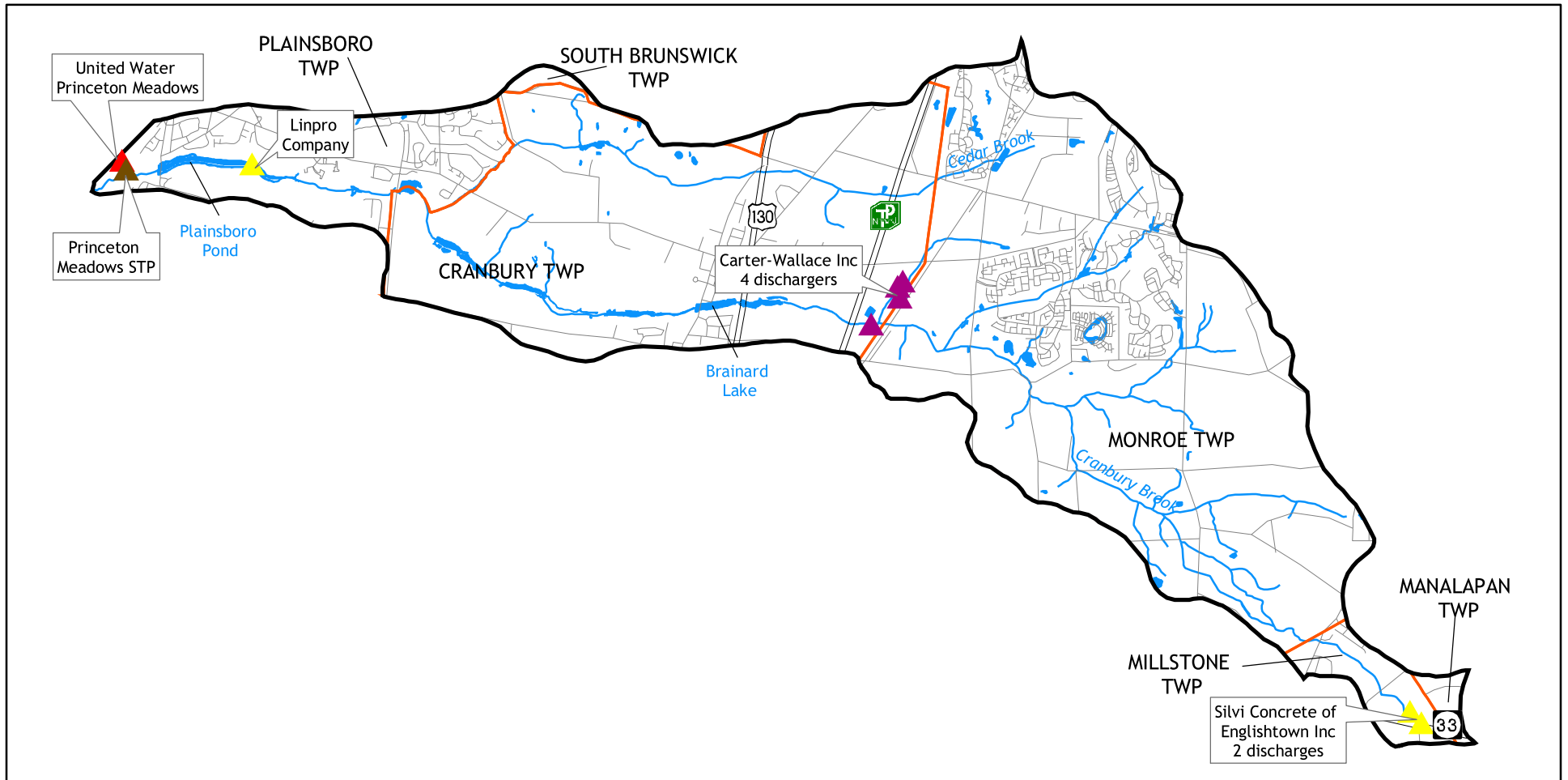
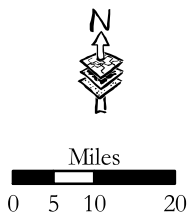
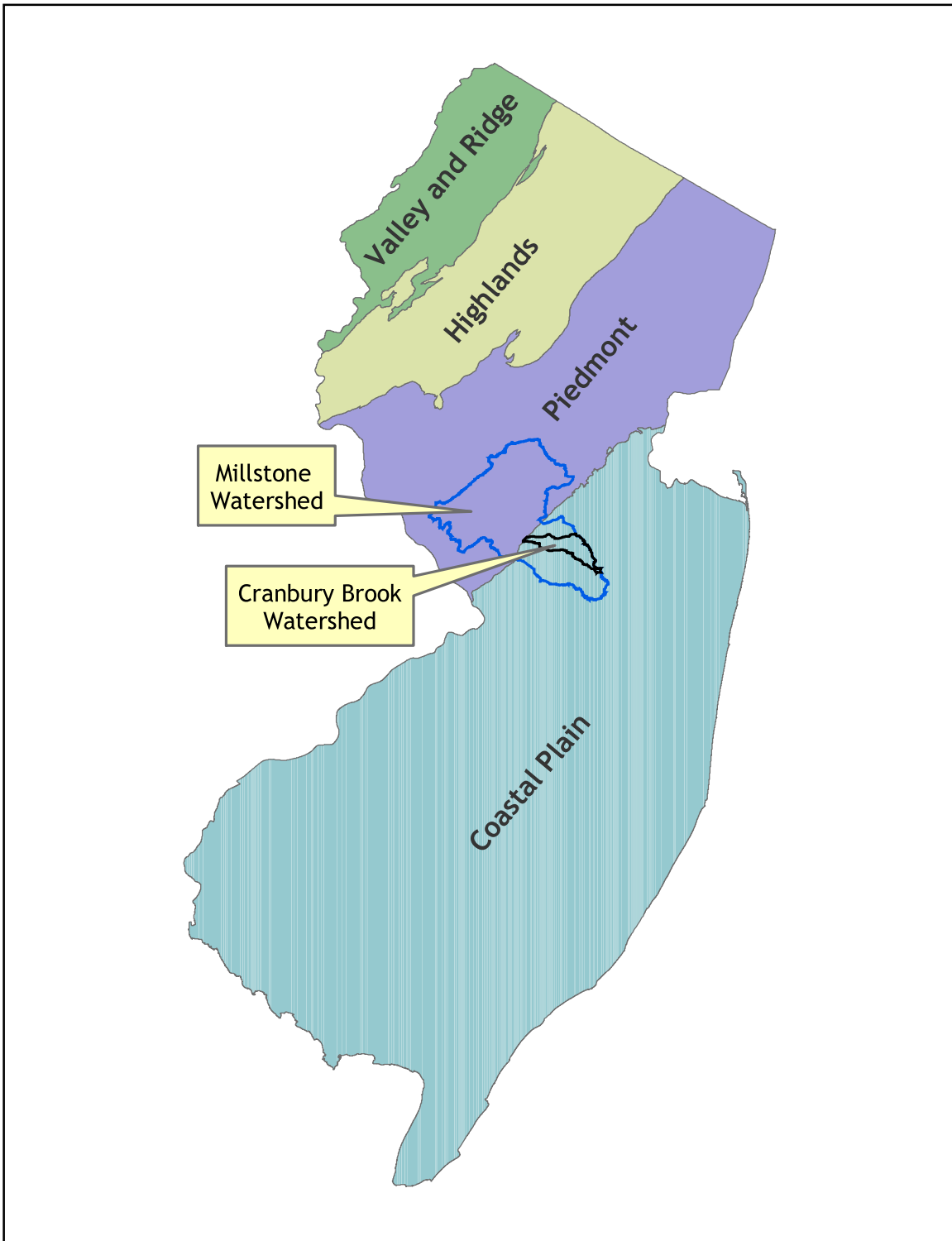


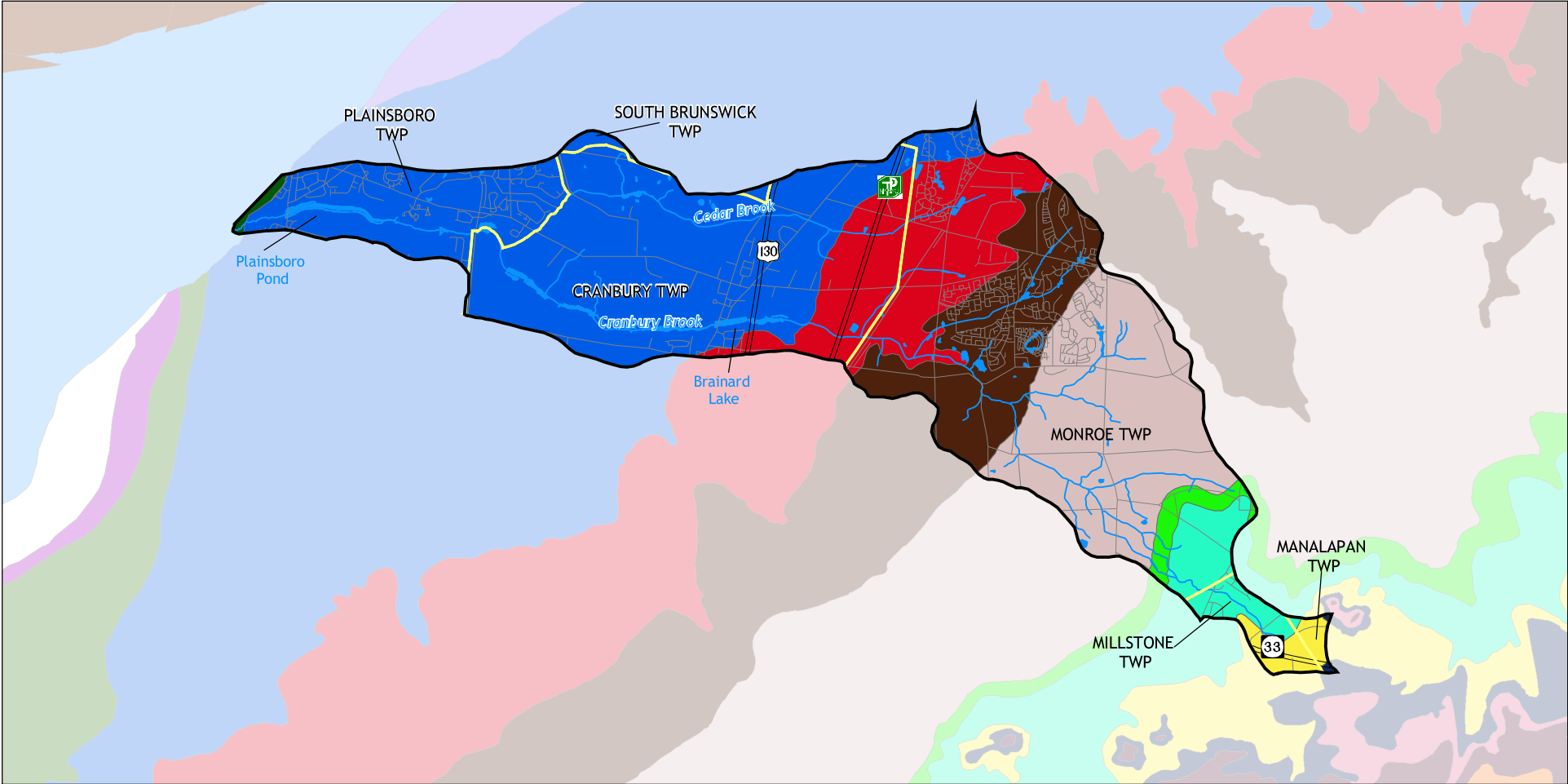
Figure 8: Physiographic Provinces of New Jersey

















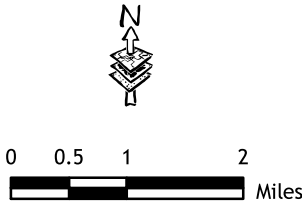
P. Sankalia, A.Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection, New Jersey Geological Survey & US Census TIGER Files. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.



