CHARACTERIZATION AND ASSESSMENT OF THE BEDEN BROOK WATERSHED

Stony Brook Millstone Watershed Association

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INTRODUCTION

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 frontlines of the battle to stop sprawl as development threatens to destroy our remaining open space. The consequences are clear: development is degrading our natural resources, putting the region's water quality and quantity at risk. Levels of nitrates, phosphates and fecal coliform bacteria are elevated in many of our waterways and our macroinvertebrate populations are showing signs of distress and lack of diversity due to exposure to high levels of pollutants. Roadways and traffic congestion are eroding our sense of place and community.

The streams of the 265-square-mile Stony Brook-Millstone Watershed (hereinafter 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. 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. During the years since 1995/97, the area has continued to experience extensive development.

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 and quantity of the streams.

In the mid-1990's, NJDEP recognized that to address water quality and quantity issues, regulating point-source pollution, or pollution from a discrete source, alone was not adequate. Nonpoint-source pollution from lawns, agricultural fields, roads and poorly managed land is a major stress on our streams, rivers and lakes. Emulating programs elsewhere in the United States, NJDEP adopted watershed management, a more holistic approach to protecting our natural resources. In partnership with local stakeholders, NJDEP has initiated this watershed-based planning process throughout the state. The 1,100-square mile Raritan River Basin is one area where this process has begun, and the Millstone Watershed is part of this larger basin. However, that project will not be completed until 2004.

Because of the time frame for the Raritan Basin Project and the large size of both the Raritan Basin and the Millstone Watershed, the Stony Brook-Millstone Watershed Association (SBMWA) wanted to initiate a project that provided a quicker link from sound characterization and assessment of natural conditions to the implementation of projects that can restore and enhance the natural environment. Research indicates that the most effective management efforts are generally confined to subwatersheds on the order of 20-50 square miles (Center for Watershed Protection, 1998). Such a localized approach allows personal contact with the community and fosters building relationships and trust. Most successful programs changing personal behavior have also cited one-to-one relationships as the key to success. Thus, this project was developed to address problems specific to a smaller subwatershed within the Millstone Watershed. Our approach is straightforward.

1. ***Select an appropriate subwatershed.*** Subwatersheds are chosen based on size and impairment. The area can be no larger than 50 square miles and we first target those subwatersheds within the larger Millstone Watershed that show some form of impairment. Thus, we began with Beden Brook and will follow with Rocky Brook. SBMWA plans to do this project for all the subwatersheds within our 265 square mile watershed.
2. ***Understand the subwatershed.*** In order to understand the causes of the problems and identify appropriate solutions, a characterization and assessment report of the impaired subwatershed is prepared. This report identifies the current status of the environment (characterize) and compares this to community goals and adopted standards in New Jersey (assess). Information is collected on soil types, geology, land use changes, water quality, rare and/or endangered species, critical habitats and population changes.
3. ***Analyze the data.*** The information obtained from the characterization and assessment is analyzed individually and then integrated with other data from the watershed to pinpoint the potential causes of the water quality problems.
4. ***Select appropriate restoration techniques.*** Once the subwatershed is identified and evaluated, working with our partners, SBMWA selected the most effective watershed management tools to restore, enhance or protect water quality. For example, if nonpoint-source pollution from residential lawns or golf courses is identified as a concern, the focus should be on implementing education programs for homeowners and golf courses in these areas, rather than for agriculture or businesses. 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. The Watershed Association, with 52 years of experience in water quality protection, has a large arsenal of tools that have been utilized successfully in the past:
    - Extensive experience in education working with both adults and children;
    - Streambank restoration, riparian buffer creation and reforestation;
    - Working with the North Jersey Resource Conservation and Development Council to assist farmers in implementing agricultural Best Management Practices (BMPs);
    - River Friendly Programs: one-on-one education of residents, businesses, golf courses, schools and municipalities on BMPs for their property;
    - StreamWatch: our successful, long-term water quality monitoring program;
    - Municipal assessments: working with municipalities to integrate the vision for the municipality into their zoning and ordinances; and
    - Open space acquisition planning.
5. ***Evaluate Progress.*** As this project moves forward, SBMWA will evaluate progress and update methodologies to ensure that new data is incorporated into future characterization and assessment reports. Projects implemented to improve environmental health will be monitored to follow progress and success.

The Beden Brook Watershed was the first subwatershed chosen to undergo scrutiny. It is approximately 50 square miles, at the upper range of our size requirement for this project, and is identified by NJDEP as impaired in several places. This Characterization and Assessment Report is the result of our investigation. Figure 1 places this Watershed within the context of both the larger Millstone Watershed and the state of New Jersey. This Report brings together information and scrutinizes the data to provide an understanding of why water quality in some areas is impaired. As the SBMWA has done for many years, we will work with residents, municipal officials and businesses to implement the best strategies for responding to the causes of the impairment and improving environmental quality.

For this report, we will refer to the entire Beden Brook area as a Watershed. We will refer to drainage areas within Beden Brook, including Pike Run, Beden Brook, Cruser Brook and Rock Brook, as subwatersheds.

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

SBMWA is not alone in their 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 the solution, like recycling, involves everyone – our elected officials, business leaders, golf course superintendents, and each resident. This report summarizes the causes of the problem and outlines recommendations for solutions. It is up to everyone who lives, works and plays in the Beden Brook Watershed to work together to provide a vision for this area and strive to protect the environment and quality of life that we value.

LANDSCAPE

The Beden Brook Watershed has many features that influence the natural resources and diversity of flora and fauna found there. These areas need to be preserved and improved in order maintain the character of this watershed.

TOPOGRAPHY

The Beden Brook Watershed covers over 31,800 acres (approximately 50 square miles) that lie in part or all of Hopewell Township, Hopewell Borough, and Princeton Township (all in Mercer County), Montgomery Township, Hillsborough Township, and Rocky Hill Borough (all in Somerset County), and East Amwell Township (Hunterdon County) (Figure 2). Within the Watershed, 58% of the area lies within Montgomery Township, 20% within Hillsborough Township, and Hopewell Borough and Township together make up over 15% (Table 1).

Zion Road and Hillsborough Road, both in Hillsborough, approximate the northern boundary of the Watershed. The southern boundary falls slightly south of Cherry Valley Road in Princeton. The western border is in Hopewell Township (west of Hopewell Borough) and East Amwell. The eastern boundary is at the confluence of Beden Brook with the Millstone River.

Streams in the Watershed include Cruser Brook, Pike Run, Rock Brook, Roaring Brook, Back Brook and Beden Brook as well as many smaller unnamed tributaries. Beden Brook, approximately 10 miles long, originates near Hopewell Borough and crosses the southern half of Montgomery

Township to its confluence with the Millstone River north of Rocky Hill Borough. Many tributaries to the Beden Brook, including Pike Run, Cruser Brook, and Rock Brook, originate in the Sourland Mountains. Cruser Brook flows east to its confluence with Pike Run. Pike Run and Rock Brook both flow south and east to their confluence with Beden Brook. Beden Brook flows south and east, draining the northern slopes of Mount Rose and southeastern slopes of the Sourland Mountains and Pheasant Hill (Coastal Environmental Services Inc., 1995).

A major physiographic feature within the northwest section of the Beden Brook Watershed is a portion of the Sourland Mountains range (Figure 2). The Sourland Mountains cover a total area of 60 square miles and rise 568 feet above sea level (Lord, 1999). Since much of this area is covered with forests and remains largely undeveloped, groups are working to preserve the Sourlands as open space accessible for recreation. The Sourland Mountains contain the headwaters of many tributaries of Beden Brook, including Back Brook, Roaring Brook, and Pike Run (Figure 2). It is important that these areas are preserved, because previous studies have shown that the headwaters of rivers are exceptionally vulnerable to watershed changes (USGS, 1998b). If development is concentrated in headwaters, impacts are greater than if the development is located downstream and headwaters are preserved. At least two factors are involved here. First, headwater areas have much lower stream flows. Thus, pollutant and stormwater impacts are magnified because of the limited dilution and carrying capacity of headwaters. Second, streams with degraded headwaters seem slower to recover from degradation than streams with unstressed headwaters (May et. al., 1997).

Table 1: Municipalities within the Beden Brook Watershed.

Municipality	County	Acres	Percentage of Total
Montgomery Township	Somerset	18,592	58.4%
Hillsborough Township	Somerset	6,574	20.7%
Hopewell Township	Mercer	4,497	14.1%
East Amwell Township	Hunterdon	934	2.9%
Princeton Township	Mercer	749	2.4%
Hopewell Borough	Mercer	448	1.4%
Rocky Hill Borough	Somerset	17	0.1%
TOTAL		31,811	100%

GEOLOGY

Rock formations exert an influence on soils and therefore on vegetation and agriculture, drainage, water transportation, water supply, and types of land use. The native vegetation in most of the soils in the Beden Brook Watershed is woodland dominated by oaks, which has been cleared for agriculture. The soils of the Sourland Mountains, which can be rocky, have mixed hardwoods dominated by oak and hickory. Due to the variable resistance to erosion exhibited by the sedimentary rock formations in the Watershed, stream patterns and topography are controlled by outcrop patterns and the orientation of the underlying bedrock. Valleys are present in areas where fractured, readily eroded rocks are exposed at the surface, while ridges form in areas of more sparsely fractured, erosion-resistant rock formations. Streams in the larger valleys are generally aligned parallel to the strike of the bedrock formations, and are intersected by other streams and tributaries oriented parallel or sub-parallel to the dip direction. The dip-aligned streams may be associated with zones of bedrock fractures, which cut across the strike of bedding (USGS, 1995b).

Ground water flow is controlled in part by fractures concentrated along bedding in the dipping bedrock units. Bedding orientation affects flow paths to streams and the areas in which discharge to the streams occurs. As a result, dip-aligned streams, which cut across strike and intercept numerous bedding planes, tend to receive a greater quantity of ground water discharge than do strike-aligned streams, which intersect fewer bedding planes (Lewis, 1992).

Based on measurements made under low-flow conditions (i.e., following a period of little or no precipitation), stream discharge increases in the downstream direction for both Beden Brook and its tributary Rock Brook. Under low-flow conditions, therefore, Beden Brook and Rock Brook are gaining streams whose flow is sustained primarily by the discharge of ground water. This pattern was also observed at locations measured in adjacent drainage basins (USGS, 1993b).

The Beden Brook Watershed lies in the Piedmont Physiographic Province (Figure 3). Bedrock formations within the Piedmont are of Late Triassic and Early Jurassic age (230 to 190 million years old) and are part of the Newark Supergroup. Three formations of the Newark Supergroup are present within the Beden Brook Watershed: from oldest to youngest, the Stockton, Lockatong, and Passaic (part of the Brunswick Group) (Figure 3). In the area of the Beden Brook Watershed, they crop out as a northeast-striking belt of rocks, with a gentle northwesterly dip of about 15 degrees. The sequence of three outcropping sedimentary units (Stockton, Lockatong and Passaic) is disrupted in the northwestern portion of the Watershed, as a result of vertical displacement along the Hopewell Fault, which extends northeast through the area. In addition, later diabase rocks of Jurassic age cut through the sequence of sedimentary rocks within the Watershed (USGS, 1998a).

The Stockton Formation consists of red and gray thin-bedded to thick-bedded, very fine-grained to coarse-grained sandstone, siltstone, and shale. Within the Beden Brook Watershed, it is present in outcrop only as a wedge northwest of the Hopewell Fault (USGS, 1995b). The Stockton sandstone is a good building material and was a major source of the brownstone used in the construction of regional historic homes as well as urban row housing in metropolitan New York in the nineteenth century. Nassau Hall at Princeton University used local sandstone and the Joseph Stout house may also be constructed of local sandstone (Coastal Environmental Services Inc., 1995; Hunter and Porter, 1990).

The Lockatong Formation is composed of dark gray and reddish-brown beds of siltstone and shale with minor amounts of fine-grained sandstone. Many of the siltstone and sandstone beds are extremely hard, chemically cemented siltstone and sandstone (argillite). Rocks of the Lockatong Formation are generally more resistant to erosion than are adjacent units and therefore form ridges, such as the face of the Sourland Mountains (Rogers, Golden and Halpern, 1984) (Figure 3). Used less frequently than the Stockton sandstone, this argillite has been used as building stone most often in farmhouse outbuildings. Prehistoric people used this type of rock when manufacturing tools, such as arrowheads.

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

The diabase (trap rock) is a fine-grained to coarse-grained, dark gray to black igneous rock, which has intruded between the beds of the Newark Supergroup sediments. It is extremely hard and resistant to weathering. Diabase is found at the top of the Sourland Mountains and forms a topographic feature known as the Princeton Ridge, which extends from Rocky Hill to Mount Rose (Rogers, Golden and Halpern, 1995). This can be seen along the southern boundary of the Beden Brook Watershed (Figure 3).

Although the geologic formations discussed above extend thousands of feet below the land surface, interconnected, water-bearing fractures are present only to depths of about 500 feet. Within each of the formations, variations in rock type and degree of associated fracturing result in an alternating vertical sequence of fractured water-bearing units and less-fractured confining units. These units are inclined toward the northwest part of the Watershed, consistent with the dip of the bedrock formations. Vertical interconnection among the units occurs along high-angle joints, which cut through confining units, and along faults, which are more vertically extensive and are associated with adjacent zones of intensely fractured rock (USGS, 1995b).

Unconfined (water-table) conditions typically exist within the upper zone of water-saturated subsoil, weathered bedrock and competent bedrock. The depth below which confined conditions exist may vary between 50 and 150 feet below land surface (USGS, 1995b).

The bedrock aquifers in the Beden Brook Watershed provide variable, and in some locations poor, ground water yield to wells. The Hopewell Township Master Plan lists three reasons for poor ground water yield in the area (Carl G. Lindbloom Associates, 1986):

- Poor percolation conditions of the underlying geological formations and steep slopes result in quick runoff and limited ground water recharge and hence poor to very poor ground water yields.
- Considerable differences in stream flows in the numerous short branches running at right angles to the main stream. In this trellis pattern, runoff is more likely to be rapid, therefore contributing to the high fluctuation of stream flow.

- Hopewell Township currently depends on individual wells and ground water resources to meet its water demand. Where multiple wells penetrate the same bedrock fracture, demand often exceeds the supply and recharge capabilities of the aquifer.

In general, wells constructed in the Lockatong Formation and diabase units provide yields lower than those installed in the Passaic Formation and Stockton Formation. Wells near surface water bodies exhibit average yields approximately twice as great as those that are not near surface water (Vecchioli and Palmer, 1962). Based on measurements of stream discharge in the Stony Brook drainage basin, which has a geologic setting similar to that of the Beden Brook Watershed, induced infiltration of surface water may occur as a result of ground water withdrawals adjacent to surface water bodies in the Watershed (USGS, 1993b). Therefore, excess ground water withdrawals may reduce surface water levels.

SOILS

The Beden Brook Watershed falls in the Northern Piedmont Lowland, where the soil is dominantly silty and commonly shaly or stony. Most of the soils are underlain by hard bedrock at a depth of 2 to 20 feet (USDA SCS, 1972). The dominant soil in the Beden Brook Watershed is the Penn series (Figure 4). It consists of reddish-brown, moderately deep (20 to 40 inches to bedrock), well-drained soils formed in materials weathered from noncalcareous reddish shale, siltstone, and fine-grained sandstone normally of Triassic age. Penn soils are on nearly level to steep and moderately dissected uplands.

Other soils derived from shale, siltstone, slate and/or sandstone, associated with the Penn series are the shallow (10 to 20 inches to bedrock) Klinesville series, the moderately deep (20 to 40 inches to bedrock) Reaville series, and the very deep (depth to stratified sand and gravel more than 40 inches) Rowland series formed in alluvial sediments (Figure 4). These reddish brown soils fall into the group of soils with moderately fine to fine textures, impeding the downward movement of water. They are seen in the gently sloping uplands, the significant feature of the eastern part of the Watershed. This region of the Beden Brook Watershed has seen the greatest amount of development in the 10 years during which data are available (1986 – 1995/97). The increase in the impervious surfaces coupled with the slow infiltration rates of the soils could lead to increased runoff and chances of flash flooding. In the southwestern region of the Watershed, the Penn series is associated with the soils of the Bucks series. These are deep (40 to 55 or more inches to bedrock) soils that formed in a silt mantle over weathered red shale, siltstone, or fine-grained sandstone. These soils have moderately coarse textures and are well drained, resulting in moderate infiltration rates and runoff (USDA NRCS, 2001) (Figure 5).

Another extensively occurring series in the Watershed is the Chalfont series (Figure 4). These soils, found on the slopes of the Sourland Mountains, are deep to very deep (3½ to 8 feet or more), soils formed in a loess mantle overlying a weathered residuum of shale and sandstone. They are somewhat poorly drained with medium to fast runoff and slow permeability (Figure 5).

The soils associated with the Sourland Mountains are from the Neshaminy and Mount Lucas series (Figure 4). These yellow to dark brown, deep to very deep soils were formed in materials weathered from igneous rocks like diabase and other dark-colored rocks. The moderately coarse-textured soils of the Neshaminy series are well drained and have moderate infiltration rates, therefore, runoff is slow to rapid (Figure 5). The Mount Lucas series is poorly drained and has slow infiltration rates.

ENDANGERED/THREATENED SPECIES

Due to the loss of habitat, pollution, invasive plants and development, many species of plants and animals are losing the basic materials they need to survive (food, shelter, and clean water.). Having specialized habitat requirements for survival can also impact animal and plant populations in the Watershed. Endangered species are those whose survival in New Jersey is in immediate danger. Threatened species are those who may become endangered if conditions that harm them continue to deteriorate.

For example, the bog turtle (*Clemmys muhlenbergii*) is usually found in bogs, swamps, and clear, slow-moving meadow streams with muddy bottoms. Bog turtles have specific vegetation requirements for the environments where they reside, such that sedge tussocks, skunk cabbage, cattail, jewelweed, and smartweed are essential to bog turtle habitats.

In the Beden Brook Watershed, 15 known recorded rare species and natural communities are found, which include nine vertebrates and six vascular plants (Table 2). These species range from the threatened wood turtle (*Clemmys insculpta*) to the endangered bobcat (*Lynx rufus*) to the imperiled plant Crawford's sedge (*Carex crawfordii*). The municipalities and surrounding areas also support a variety of endangered/threatened species (Table 2).

Table 2: Number of endangered/threatened species in the Beden Brook Watershed by USGS Quadrangle Map.*

USGS Quad Map Name	Vertebrates	Vascular Plants	Invertebrates
Hopewell	9	5	0
Rocky Hill	8	8	0
Monmouth Junction	6	9	0
Pennington	5	12	3

* NJDEP's Natural Heritage Program gives the location of endangered or threatened species by referring to the USGS Quadrangle Map where the organism was found. This reduces the ability of people to pinpoint the location of the organism's habitat, and thus reduce the impact on that particular organism. Nearly all of the Beden Brook Watershed is found within the Rocky Hill Quadrangle Map.

CRITICAL HABITATS

NJDEP Division of Fish and Wildlife has developed a project to help land managers as well as planners and regulatory agencies integrate wildlife protection into their overall land use goals. The 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, Myers and Valent, ND). Figure 6 provides an overview of the conservation priority areas for forests, wetlands and grasslands within the Beden Brook watershed. The Sourland Mountain region and areas near Route 518 contain areas of moderately high priority for forest conservation. There are also some moderate priority areas for wetland and grassland conservation. Note that the areas within the Sourland Mountains that are in white are areas that have been developed. They could have contained high priority sites before development.

This information, when combined with other GIS data layers, such as roads, development and publicly owned land can provide state, county, municipal, and private agencies, as well as citizens, with an approach to identify important habitats and protect them by prioritizing conservation acquisitions, guiding regulators and planners, providing citizens with conservation tools and guiding the stewardship of conserved areas.

CONTAMINATED SITES

Contaminated sites are generally the result of spills, leaks, or careless practices with chemicals and other hazardous materials. These sites are important because the substances involved can be highly toxic, and become hazards to human health as well as to the natural environment. Common contaminants found on contaminated sites include metals, petroleum products and by-products, organic solvents, and pesticides. Once discovered, several different branches of NJDEP manage these sites. A federal trust fund (the "Superfund") was established by Congress by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, and is authorized for particularly large, extensive or dangerous contamination events. Superfund monies are available to remediate sites on the National Priority List, a ranking of sites that the U.S. Environmental Protection Agency (USEPA) has determined might represent long-term threats to public health and the environment.

Note that the listing of contaminated sites gives the name of the current owner of the property where the contaminated site is located. The current site owner and the Potentially Responsible Party (PRP) for the contamination are not necessarily the same. Site managers are currently investigating the sites found on this list. There are also many residential sites that contain underground storage tanks (USTs) that have not been described or mapped.

Superfund Sites

There are two Superfund sites in the Beden Brook Watershed: the GSA Depot in Hillsborough, and the Montgomery Township Housing Development in Montgomery (Appendix C). The latter site is on the National Priority List for remediation activities (Figure 7).

The GSA Depot was formerly used for several military activities, including weapons shipping, target practice, gasoline distribution, and internment of toxic compounds. There are several different parts of the facility. A detailed site investigation was completed in 1995, and in 1997, several USTs were closed on the property. Metal, organic, and pesticide contamination has been found in groundwater and soils, and pathways exist for pollutant runoff to surface water as well.

The Montgomery Township Housing Development site involves approximately 77 residences previously serviced by private wells. Following the discovery of trichloroethylene (TCE) contamination in a nearby municipal well (Rocky Hill Municipal Wells, in a separate subwatershed, is also a Superfund site) the Montgomery Township Housing Development wells were tested and found to have elevated levels of TCE. In 1987, all but six residences were connected (some declined) to the public water supply. TCE is used in dry cleaning and de-greasing industrial machinery. TCE is a powerful toxin that can remain resident in groundwater for extended periods, but volatilizes easily once exposed to air. Inhalation, skin contact, and direct ingestion all cause adverse reactions in humans. Ingestion of or exposure to large amounts of TCE can be fatal.

A PRP, Princeton Gamma Tech, has been identified, and research and negotiations are still underway to determine the cause of and solutions for this contamination. Princeton Gamma Tech is of the opinion that the TCE contamination is a regional groundwater problem in the Beden Brook Watershed. No legal or scientific ruling on this matter has been released yet.

Other Contaminated Sites

There are several commercial establishments in the subwatershed that have closed USTs of varying sizes, most of which were used to store petroleum products. Closure of a UST involves draining the tank and supply lines, excavation around the tank and testing the soil for contamination, and often subsequent monitoring of groundwater for likely contaminants (such as lead, base neutral organics, petroleum hydrocarbons, and volatile organics). The contamination from each tank, with some sites having as many as 29 USTs, may range from no contamination to large-scale groundwater and potable water contamination.

One large potential source of contamination by USTs is the North Princeton Developmental Center, largely because the extent of groundwater contamination from the 21 USTs on-site is currently unknown. In the 1980s, an underground leak of gasoline contaminated Rock Brook, requiring placement of an absorbent boom in the water. In addition, two other events at the same site resulted in direct petroleum discharges to Rock Brook. If flow patterns are consistent throughout the site, Rock Brook may be vulnerable to further contamination from petroleum hydrocarbons in other USTs at the North Princeton Developmental Center. Several sites around the subwatershed show contamination of groundwater by TCE, from known and/or unknown sources.

Other site contamination is local, mostly petroleum products requiring a soil cleanup or removal. Many homes in the Beden Brook Watershed use heating oil, kept in USTs, which are usually 550-gallon tanks with stored #2 fuel oil. As these tanks age, they may develop leaks. Several of these cases have been opened, remediated (or not), and then closed (or not). Records are very sparse, the number of houses is large, and the pattern is inconsistent. Contamination is generally limited to the soil around the tank, unless the leak is a serious one. For privacy and cost-benefit reasons, SBMWA has not made any further effort to enumerate, locate, or identify residential USTs, either intact or leaking, in this subwatershed.

POINT SOURCE DISCHARGERS

Point source dischargers are facilities that discharge waste directly into surface water or groundwater, and they 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. NJDEP regulates these facilities, and several federal and state laws govern these 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 that discharge.

Dischargers to Surface Water

There are currently 14 licensed point source dischargers in the Beden Brook Watershed (Figure 8, Appendix C). The point source dischargers to surface water in the Beden Brook Watershed consist primarily of seven sewage treatment plants (STPs) of varying sizes, all discharging less than 1 million gallons per day (MGD) in volume. The largest discharger in the watershed is Montgomery Township's Pike Brook STP. Even though two municipal STPs in Montgomery (Pike Brook and Montgomery High School) had been operating at only 50% capacity in 1998, they were both expanded and are now running at very low capacities (Appendix C). The recently-expanded Pike Brook STP in particular has a history of serious effluent violations and is being held to very stringent effluent requirements under its new permit (OMNI Environmental Corporation, 2000).

The discharge from the 3M Corporation is primarily stormwater, and for the most part unremarkable (Appendix C). The 3M Corporation, however, has had problems with a cloudy discharge of fine white sediment to Pike Run, apparently mining dust collecting in roof drains and washing into the stream. Employees have made one effort to clean it up and a fine of $3,000 was imposed, but the discharge is still visible to SBMWA's volunteers walking in the area. Johnson & Johnson Personal Products does discharge some boiler condensate and other waters into Back Brook, but average flow is only 0.027 million gallons per day (MGD) (Appendix C).

Despite these seemingly low discharge rates, it is important not to understate the impact of the sanitary discharges to Beden Brook. This stream ceased flowing in 1993, 1995, and 1999 after a prolonged drought in the summer. The ratio of effluent water to baseflow, particularly in summer months, may be a problem. In addition, many plants report sewer overflows following heavy rains, which have forced the release of untreated effluent to the receiving waters. The Pike Brook STP, a large-volume discharger, and the Carrier Foundation STP, a smaller-volume discharger, have both experienced numerous violations in the past.

Dischargers to Groundwater

There will soon be no active discharges to groundwater in the Beden Brook Watershed. Johnson & Johnson Personal Products, the only discharger to groundwater in the region, is currently eliminating an infiltration/percolation lagoon in favor of a discharge to surface water (Appendix C). The holding tanks at each STP in the watershed are registered with NJDEP as potential sources of groundwater contamination in the case of a leak.

POPULATION

Increasing populations in the Beden Brook Watershed are creating land use patterns that are detrimental to water quality.

People within a watershed have both direct and indirect impacts on water quality and therefore, also have opportunities to responsibly manage and improve water quality. Increasing population in the Beden Brook Watershed is adding to the pressures of waste disposal and water treatment, an increased need for housing to be built, and increased water usage.

Population is increasing and development is progressing rapidly in the Beden Brook Watershed. However, the current trend is in spreading out over the landscape, instead of clustering in hamlets, villages, town centers or the boroughs. Residents are moving away from established centers in order to live in more rural settings. People's dependence on the automobile and the lack of reliable public transportation in the state have encouraged this pattern of development.

Overall, the population has increased more than six-fold in 70 years, from 14,765 people in 1930 to 93,399 in 2000 (Table 3). Between 1930 and 2000, population changes for people living within the municipalities found partially or fully within the Watershed show that overall growth occurred in each (Figure 9, Table 3, Graph 1).

This sprawling population growth has a more detrimental impact on water quality than clustering development in town centers. As agricultural lands, forested areas, and wetlands are developed into residences and office buildings, they create residential and business destinations that attract more development (Center for Watershed Protection, 1998). These areas tend to have a higher percentage of impervious cover, material that prevents water from percolating back into the ground. Among other things, this increase in impervious cover alters flooding patterns, heightens pollutant loads to streams, raises water temperatures, and also reduces baseflow in streams during drought (Center for Watershed Protection, 1998). Development that is sprawled over the landscape makes systematic stormwater control extremely difficult, as well as fragment forests and other habitats thereby causing a decline in ecological health. Established centers that concentrate populations and impervious cover allow for more effective and efficient stormwater practices and minimize habitat fragmentation. Municipalities need to manage the additional infrastructure and development patterns such that water quality is protected.

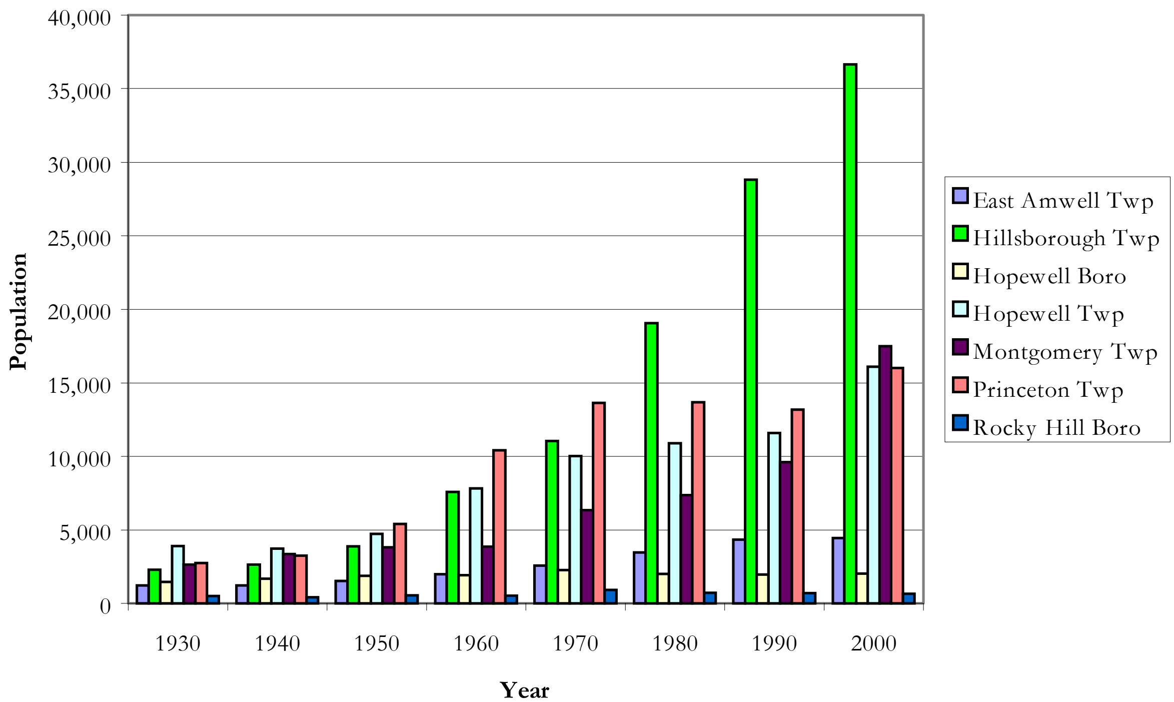
Table 3: Population changes in the municipalities that comprise the Beden Brook Watershed from 1930 - 2000. *

Municipality	1930 Population	2000 Population	% Population Change
Hopewell Borough	1,467	2,035	39%
Hopewell Township	3,907	16,105	312%
Princeton Township	2,738	16,027	485%
Hillsborough Township	2,283	36,634	1,505%
Montgomery Township	2,648	17,481	560%
Rocky Hill Borough	512	662	29%
East Amwell Township	1,210	4,455	268%
TOTAL	14,765	93,399	532%

* The populations listed are for the entire municipality and not just for the portion found in the Beden Brook Watershed.

Hopewell Borough is located entirely in the Beden Brook Watershed and contains much of the headwaters for Beden Brook. Despite contributing to only 1.4% of the overall area of the Watershed, it represents the most densely populated municipality with 3,225 residents per square mile, according to 1990 data (MSM, 1997). The residents in the Borough need to be especially aware of their roles in impacting and improving water quality in Beden Brook, as the Borough lies in a headwater region.

Graph 1: Historical population of municipalities of the Beden Brook Watershed.*



* The populations listed are for the entire municipality and not just for the portion found in the Beden Brook Watershed.

The largest population increase occurred in Hillsborough Township. Hillsborough experienced a 1,505% increase in residents between 1930 and 2000, as it went from 2,283 residents in 1930 to a population of 36,634 in 2000 (Table 3). Despite its small contribution to the Beden Brook Watershed (making up 20.1% of the overall watershed's area), Hillsborough contributes 39.2% of the population for the municipalities found all or part in the Beden Brook Watershed. With such an increasing population in one municipality, local governance needs to thoughtfully plan out the future direction of development within Hillsborough.

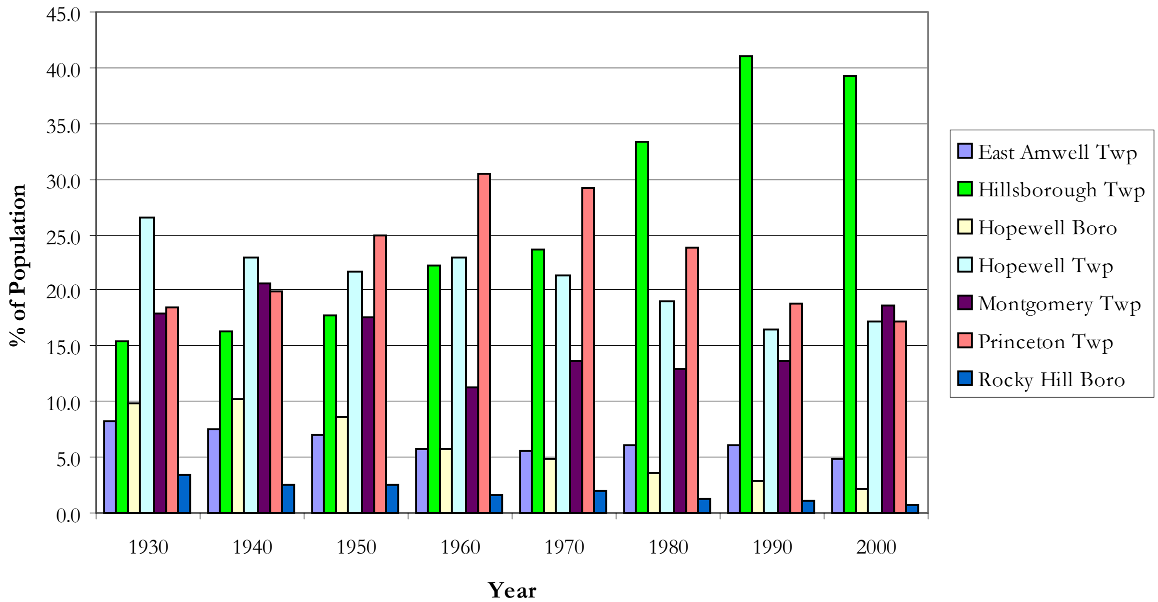
The smallest change in population was found in Rocky Hill Borough with only a 29% increase in population over 70 years (Table 3, Graph 2). Hopewell Borough also marginally increased its population, with a 39% increase in the number of people living there (Table 3, Graph 2). This small increase was due to the fact that 68% of residential areas in the Borough were built prior to 1939 (Carl G. Lindbloom Associates, 1986). In fact, over the last 30 years, both Hopewell and Rocky Hill Boroughs lost residents while the other municipalities gained residents (Table 4). Between the years 1970 and 2000, Hopewell Borough lost 236 residents, or 10% of its residents, as the population went from 2,271 to 2,035. Rocky Hill Borough lost 255 residents, or 27% of its population, over the last 30 years. This shows that growth patterns are occurring in the larger, less developed townships and not the centrally developed boroughs, which are actually losing residents.

Table 4: Population changes in the municipalities that comprise the Beden Brook Watershed from 1970 - 2000. *

Municipality	1970 Population	2000 Population	% Population Change
Hopewell Borough	2,271	2,035	-10%
Hopewell Township	10,030	16,105	61%
Princeton Township	13,651	16,027	17%
Hillsborough Township	11,061	36,634	231%
Montgomery Township	6,353	17,481	175%
Rocky Hill Borough	917	662	-27%
East Amwell Township	2,568	4,455	73%
TOTAL	46,851	93,399	99%

* The populations listed are for the entire municipality and not just for the portion found in the Beden Brook Watershed.

Graph 2: Percentage of total population of municipalities of the Beden Brook Watershed.*



* The percentages of populations listed are for the entire municipality and not just for the portion found in the Beden Brook Watershed.

The other municipalities within the Beden Brook Watershed also have increased populations (Table 3). Between 1930 and 2000, Princeton went from 2,738 to 16,027 residents, increasing by 485%. Montgomery experienced the second highest population growth, with an increase of 560% of its residents over 70 years, and an increase of 175% over the last 30 years (Table 3, Table 4).

LAND USE

Land use changes in the Beden Brook Watershed have shown an increase in developed and urban areas and a corresponding decrease in agricultural areas. Associated increases in impervious cover were seen in 1995.

Wetland areas remain at comparable levels for both 1986 and 1995/97. This is true both in the overall watershed and in the riparian corridors (100-foot buffers on either side of a stream).

Populations in the Beden Brook Watershed are on the rise, and appropriate residential areas continue to be built to accommodate this increasing population. These changes are reflected in the different land use categories between 1986 and 1995/97 (Figure 10, Figure 11, Figure 14). Forests, agriculture, urban/developed land and wetlands make up the majority of land usage in the Watershed and will be discussed in more detail. The remainder of the land use in the watershed is made up of either water (0.3% of the Beden Brook Watershed) in the form of streams, lakes, ponds, reservoirs and other waterbodies, or barren land (2% of the Beden Brook Watershed) as developing land, quarries and mines (Table 5).

The information for land use comes from NJDEP land use/land use cover information from 1986 and 1995/97, but much development has occurred since the last flyovers in 1995/97. Land use was interpreted from photographs that were taken during flyovers in 1986, and 1995 and 1997.

Land use has changed dramatically in the years between 1986 and 1995/97, primarily due to a gain in urban areas and a loss of agricultural land. Between 1986 and 1995/97, the landscape of Beden Brook has changed due to shifts in land use as well as increases in population and local preservation efforts (Figure 10, Figure 11). The changes in land use were a loss of 22.6% of agricultural lands and an increase in urban areas by 28.1% (Table 5). To accommodate the increasing population, these lands are likely being developed to provide housing and services for the new residents.

Of special note is the increase in barren lands within the Beden Brook Watershed. Between 1986 and 1995/97, there was a 109.9% increase in barren lands (Table 5). This represents an increase between these two years, but still makes up a small percentage of the Watershed (2% in 1995/97) (Table 5). This was most likely due to clearing of land in the process of becoming part of the developed or urban land use category. Therefore, a barren land use represents a temporary condition.

FORESTS

In both 1985 and 1995/97, the largest land use category within the Beden Brook Watershed was forests (Table 5). Forests improve water quality by filtering pollutants, reduce flooding by slowing stormwater, and provide habitat to a variety of plant and animal species. It has been shown that the best indicator of the presence of an unimpaired benthic macroinvertebrate community is the total area of forested land located upstream of a sampling site (USGS, 1998b).

Since 1986, there has been a gain of 2.8% forested land (Table 5). In 1986, over 34% of the Watershed, or 10,896 acres, was forested. (Figure 12) In 1995/97, approximately 35% of the Watershed, or 11,207 acres, was covered with forests (Table 5, Figure 13). In recently abandoned fields, early stages of succession on the lower slopes of the Sourland Mountains are marked by an influx of grasses and herbaceous perennials such as ragweed, Queen Anne's lace, black-eyed Susan, daisy, and goldenrod. Mature upland oak-hickory forests cover areas where farm fields were abandoned by the early twentieth century. In a few uncultivated and undeveloped portions of the lowlands, oak-maple woodland can be found (Hunter and Porter 1990). The majority of the woodlands are found in the southern portion of the Beden Brook Watershed and in the northwestern region (Figure 13). The Sourland Mountains remain heavily forested and contain the majority of this Watershed's wetlands, as well (Figure 13).

Table 5: Land use changes from 1986 to 1995/97.

Land Use Category	Total Acreage 1986	% of Total Acreage 1986	Total Acreage 1995/97	% of Total Acreage 1995/97	% Change in Land Use 1986-1995/97*
Forest	10,896	34.2%	11,207	35.2%	+2.8%
Agriculture	9,880	31.1%	7,643	24.0%	-22.6%
Urban/Developed	6,054	19.0%	7,756	24.4%	+28.1%
Wetlands	4,591	14.4%	4,482	14.0%	-2.4%
Barren Land	296	0.9%	621	2.0%	+109.9%
Water	94	0.3%	102	0.3%	+9.0%
TOTAL	31,811		31,811		

Source: NJDEP Land-Use Data 1995/97
*Negative percent changes represent a loss in acreage while positive numbers represent a gain in acreage.

AGRICULTURE

In 1986, approximately 31% of the Beden Brook Watershed, or 9,880 acres, was in agricultural use (Table 5). According to the 1995/97 data, there is approximately 24%, or 7,643 acres, in the Beden Brook Watershed. This represents a loss of over 22% of the available agricultural lands (Table 5, Figure 14). Most of the agricultural land is found in the northern and central part of the region. Corn, soybeans and small grains are grown today, and there is some rearing of livestock (cattle and horses) as well as some dairy farming (Hunter and Porter 1990).

In Hopewell Township, virtually all the tillable land was cleared for agriculture more than 175 years ago. Up until twenty years ago, the land was primarily used for dairy farming (Rogers and Golden Inc. 1975). Until recently, agriculture was a major source of employment.

URBAN

Approximately 24% of the Watershed, or 7,756 acres, was developed into urban areas in 1995/97, or those areas providing residential, recreational, and industrial uses. This is a gain of over 28% from 1986, when there were 6,054 acres of urban land use in the Beden Brook Watershed (Table 5, Figure 14). Hopewell Borough represents a major area of residential development, as 68% of the residential areas within Hopewell Borough were built prior to 1939 (Carl G. Lindbloom Associates, 1986). The majority of the urban areas lie along major roadways, such as Route 206 and near the

Riverside and Pike Run developments, in the Pike Run area. Montgomery Township experienced the greatest increase in population and development of lands into urban areas as a result of residential housing. The Cherry Valley, Pike Run and Stage II developments are among the largest residential subdivisions in the Beden Brook Watershed and are all located in Montgomery (Rogers, Golden and Halpern 1984).

In the Watershed, urban development generally falls into one of four categories:

- Older villages such as Hopewell Borough;
- Older, scattered strip frontage lots found along rural roads;
- Isolated farm homes or homes on large lots in the agricultural and mountainous areas; and
- More recent developments that occur on flat farmland and as small subdivisions

Commercial and recreational interests are a vital part of this Watershed. Houghton Mifflin, AT&T, Johnson & Johnson Personal Products, Janssen Pharmaceutica, North Princeton Development Center, and the two quarries all have large properties in the region. These commercial areas are located near many of the waterways in the Beden Brook Watershed.

Two golf courses, The Bedens Brook Club and Cherry Valley Country Club provide recreational opportunities for local residents. These two golf courses are located along Beden Brook, and both withdraw groundwater from wells in the bedrock aquifer near the brook. These withdrawals may locally reduce or eliminate the natural discharge of groundwater to Beden Brook. In combination with other factors (i.e., drought conditions, evapotranspiration), this diversion of groundwater may account for the periodically observed lack of flow in the brook between Province Line Road and Mountain View Road (Coastal Environmental Services, Inc., 1995).

WETLANDS

Wetlands are those areas inundated or saturated by surface water or groundwater 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 (University of North Carolina WATERSHEDSS, 2001). 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 young animals.

Of the total 31,800 acres in the Beden Brook Watershed, there are 4,483 acres of wetlands, representing 14.1% of the entire Watershed area (Table 6). Deciduous wooded wetlands are the most abundant wetlands, which make up 58.9% of all wetland areas in the Watershed (Table 6). Deciduous wooded wetlands are forested wetlands with closed canopy swamps dominated by trees associated with watercourses and isolated wet soils (NJDEP, 2000). In 1986, 14.1% of the Watershed was wetlands. Deciduous wooded wetlands made up 64.1% of these wetlands. The loss of these particular wetlands between 1986 and 1995/97 resulted from agriculture.

Table 6: Wetlands by type in the Beden Brook Watershed.

Wetland Type	Acres in 1995/97
Deciduous Wooded Wetlands	2,881
Agricultural Wetlands (Modified)	537
Deciduous Scrub/Shrub Wetlands	401
Herbaceous Wetlands	212
Former Agricultural Wetlands (Becoming Shrubby – Not Built-Up)	105
Disturbed Wetlands (Modified)	102
Mixed Scrub/Shrub Wetlands (Deciduous Dominated)	65
Managed Wetlands in Maintained Lawn Greenspace	62
Mixed Forested Wetlands (Deciduous Dominated)	35
Managed Wetlands in Built-Up Maintained Recreational Area	34
Coniferous Wooded Wetlands	14
Wetlands Right-of-Way	13
Mixed Brush and Bog Wetlands (Coniferous Dominated)	11
Coniferous Scrub/Shrub Wetlands	10
Mixed Forested Wetlands (Coniferous Dominated)	1
TOTAL	4,483

Source: NJDEP Land-use data 1995/97.

Deciduous wooded wetlands are common in the Northeastern United States and provide habitat for many critically important species of wildlife. Many of the common tree species found in New Jersey forested wetlands include Red Maple (*Acer rubrum*), Black Willow (*Salix niger*), Swamp Oak (*Quercus bicolor*) and Sweetgum (*Liquidambar styrciflua*).

The deciduous wooded wetlands found in the Beden Brook Watershed are found mostly in the Sourland Mountains or at the headwaters of many streams and their tributaries (Figure 11). The location of these areas is critical to maintaining healthy streams in the Beden Brook Watershed, as riparian forests are important sinks for polluted runoff. Many studies have determined the effectiveness of riparian forests 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).

Approximately 108 acres of wetlands were lost between 1986 and 1995/97 in the Beden Brook Watershed. This loss is above the USEPA's policy of "No Net Loss" for wetlands. However, 97.6% of the 1986 wetlands remain in this watershed in 1995/97. A more detailed analyses of the GIS data comparing 1986 to 1995/97 land use categories, reveals that 273 acres were lost, while an additional 155 new wetland acres were created, with an overall loss of 108 acres, plus 8 acres converted to open waters. The 155 acres of created wetlands can be divided into three general categories as follows:

- 43 acres of managed wetlands including lawn greenspace and recreation areas and utilities right of ways;
- 76 acres of disturbed wetlands and;
- 36 acres of mixed forested and scrub/shrub wetlands.

Wetlands creation has been estimated to cost developers approximately $25,000 to $100,000 per acre. Thus, in the Beden Brook Watershed, 155 acres were created at an estimated cost of $3 to $15 million.

IMPERVIOUS COVER

Impervious cover is that 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, 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 could prevent the percolation of water into the aquifer and can impair local groundwater resources. Impervious surfaces could 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, substances carried by the runoff get carried to streams and lakes and contribute to water quality degradation. Research has shown that stream ecosystems and water quality degrade as the amount of impervious surface within an area increases (Center for Watershed Protection, 1998). The first limit to impervious areas appears at approximately 10% impervious cover, where sensitive elements are lost from the system. A second limit appears at approximately 25-30% impervious cover, where there is a shift to poor stream conditions that include diminished aquatic diversity, water quality, and habitat functioning (Center for Watershed Protection, 1998).

Beden Brook Watershed has an overall impervious area of 5.3%, suggesting little to some water quality degradation (Figure 15). The highest percentages of impervious areas are found in Hopewell

Borough, which is rated at 11% or higher for most of the borough (Figure 15). This suggests that the borough is heavily developed and could be contributing to water quality problems in Beden Brook. Much of this impervious area is due to residential areas that were built prior to 1939 (Carl G. Lindbloom Associates, 1986). The best predictor of the presence of a severely impaired benthic macroinvertebrate community is the total area of urban land in close proximity to sampling sites (USGS, 1998). Since Hopewell Borough represents the headwaters of the Beden Brook, management of development in areas surrounding it should be a high priority.