Figure 9: Geology of Cranbury Brook Watershed



- | | |
|--|---|
|  Municipal Boundaries | Bedrock Geology |
|  Major Roads |  Navesink Formation |
|  Roads |  Mt. Laurel Formation |
|  Streams |  Wenonah Formation |
|  Lakes |  Marshalltown Formation |
| |  Englishtown Formation |
| |  Woodbury Formation |
| |  Merchantville Formation |
| |  Magothy Formation |
| |  Stockton Formation |



P. Sanklaia, A. Rowan 7/04 - 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 10: Hydrologic Soil Groups in Cranbury Brook Watershed

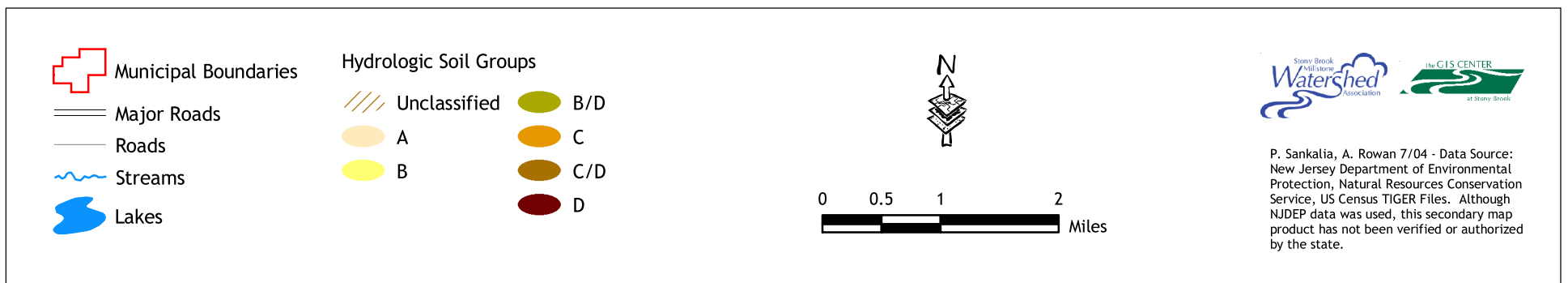
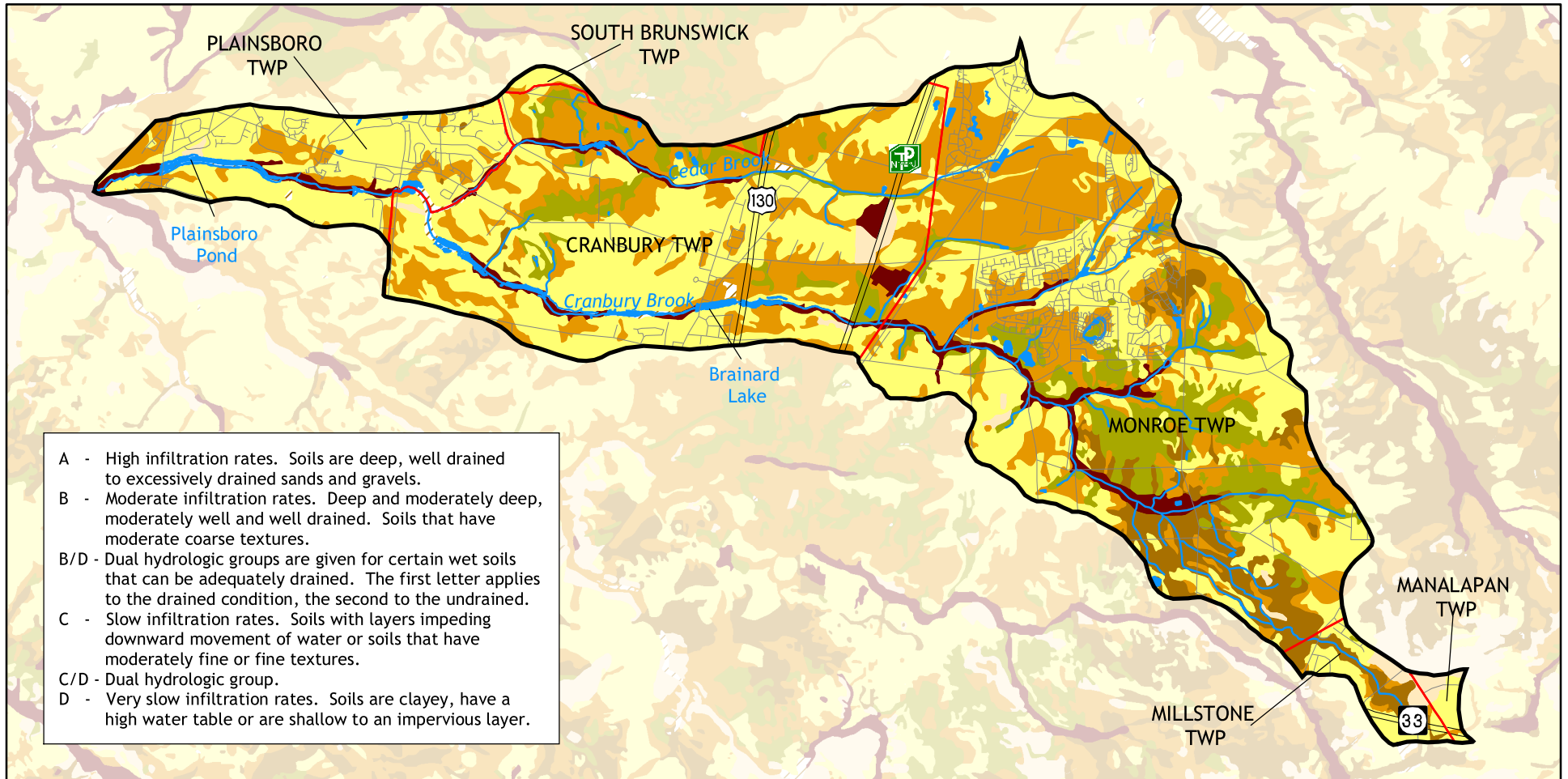
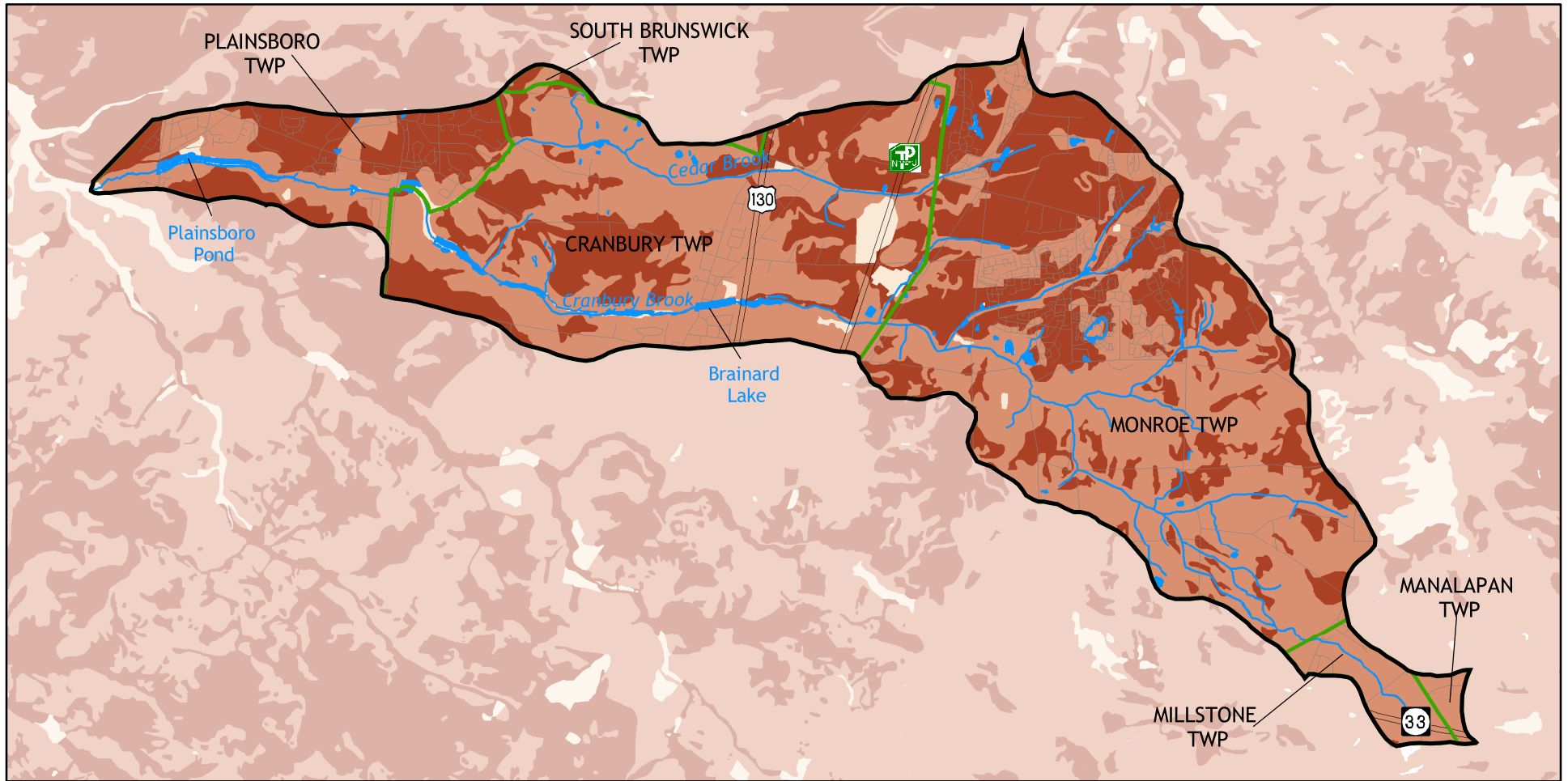










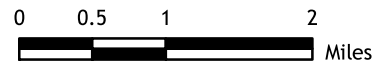
Figure 11: Soil Erodibility in Cranbury Brook Watershed



Soil Erodibility (K Factor)

-  Low (0.16 and below)
-  Med (0.17-0.31)
-  High (0.32 and above)

-  Municipal Boundaries
-  Major Roads
-  Roads
-  Streams
-  Lakes



P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection, Natural Resources Conservation Services, US Census Bureau. This secondary map product has not been verified or authorized by those agencies.