The Beden Brook Watershed was broken down into smaller subwatersheds to analyze impervious cover. Beden Brook, Cruser Brook, Pike Run, and Rock Brook were evaluated and all were under 10% impervious cover (Figure 16, Figure 17, Figure 18, Figure 19). The Pike Run Watershed has the highest rating at 6.6%, mainly due to the contribution of the GSA Depot (Figure 18). This area of Montgomery and Hillsborough is also experiencing a growth in development. Cruser Brook has only 1.9% impervious cover as it contains a portion of the Sourland Mountains (Figure 17), as does Rock Brook with a percentage of 3.2% (Figure 19).

In each of the subwatersheds, the majority of the lands covered with higher impervious area are congregated closer to streams (Figure 16, Figure 17, Figure 18, Figure 19). This means that those streamside residences, business campuses, golf courses, and farms need to be evaluated as part of the SBMWA's River-Friendly Programs, educational programs to reduce nonpoint-source pollution from these areas.

A large, highly impervious site is found in the northern part of the watershed: the General Services Administration (GSA) Depot. This property in Hillsborough Township was rated in the 76-100% category of impervious area. This large site is next to the headwaters of Pike Run and should be looked at carefully if future development plans are proposed.

An analysis of the building permits issued from 1995-2000 in Montgomery shows an increase in impervious surfaces of approximately 163 acres. This was the only available building permit data at the time of writing. This municipality alone brings the total impervious acreage from approximately 1,517 acres in 1995/97 to approximately 1,680 acres in 2000.

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 plant root growth, stormwater control by slowing water flow, and habitat for many species of plants and animals.

There is no set width for a riparian corridor. However, for the purposes of this study, we have chosen to look at the area 100 feet from the stream. This distance is often used in studies as providing water quality protection and nutrient removal (Wagner, 1999). In the Beden Brook Watershed, 1,718 acres of land, or 5.4% of the entire Watershed, are found within the 100-foot corridor. In 1985, the Beden Brook Watershed contained 152 acres of agricultural land, 0.8 acres of barren land, 299 acres of forest, 166 acres of urban area, 1,037 acres of wetlands and 63 acres of water within the riparian corridor (Table 7). In 1995/97, these acres were categorized at 129 acres of agricultural land, 1.5 acres of barren land, 312 acres of forest, 179 acres of urban area, 1,034 acres of wetlands and 63 acres of water (Table 7).

Table 7: Land use within 100-foot stream buffer in Beden Brook Watershed.

Land Use Category	Total Acreage 1986	% of Total Acreage 1986	Total Acreage 1995/97	% of Total Acreage 1995/97	% Change in Land Use 1986 – 1995/97*
Forest	299.1	17.4	312.4	18.18	4.45
Agriculture	152.4	8.9	129.4	7.53	-15.09
Urban/Developed	166.5	9.7	178.7	10.40	7.33
Wetlands	1,036.9	60.3	1,033.7	60.15	-0.31
Barren Land	0.80	0.05	1.5	0.09	91.25
Water	62.8	3.7	62.8	3.65	0.05
TOTAL	1,718.5	100.00	1,718.5	100.00	

Source: NJDEP Land-Use Data 1995/97
*Negative percent changes represent a loss in acreage while positive numbers represent a gain in acreage.

The riparian corridors in the Beden Brook Watershed are doing well. The largest percentage of riparian corridor land use for both 1985 and 1995/97 is wetlands, at 60% of the land use within this 100-foot corridor (Table 7). The second highest land use within the riparian corridors was forests, at 17% in 1986 and 18% in 1995/97 (Table 7). Therefore, riparian corridors need to be protected from encroachment in the Beden Brook Watershed to maintain the forests and wetlands buffering the streams.

WATER QUALITY

Water quality has degraded due to the impacts of increasing water usage, by a growing population and increased impervious cover from the development of agricultural areas into residential and business areas.

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

Beden Brook relies on surface runoff for the majority of its flow. Thus, non-point source pollution, associated with suburban development and activities, is of particular concern in this watershed. Fertilizers and pesticides from yards, farms and golf courses, animal wastes (both farm animals and pets), sediments from construction and erosion, detergents, and toxic chemicals from cars and household cleaning and yard care products are all examples of nonpoint pollution. In addition, eight sewage treatment plants discharge into the watershed streams.

Because of this reliance on surface runoff, the impact of changes in precipitation becomes important in the Beden Brook Watershed. Prior studies have shown that the average yearly precipitation for Hopewell Township is 45.1 inches (Blasland, Bouck, & Lee, Inc., 2000). Precipitation data was available for Hopewell Township from 1996-2000 and shows that total rainfall has been around this average. In 1996, total rainfall was 49.1 inches, and precipitation from 1997-2000 was recorded at 45.6 inches, 42.0 inches, 48.5 inches and 36.8 inches, respectively (Table 8).

Table 8: Precipitation in Hopewell Township from 1996 – 2000.

Year	Precipitation in Inches
1996	49.1
1997	45.6
1998	42.0
1999	48.5
2000	36.8

Note that while precipitation data from Hopewell Township's Health Department is used for an overall indication of regional Beden Brook Watershed weather patterns, it is directly related to Hopewell Township only, and is less correlated with other municipalities in the Watershed.

Water quality data was gathered from a variety of sources (Figure 20, Figure 21, Figure 22). Omni Environmental Corporation, the Stony Brook Regional Sewerage Authority (SBRSA), and SBMWA have all conducted chemical monitoring at various sites within the Beden Brook Watershed. The biological assessment data was gathered from the Stony Brook-Millstone Watershed Association's biological action teams' (BATs) data from 1996 and NJDEP's Ambient Biomonitoring Network (AMNET) 1994 and 1999 data for the Raritan River drainage basin. Visual assessments were collected from reports by employees, interns, and volunteers at SBMWA. SBMWA has conducted volunteer chemical water quality monitoring in this Watershed since 1992, and biological and visual assessment data since 1996.

Visual assessments provide an overall sense of water quality through qualitative surveys. Biological assessments give information on long-term water quality, but do not reveal the type 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 available to reveal trends.

VISUAL ASSESSMENTS

Visual assessments are a valuable tool in obtaining a gross evaluation of impacts and health of streams. Observational data can be difficult to compare between areas, however. An effort was made to quantify these observed characteristics, based upon visual assessment protocols used by the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service (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 – 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. These numbers are to be used with caution, since the data are based on qualitative judgments.

Information presented for the visual assessments was developed from the collected reports of several different employees, interns, and volunteers at SBMWA. Twelve walkable stream segments, called "beats", are located in the Watershed along Beden Brook, Rock Brook, and Pike Run (Figure 20). All walks were completed in the summer (between May and July) of 2000. SBMWA staff and interns walked their "beat" after being trained in what to look for and how to assess water quality problems in an area. They photographed interesting sites or problems, and recorded assessments of stream health. A video record was made of all the walkable streams covered by this assessment in the fall of 2000. This video is being used to verify the field observations made by staff during the summer surveys.

The visual assessment scores ranged from 2.15 along a segment of Beden Brook (BDB2) to a 4.00 on the headwaters of Rock Brook (RB1) (Appendix B Table B-1). The average score for all stream segments in this Watershed is 3.22. The most common problems seen on the visual surveys were erosion and heightened algal growth. These impacts are most often associated with nonpoint source pollution from land use disturbances. Construction activities, increasing impervious cover, and loss of forests can contribute to accelerated stream erosion. As increased development, recreational, and residential areas appear in the Watershed, larger amounts of lawn and turf landscaping, and associated fertilizers, add to excess algal growth.

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 aquatic macroinvertebrates. They are used as indicator organisms by the varying sensitivities to pollution each species exhibits. For example, mayfly nymphs are very sensitive to pollution and are only abundant where water quality is good, while leeches and worms can survive waters with poor water quality.

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.

SBMWA StreamWatch volunteers collect aquatic macroinvertebrates at three sites in Beden Brook Watershed (Figure 21). These volunteers, part of SBMWA's biological action teams (BATs), have collected and identified macroinvertebrates in spring, summer and fall each year since 1996. The organisms from these samples are identified to the family level and the data are entered into a database and evaluated with the same procedures used by NJDEP.

Biological data have been collected from our StreamWatch volunteer monitoring program and from the NJDEP monitoring program (Figure 21). At least 100 organisms are required from each sampling event. "Too few in sample" indicates that the monitors were unable to collect enough organisms for statistical analysis for some sampling events. This is also indicative of impairment to aquatic life in the stream.

The three sites on the main stem of Beden Brook currently monitored by SBMWA's volunteers are (Figure 21):

- Beden Brook at River Road, north of Route 206 (BD1).
- Beden Brook at Great Road, near Cherry Valley Country Club (BD3).
- Beden Brook at Aunt Molly Road (BD4).

In general, Beden Brook does not fully support the breadth and diversity of aquatic life representative of a healthy stream ecosystem (Appendix B Table B-2, Appendix B Table B-3). All three sites are listed as "moderately impaired," although both BD1 and BD4 were given "severely impaired" ratings in 1997 and 1999, respectively, by SBMWA analysts (Appendix B Table B-2, Appendix B Table B-3).

The eight NJDEP sampling sites in the Beden Brook Watershed are (NJDEP, 2000) (Figure 21):

- Beden Brook at Route 206 (ANO401) and at Aunt Molly Road (ANO398).
- Rock Brook at Long Hill Road (ANO399) and at Burnt Hill Road (ANO400).
- Pike Run at Route 206 (ANO402) and at Route 533 (ANO405).
- Cruser Brook at Route 206 (ANO403).
- Back Brook at Route 206 (ANO404).

Sites ANO398 and ANO405 sampled by the NJDEP correspond to BD4 and BD1, respectively, sampled by SBMWA volunteers (Figure 21).

According to the AMNET reports from 1994 and 1999, all but two sampling events in the Watershed were rated as "moderately impaired." (NJDEP, 1995; NJDEP, 2000). Cruser Brook was "non-impaired" in 1994 and Pike Run was "severely impaired" in 1999 (Appendix B Table B-3).

Under section 303(d) of the Clean Water Act, states are required to produce a list of waterways not meeting Surface Water Quality Standards. These lists are produced every two years. The most recent 303(d) list published by NJDEP (1998), ranks the biological health of Beden Brook, Pike Run, and Rock Brook as "moderately impaired."

In the 1992 State Water Quality Inventory Report, six of the fourteen biological assessments from Beden Brook indicate moderate impairment; the remaining eight indicate non-impaired conditions. The report states that a decline in biological health was noted from 1987 and 1991, with nutrient enrichment as one source of the impairment (State of NJDEP, 1992). This coincides with the visual assessments noting algal growth as a result of excess nutrients in the Beden Brook Watershed.

CHEMICAL ASSESSMENTS

The 1996 State Water Quality Inventory Report states that total orthophosphate levels are elevated, with 50% of all samples from throughout New Jersey exceeding the 0.1-mg/L criteria (NJDEP, 1996). Inorganic nitrogen median levels are 1.6 mg/L, with 28% of samples exceeding 2.0 mg/L (NJDEP, 1996). Fecal coliform levels are elevated, as well.

SBMWA's chemical action teams (CATs) monitor four chemical monitoring sites on Beden Brook (Figure 22). Chemical monitoring is conducted every other weekend throughout the year. Volunteers monitor six parameters: dissolved oxygen (DO), pH, nitrates, orthophosphates, water temperature and turbidity. For this assessment, water quality was determined for four of these six parameters: DO, nitrates and orthophosphates. These three are indicative of nonpoint pollution and eutrophication in waterways.

The four sites on the main stem of Beden Brook currently monitored by SBMWA's volunteers are (Figure 22):

- Beden Brook at River Road, north of Route 206 (BD1).
- Beden Brook at Opossum Road, upstream of the bridge (BD2).
- Beden Brook at Great Road, near Cherry Valley Country Club (BD3).
- Beden Brook at Aunt Molly (BD4).

Chemical monitoring has been performed on a regular basis along Beden Brook. Site BD1 (at River Road north of Route 206) has been monitored since 1992 and the other three have been monitored since 1993. SBMWA data for this report have been analyzed from 1993 – September 2000.

Omni Environmental Corporation performed monitoring from 1991 – 1995 as part of a water quality model for the Stony Brook Regional Sewerage Authority (SBRSA) (Omni Environmental, 1995). Eight stations were monitored as part of the study but four had insufficient data for a proper analysis (Figure 22):

- BBu: Beden Brook at Aunt Molly Road Bridge; approximately 250 feet upstream of the STP discharge.
- BB1: Beden Brook at approximately 250 feet downstream of STP discharge.
- BB2: Beden Brook at Province Line Road Bridge.
- BB3: Beden Brook at Great Road Bridge.

BBu is the furthest upstream and is approximately the same site as SBMWA's BD4 (Figure 22).

Overall, the DO levels for all StreamWatch CAT sites and Omni Environmental sites do not violate the Surface Water Quality Standards (7.0 ppm). If there are violations in individual years, the violation is minor and short-lived with minimal impact on the stream's health (Appendix B Table B-4, Appendix B Table B-5).

For nitrates and orthophosphates, the headwaters of Beden Brook (BD4/BBu) have good water quality (Appendix B Table B-4, Appendix B Table B-5).

Both nitrate and nitrate-nitrogen levels (SBMWA and Omni Environmental sampling programs, respectively) showed elevated levels on Beden Brook between Province Line Road (BB2) and Route 601, The Great Road (BD3/BB3). This is the same segment of stream that received the lowest score on the visual assessments: BDB2.

At BD4, the nutrients show a slight trend toward increasing levels for the past eight years entering the brook (Appendix B Table B-4). As the flow continues downstream towards BD3, the nutrients show a far greater increasing trend. At BD2, the nitrate levels start to increase as the water flows past the Aunt Molly Sewage Treatment Facility. The nutrient levels start to slightly increase again as the water flows past station BD1.

Stony Brook Regional Sewerage Authority data obtained for the Hopewell Wastewater Treatment Facility shows that the Hopewell Facility is performing within acceptable values when compared to the State's Surface Water Quality Standards (Appendix B Table B-6).

These chemical assessments coincide with both the biological and visual assessments of Beden Brook (see appropriate sections for more information). Degradation of the lands surrounding the headwaters and developing land uses are most likely the source of these water quality problems.

Conclusions

In general, chemical, biological and visual indicators suggest that the Beden Brook subwatershed is a stressed environment with declining water quality. SBMWA chemical monitoring results for Beden Brook show that both the mean and average values for nitrates are increasing. Biological data from NJDEP indicates that water quality is either remaining at moderately impaired or (in Pike Run) has gone from a moderately impaired rating to severely impaired. There are also potential pollution problems in groundwater and wetlands if these resources are not adequately protected. The Beden Brook Watershed does have characteristics that protect water quality, which need to be preserved. For example, forests, cited as the single best indicator of environmental health in a watershed (USGS, 1998b), have increased within Beden Brook. According to our GIS analysis, riparian corridors are doing well. Wetlands and forests make up 78% of the 100-foot riparian buffers surrounding the waterbodies within the Beden Brook Watershed.

The key question is: What does all this information mean and how can it be synthesized to reveal a link between cause and affect? When analyzing the data, trends and recommendations were made for the entire Beden Brook Watershed, as well as the smaller subwatershed. These include the Pike Run, Cruser Brook, Rock Brook and Beden Brook Subwatersheds.

<u>BEDEN BROOK WATERSHED</u>

The analysis of the available information for the Beden Brook Watershed provides information on general trends and recommendations. The next step is to understand where efforts should be directed to improve areas with declining environmental health and preserve areas that are healthy. What follows are the trends in the Beden Brook Watershed and the recommendations, in italics, to improve environmental health.

Agricultural areas are being lost to suburban development throughout the watershed. Historically, farms were located in close proximity to streams and other waterways to allow for irrigation. When converted to housing or office complexes, farm fields are too often replaced with lawns instead of riparian buffers. GIS mapping indicates this trend via an increase in development and impervious areas around the streams.

1. ***Due to the loss of farmland, preservation efforts need to be encouraged. The proximity of many farms to streams also means that River-Friendly Farm Programs need to continue to educate farmers on wise crop management and riparian buffer implementation.***

In order to perform analysis of water quality trends, monitoring data must be available. There is a lack of basic water quality information for many of the streams, with the exception of Beden Brook. The tributaries in the watershed (Back Brook, Cruser Brook, Pike Run and Rock Brook) have not been as thoroughly studied as the main stem of Beden Brook (Figure 20, Figure 21, Figure 22).

2. ***More data needs to be collected in Back Brook, Rock Brook, Cruser Brook, and Pike Run in order to properly characterize and assess the water quality in these areas. This is especially important, as these streams are located primarily in Montgomery Township, which is undergoing increasing development (Figure 10, Figure 11, Figure 14).***

The Sourland Mountains are a unique resource within this watershed. The area remains primarily forest and wetlands and is the headwaters for many streams. According to NJDEP Division of Fish and Wildlife's Landscape Project, there are areas of moderately high conservation priority for forests, wetlands and grasslands. The Sourland Planning Council, a local non-profit organization, has initiated efforts to preserve this resource. The five municipalities that contain the Sourland Mountains (East Amwell, Hillsborough, Hopewell, Montgomery and West Amwell), as well as the Counties, support this preservation effort.

3. ***The State should support preservation efforts by local non-profits, municipalities and counties for the Sourland Mountains. Local municipalities and land trust organizations should integrate NJDEP Landscape Project information into open space preservation initiatives.***

Analysis of the 100-foot area around the streams in Beden Brook Watershed reveals that the land use in 1995/97 was primarily wetlands and forests (78%). Stream corridors provide habitat, remove sediment and pollutants and slow stormwater. Thus, it is important to preserve, manage and protect these areas.

4. ***Municipalities and individual residents must preserve stream corridors to ensure that they are primarily forest and wetland. Stream Corridor Protection Ordinances and***

deed restrictions should be considered in order for the corridors to continue to function properly and protect water quality.

5. ***Municipalities should integrate information about natural features such as soils and geology into their planning efforts in order to proactively plan to ensure adequate groundwater recharge, water quality and open space preservation.***

Nonpoint-source pollution is contributing to water quality decline in some areas. Specific areas will be outlined in the subwatersheds where this trend occurs.

6. ***To reduce nonpoint source pollution, River-Friendly Programs should be targeted at citizens, businesses and golf courses in the fastest-developing areas, such as Hillsborough and Montgomery.***

SUBWATERSHEDS

Each subwatershed has its own story to tell about areas that need enhancement and preservation. Focusing on a smaller subwatershed also allows for closer inspection of the relationship between geology, soils, land use, impervious cover and water quality. For example, geology exerts an influence on soils and thus on vegetation, drainage, water movement and water supply. Impervious surfaces, both the amount and placement near stream corridors, can also impact water quality.

Beden Brook Subwatershed

Beden Brook flows east from its headwaters in Hopewell Borough through Montgomery Township until it reaches the Millstone River near Rocky Hill Borough. Geologically, the Brunswick Formation, which is generally a poor aquifer, primarily underlies the Beden Brook subwatershed. The soils are mostly in hydrologic group C and have slow infiltration rates. There are areas of group B, which has moderate infiltration rates and moderately coarse textures. However, most of this group is found in Hopewell Borough and was topped by impervious cover when the Borough was developed in the 1930s. The Borough has a high percentage of impervious cover, with much of it at 25% and above (Figure 16). This creates greater amounts of runoff from the Borough and a higher potential for flooding of downstream areas.

7. ***SBMWA supports the clustered, mixed-use development that has occurred in Hopewell Borough. We recommend that the municipal leaders review their stormwater management practices and look for opportunities to upgrade existing structures when renovations are considered.***
8. ***We also recommend that an assessment of Hopewell Borough's ordinances be performed in order to determine protection opportunities for stream corridors.***
9. ***We also recommend targeting the residents of Hopewell Borough for future River-Friendly Resident education programs.***

This subwatershed contains many known contaminated sites that could be a source of potential concern (Figure 7). Within the Millstone Watershed, 52% of the public community supply wells are within a half-mile of a known contaminated site (New Jersey Water Supply Authority, 2001).

10. ***Currently, NJDEP monitors and tests the soils and groundwater in the vicinity of a known contaminated site. The agency also outlines necessary remediation strategies, when necessary. Due to the reliance on community supply wells and***

private wells for drinking water, local municipalities and their health departments should pay close attention to the status of these sites and the monitoring results.

We are fortunate to have a great deal of chemical, biological and visual water quality data for the Beden Brook Subwatershed from SBMWA, NJDEP, and various consulting firms. Water quality is degraded along Beden Brook, as evidenced by increasing nutrients (Appendix B Table B-4, Appendix B Table B-5). Moderate impairment to the macroinvertebrate community, and the lowest rated visual assessment for the stream segment from Province Line Road to the Great Road (Figure 20). The surrounding land uses for that stretch of Beden Brook are directly impacting the water quality as well as quantity. Between 1986 and 1995/97, agricultural lands in this area were developed into residential housing and a golf course. There are also two STPs, the SBRSA's Hopewell STP and the Cherry Valley STP, discharging into this stream reach (Figure 8). Surrounding this area are also two golf courses, which may be contributing to polluted runoff problems in Beden Brook (Figure 11).

The golf courses are not only adding runoff to the stream but also withdraw water from the area. Residents in the surrounding area are also pulling ground water for many uses around the home. Beden Brook is primarily fed by groundwater, making it a "gaining" stream (see *Geology* section for more detail). The withdrawals to ground water make the impact from polluted runoff more.

11. ***It is a priority that these golf courses and associated residential developments become actively involved in our River-Friendly Golf Course and Resident Certification Program.***

Rock Brook Subwatershed

Rock Brook begins in the forested Sourland Mountains and travels through the rapidly developing Montgomery Township until it reaches Beden Brook above Route 518. In the portion of the Sourland Mountains within the subwatershed, the geology is primarily of the Stockton Formation and has steep slopes and mostly hydrologic soil groups B and C. As Rock Brook leaves the Sourland Mountains, much of the higher impervious surface is found along the Brook. This combined with the natural geology and soil types could result in the eutrophication, erosion and declining water quality that were seen. NJDEP biological sampling has rated the two sites here as moderately impaired (Figure 20, Figure 21, Figure 22).

12. ***For this subwatershed, we recommend increasing the monitoring sites, protecting the riparian areas from development, monitoring ground water quality (as this is a gaining stream) and preserving the area surrounding Rock Brook's headwaters, the only area to receive an "excellent" rating for visual assessment in the Beden Brook Subwatershed (Figure 20). Many of our general recommendations for the entire watershed can also be applied to this area.***

Cruser Brook Subwatershed

The headwaters for Cruser Brook and the associated Roaring Brook are in the Sourland Mountains in Hillsborough Township. The Brook flows east through Montgomery Township until it joins with Pike Run. Cruser Brook Subwatershed has one NJDEP biological monitoring site, which was rated as non-impaired in 1993 and moderately impaired in 1998 (Appendix B, Table B-3). When analyzing the data for this subwatershed, it was noted that the highest impervious cover is near this sampling site, where Route 206 crosses Cruser Brook. Much of this concentration of development has occurred since 1986 as agricultural land has been converted to urban development and could be the cause of the decline in water quality (Figure 14, Figure 17). The majority of Cruser Brook subwatershed, however, is not densely developed.

13. ***This area should be studied further to determine the source(s) of potential pollution in order to improve the water quality.***
14. ***Municipalities should ensure that stream corridors, critical habitat and other key features are preserved and that development is directed to the appropriate areas within this subwatershed.***
15. ***Many of the general recommendations for the entire watershed can be applied to this area, particularly the need for further water monitoring data. Because Cruser Brook is still relatively undeveloped, baseline data is essential to track changes and to ensure that this area is preserved.***

Pike Run Subwatershed

The final subwatershed, Pike Run, begins in the northwest region of Beden Brook Watershed. It flows east through Montgomery Township, dips to the south and flows parallel to Route 206 until it joins with Beden Brook. Back Brook and Pine Tree Run also are included in this subwatershed and feed into Pike Run.

Pike Run had the greatest conversion of agricultural lands to developed lands. This development was mostly single-family homes, very often located near streams (Figure 14). This subwatershed has the highest percent impervious surfaces and much of this is near streams (Figure 18). NJDEP biological sampling results indicate that station ANO402 at Route 601 where Pike Run crosses was moderately impaired when sampled in both 1993 and 1998. Site ANO405, at Route 206, has declined. It was rated moderately impaired in 1994 and severely impaired in 1999 (Appendix B Table B-3). SBMWA's visual assessment of this area indicates that the quality declines from good to fair as Pike Run flows to Beden Brook (Appendix B).

When evaluating the soils, geology and other landscape features, there appear to be few critical constraints for development. This could be the key reason that the land use has changed so quickly from 1986 to 1995/97 (Figure 10, Figure 11, Figure 14).

16. ***The municipalities must be careful to protect the natural resources such as forests and riparian buffers to ensure that no further water quality degradation is seen.***
17. ***River-Friendly Certification Programs efforts should be concentrated in this region.***
18. ***Many of our general recommendations for the entire watershed can also be applied to this area.***

This characterization and assessment report for the Beden Brook Watershed provides an overview of the trends seen within this area between 1986 and 1995/97. Within that time, there has been a decline in water quality in some areas, a loss of agricultural lands and an increase in impervious cover. However, there are also areas that are primarily forest and wetlands: the Sourland Mountains and the 100-foot area surrounding the streams. This offers the municipalities, businesses, golf courses, residents and farmers an opportunity to react to the current situation and also use the data within this report to act proactively. Collectively, there must be some vision for this region and a plan to move toward that vision. The recommendations put forth in this report offer an opportunity for those that live, work and play within this watershed to enhance, protect and preserve environmental health as well as their own quality of life.

List of Acronyms

AMNET	NJDEP's Ambient Biomonitoring Network
BAT	Biological Action Teams
BEES	Building Environmental Education Solutions, Inc.
CAT	Chemical Action Team
CWA	Clean Water Action
DO	Dissolved Oxygen
EPT	Ephemeroptera-Plecoptera-Tricoptera (macroinvertebrate families)
FBI	Family Biotic Index
GIS	Geographic Information System
GSA	General Services Administration
MDDNR	Maryland Department of Natural Resources
MGD	Million Gallons per Day
MSM	Middlesex-Somerset-Mercer Regional Council
NJDEP	New Jersey Department of Environmental Protection
NJWSA	New Jersey Water Supply Authority
NO_3	Nitrate
NRCS	Natural Resources Conservation Services
PO_4	Phosphate
PRP	Potentially Responsible Party
RAT	River Action Teams
SBMWA	Stony Brook-Millstone Watershed Association
SBRSA	Stony Brook Regional Sewerage Authority
STP	Sewage Treatment Plant
SWQS	Surface Water Quality Standards
TCE	Trichloroethylene
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

GLOSSARY

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

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

Benthic Organism: Any of a diverse group of aquatic plants and animals that lives on the bottom of marine and fresh bodies of water. The presence or absence of certain benthic organisms can be used as an indicator of water quality.

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

Deciduous: A plant (usually a tree) that loses its leaves during an unfavorable time of year (autumn in North America).

Detention Basin: An embankment and associated area for impoundment of water, which is normally dry.

Dip: The angle that a sedimentary bedding plane or other structural surface makes with the horizontal, measured vertically in the direction of steepest inclination.

Endangered Species: Animals, plants, birds, fish, or other living organisms threatened with extinction by human-induced or natural changes in the environment.

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.

Fecal Coliform: Bacteria found in the intestinal tracks of mammals. These bacteria in water or sludge are indicators of pollution and possible contamination by pathogens.

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

Gaining Streams: Streams whose flow is sustained primarily by the discharge of ground water.

Ground Water: The portion of water beneath the land surface that is below the water table, where the pore spaces are filled with water.

Headwater Stream: The beginnings or sources for watercourses; typically, the point in the landscape where sufficient runoff collects in intermittent streams.

Imperiled: Endangered.

Impervious Cover: Any surface in the landscape that cannot effectively absorb or infiltrate rainfall. The amount of impervious cover in a subwatershed has been used as and indicator to predict the severity of the impairments to local stream.

Inorganic Nitrogen: Chemical parameter monitored for water quality assessment. A nitrogen compound not containing carbon.

Loess Mantle: A widespread, homogeneous, porous, highly calcareous, fine-grained blanket deposit (generally less than 30 m thick), consisting primarily of silt with subordinate grain sizes ranging from clay to fine sand.

Macroinvertebrates: Indicator organisms in water bodies that exhibit varying sensitivities to pollution.

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.

Nutrients: Any substance that is assimilated by organisms and promotes growth. Nitrogen and phosphorous are nutrients that promote the growth of algae. There are other essential and trace elements that 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: Slow movement of water through small openings within a porous material.

Pervious Surface: Surface with the capacity for transmitting a fluid. Also: permeable surface.

Physiographic Province: The distribution of land area in New Jersey into distinct divisions determined by geological history and physical character.

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

Potable Water: Raw or treated water that is considered safe to drink

Retention Basin: An embankment and associated area for impoundment of water, which retains a permanent pool of water.

Riparian Area: Land situated on or abutting upon a stream bank.

Strike: The direction or trend taken by a structural surface, such as a bedding or fault plane, as it intersects the horizontal.

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

Threatened Species: Species that may become endangered if conditions that harm them continue to deteriorate.

Tillable Land: Land suitable for agricultural use.

Trellis Pattern: A drainage pattern characterized by parallel main streams intersected at or nearly at right angles by their tributaries, which in turn are fed by elongated secondary tributaries parallel to the main streams, resembling in plan the stems of a vine on a trellis.

Triassic Age: The first period of the Mesozoic era (after the Permian of the Paleozoic era, and before the Jurassic), thought to have covered the span of time between 225 and 190 million years ago.

Turbidity: The condition of reduced clarity of a fluid due to suspended matter.

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.

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

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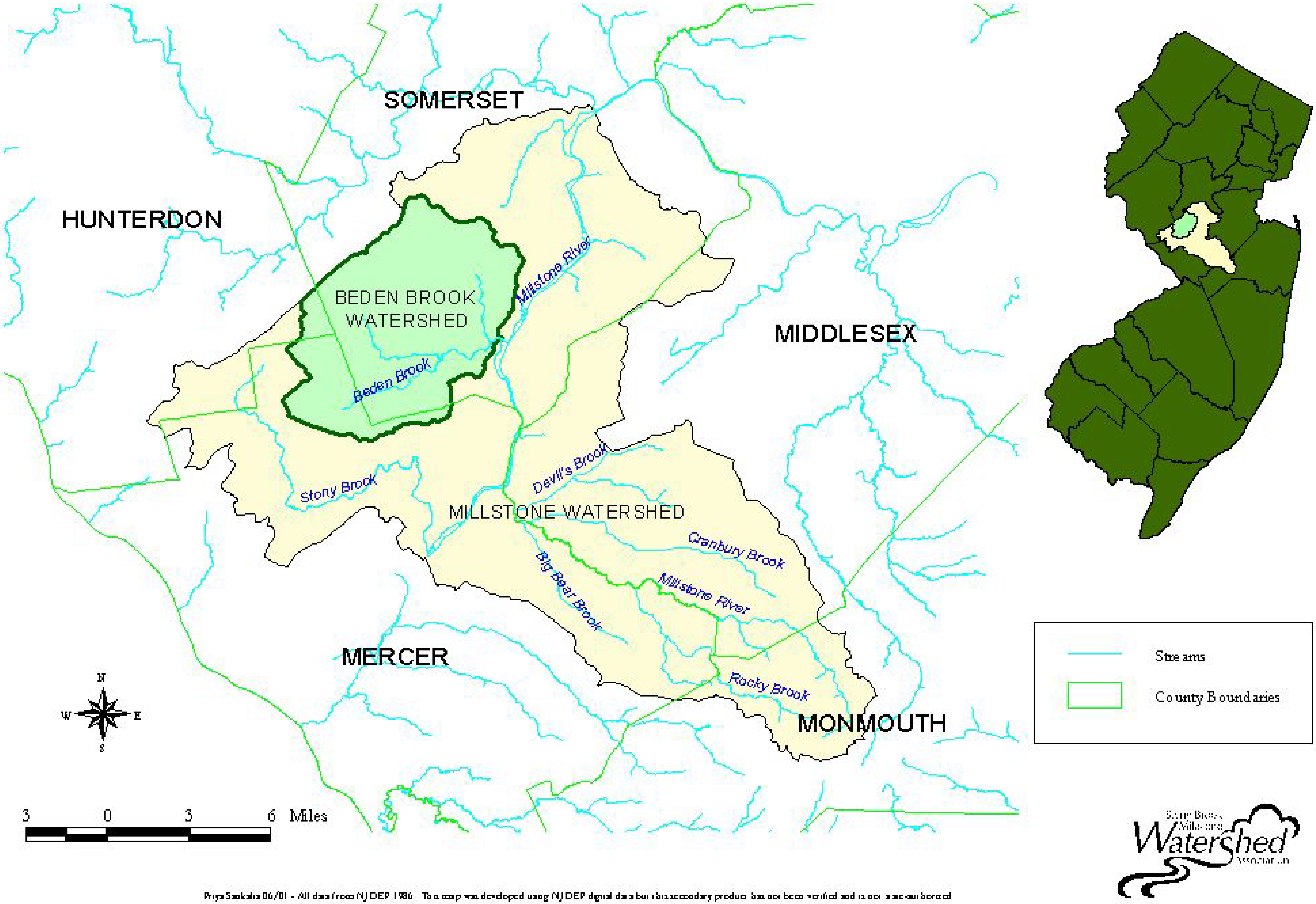
Wildlife Habitat Council, 1999. Personal communication.

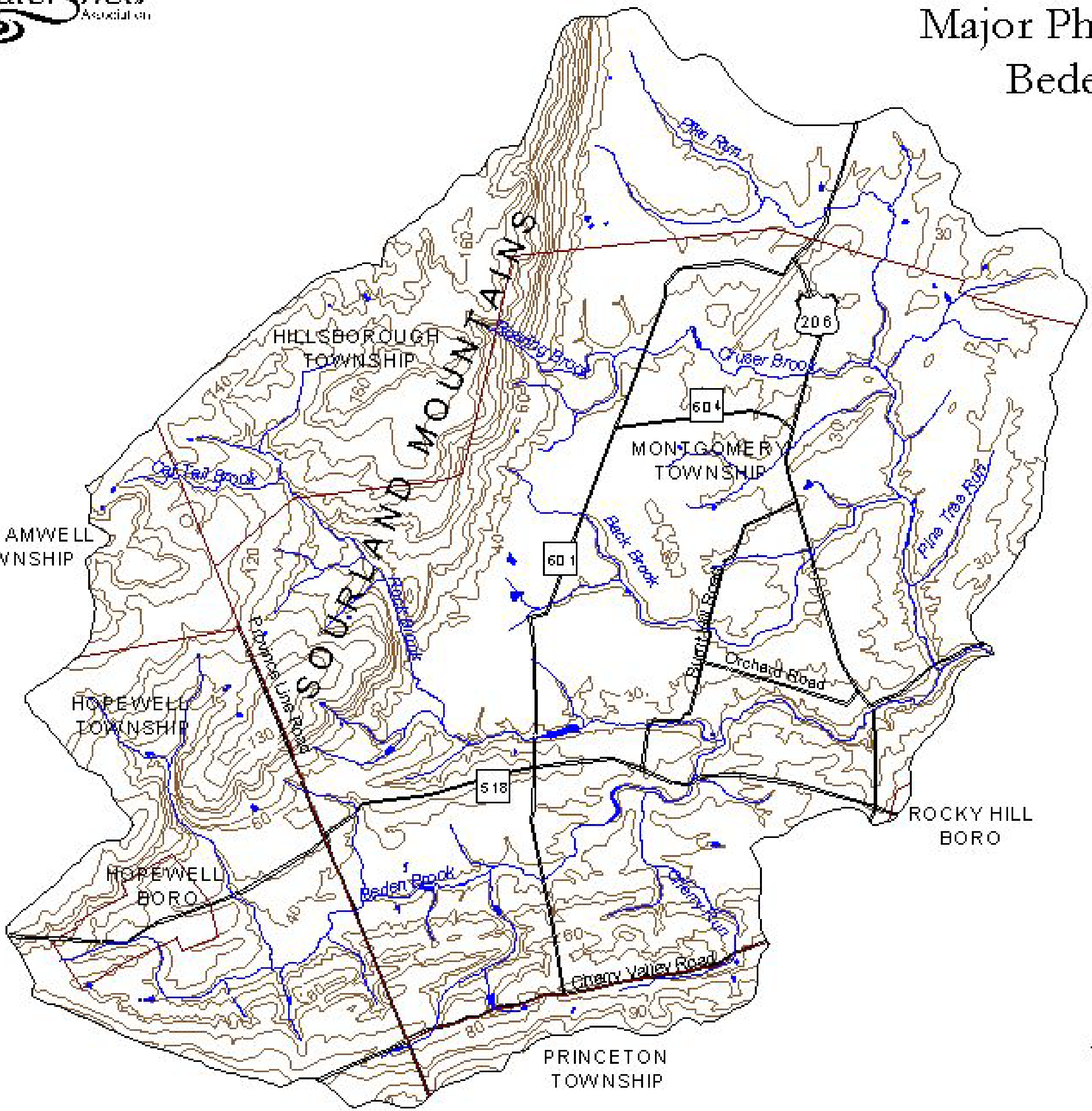
APPENDIX A:
Figures

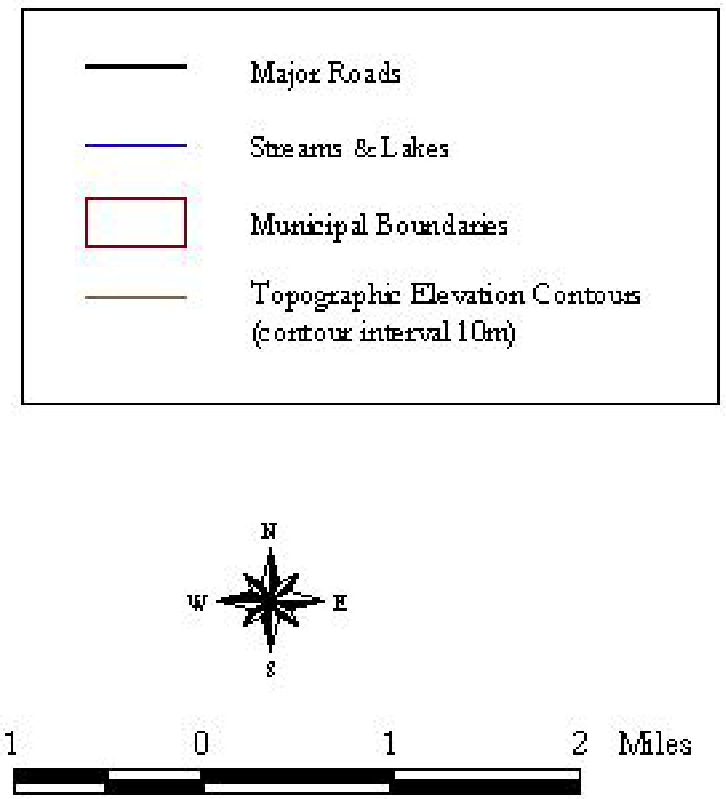
Figure 1
Beden Brook Watershed and Millstone Watershed



Stony Brook-Millstone Watershed Association

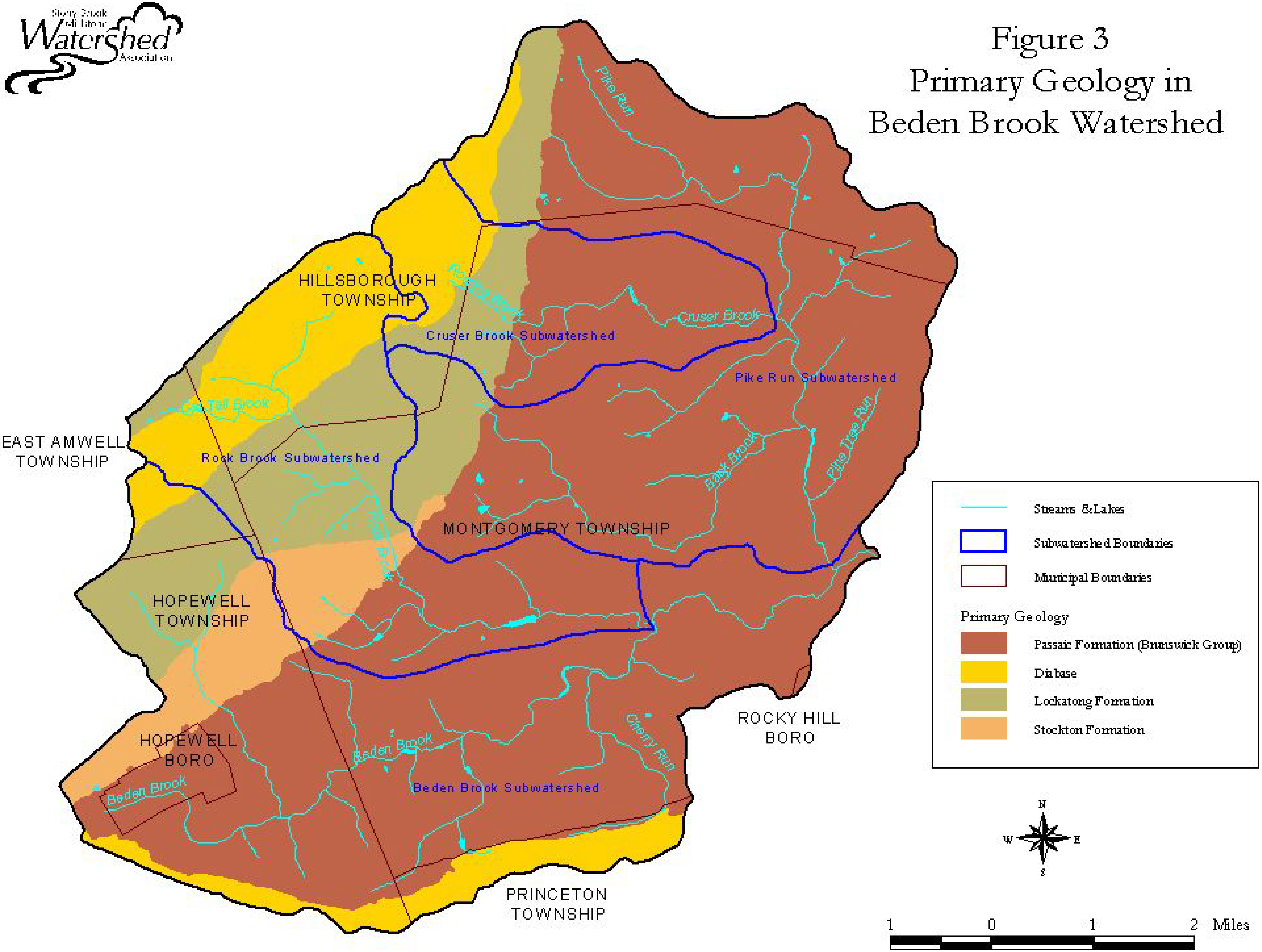
Figure 2
Major Physiography and Roads in Beden Brook Watershed





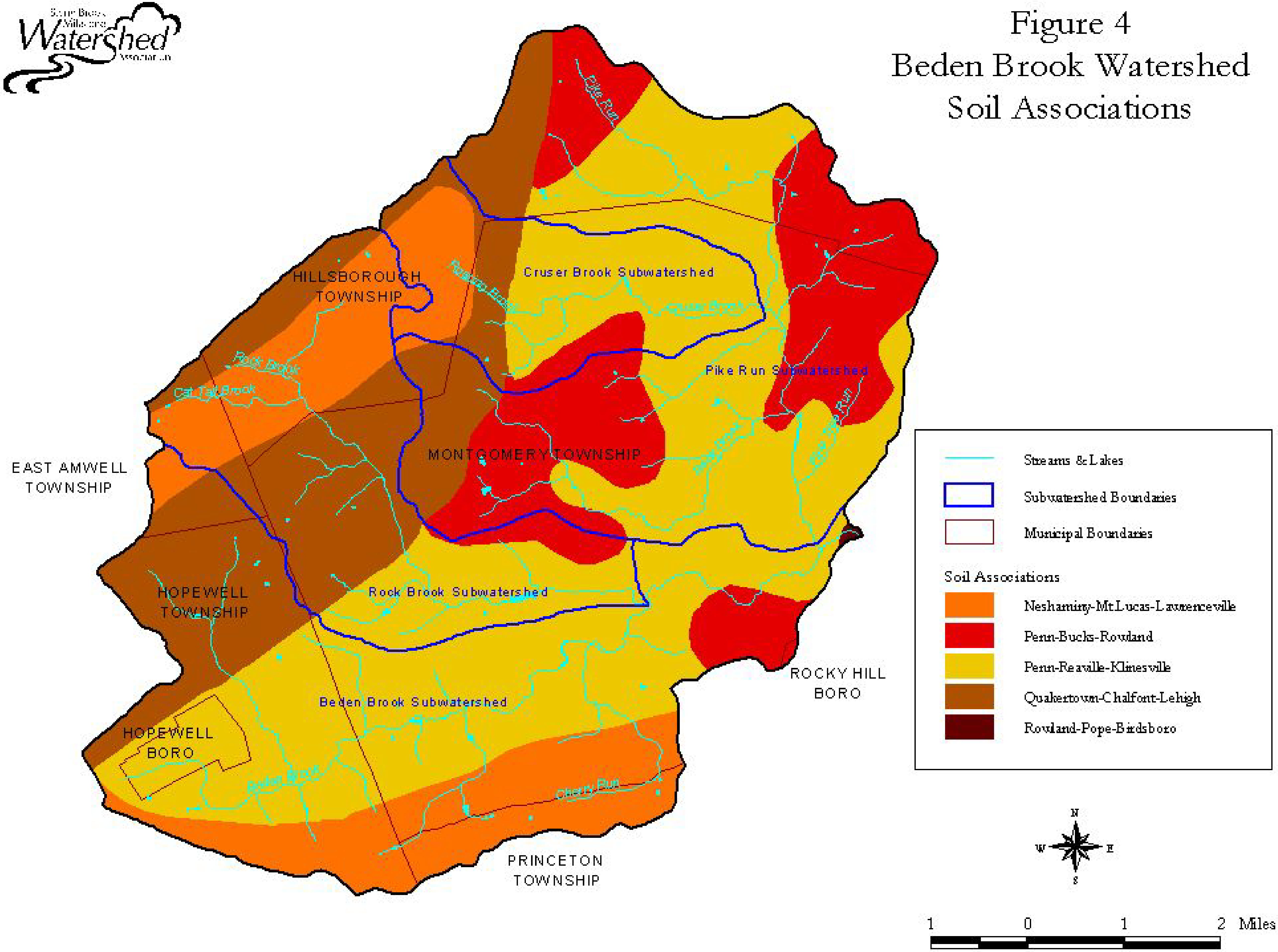
Priya Sankalia 06/01 -- Data from NJDEP 1986 Roads from US Census TIGER Files Topographic Elevation from NJGS 2000 This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 3
Primary Geology in Beden Brook Watershed



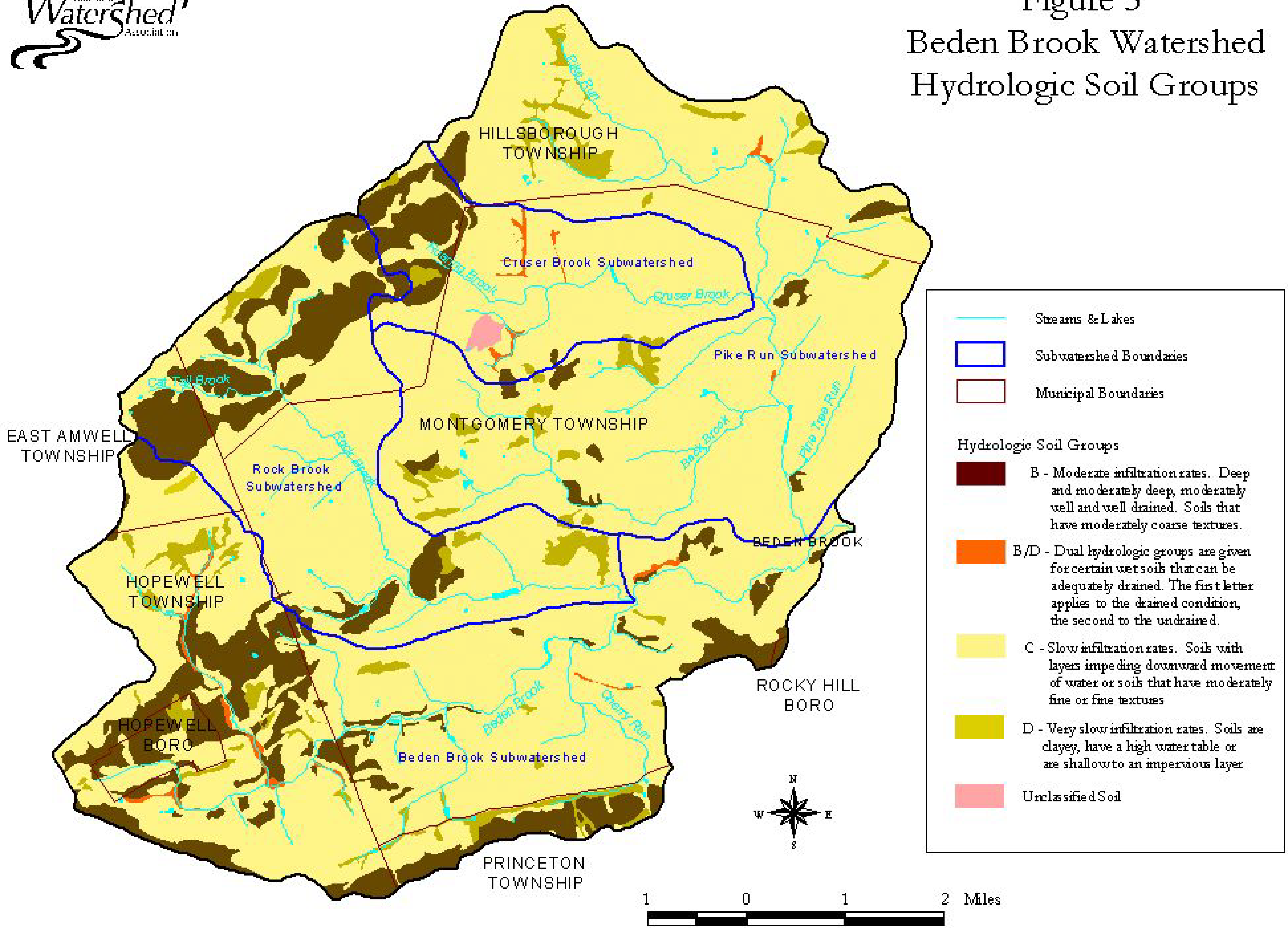
Priya Sankalia - 06/01 - Data from NJDEP 1986 This map was developed using NJDEP digital data, but this secondary product has not been verified and is not state-authorized

Figure 4
Beden Brook Watershed
Soil Associations



Map Created 6/01 - All data from NJDEP 1986 except soil data from NRCS 1994. This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not state-authorized.