Figure 12: 1995/97 Land Use in Cranbury Brook Watershed

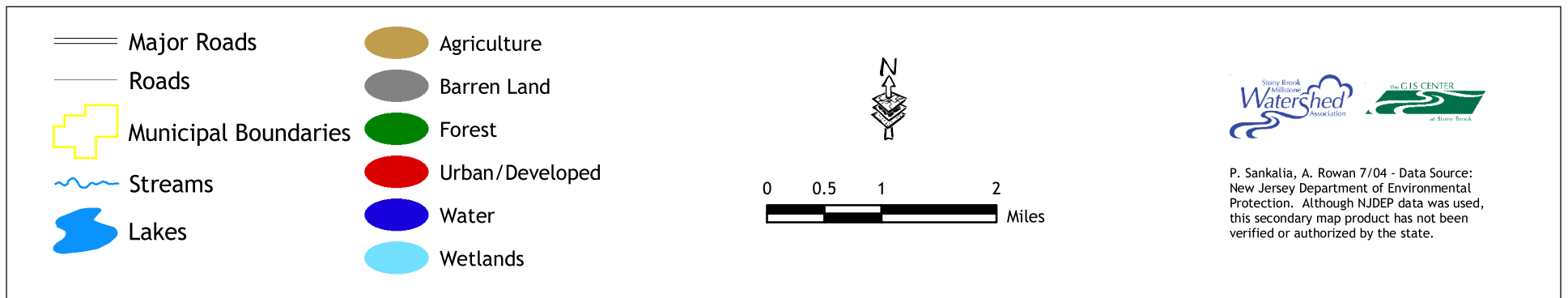
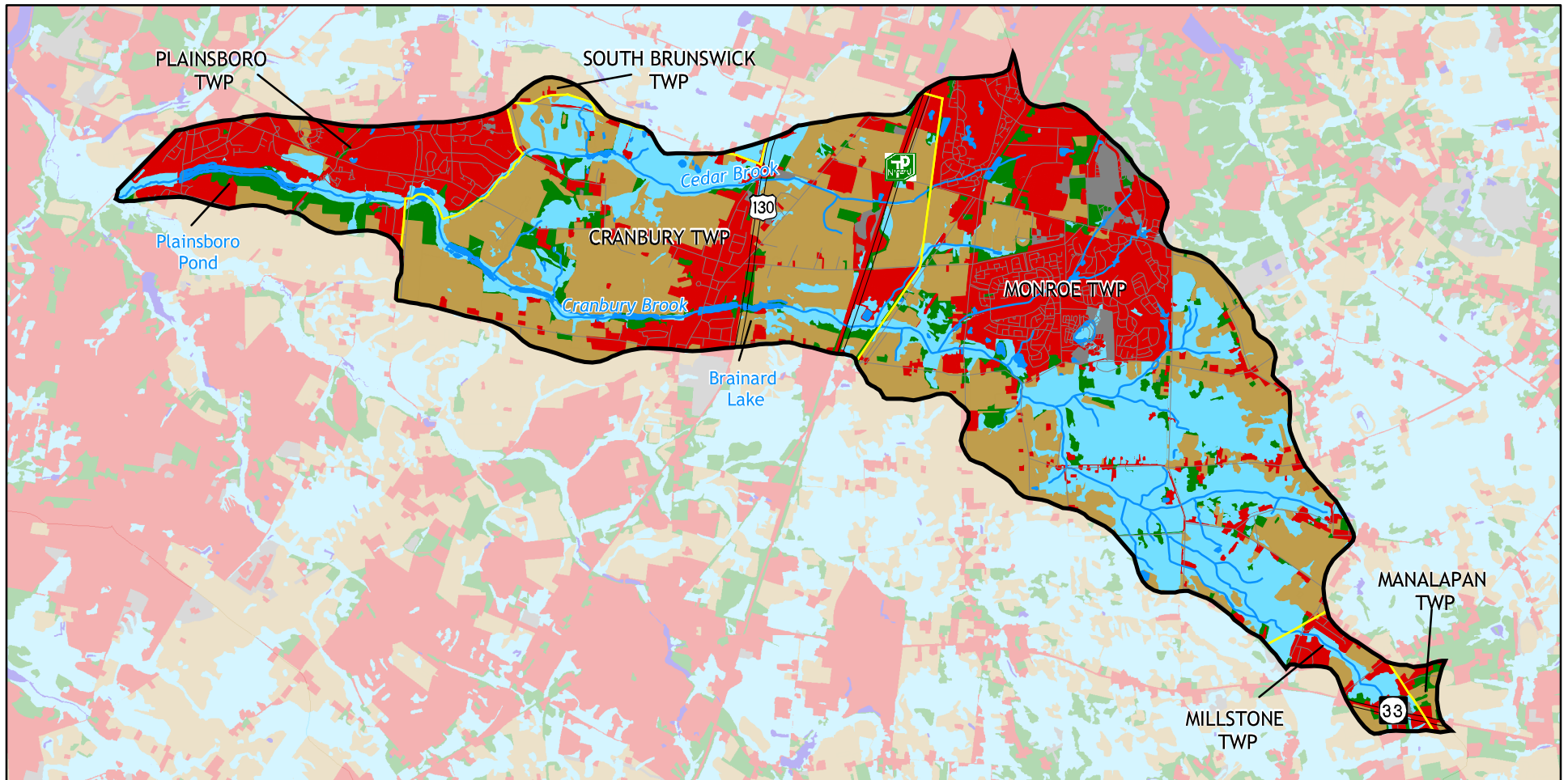
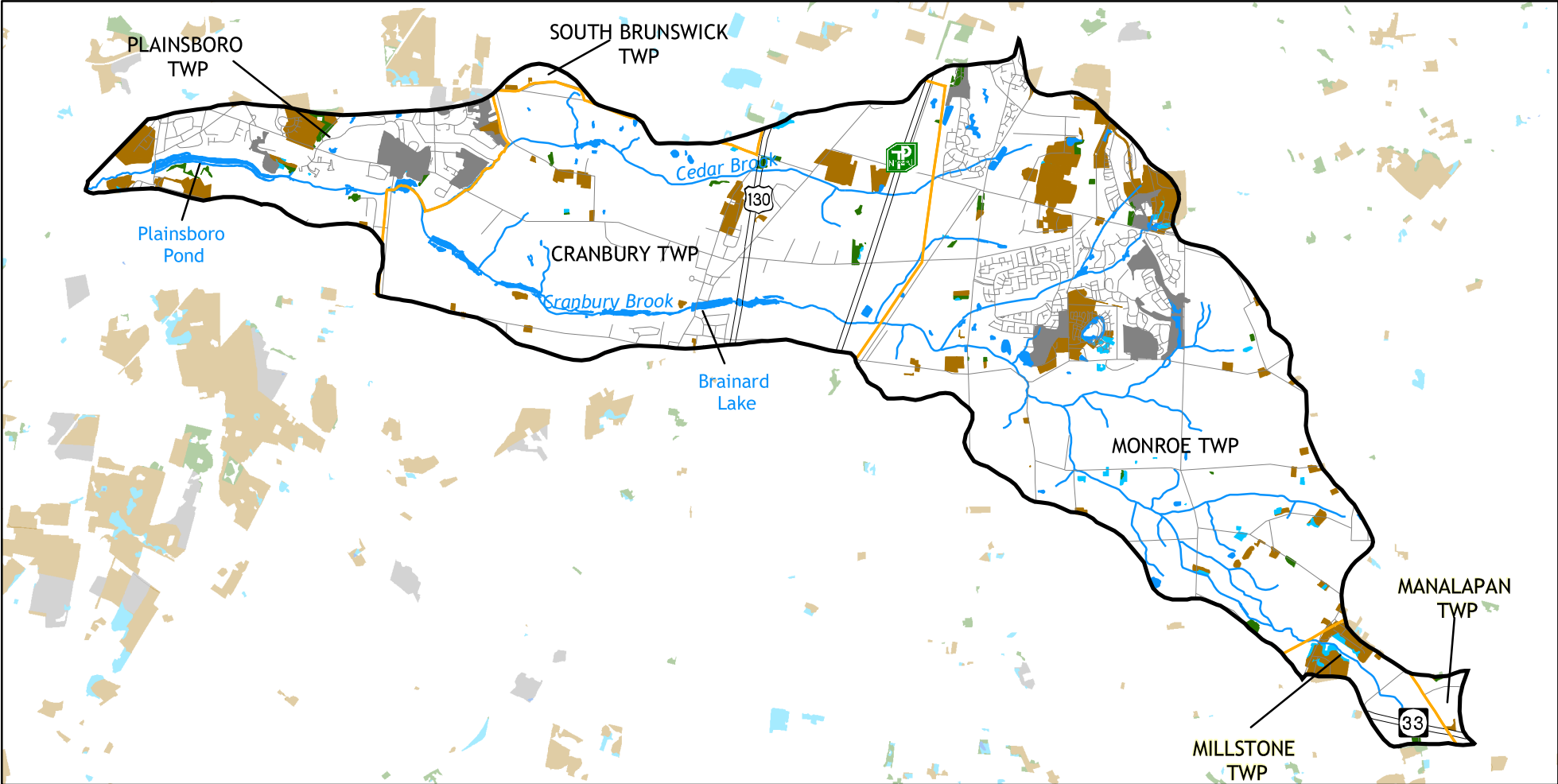


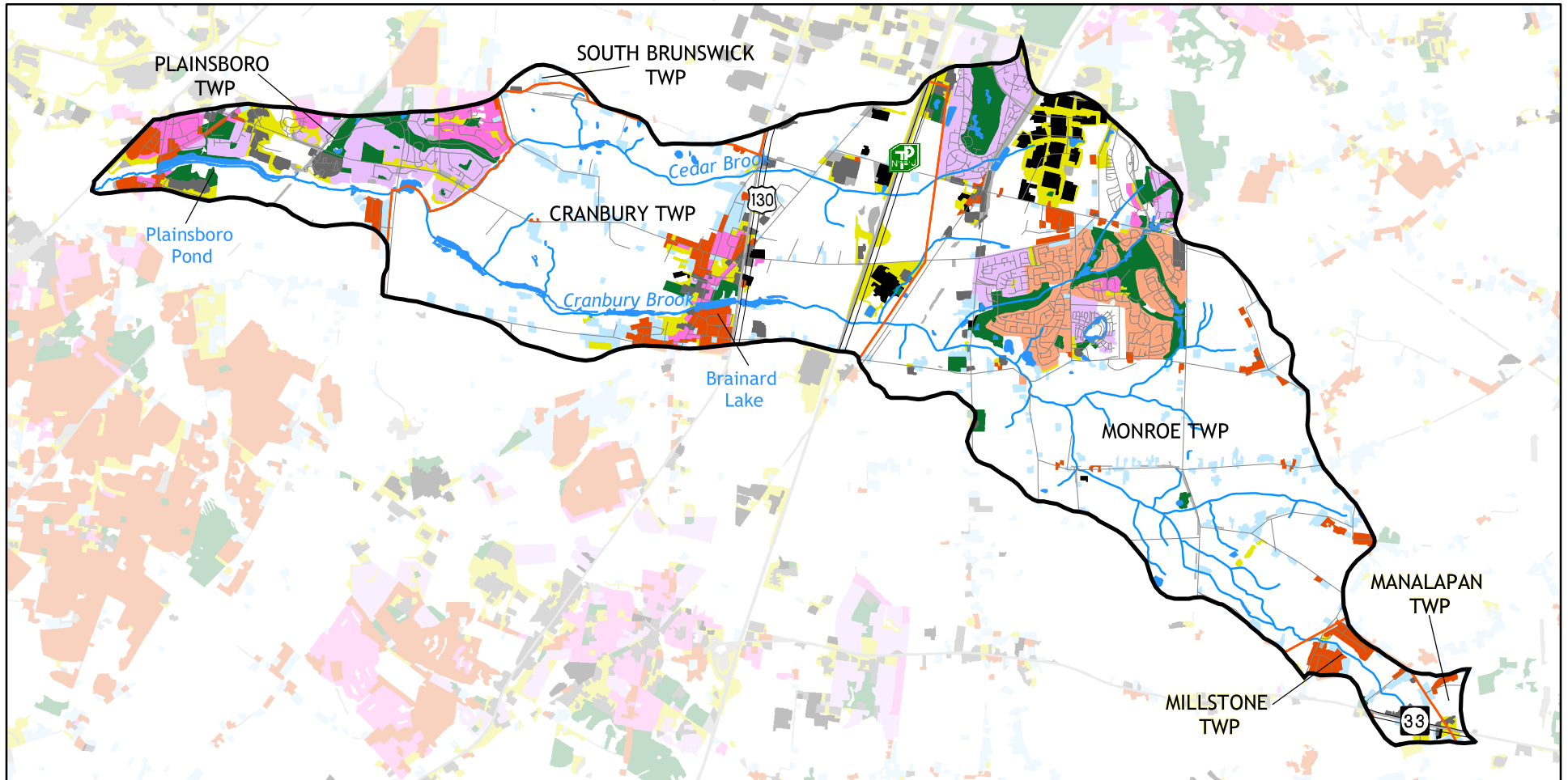
Figure 13: Land Use Changed to Urban/Developed Between 1986 and 1995/97 in Cranbury Brook Watershed