Figure 5
Beden Brook Watershed
Hydrologic Soil Groups



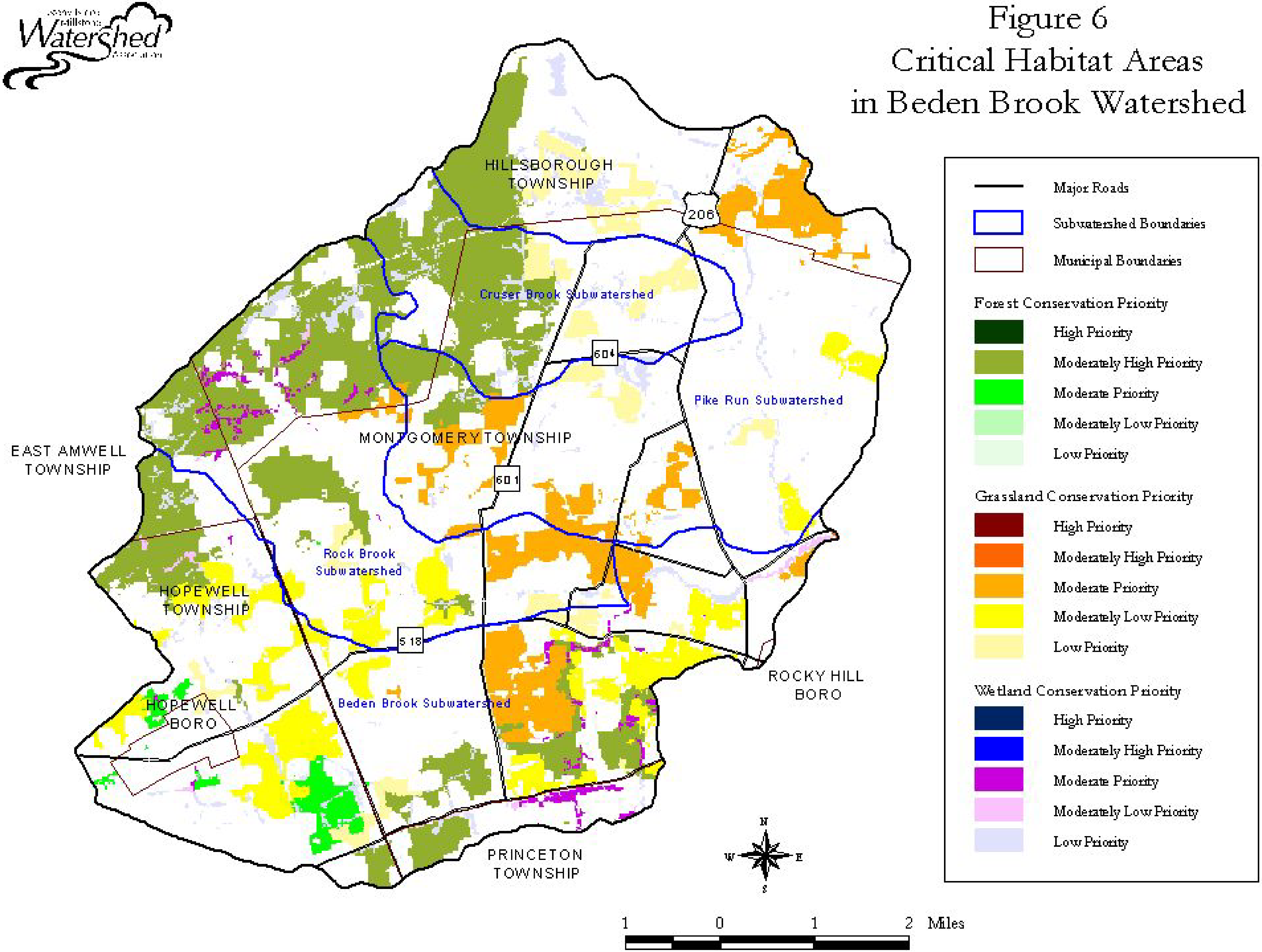
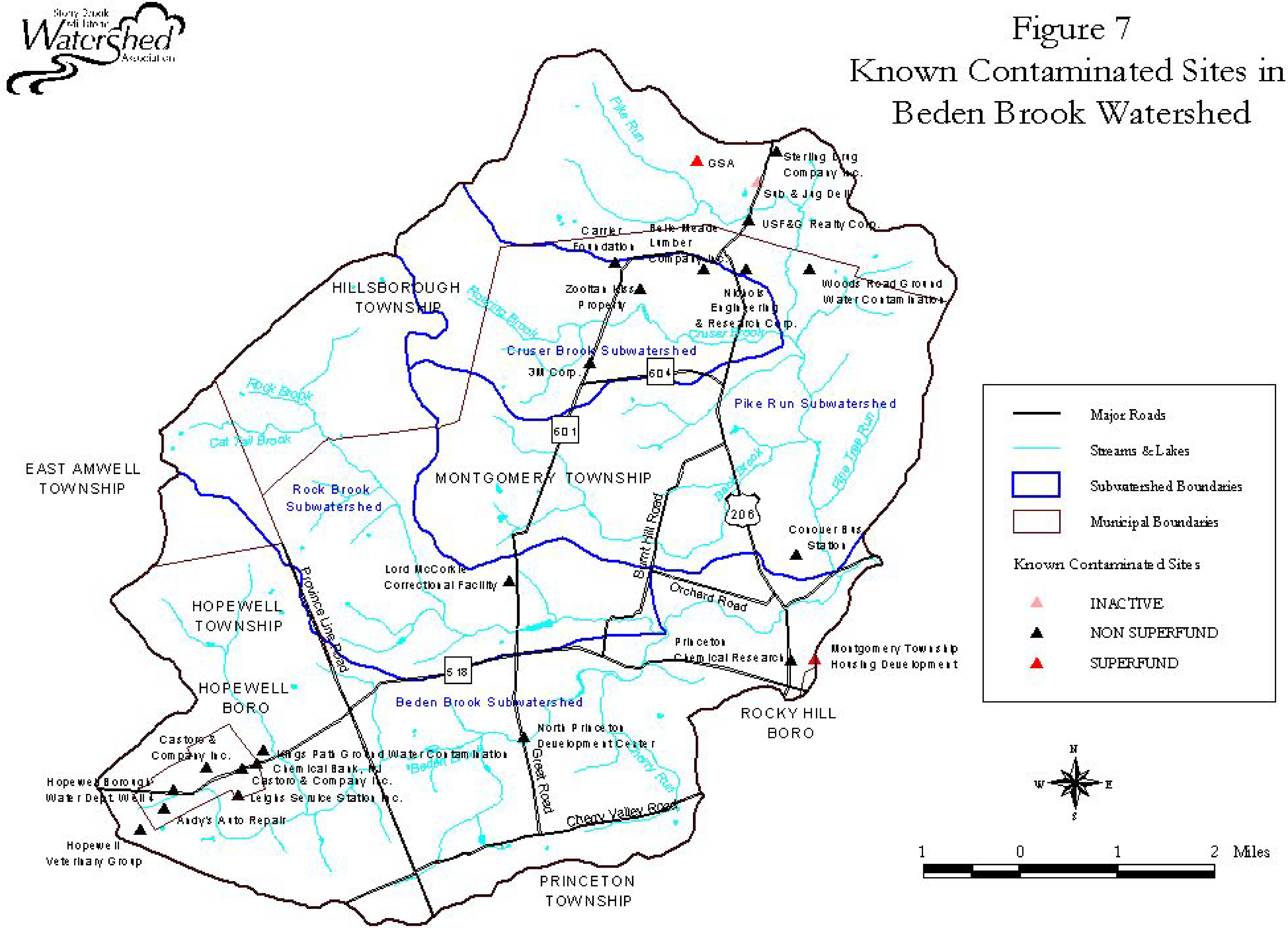


Figure 6
Critical Habitat Areas in Beden Brook Watershed

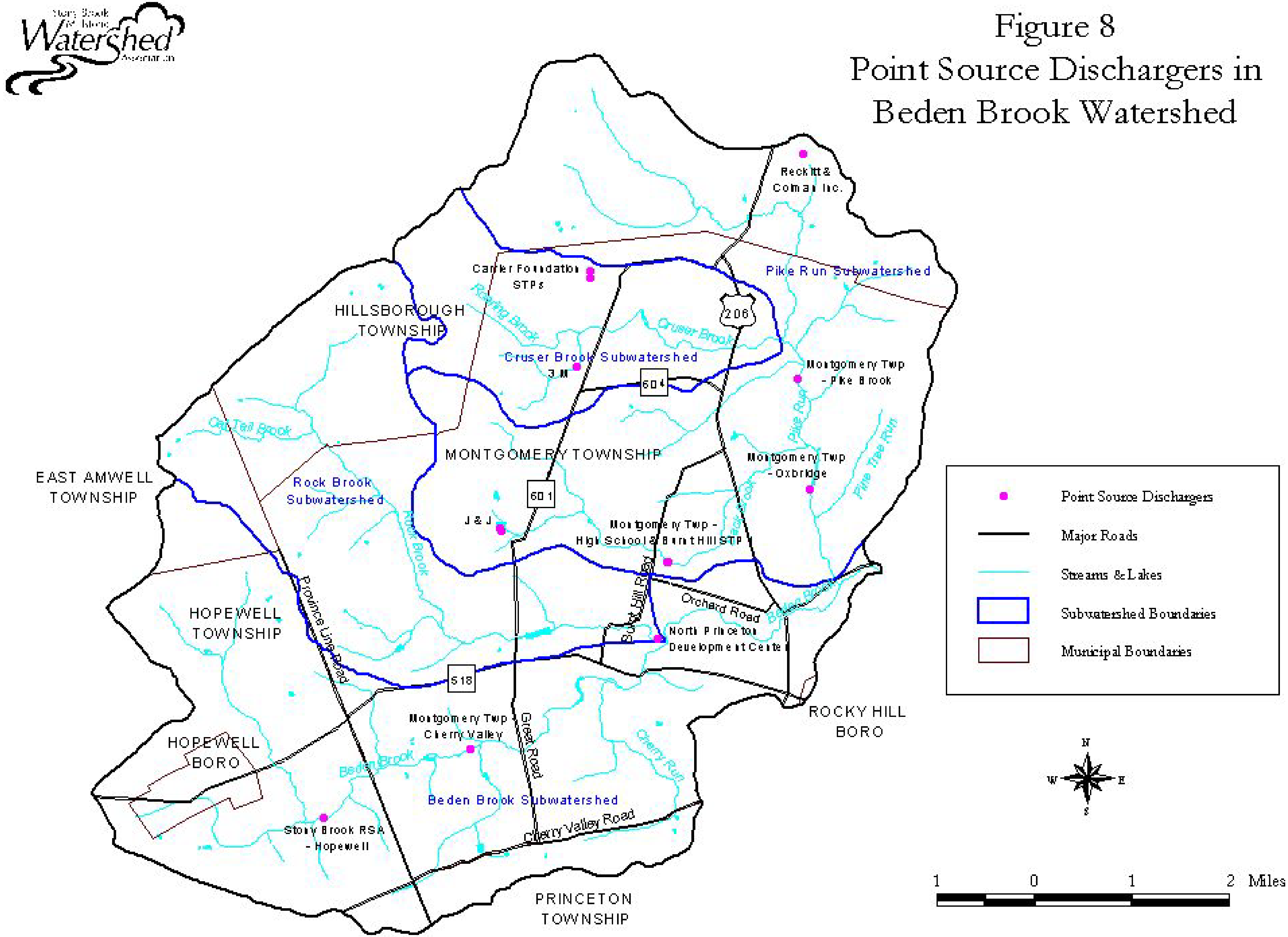
P. Sankala - Landscape Project data from NJDEP, Division of Fish and Wildlife
This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not state-authorized

Figure 7
Known Contaminated Sites in Beden Brook Watershed



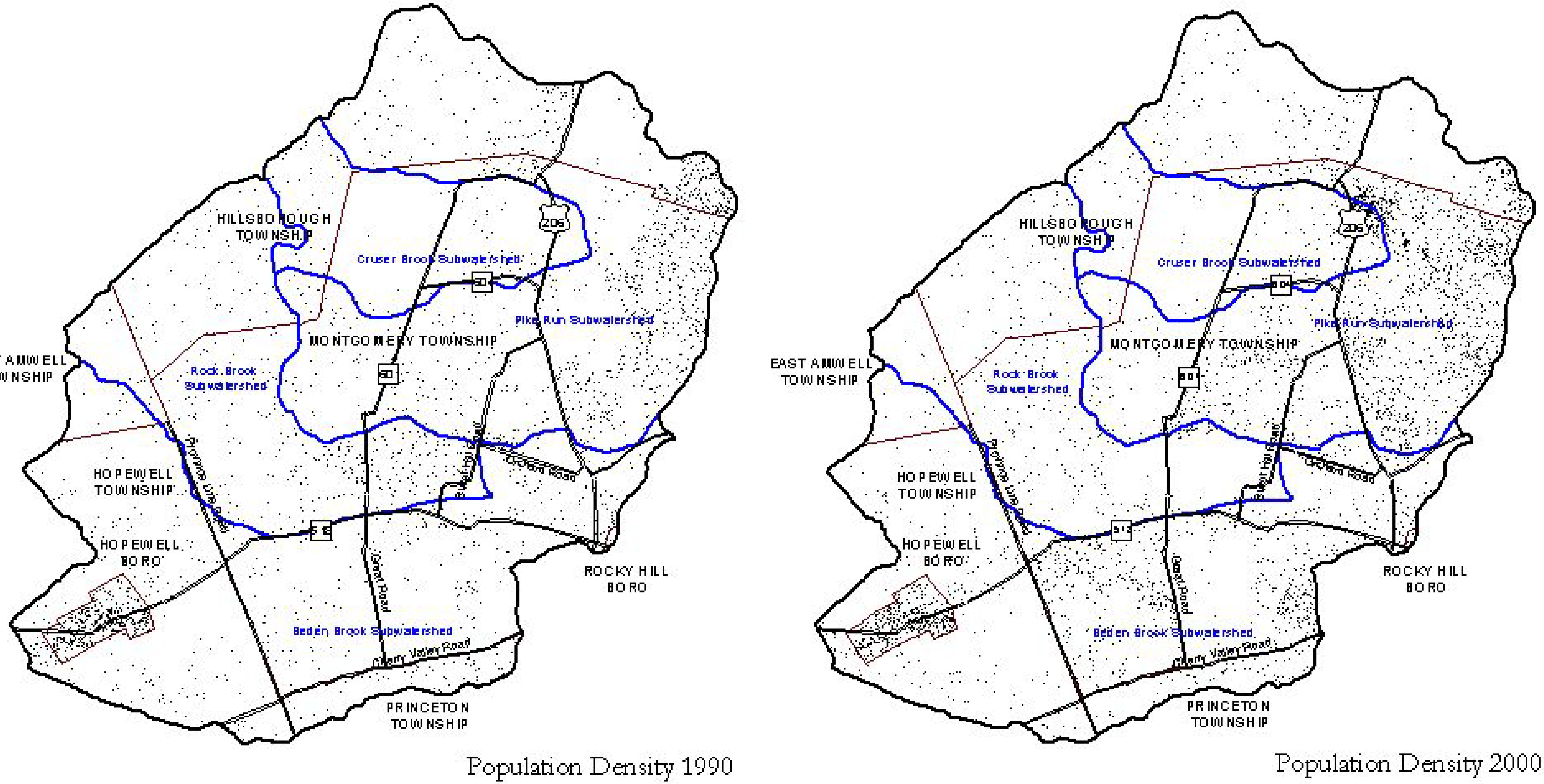
Priya Sankala 06/01 -- All data from NJDEP 1986, Known Contaminated Sites and Point Source Dischargers recorded 1997, updated 2001. This map was developed using NJDEP data but, this secondary product has not been verified and is not state-authorized.
Note that the listing of contaminated sites gives the name of the current owner of the property where the contaminated site is located. The current site owner and the party responsible for the contamination are not necessarily the same.

Figure 8
Point Source Dischargers in Beden Brook Watershed

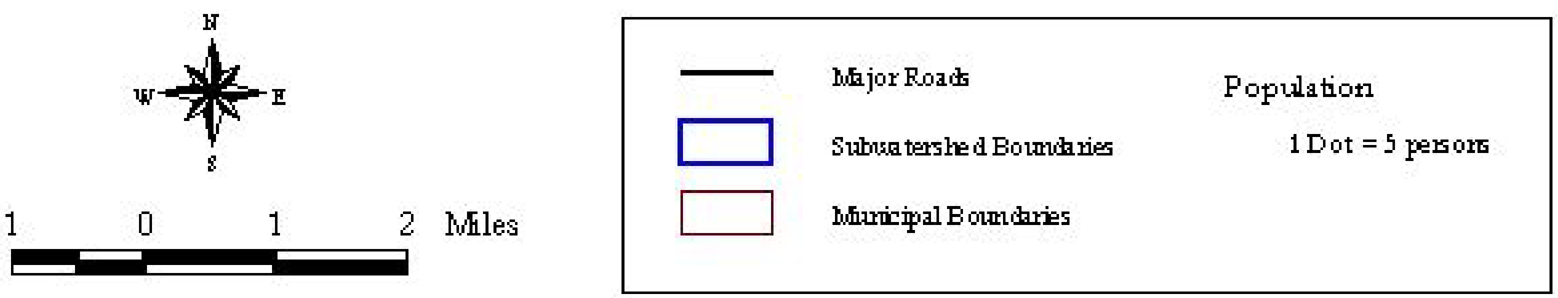


Priya Sankalia 06/01 -- All data from NJDEP 1986, Point Source Dischargers recorded 1997, update 2001. This map was developed using NJDEP data but, this secondary product has not been verified and is not state-authorized

Figure 9
Population Density in Beden Brook Watershed

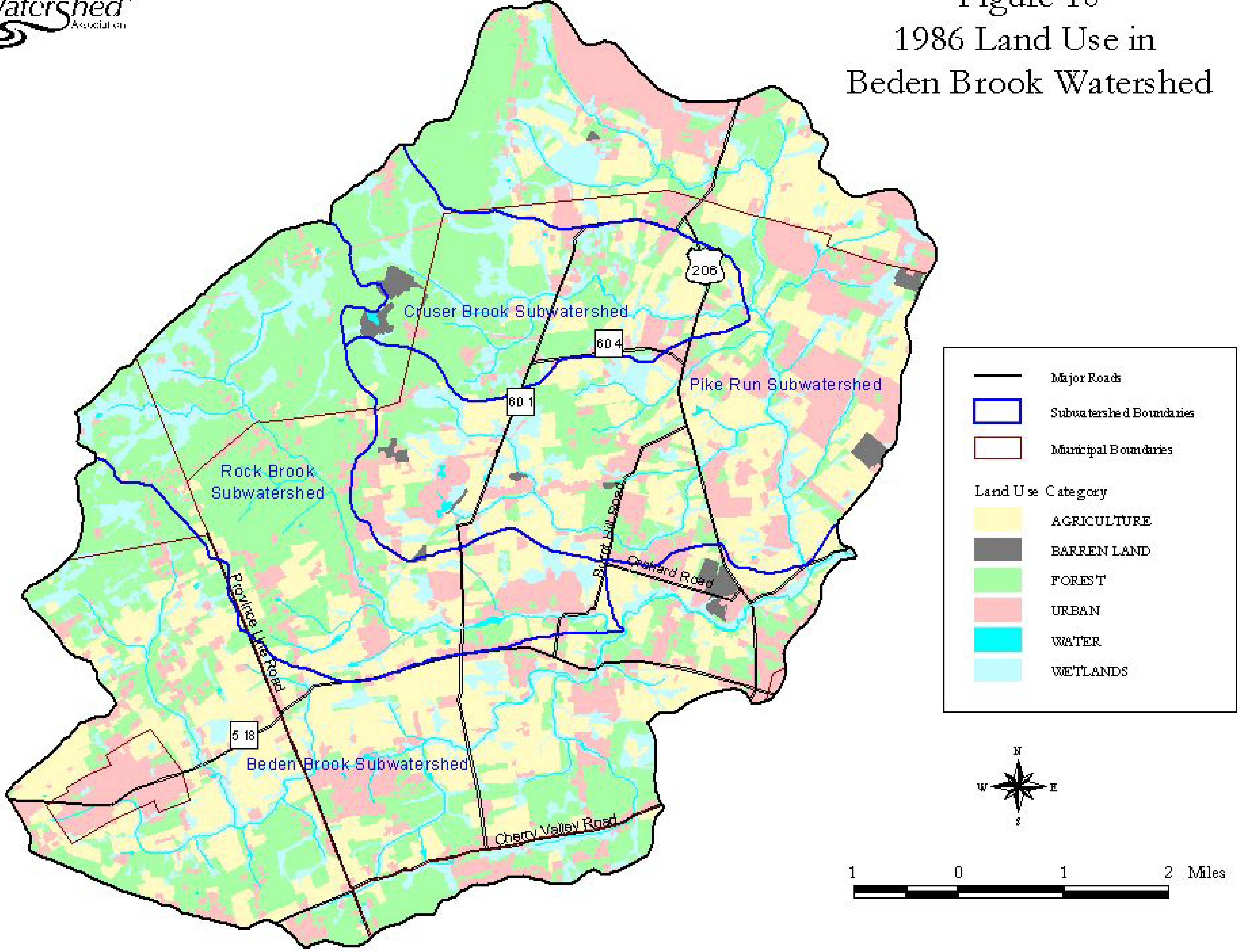


Note: Dots represent the total population within a census block, not the physical location of the population's residence.