<ul style="list-style-type: none"> Major Roads Roads Municipal Boundaries Streams Lakes 	<p>1986 Land Use</p> <ul style="list-style-type: none"> Agriculture Barren Land Forest Water Wetlands
---	--

P. Sankalia, A. Rowan 7/04 - 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 14: Urban/Developed Land Use (1995/97) in Cranbury Brook Watershed

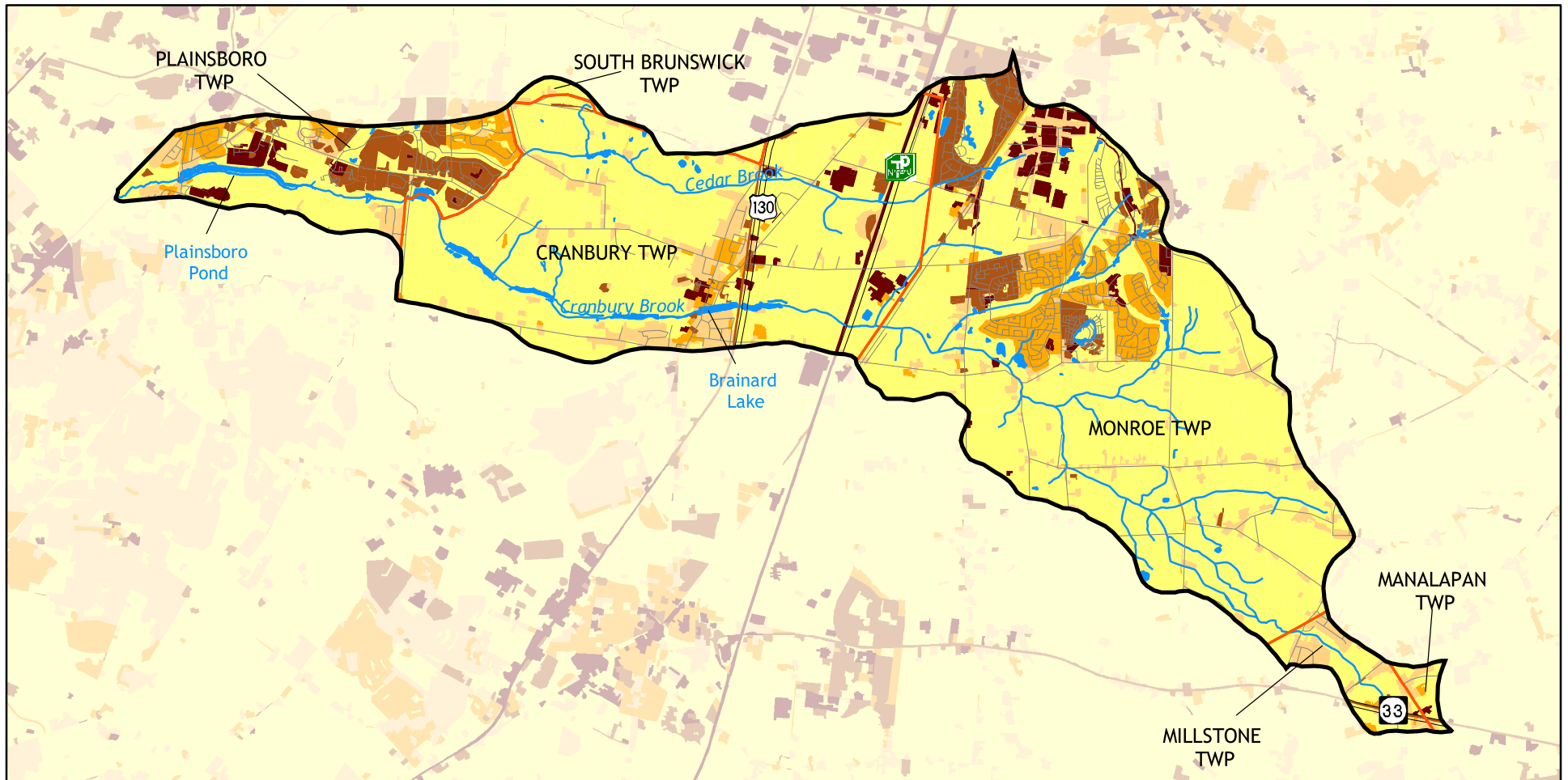












Major Roads	Industrial
Roads	Transportation/Communications
Municipal Boundaries	Mixed Urban or Built-Up Land
Streams	Mixed Residential
Lakes	Residential, High Density, Multiple Dwelling
Athletic Fields/Rec Land	Residential, Rural, Single Unit
Commercial/Services	Residential, Low Density, Single Unit
	Residential, Med Density, Single Unit


0 0.5 1 2 Miles

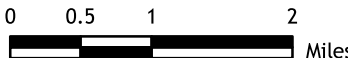
P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.



Figure 15: Impervious Surfaces (1995/97) in Cranbury Brook Watershed



 Major Roads	% Impervious Surfaces
 Roads	 0 - 5
 Municipal Boundaries	 6 - 25
 Streams	 26 - 50
 Lakes	 51 - 75
	 76 - 100

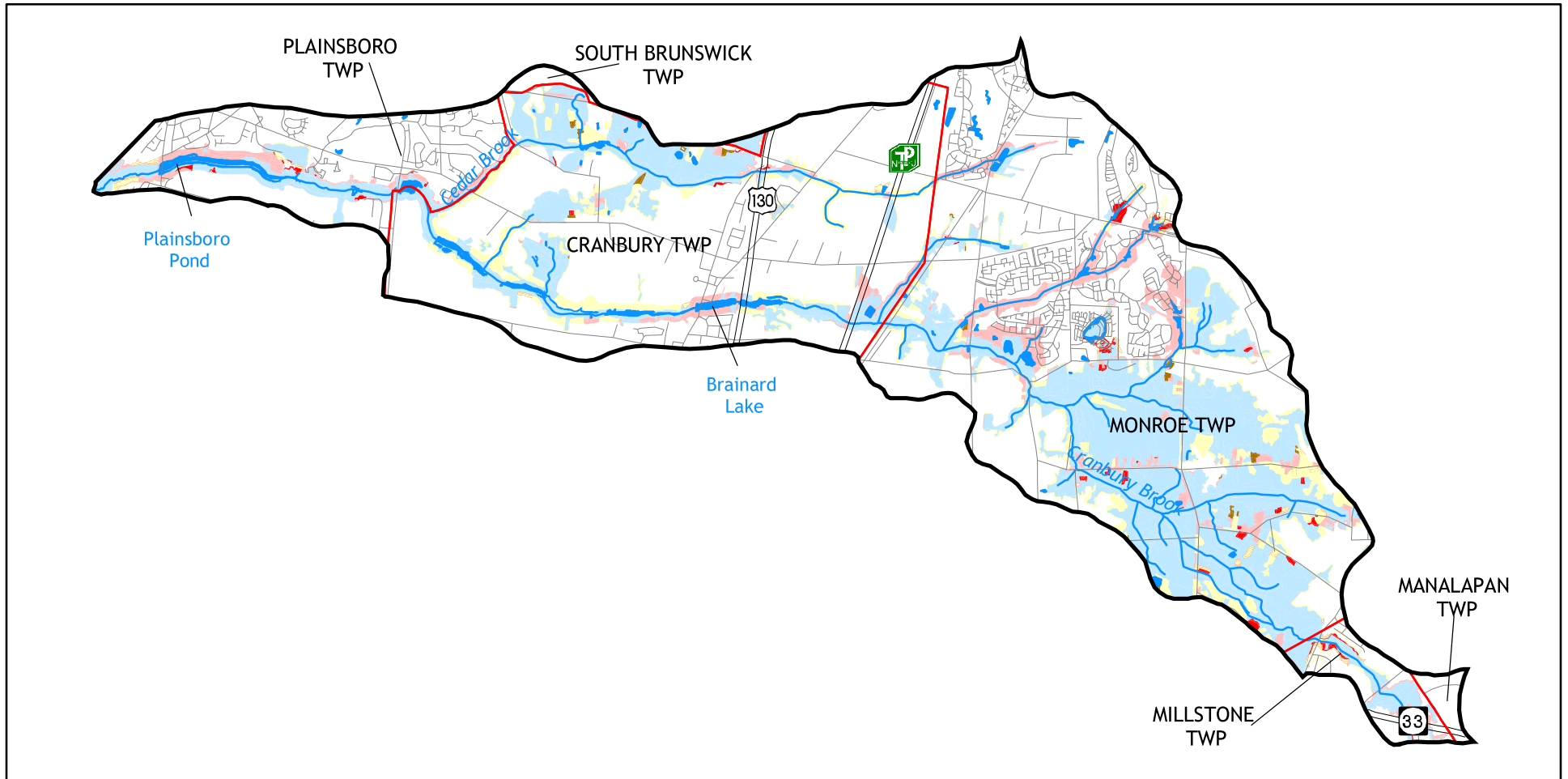


















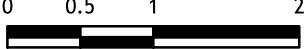
P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.



Figure 16: Riparian Land Cover Conversion in Cranbury Brook Watershed



 Municipal Boundaries	Riparian Areas
 Major Roads	 Agricultural Development before 1986
 Roads	 Agricultural Development 1986 to 1995/97
 Lakes	 Urban Development before 1986
 Streams	 Urban Development 1986 to 1995/97
	 Remaining Riparian Area