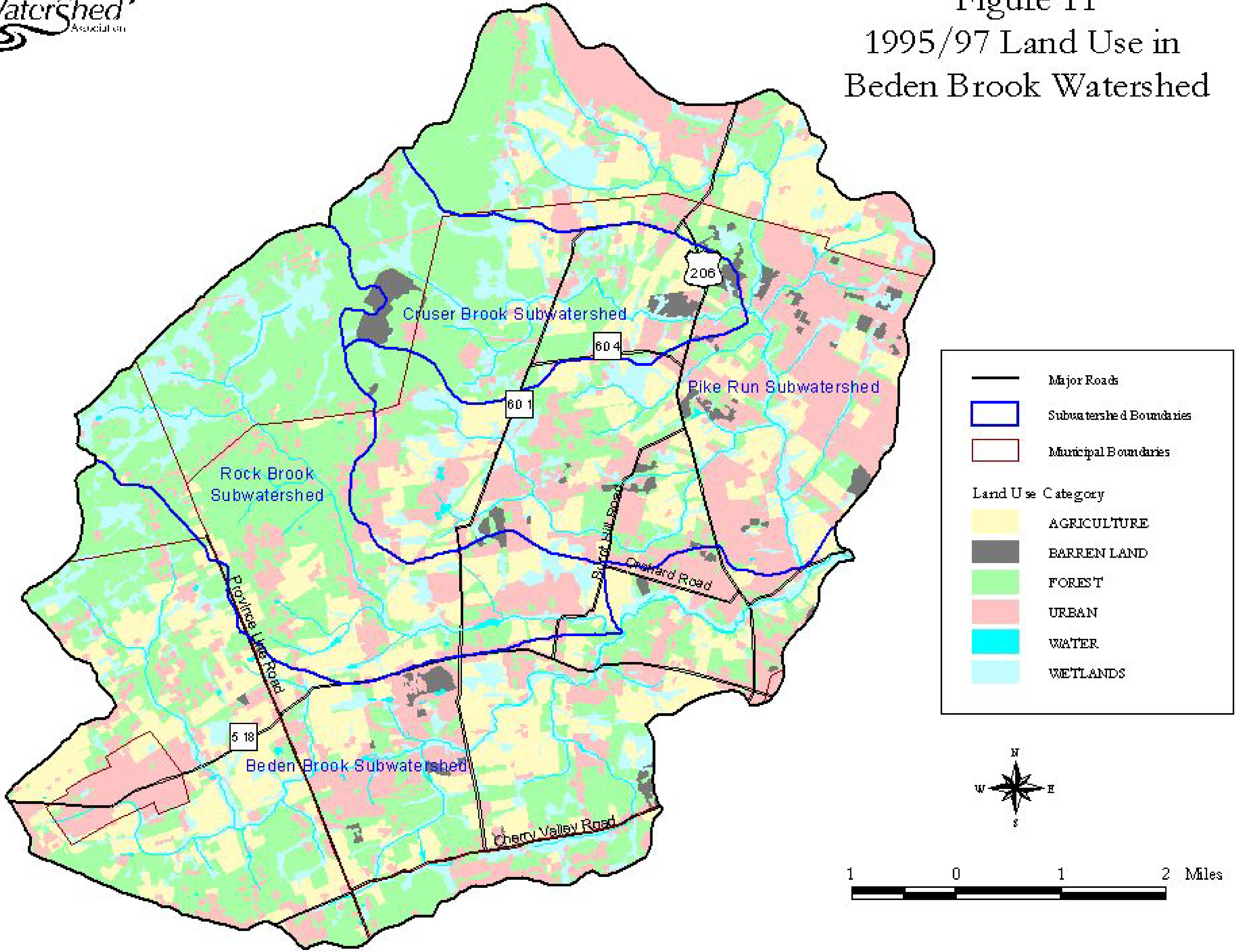
Priya Sankalia 06/01 -- All data from NJDEP 1986 except population data from US Census 1990 and US Census Redistricting data from 2000
This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 10
1986 Land Use in Beden Brook Watershed



Priya Sankalia 06/01 -- Data from NJDEP 1986 and 1995/1997. This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 11
1995/97 Land Use in Beden Brook Watershed



Priya Sankalia 06/01 -- Data from NJDEP 1986 and 1995/1997. This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

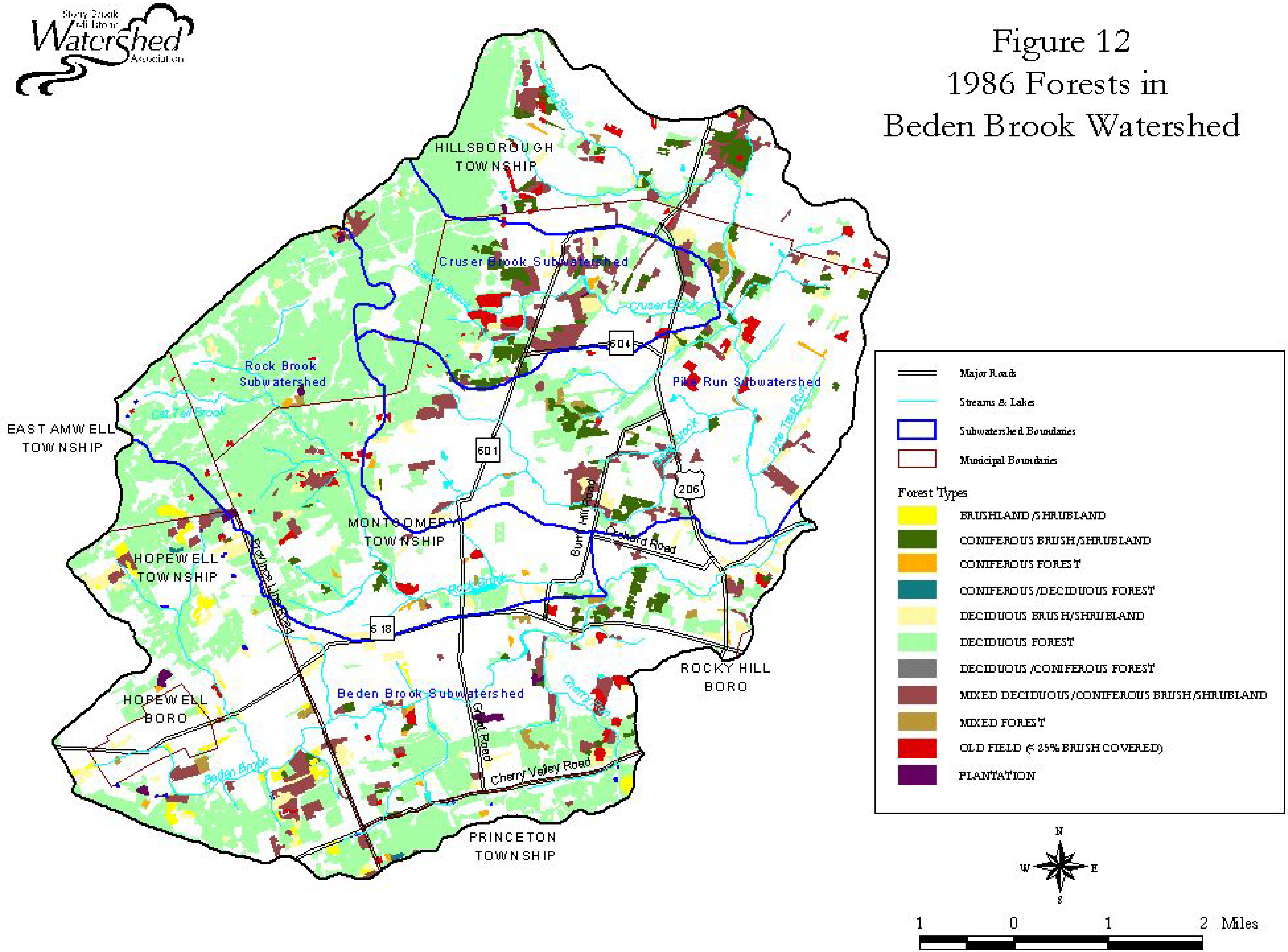
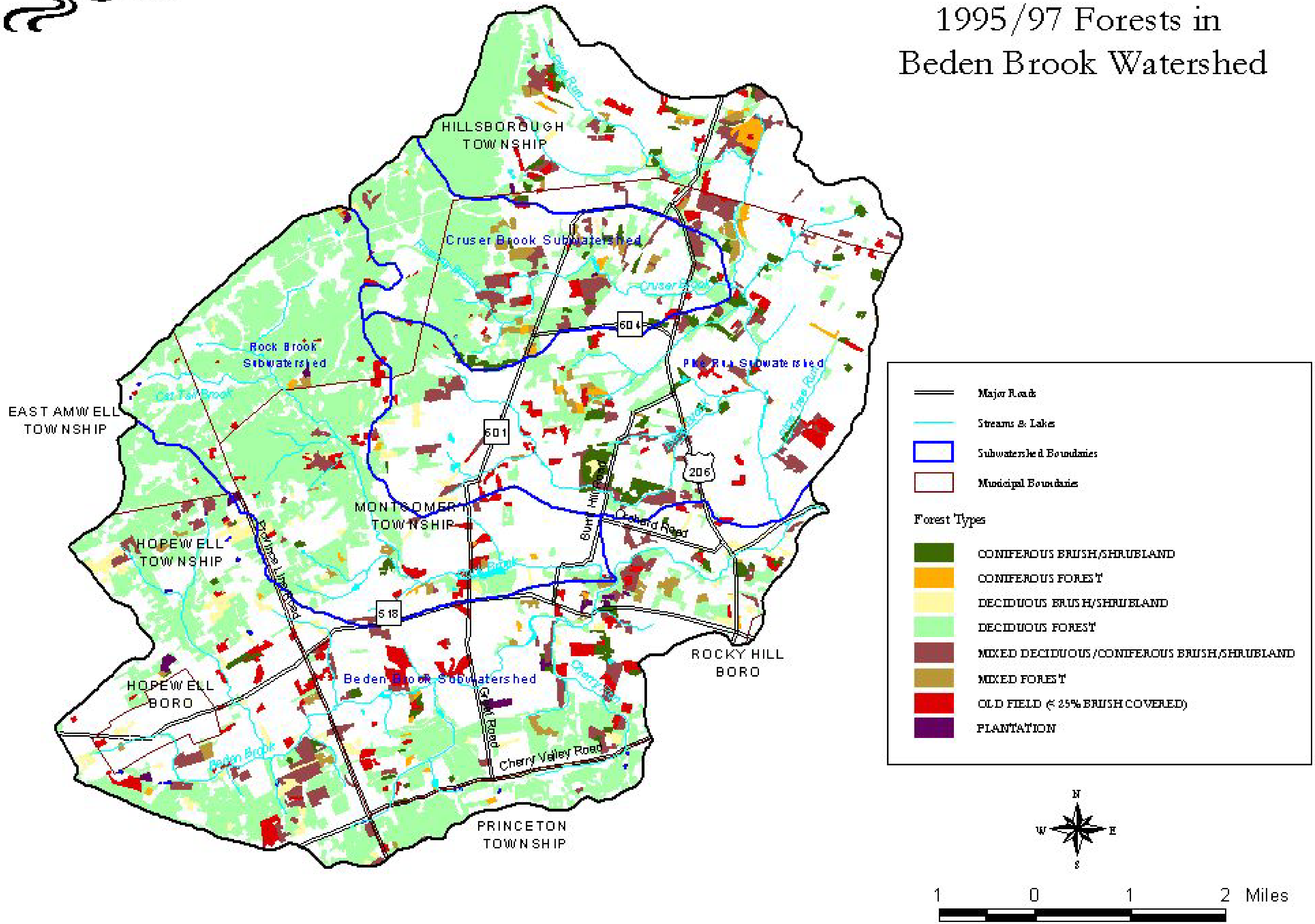


Figure 12
1986 Forests in
Beden Brook Watershed

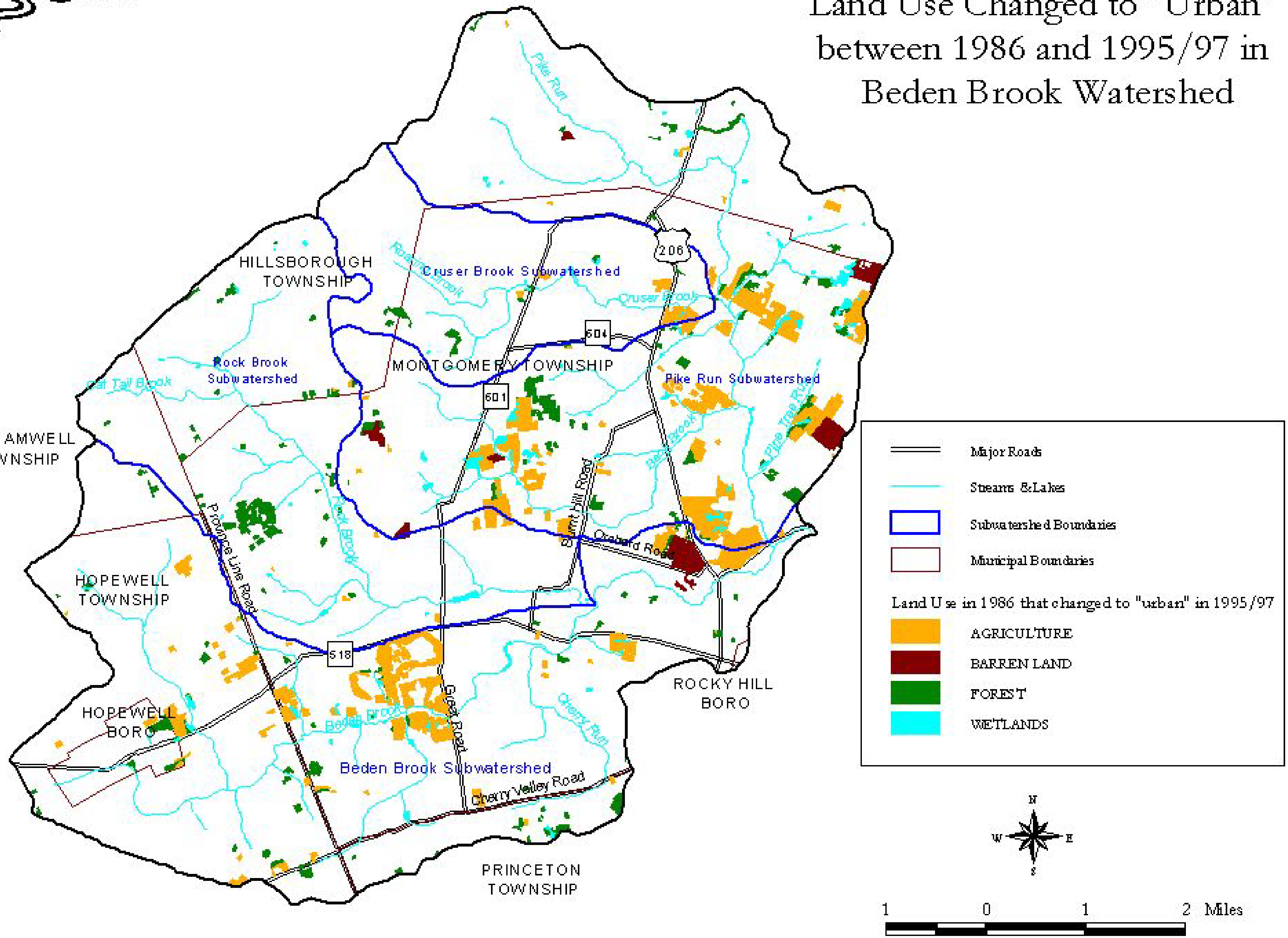
Priya Sankalia - 06/01 Data from NJDEP 1986 and 1995/97. Roads from US Census TIGER files. This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 13
1995/97 Forests in Beden Brook Watershed



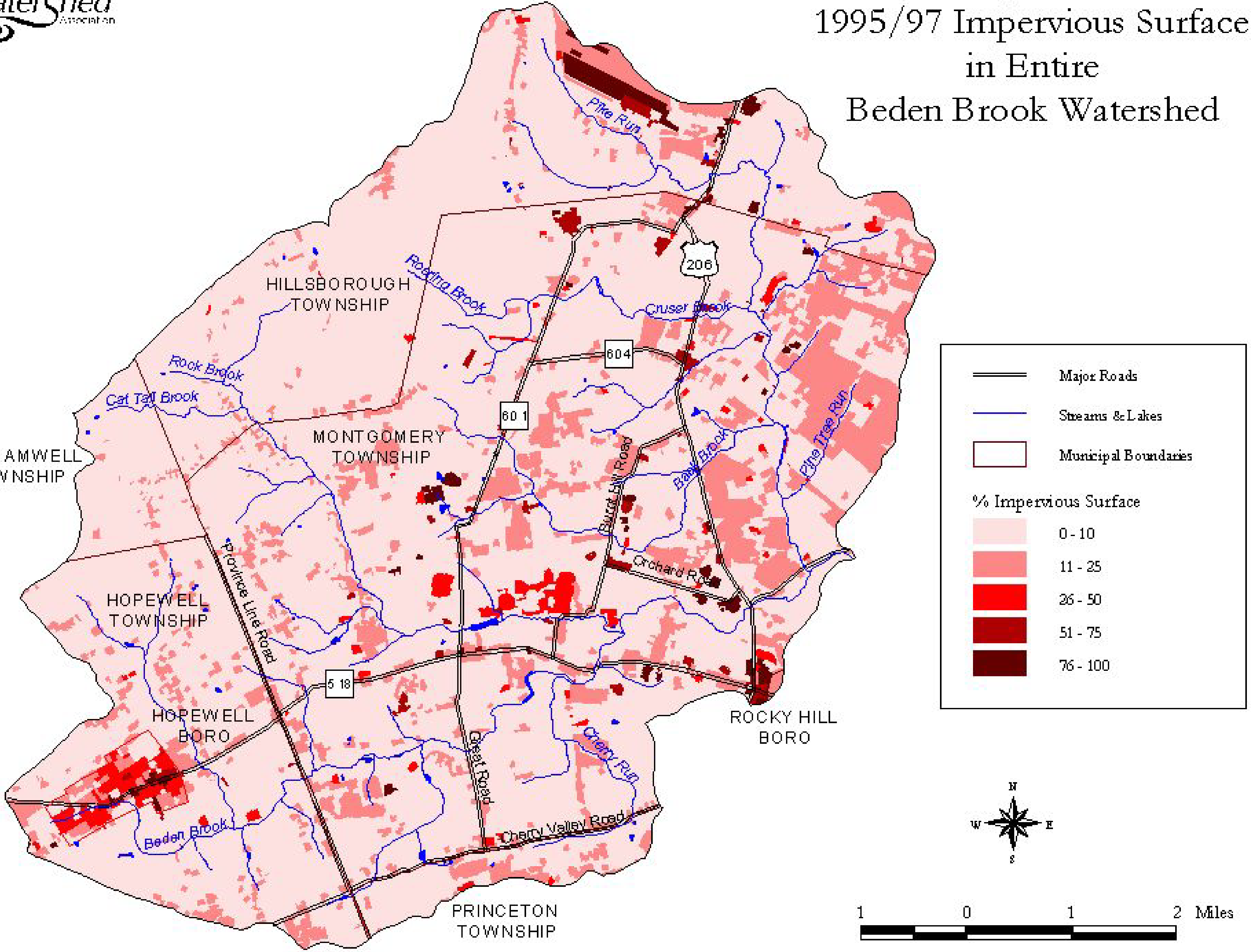
Priya Sankalia - 06/01. Data from NJDEP 1986 and 1995/97. Roads from US Census TIGER files. This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 14
Land Use Changed to "Urban" between 1986 and 1995/97 in Beden Brook Watershed



Priya Sankalia - 06/01 Data from NJDEP 1986 and 1995/97. Roads from US Census TIGER files. This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized.

Figure 15
1995/97 Impervious Surfaces in Entire Beden Brook Watershed



Priya Sankalia 06/01 -- Data from NJDEP 1986 and 1995/1997 Roads from US Census TIGER Data This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

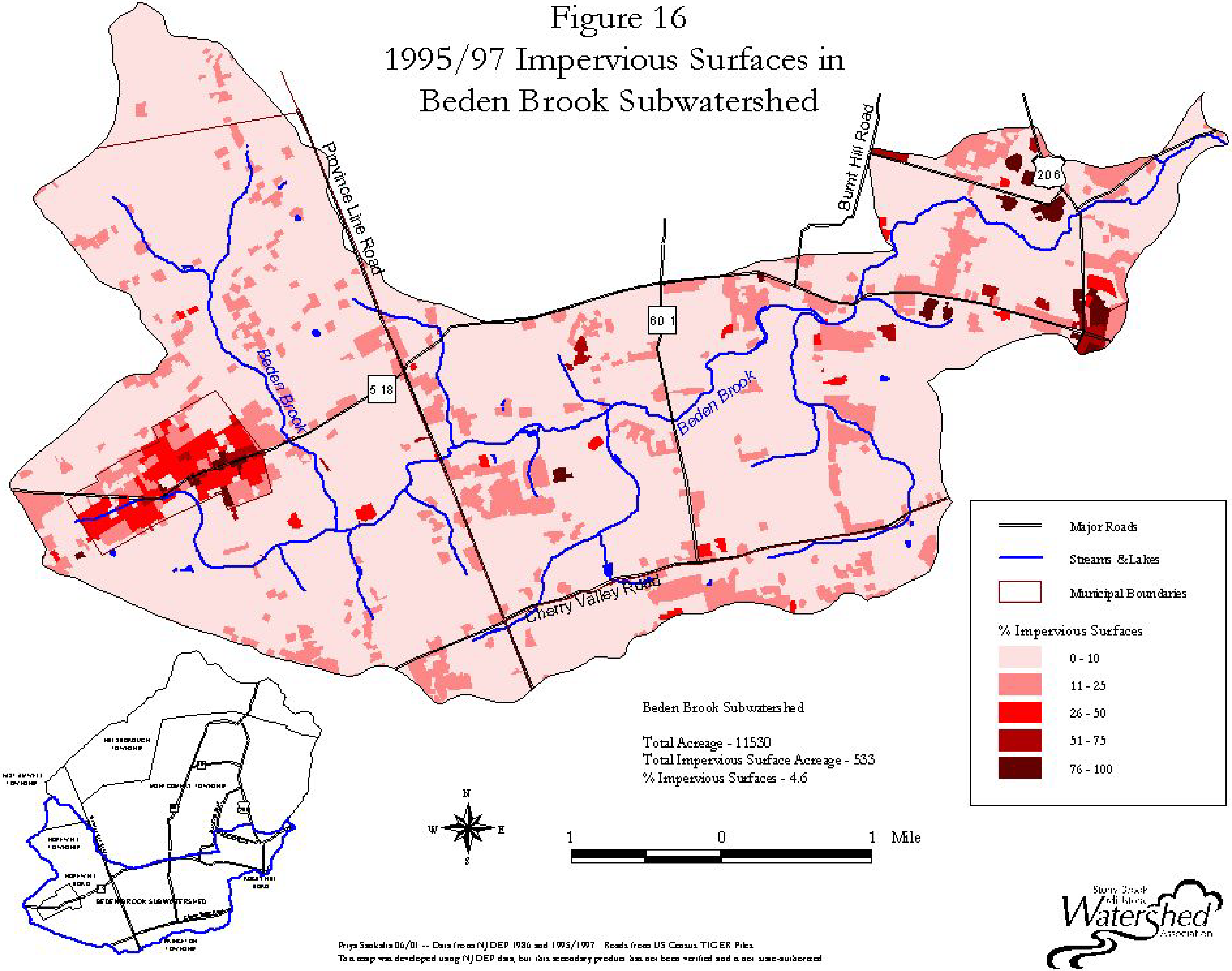
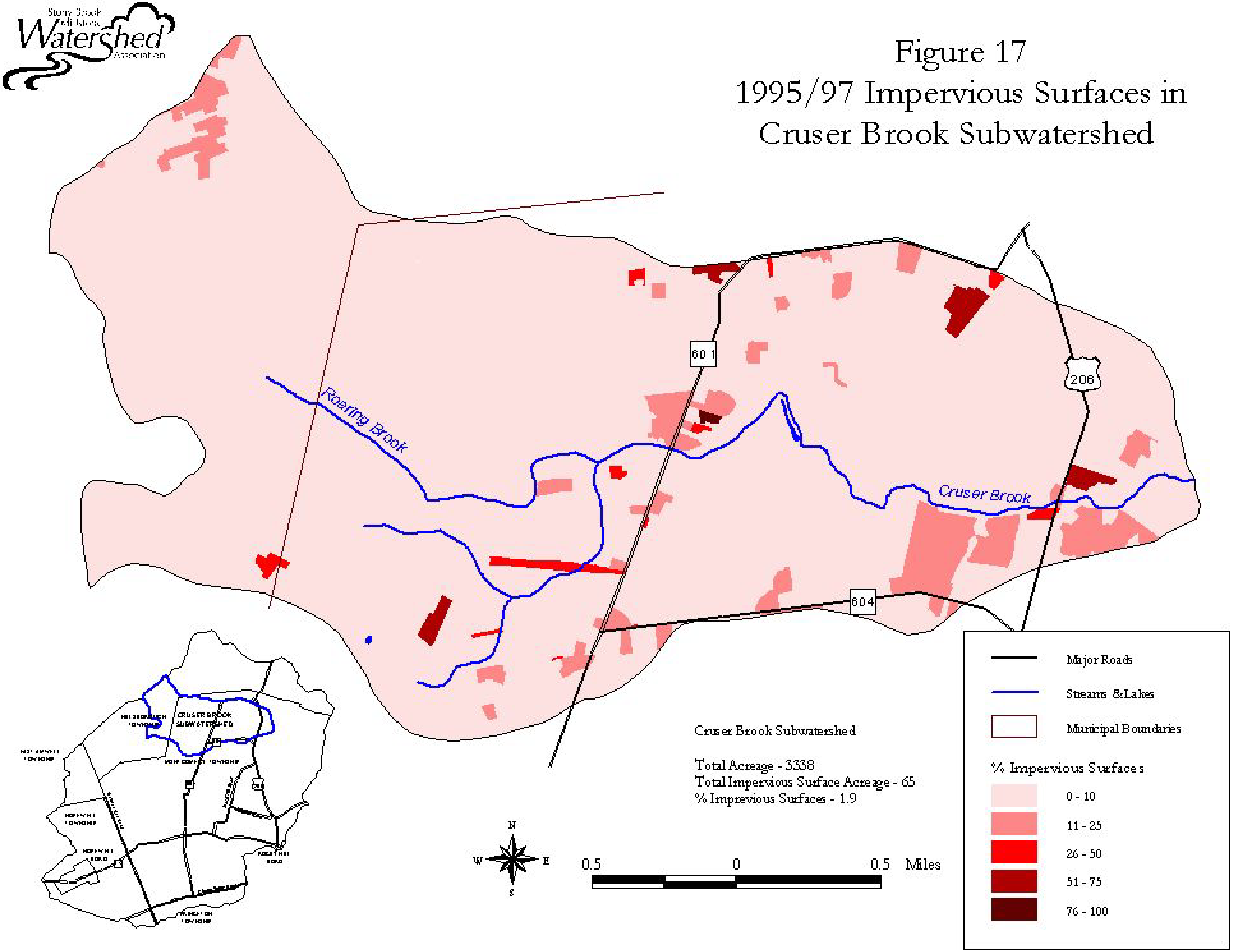


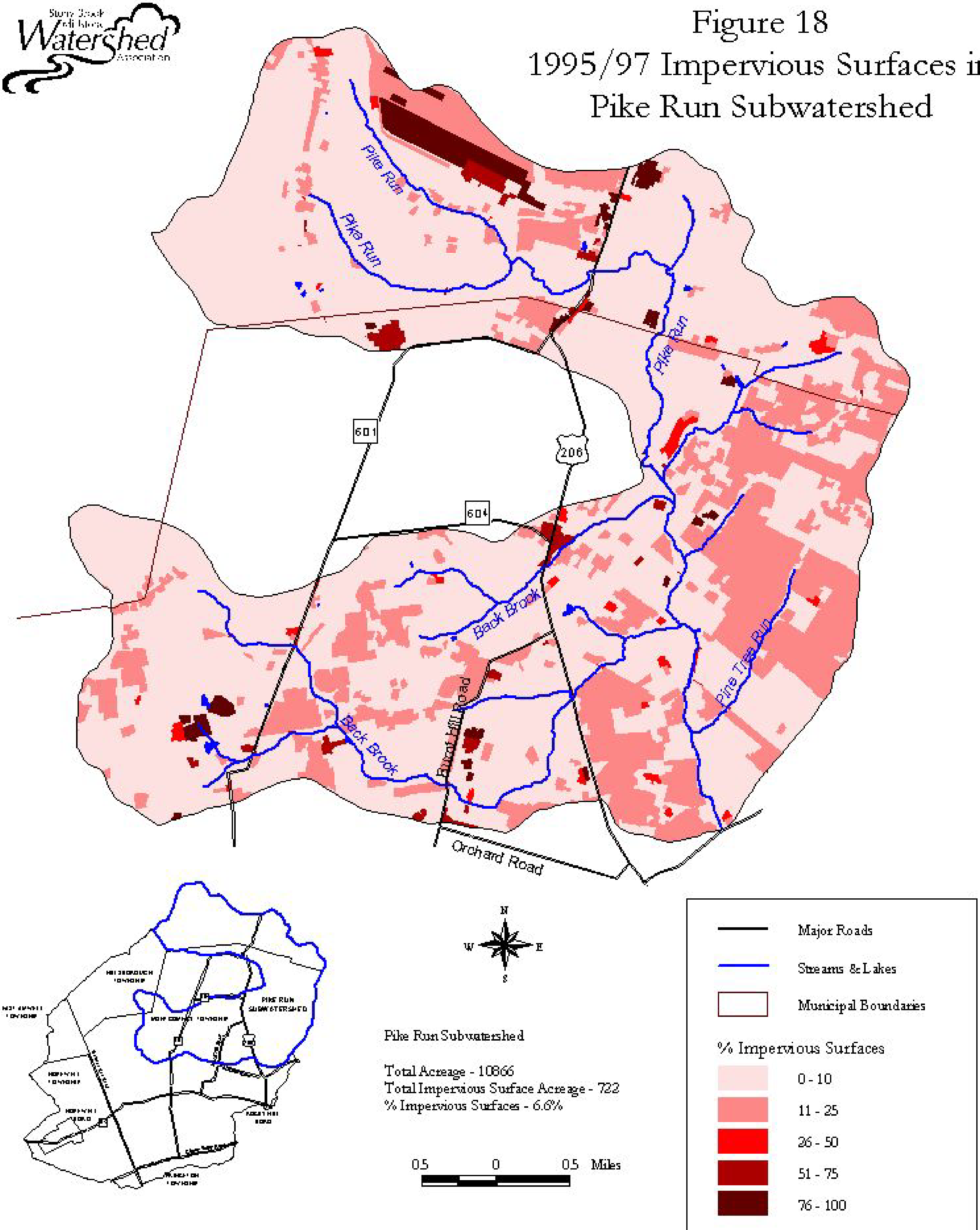
Figure 16
1995/97 Impervious Surfaces in Beden Brook Subwatershed

Figure 17
1995/97 Impervious Surfaces in Cruser Brook Subwatershed



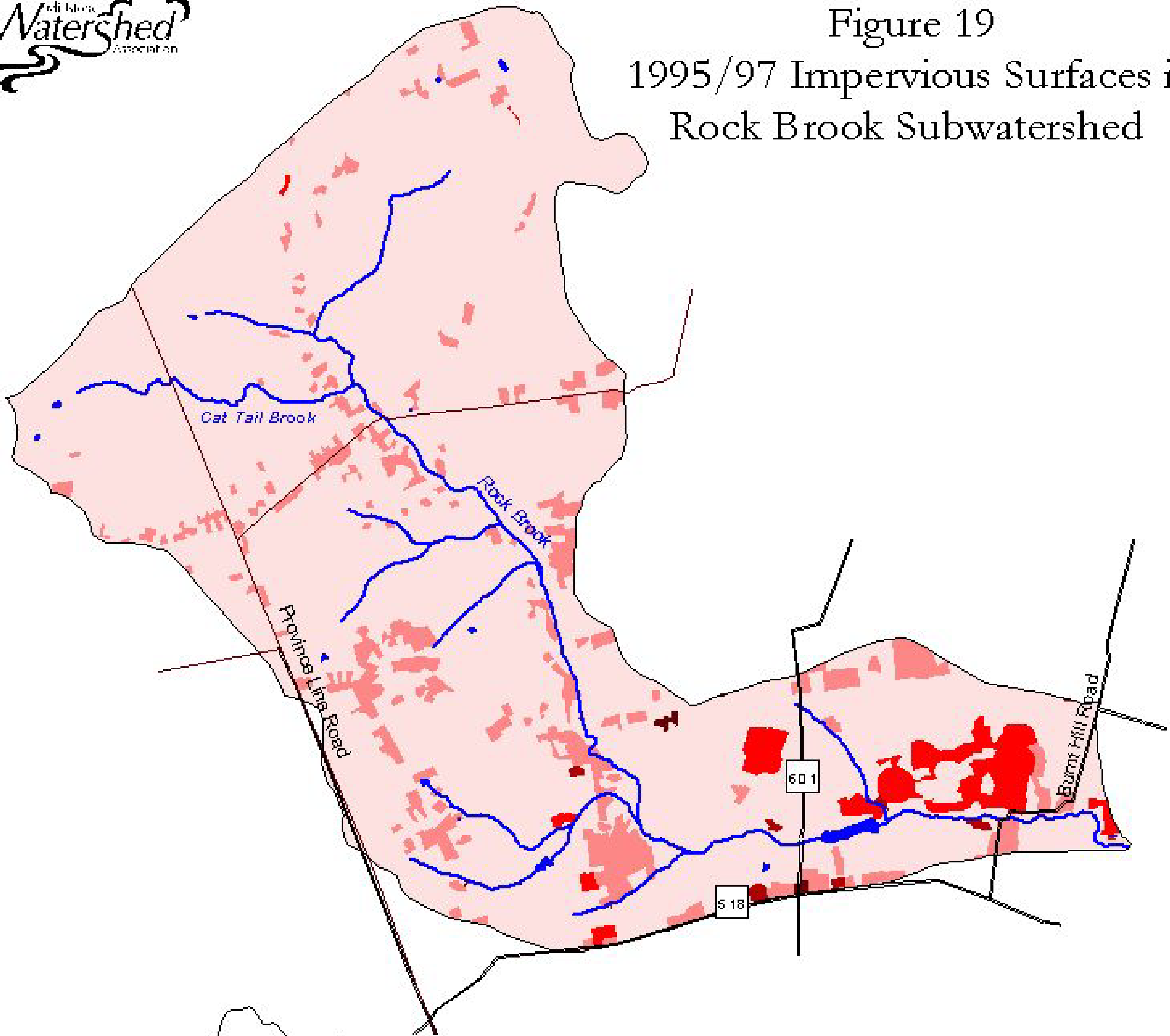
Priya Saxkalia 06/01 -- Data from NJDEP 1986 and 1995/1997. Roads from US Census TIGER Files. This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

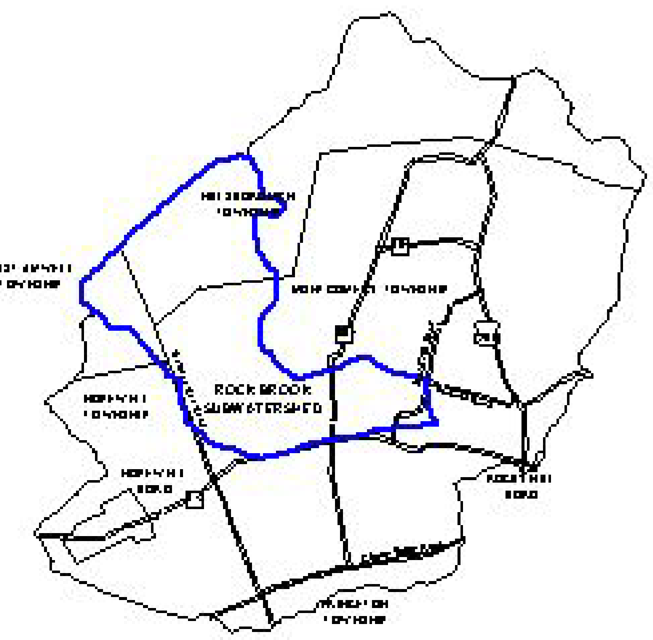
Figure 18
1995/97 Impervious Surfaces in Pike Run Subwatershed



Priya Sankalia 06/01 -- Data from NJDEP 1986 and 1995/1997 Roads from US Census TIGER Files
This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 19
1995/97 Impervious Surfaces in Rock Brook Subwatershed





Rock Brook Subwatershed

Total Acreage - 6078
Total Impervious Surface Acreage - 197
% Impervious Surfaces - 3.2

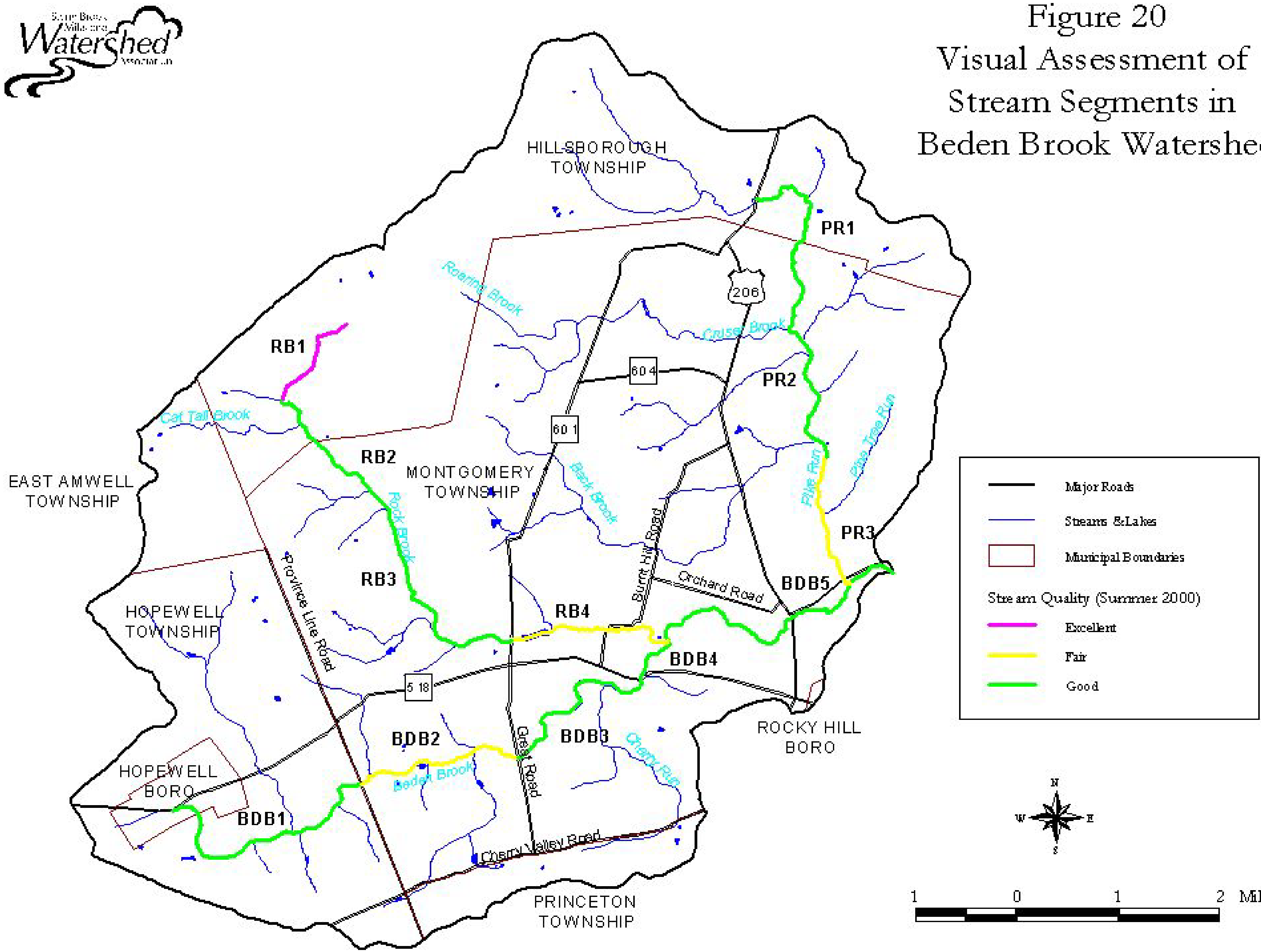
0.5 0 0.5 Miles

Major Roads
Streams & Lakes
Municipal Boundaries

% Impervious Surfaces
0 - 10
11 - 25
26 - 50
51 - 75
76 - 100

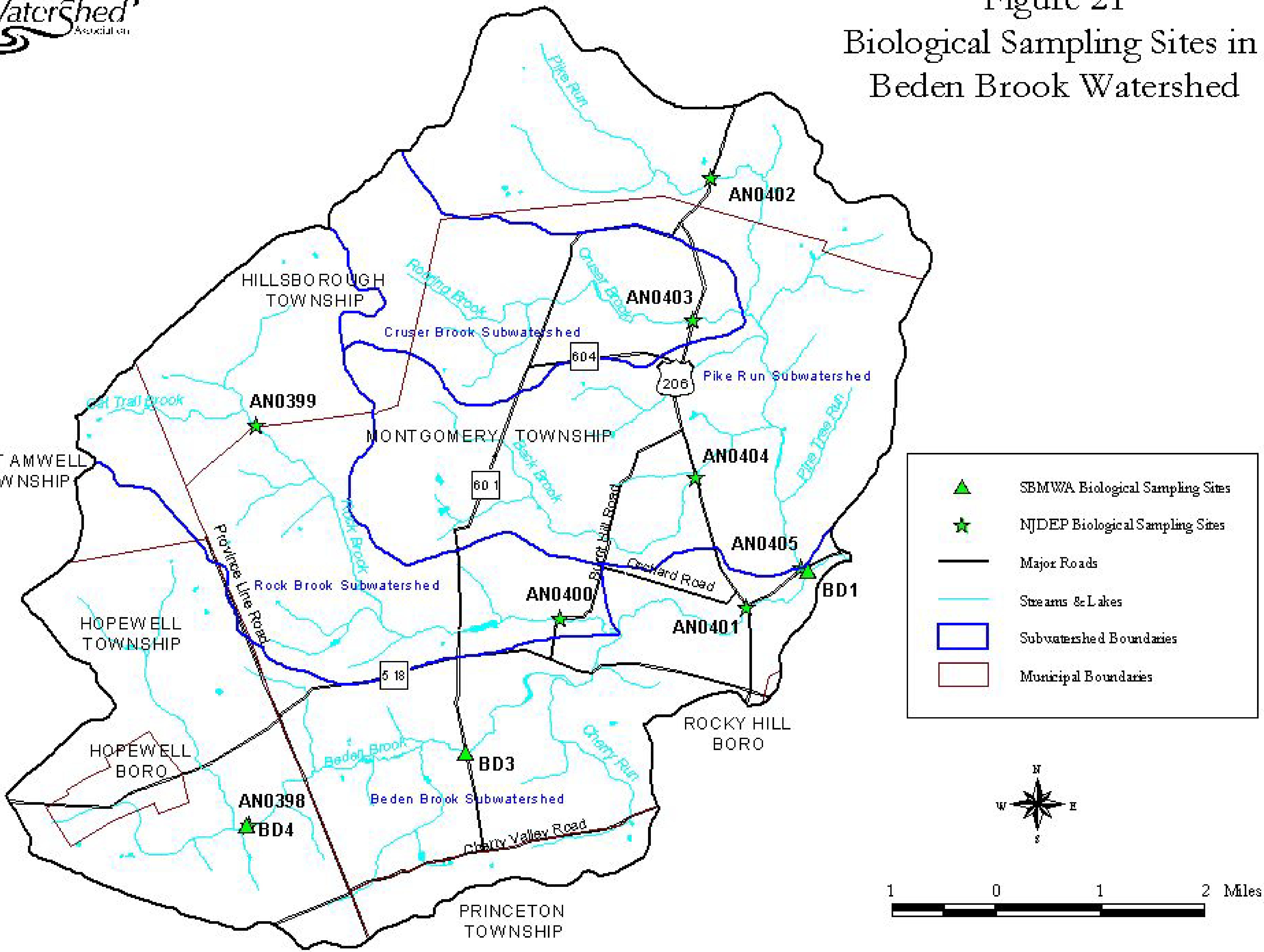
Priya Sankalia 09//00 -- Data from NJDEP 1986 and 1995/1997 Roads from US Census TIGER Files
This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 20
Visual Assessment of Stream Segments in Beden Brook Watershed



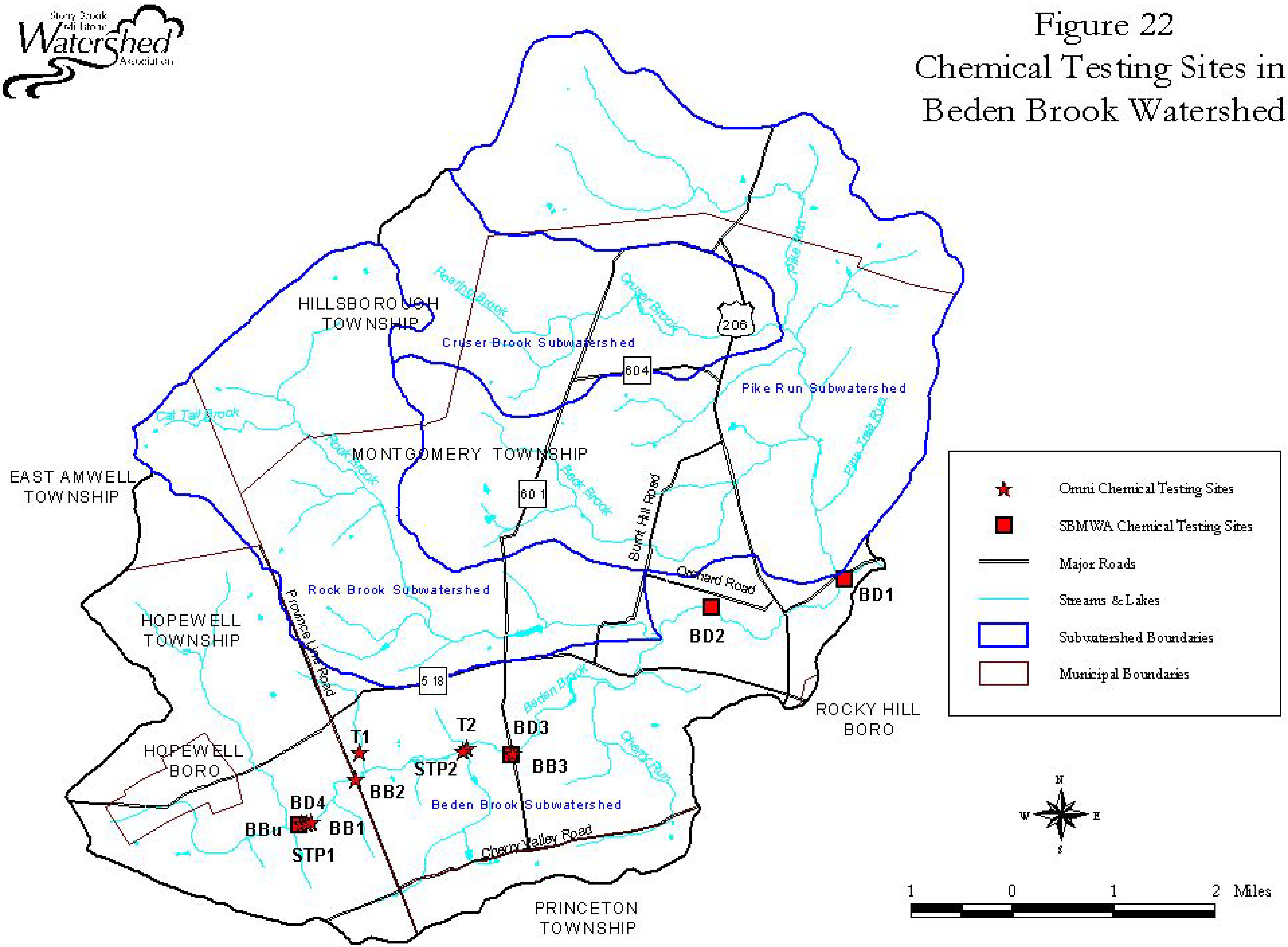
Priya Sankalia 06/01 - All data from NJDEP 1986 except Roads from US Census TIGER files and Visual Assessment data from SBMWA. Part of this map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 21
Biological Sampling Sites in Beden Brook Watershed



Priya Sankalia - 6/01 All data from NJDEP 1986 except Roads from US Census TIGER Data 1990 and Biological Sampling Sites from NJDEP 2001 and SBMWA 2000
This map was developed using NJDEP data, but this secondary product has not been verified and is not state-authorized

Figure 22
Chemical Testing Sites in Beden Brook Watershed



Priya Sankalia - 6/01 All data from NJDEP 1986 except Roads from US Census TIGER Data 1990 and Chemical sites from SBMWA and Omni Environmental Corp, 2000. This map was developed using NJDEP data but this secondary product has not been verified and a

APPENDIX B:
Water Quality Data

Table B-1: Visual assessment average scores and observation narratives.*

<u>BEDEN BROOK (AVERAGE SCORE: 3.12)</u>

Stream Segment: BDB1. Score: 3.05
Beden Brook becomes walkable as it crosses under Carter Road in Hopewell Township. The stream there is small, and slow moving, with a gentle downward gradient. After leaving the woods, Beden Brook enters a long stretch of farm fields, where multiflora rose grows over much of the streambanks. Where the roses are not present, the banks show active erosion. The stream is inaccessible and bordered by private land all the way until Province Line Road. For the most part, human activity is not visible from the stream, except one or two farm fields that come within 20 feet. Even this high up, the stream shows large populations of algae.