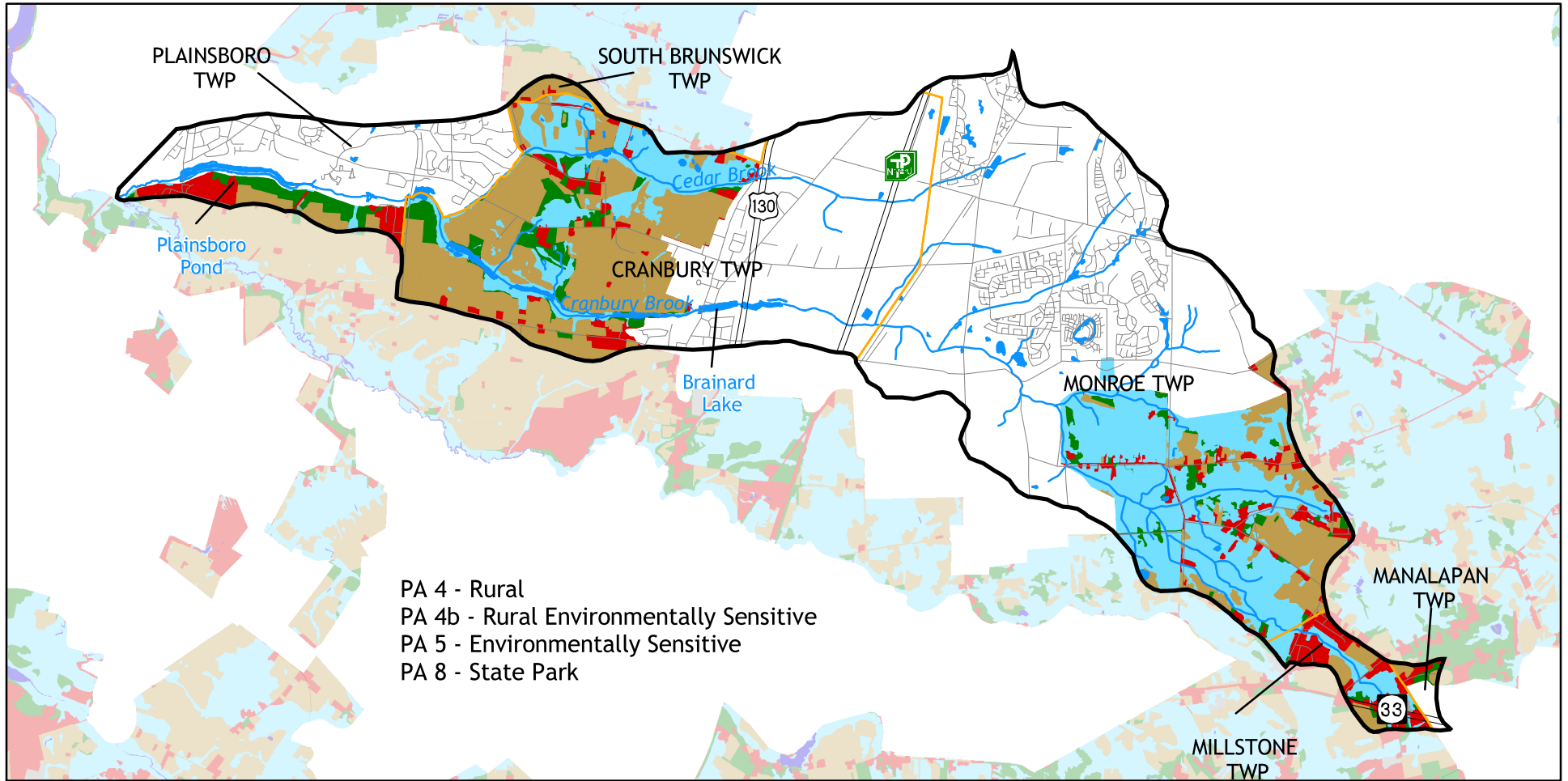




P. Sankalia, A. Rowan 7/04 - Data Sources: New Jersey Department of Environmental Protection, Raritan Basin Watershed Management Project. This secondary map product has not been verified or authorized by those agencies.

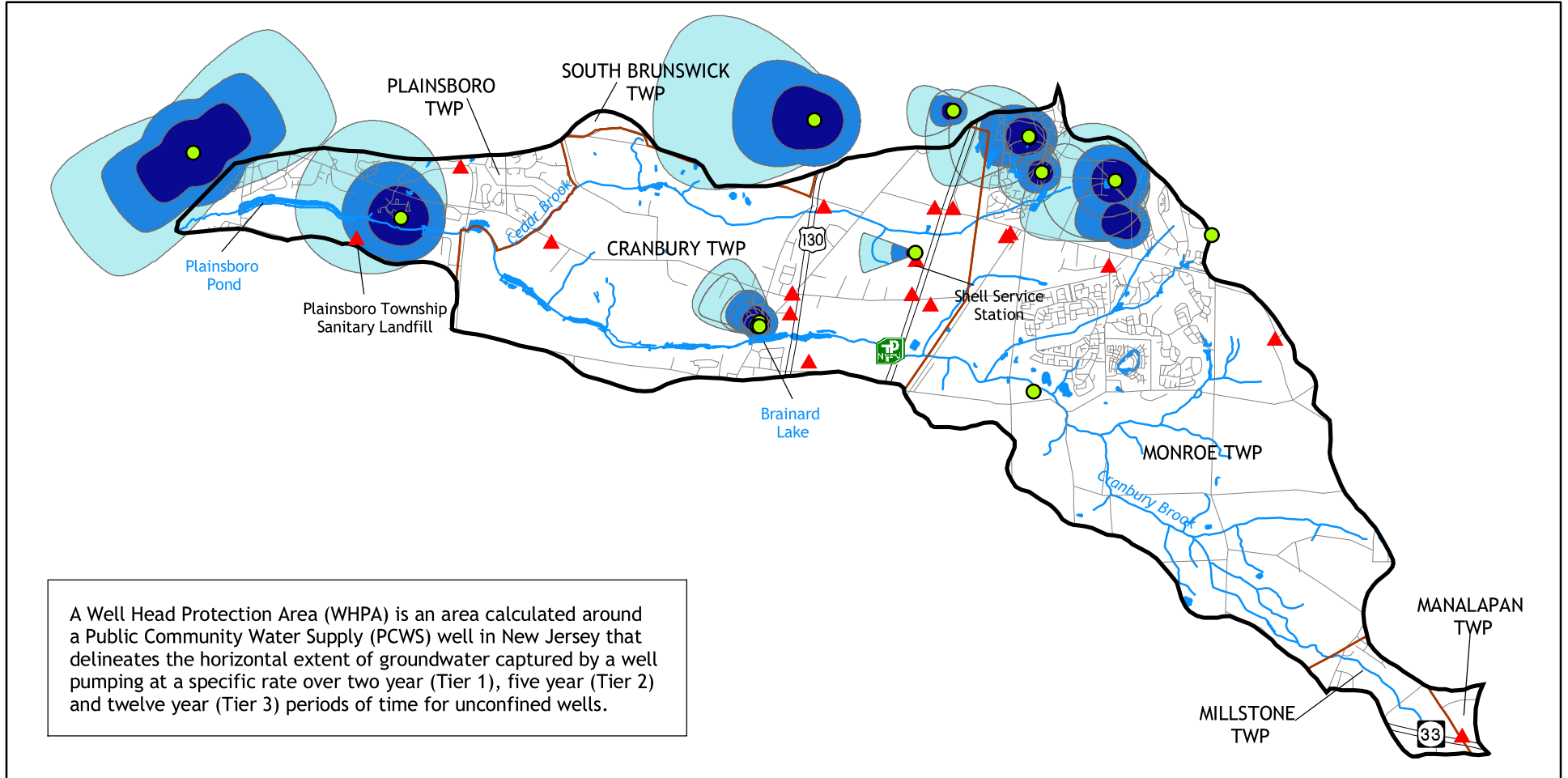
Figure 17: Land Use (1995/97) in State Planning Areas PA 4, 4b, 5 & 8 in Cranbury Brook Watershed



<ul style="list-style-type: none"> Major Roads Roads Municipal Boundaries Streams Lakes 	<p>Land Use</p> <ul style="list-style-type: none"> Agriculture Barren Land Forest Urban/Developed Water Wetlands 			
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P. Sankalia, A. Rowan 7/04 - Data Sources: New Jersey Department of Environmental Protection, NJ Office of Smart Growth, US Census Bureau. This secondary map product has not been verified or authorized by those agencies.

Figure 18: Community Water Supply Well Head Protection Areas in Cranbury Brook Watershed

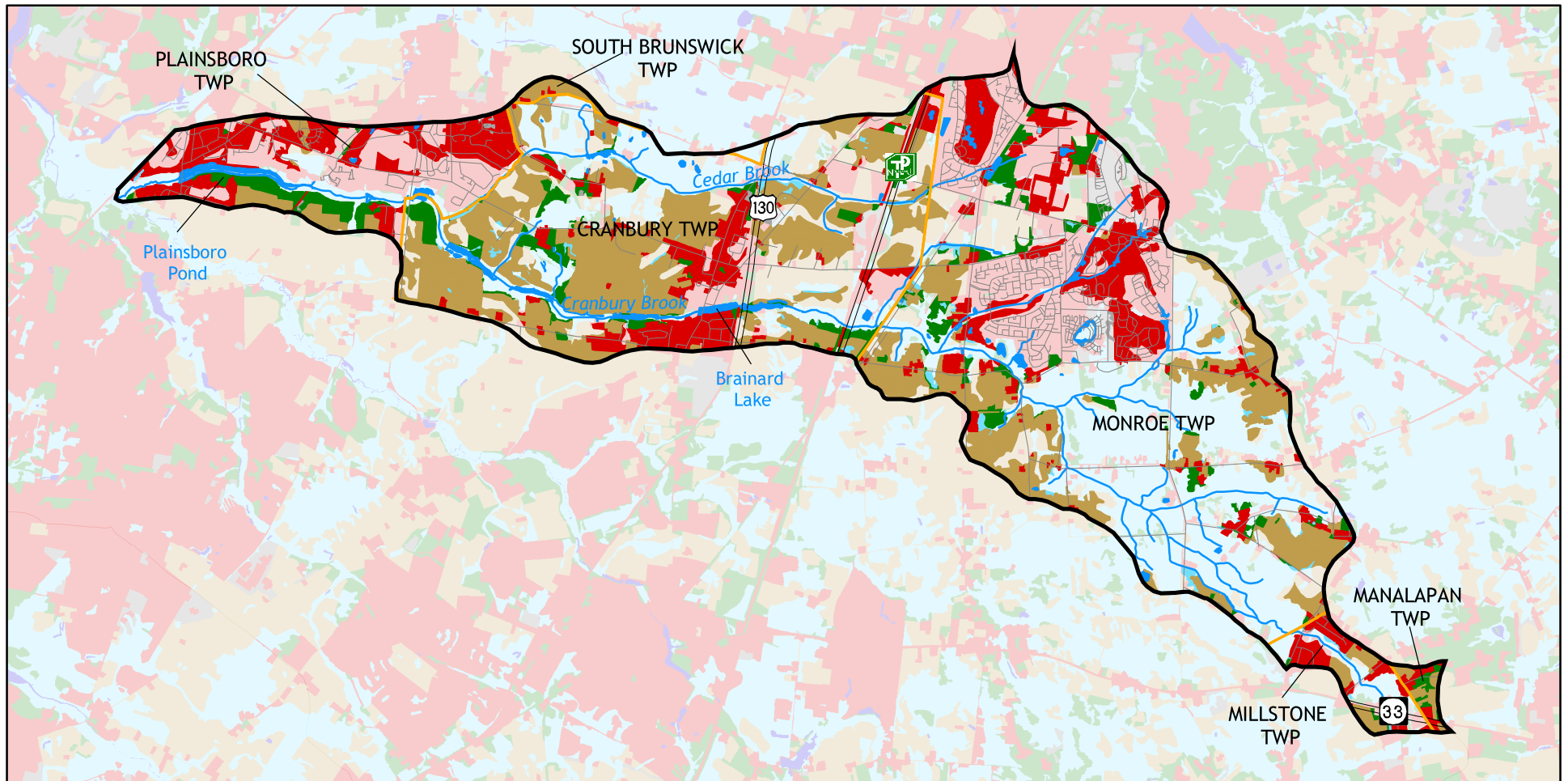











	Public Wells		Lakes
	Known Contaminated Sites		Tier 1 (2 Years)
	Municipal Boundaries		Tier 2 (5 Years)
	Major Roads		Tier 3 (12 Years)
	Roads		
	Streams		

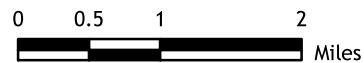
0 0.5 1 2 Miles

P. Sankatia, A. Rowan 7/04 - Data Source: New Jersey Geological Society and 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 19: Land Use (1995/97) in Areas of High Ground Water Recharge in Cranbury Brook Watershed



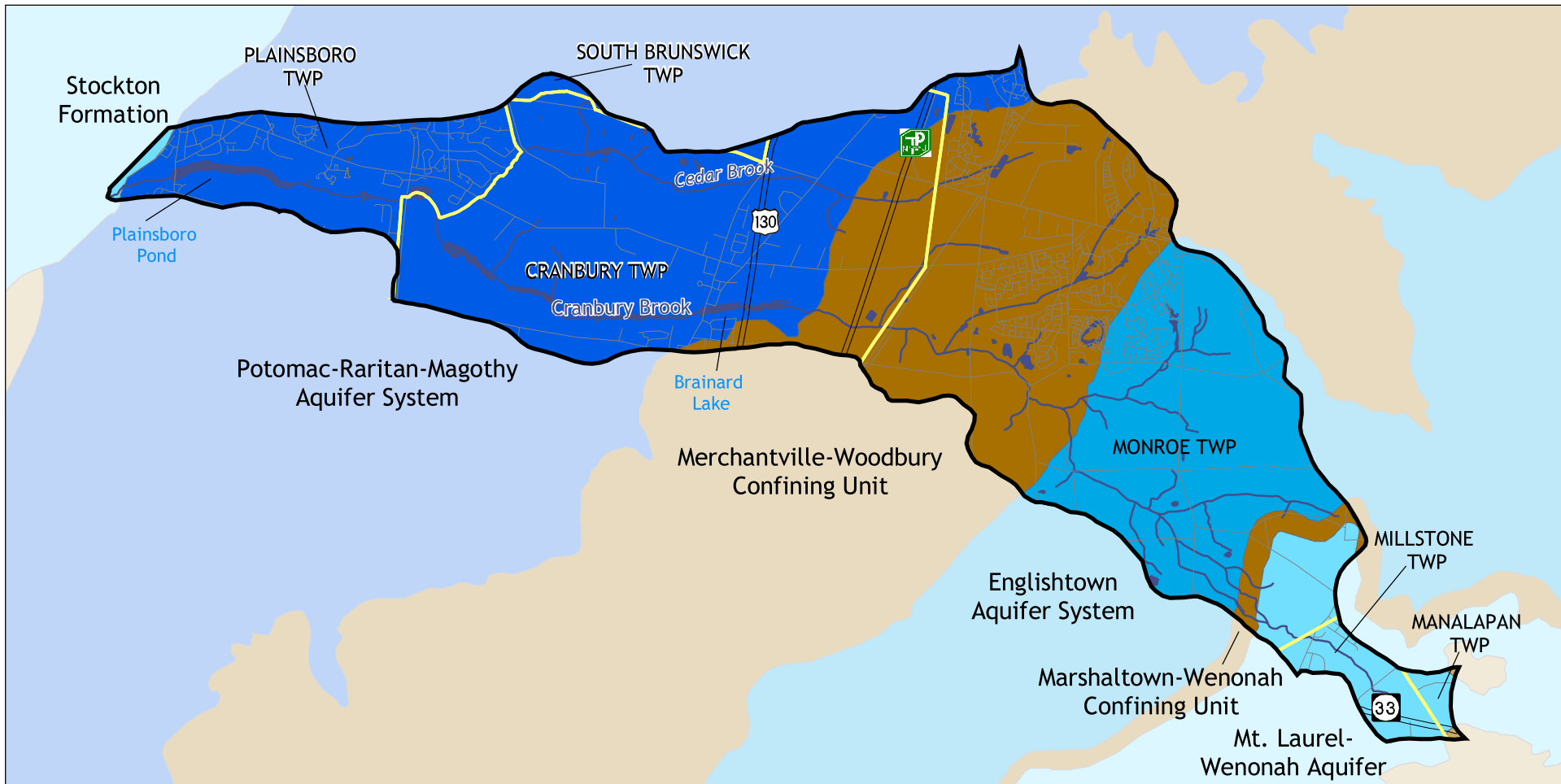
- | | |
|--|---|
|  Major Roads |  Agriculture |
|  Roads |  Barren Land |
|  Municipal Boundaries |  Forest |
|  Lakes |  Urban/Developed |
|  Streams |  Water |
| |  Wetlands |








"High" recharge defined as 10 in/yr or more.

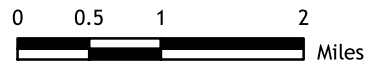
P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 20: Aquifers of Cranbury Brook Watershed



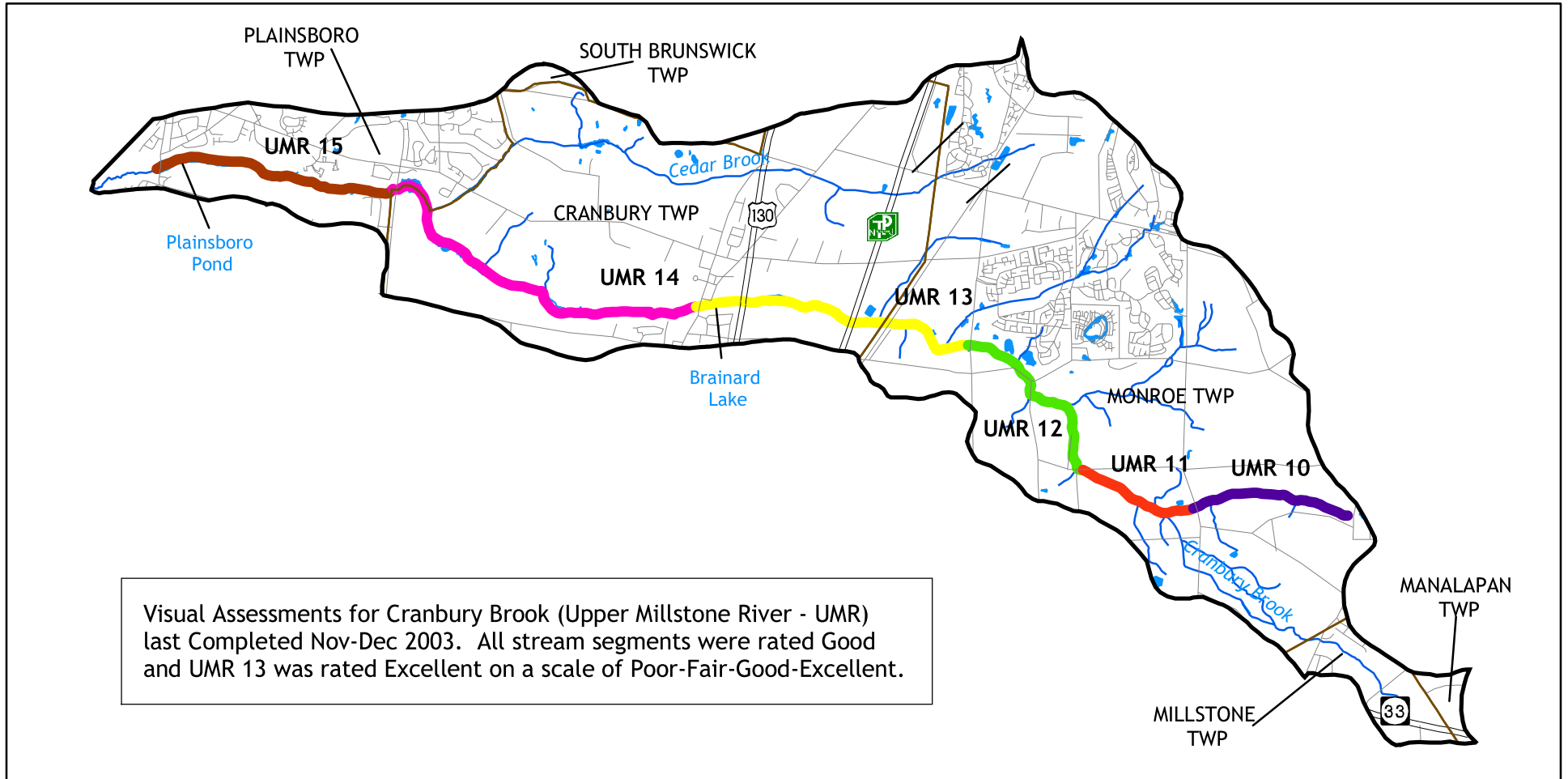
-  Municipal Boundaries
-  Major Roads
-  Roads
-  Streams
-  Lakes







- Aquifer Rank: Average Yield of High Capacity Wells**
-  A: >500 gal/min
 -  B: 250-500 gal/min
 -  C: 100-250 gal/min
 -  D: 25-100 gal/min
 -  E: <25 gal/min





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



Figure 21: Visual Assessment Stream Segments in Cranbury Brook Watershed



	Municipal Boundaries	
	Major Roads	
	Roads	
	Streams	
	Lakes	

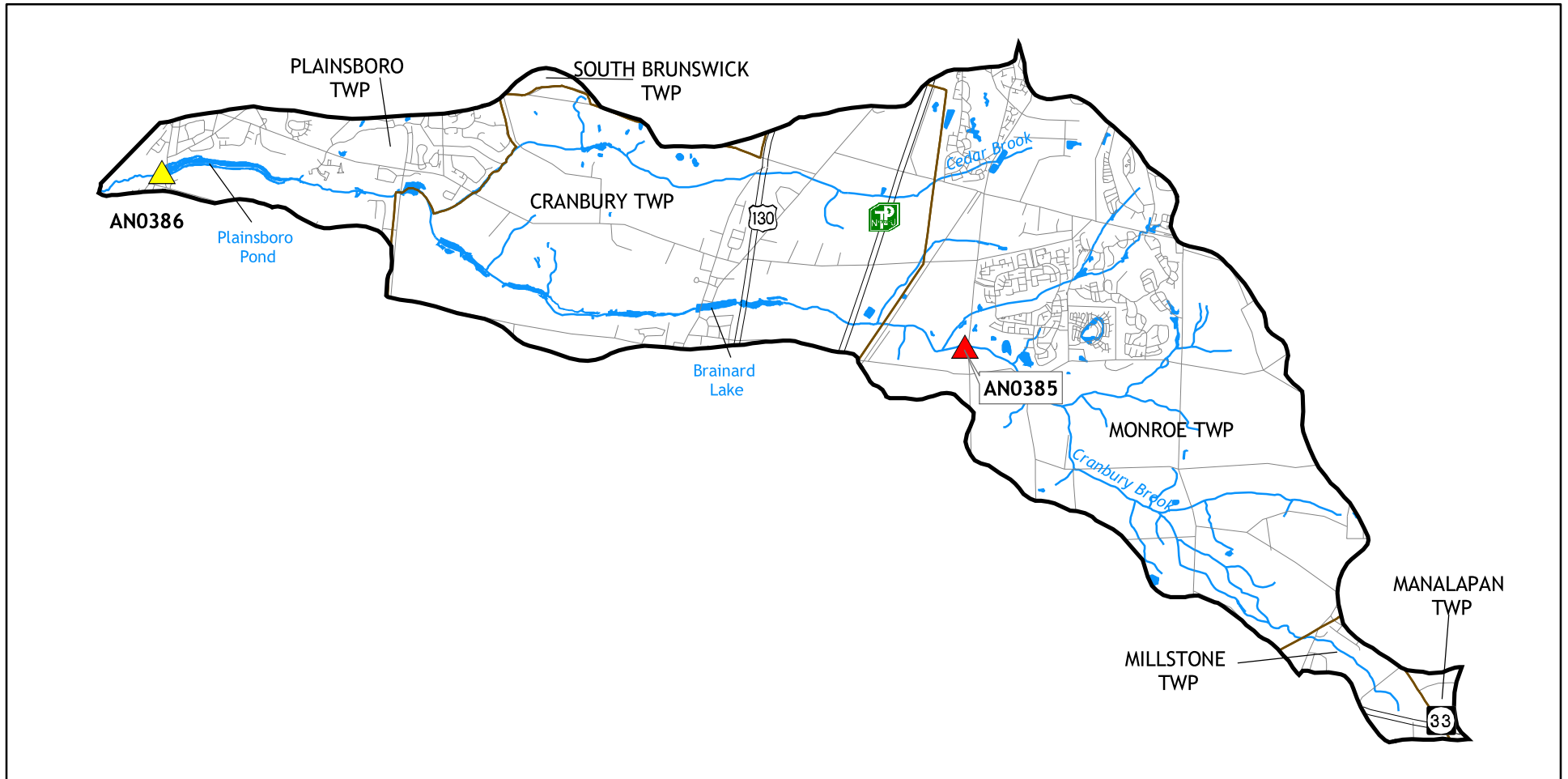











P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

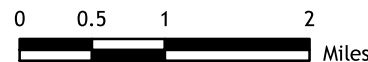
Figure 22: AMNET Sites in Cranbury Brook Watershed



-  Municipal Boundaries
-  Major Roads
-  Roads
-  Lakes
-  Streams

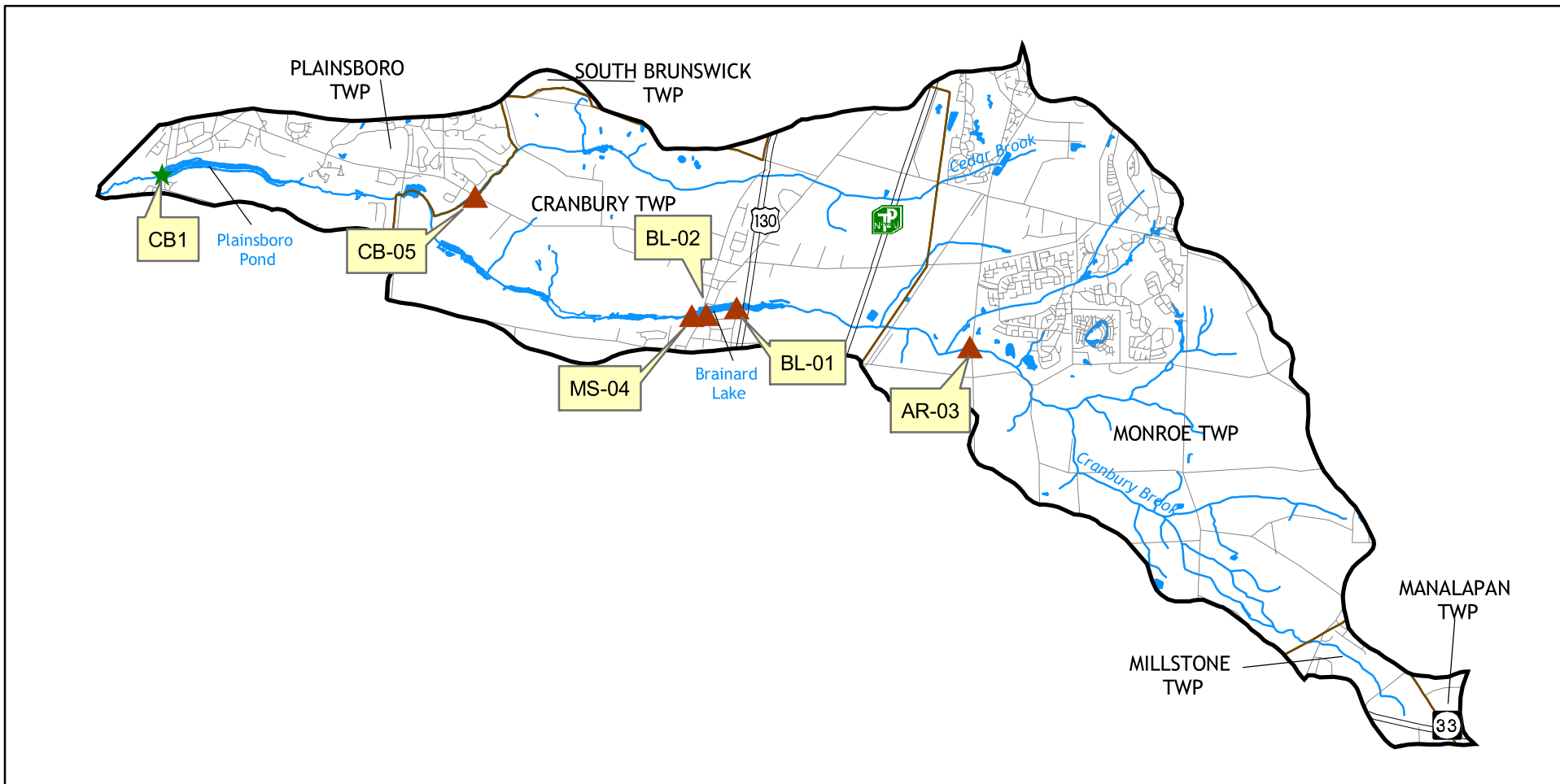
Site Impairment
Sampling - 1st Round, 2nd Round








-  Moderate, No Sample
-  Moderate, Severe




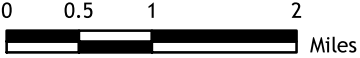
P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.



Figure 23: Chemical Monitoring Sites in Cranbury Brook Watershed



	Municipal Boundaries		SBMWA CAT Site
	Major Roads		Cranbury Twp EC Sites
	Roads		
	Lakes		
	Streams		

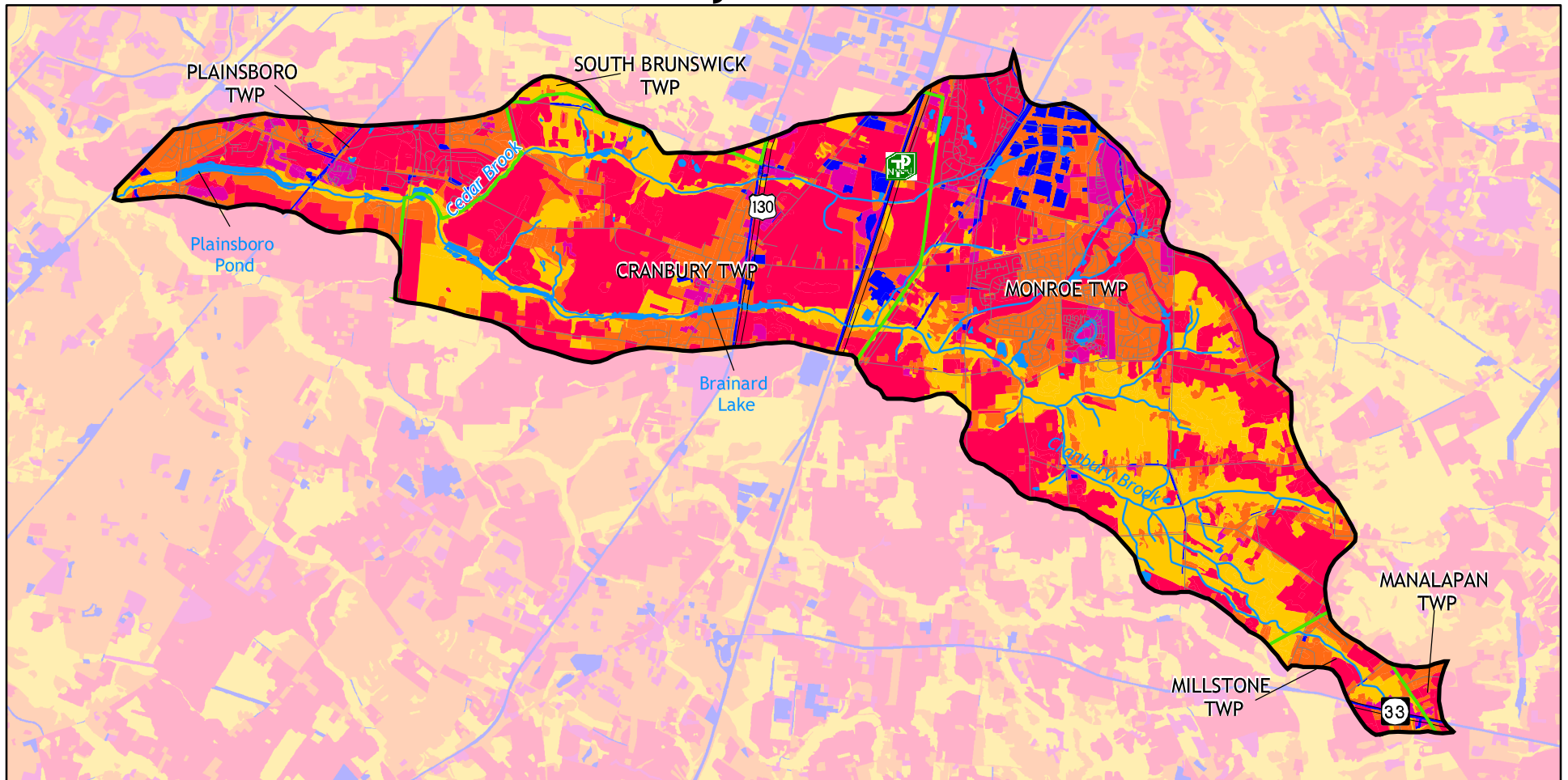




P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

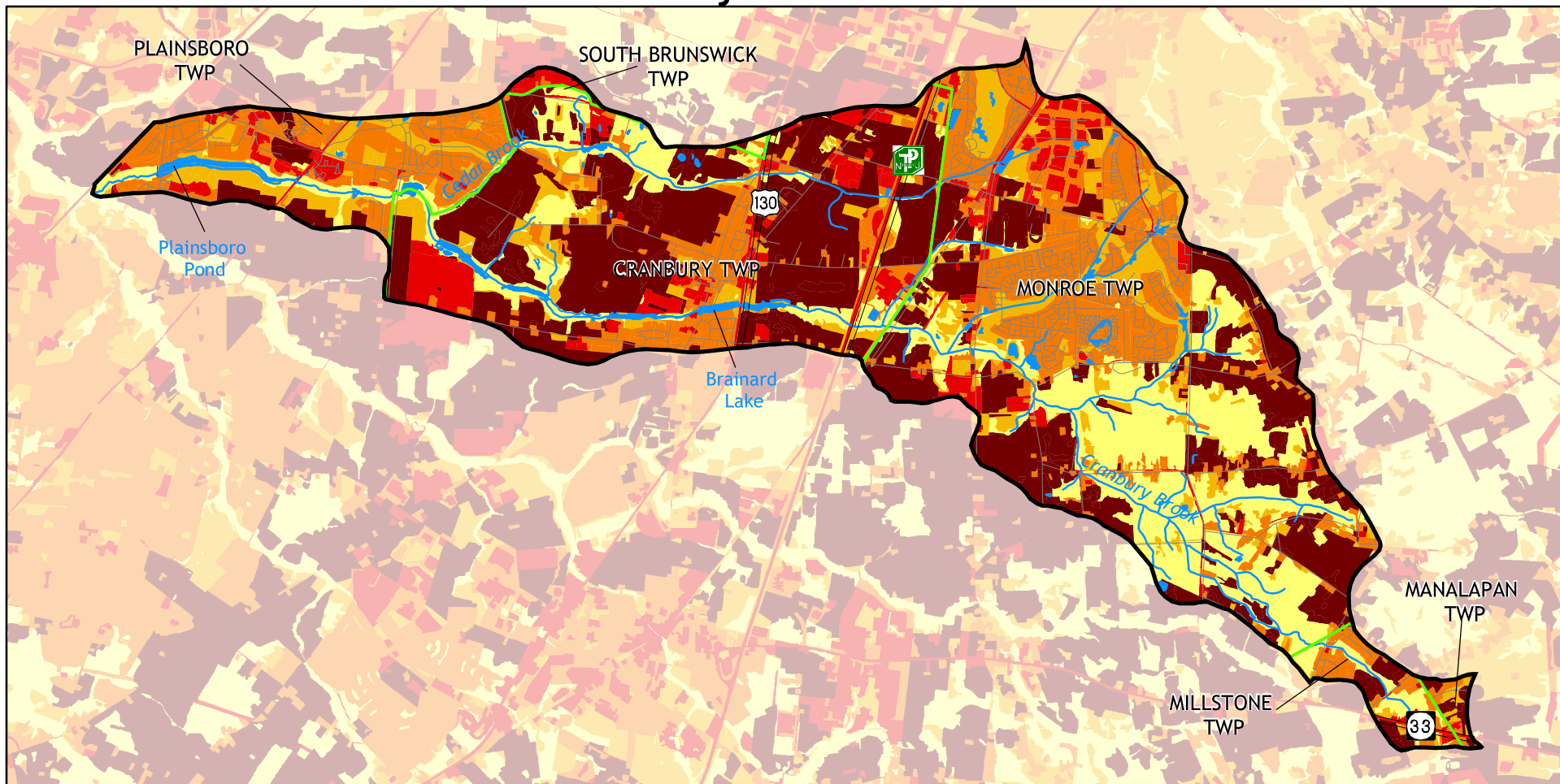
Figure 24: Nonpoint-Source Nitrogen Loadings in Cranbury Brook Watershed



	Major Roads	Nitrogen Loadings
	Roads	lb/acre/year
	Municipal Boundaries	0.000
	Streams	0.001 - 1.619
	lakes	1.620 - 3.035
		3.036 - 4.047
		4.048 - 5.585

P. Sankatia, A. Rowan 7/04 - 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.

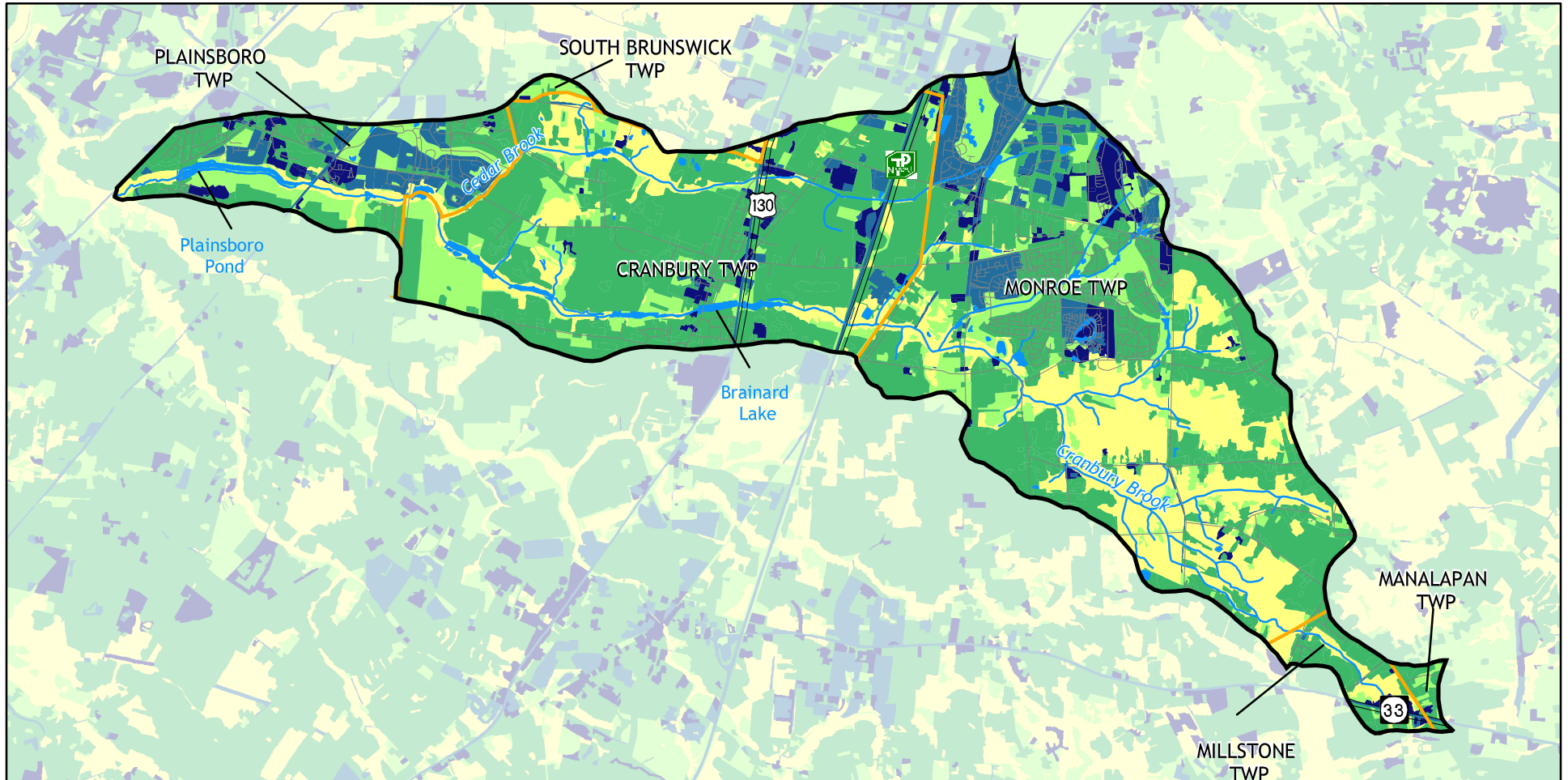
Figure 25: Nonpoint-Source Phosphorous Loadings in Cranbury Brook Watershed














	Major Roads	Phosphorous Loadings lb/acre/year	
	Roads		
	Municipal Boundaries		-0.101 - 0.000
	Streams		0.001 - 0.121
	Lakes		0.122 - 0.324
			0.325 - 1.214
			1.215 - 1.821

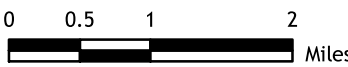
P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.



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



 Major Roads	Total Suspended Sediments lb/acre/year
 Roads	
 Municipal Boundaries	 -80.9 - 0.0
 Lakes	 0.1 - 202.3
 Streams	 202.4 - 404.7
	 404.8 - 809.4
	 809.5 - 1618.8

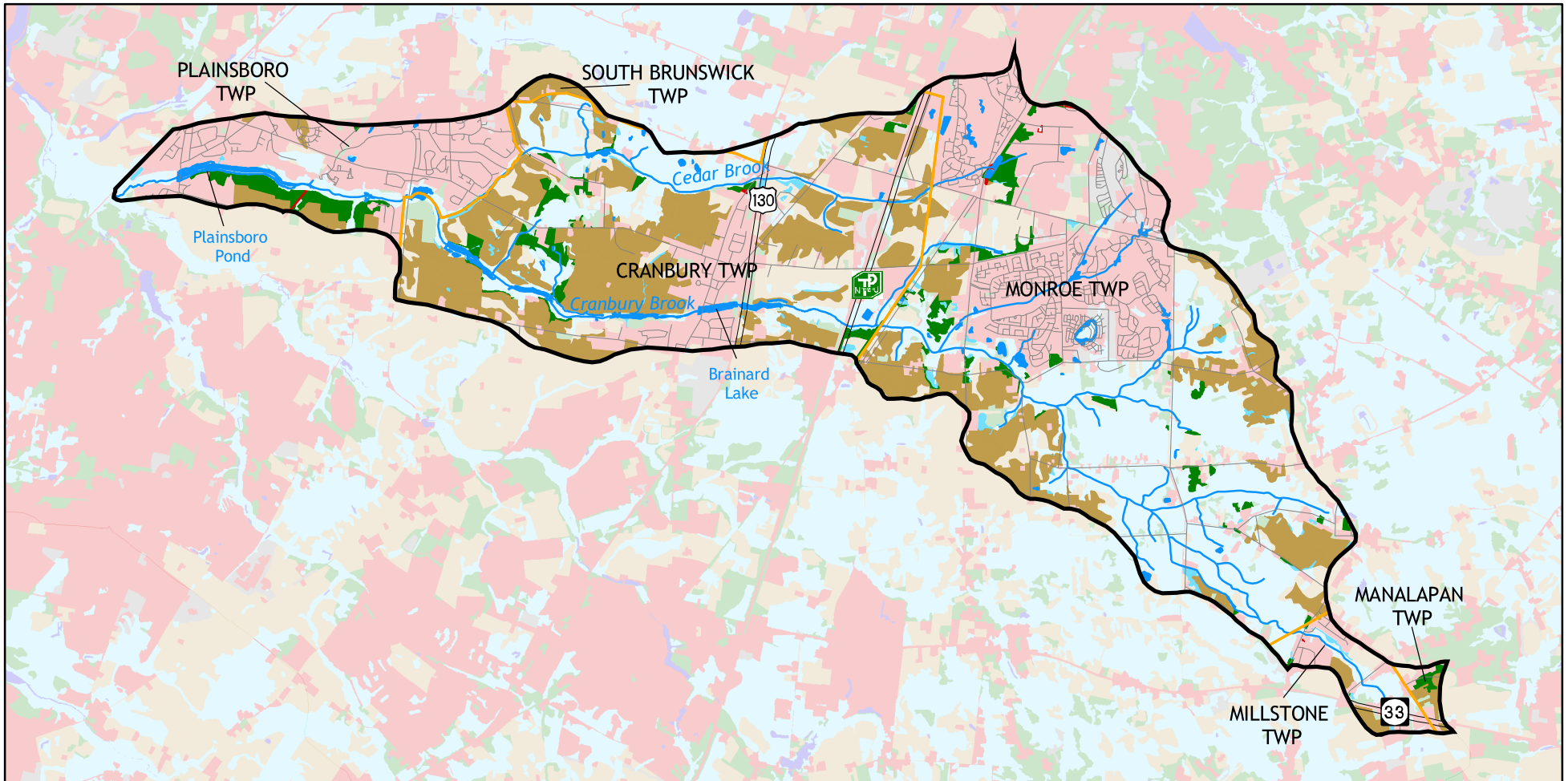




P. Sankalia, A. Rowan 7/04 - Data Source: New Jersey Department of Environmental Protection. Although NJDEP data was used, this secondary map product has not been verified or authorized by the state.

Figure 27: Land Use (1995/97) in Areas with Critical Habitats and High Ground Water Recharge in Cranbury Brook Watershed

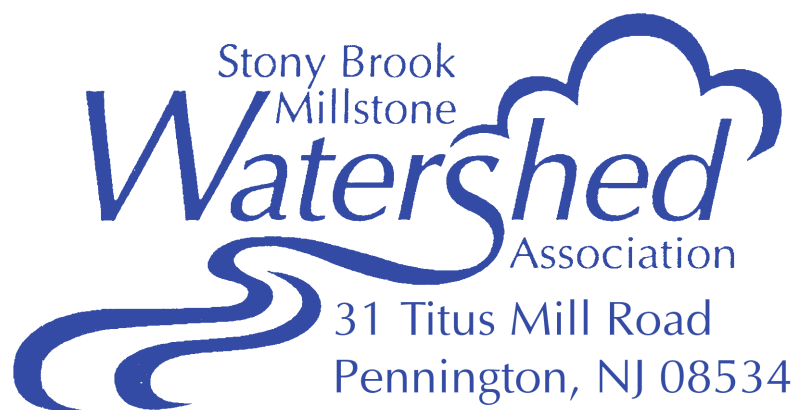


Major Roads	Agriculture
Roads	Barren Land
Municipal Boundaries	Forest
Streams	Urban/Developed
Lakes	Wetlands

0 0.5 1 2 Miles

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

 P. Sankalia, A. Rowan 7/04 - 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.



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