Stream Segment: BDB2. Score: 2.15
Bridge construction at Province Line Road has contributed a massive sediment load to the water for approximately half a mile. This may be cleared in the next flood. The brook here flows through two golf courses, through areas with no buffer (and accompanying erosion problems) and also through well-buffered and fully forested stretches. Cherry Valley Golf Course, downstream of the Beden Brook Golf Club, has more significant erosion problems and greater need for buffering vegetation than does Beden Brook Golf Club. The superintendent of the Beden Brook Golf Club has expressed a strong interest in working with SBMWA to improve buffering vegetation on stretches of Beden Brook. There are several old farm dams on this stretch. Algae problems worsen on this stretch, perhaps due to nutrient contributions from the Aunt Molly Road STP, one detention basin, and both golf courses.

Stream Segment: BDB3. Score: 3.40
Below Great Road, Beden Brook disappears back into the woods, where its gradient increases somewhat, the streambed becomes bedrock (shale), and the stream remains forested almost continually until it meets the Millstone River. This section is in good health, although the algae problem from upstream persists. Erosion is occurring, but no access is possible for possible restorations.

Stream Segment: BDB4. Score: 3.60
From Cherry Hill Road to the confluence with Rock Brook, the stream is well shaded, though the forest understory is sparse (probably due to deer predation on young trees). Above Rock Brook, a small, silty tributary enters from the south (source unknown). When the two large streams join farther downstream, Rock Brook is noticeably warmer than Beden Brook. Immediately below this point for approximately half a mile, the stream is poorly shaded and bounded on both sides by the state-owned Skillman Dairy Farm. There are some possibilities for large-scale erosion-control work on Beden Brook in this area. Though cattle are fenced out of the stream, manure is stockpiled on adjacent fields. Beden Brook then re-enters the woods and remains well shaded and well buffered until Opossum Road.

Table B-1 (continued): Visual assessment average scores and observation narratives.*

Stream Segment: BDB5. Score: 3.40
This stretch, from Opossum Road to the confluence with Pike Run, is the last stretch of Beden Brook surveyed. The stream remains in the woods, well buffered and well shaded, for the entire reach. One farm field encroaches on the stream. The stream bottom here is clay and silty, with some exposed bedrock, as the stream widens and slows considerably below Opossum Road. One item of concern is a house, which has been abandoned and not cleaned up following a flood. An in-ground pool, with accompanying treatment machinery and chemicals, is a source of concern. Also seen on the site were containers of gasoline and several household cleaners. Where Pike Run enters Beden Brook, Pike Run is cloudy.

ROCK BROOK (AVERAGE SCORE: 3.49)

Stream Segment: RB1. Score: 4.00
This stretch of stream is nearly pristine. Barely walkable at the crossing with Long Hill Road, Rock Brook trickles through undisturbed forest the entire way to Montgomery Road. The stream is apparently fed by surface water (shows no flow in a dry period despite recent rainfall and high soil moisture, then very sharp increase in flow after rainfall). Banks are eroded in places, and the stream bottom is boulders and sand. Stream gradient is steep, and fast-draining, fast-flowing runoff is probably the cause of much of the erosion observed. The headwaters are in the Sourlands Preserve. Though the level of land-use protection in this area is unknown, StreamWalkers saw the beginnings of at least one large residential development in this stretch.

Stream Segment: RB2. Score: 3.50
This stretch of stream appears to be in relatively good health. Notes show some encroachment on the stream corridor, as well as three disused man-made dams and an electric fence strung across the stream. The purpose of the fence is unknown. Gradient remains relatively steep, and flow is fast after rains and slow during dry periods. The road comes close to the stream at this point, and remains quite close for most of the reach. Erosion is active here, with forested banks 15 feet high not uncommon (same case on RB3, downstream).

Stream Segment: RB3. Score: 3.80
At Grand View Road, gradient is steep and flow strong (at least in wet weather). Farther down the reach, two lawns encroach very close to the stream, one of which shows signs of regularly dumping grass clippings into the water. Otherwise, the stream is well buffered and well shaded. Two warmer tributaries (both small) enter from the west and south respectively. The latter is warm and silty, draining a detention basin in the Rock Brook development on Route 518. An abandoned building, part of the state property north of Route 518, is close to the river, but shows no signs of any chemical storage or leakage. Hollow Road is close to the stream for much of this reach. Near the bottom of the reach, water velocity decreases considerably and turbidity increases.

Table B-1 (continued): Visual assessment average scores and observation narratives.*

Stream Segment: RB4. Score: 2.65
Rock Brook is impounded by a dam (part of the North Princeton Developmental Center) just downstream of Great Road. The water is turbid and the lakeshore is exposed in many places to goose traffic. Depth of the lake is unknown. Canada geese infest the lawn adjacent to the lake, and some very positive work could be done to improve buffer areas here. Stream quality appears much lower here, possibly from goose feces and high temperatures in the impoundment. Below the impoundment, the first heavy growths of algae begin to appear. In addition, land use surrounding the stream changes during this stretch, to include residential and light industrial facilities. Temperature and water quality data above and below the impoundment would be very interesting to record. At the end of the reach, Rock Brook flows through the Skillman Dairy Farm to join Beden Brook. There are possibilities for erosion control and buffer restoration work here.

PIKE RUN (AVERAGE SCORE: 3.03)

Stream Segment: PR1. Score: 3.10
Depth and difficult access made StreamWalking difficult between Route 206 and Township Line Road. Tributaries draining from the north (GSA Depot) and northeast were not walked; their size and suitability are unknown. Below Township Line Road, land use is residential, agricultural, and forested. A golf course (Pike Brook Country Club) is adjacent to the stream but not encroaching heavily. Water color is slightly impaired, and the streambed is on the silty side. Erosion was recorded as a problem, but not an easily addressable one. Pike Run has a gentle gradient and generally slow water flow throughout its length.

Stream Segment: PR2. Score: 3.20
This reach starts on Cruser Brook, where it crosses Rt. 206. Until meeting PR1, the stream is relatively well shaded and well buffered. PR1 enters with significantly warmer water and a heavier algae load. The stream ranges from forested to exposed, with significant erosion on forested banks, but no easy access. The stream bottom is very silty/muddy in places, and water clarity suffers accordingly. Below the Pike Brook STP, aquatic plants flourish, and water slows down considerably due to an impoundment downstream. The quality of the streambed decreases also: sand and clay accumulate and the water gets deeper. The stream passes through Montgomery Park and includes two past SBMWA restoration sites, both successfully mature. Back Brook contributes a small flow of cool, clear water just near the end of this reach.

Stream Segment: PR3. Score: 2.80
The impoundment below Dead Tree Run Road makes water at the top of this reach too deep to walk. However, buffers around the pond are missing (grass is mowed close) and geese and people have free access to the water. Water in the impoundment and below is cloudy and shows significant algal growth in both the stream and pond. StreamWalkers recorded some easily accessible erosion sites on this reach. Land use is residential and forested (buffers generally good), although there is a tree farm near the stream.

*All visual assessments were performed in summer 2000 (May – July) by trained SBMWA staff and interns.

Table B-2: Biological assessment data for Beden Brook Watershed 1996 - 2000 (SBMWA Data).

Site	Date	Number in Sample	FBI	Total Taxa Richness	EPT Richness	% EPT	% Dominance	Scoring for Stream Impairment Biological Assessment
BD1	11/16/1996	106	5.6	10	2	8%	28%	Moderately Impaired
BD1	3/22/1997	101	5.9	9	2	2%	78%	Severely Impaired
BD1	8/2/1997	100	5.3	15	3	11%	31%	Moderately Impaired
BD1	10/23/1998	Too few	NA					Too few in sample
BD1	4/10/1999	104	6.5	12	0	0%	32%	Moderately Impaired
BD1	7/20/1999	131	4.3	11	3	33%	39%	Moderately Impaired
BD1	10/13/1999	Too few	NA					Too few in sample
BD1	3/25/2000	Too few	NA					Too few in sample
BD1	7/22/2000	102	4.2	10	3	70%	68%	Moderately Impaired
BD1	10/21/2000	103	4.1	10	3	28%	33%	Moderately Impaired
BD3	7/26/1997	92	4.8	14	5	29%	25%	Moderately Impaired
BD3	11/8/1997	130	4.5	12	2	44%	42%	Moderately Impaired
BD3	5/16/1998	Too few	NA					Too few in sample
BD3	8/5/1998	99	4.5	12	4	63%	60%	Moderately Impaired
BD3	10/27/1998	121	3.7	12	2	7%	30%	Moderately Impaired
BD3	4/10/1999	Too few	NA					Too few in sample
BD3	7/24/1999	103	5.5	12	3	12%	30%	Moderately Impaired
BD3	3/25/2000							Not Sampled
BD3	7/22/2000							Not Sampled
BD3	10/21/2000							Not Sampled
BD3	11/14/2000	116	5.0	11	1	8%	62%	Moderately Impaired
BD4	9/11/1996	113	4.3	12	4	81%	65%	Moderately Impaired
BD4	7/26/1997	90	4.3	12	3	52%	41%	Moderately Impaired
BD4	4/26/1998	126	3.2	18	9	64%	26%	Non-Impaired
BD4	7/28/1998	95	4.2	8	2	81%	65%	Moderately Impaired
BD4	11/27/1998	114	4.0	15	4	45%	41%	Moderately Impaired
BD4	4/10/1999	Too few	NA					Too few in sample
BD4	7/24/1999	110	8.0	2	0	0%	97%	Severely Impaired
BD4	10/9/1999	116	4.6	11	1	3%	71%	Moderately Impaired
BD4	3/25/2000	128	5.9	14	5	11%	32%	Moderately Impaired
BD4	7/22/2000	116	4.6	11	3	31%	29%	Moderately Impaired
BD4	10/21/2000	101	4.2	8	3	83%	77%	Moderately Impaired

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

Total Taxa Richness: Number of different families in the sample

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

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

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

Samples should include at least 100 organisms for statistical evaluation. Samples with fewer than 100 were included in this table for interest, but would not be included in a rigorous evaluation of stream health.

Table B-3: Biological assessment data for Beden Brook Watershed 1993, 1994, 1998 and 1999 (NJDEP Data).

Site	Date	Number in Sample	FBI	Total Taxa Richness	EPT Richness	% EPT	% Dominance	Scoring for Stream Impairment Biological Assessment
AN0398	4/5/1994	100	5.6	10	6	26%	69%	Moderately Impaired
AN0398	4/27/1999	100	5.1	16	6	23%	47%	Moderately Impaired
AN0399	4/5/1994	100	5.5	10	5	25%	69%	Moderately Impaired
AN0399	4/27/1999	105	4.8	12	4	26%	62%	Moderately Impaired
AN0400	4/5/1994	100	5.9	11	3	12%	35%	Moderately Impaired
AN0400	4/27/1999							Not Sampled
AN0401	4/5/1994	100	5.8	11	2	10%	65%	Moderately Impaired
AN0401	4/27/1999	102	5.4	14	4	7%	48%	Moderately Impaired
AN0402	11/10/1993	100	4.3	11	3	9%	51%	Moderately Impaired
AN0402	11/12/1998	100	5.9	24	3	4%	18%	Moderately Impaired
AN0403	11/10/1993	100	4.8	17	4	49%	31%	Non-Impaired
AN0403	11/12/1998	100	6.7	23	5	14%	23%	Moderately Impaired
AN0404	6/14/1994	100	4.6	10	3	40%	31%	Moderately Impaired
AN0404	6/10/1999	100	5.9	19	5	15%	21%	Moderately Impaired
AN0405	4/5/1994	34	6.8	11	2	6%	26%	Moderately Impaired
AN0405	4/27/1999	109	6.7	4	1	1%	71%	Severely Impaired

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

Total Taxa Richness: Number of different families in the sample

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

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

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

Samples should include at least 100 organisms for statistical evaluation. Samples with fewer than 100 were included in this table for in
but would not be included in a rigorous evaluation of stream health.

Table B-4: Chemical assessment of Beden Brook Watershed 1993 - 2000 (SBMWA Data).

1993 - 1994

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	5.6	6.9	9.3	9.1	11.2	12.3	0.2	0.2	0.4	0.2	0.2	0.2	0.4	0.7	1.2	0.2	0.9	1.6
BD2	5.2	7.8	10.0	9.9	13.1	16.3	0.2	0.3	1.0	0.2	0.4	0.6	0.6	1.7	2.4	0.6	1.4	2.4
BD3	1.1	6.6	9.5	9.9	12.0	15.2	0.2	0.2	0.2	0.2	0.2	0.6	0.2	0.6	1.6	0.4	1.3	4.0
BD4	5.6	8.7	11.3	11.1	13.4	15.4	0.0	0.2	0.2	0.0	0.1	0.2	0.0	0.2	0.2	0.0	0.6	1.6

1994 - 1995

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	5.9	7.7	11.1	8.2	11.3	13.2	0.2	0.2	0.4	0.2	0.5	1.0	0.2	0.7	1.6	0.2	1.2	2.8
BD2	7.2	8.8	12.5	6.5	11.4	14.7	0.2	0.4	0.6	0.2	0.2	0.6	0.4	1.6	2.4	0.3	1.5	2.4
BD3	7.8	11.3	15.4	11.8	13.1	14.5	0.2	0.6	1.0	0.2	0.5	1.0	0.4	2.3	4.0	0.4	2.3	4.0
BD4	8.0	10.2	12.4	8.9	12.4	15.7	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.4	1.6	0.2	0.5	1.2

1995 - 1996

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	5.3	7.6	13.1	9.5	11.9	14.5	0.2	0.3	0.4	0.2	0.2	0.3	0.3	1.0	1.6	0.8	1.4	2.4
BD2	5.7	7.3	10.9	9.0	11.4	14.7	0.2	0.2	0.4	0.2	0.3	1.0	0.4	1.6	2.4	0.0	1.1	2.4
BD3	7.2	11.0	13.6	10.4	12.7	14.5	0.3	0.8	1.0	0.2	0.3	0.5	0.0	2.0	4.0	1.2	2.3	4.0
BD4	4.1	9.4	15.9	9.7	12.1	15.4	0.2	0.2	0.5	0.2	0.2	0.2	0.0	0.2	0.6	0.2	0.8	1.2

1996 - 1997

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	7.2	8.5	10.7	12.6	13.3	14.5	0.2	0.4	1.0	0.2	0.2	0.4	0.2	1.6	3.2	0.2	0.7	1.6
BD2	5.4	7.3	10.3	7.3	10.0	12.3	0.2	0.3	0.4	0.3	0.6	1.0	0.2	1.1	2.4	0.2	0.9	2.4
BD3	7.4	10.8	15.8	11.9	13.8	15.8	0.2	0.5	1.0	0.2	0.3	0.5	0.3	2.0	4.0	0.0	1.3	2.4
BD4	8.2	9.8	11.9	NA	NA	NA	0.2	0.2	0.2	NA	NA	NA	0.3	1.0	1.6	NA	NA	NA

Table B-4 (continued): Chemical assessment of Beden Brook Watershed 1993 - 2000 (SBMWA Data).

1997 - 1998

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	7.0	8.3	9.1	9.2	12.6	14.8	0.2	0.2	0.3	0.2	0.2	0.3	0.0	0.9	3.2	0.4	1.1	3.2
BD2	5.2	7.2	9.2	7.4	11.3	13.6	0.2	0.3	0.5	0.2	0.2	0.3	0.2	1.0	4.0	0.4	0.8	2.0
BD3	8.8	13.1	19.0	9.9	12.3	14.2	0.2	0.4	0.5	0.2	0.3	0.5	0.8	2.5	4.0	0.5	1.5	3.2
BD4	6.9	9.4	11.6	9.4	12.3	14.7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.9	4.0	0.2	0.6	0.8

1998 - 1999

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	5.7	6.5	7.3	9.9	12.3	13.7	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.8	1.2	0.8	2.7	4.0
BD2	4.5	6.9	9.1	9.0	11.6	13.5	0.2	0.3	0.5	0.2	0.2	0.3	0.2	0.6	1.2	0.2	1.0	2.4
BD3	7.8	12.6	17.0	10.3	12.9	14.9	0.2	0.4	0.5	0.2	0.5	1.0	0.5	1.7	3.2	0.8	2.3	4.0
BD4	6.0	8.8	12.1	12.1	12.9	14.6	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.2	0.8	0.4	0.8	1.2

1999 - 2000

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	4.8	8.6	11.3	11.5	12.6	13.7	0.2	0.3	0.5	0.2	0.2	0.2	0.2	1.2	4.0	0.2	0.3	0.8
BD2	7.0	8.9	11.1	7.6	11.7	17.2	0.2	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.6	1.2
BD3	4.2	11.9	19.7	10.6	12.8	14.2	0.2	0.5	1.0	0.2	0.3	0.5	0.2	2.2	4.0	2.4	3.6	4.0
BD4	5.2	10.3	14.6	11.4	13.2	15.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	2.4	0.2	0.6	1.6

2000 - 2001

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer Nitrates			Winter Nitrates		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BD1	6.6	8.4	10.6	NA	NA	NA	0.2	0.3	0.5	NA	NA	NA	0.2	1.4	4.0	NA	NA	NA
BD2	7.0	8.3	9.9	NA	NA	NA	0.2	0.2	0.3	NA	NA	NA	0.2	0.2	0.3	NA	NA	NA
BD3	7.3	10.0	13.0	NA	NA	NA	0.2	0.4	0.5	NA	NA	NA	2.0	3.0	4.0	NA	NA	NA
BD4	7.3	9.6	12.2	NA	NA	NA	0.2	0.2	0.5	NA	NA	NA	0.2	0.8	1.6	NA	NA	NA

Table B-5: Chemical assessment of Beden Brook Watershed 1991 -1995 (OMNI Environmental Corporation Data).

1991 - 1992

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer N-NO3			Winter N-NO3		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BBU	8.0	10.5	14.0	9.0	12.0	13.6	NA	NA	NA	NA	NA	NA	0.3	0.6	0.9	0.2	0.6	1.1
BB1	8.2	10.5	13.6	9.2	12.0	13.4	NA	NA	NA	NA	NA	NA	1.1	1.8	2.2	0.3	1.7	4.0
BB2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.0	1.9	3.3	NA	NA	NA
BB3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.8	1.6	3.0	NA	NA	NA

1992 - 1993

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer N-NO3			Winter N-NO3		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BBU	10.0	12.2	15.6	10.0	12.2	15.6	NA	NA	NA	NA	NA	NA	0.1	1.4	6.0	0.6	1.2	1.9
BB1	8.5	11.4	14.2	11.0	12.3	13.4	NA	NA	NA	NA	NA	NA	1.5	6.3	10.7	0.9	1.7	2.9
BB2	5.6	10.2	13.4	10.0	12.4	13.8	NA	NA	NA	NA	NA	NA	1.0	5.1	7.3	1.0	1.9	3.3
BB3	10.3	14.0	16.4	10.0	13.1	16.0	NA	NA	NA	NA	NA	NA	0.0	1.4	2.7	0.8	1.6	3.0

1993 - 1994

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer N-NO3			Winter N-NO3		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BBU	8.1	10.8	15.6	13.0	14.0	16.0	NA	NA	NA	0.0	0.0	0.0	0.1	1.3	3.8	0.3	1.3	2.7
BB1	7.4	9.6	12.6	12.0	13.4	15.0	NA	NA	NA	0.0	0.2	0.4	1.7	3.5	7.1	0.4	4.6	21.3
BB2	6.0	10.5	14.6	13.2	15.2	15.8	NA	NA	NA	0.1	0.2	0.4	1.3	2.9	7.9	0.8	1.5	3.1
BB3	12.2	14.5	17.3	13.2	15.2	17.2	NA	NA	NA	0.0	0.1	0.3	0.3	1.8	3.3	0.4	1.3	2.3

1994 - 1995

SITE	Summer DO			Winter DO			Summer Phosphates			Winter Phosphates			Summer N-NO3			Winter N-NO3		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
BBU	8.2	9.7	10.5	10.6	12.0	13.2	0.0	0.0	0.1	0.0	0.0	0.1	0.2	1.3	4.5	0.0	0.8	2.2
BB1	8.0	9.2	10.2	10.6	11.9	13.4	0.5	0.8	1.1	0.0	0.4	1.3	0.2	2.3	4.3	0.3	1.2	2.2
BB2	9.6	10.4	11.7	11.8	12.3	13.0	0.2	0.6	1.0	0.0	0.3	1.2	1.4	2.8	4.5	1.2	1.4	1.8
BB3	9.6	12.3	16.4	12.0	12.7	13.3	0.0	0.2	0.5	0.0	0.2	0.5	1.2	1.3	1.4	1.2	1.3	1.4

Table B-6: Chemical assessment of Beden Brook Watershed 1994 - 2001 (SBRSA Data).

1994 - 1995

SITE	Summer BOD5			Winter BOD5			Summer TSS			Winter TSS			Summer NH3-N			Winter NH3-N		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
Hopewell	2.00	2.50	3.00	2.00	2.65	3.15	1.00	1.17	2.00	0.58	2.38	4.20	0.01	0.04	0.10	0.01	0.20	0.47

1995 - 1996

SITE	Summer BOD5			Winter BOD5			Summer TSS			Winter TSS			Summer NH3-N			Winter NH3-N		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
Hopewell	1.00	2.74	3.95	1.00	1.75	2.65	1.00	1.45	2.23	0.70	1.23	2.30	0.04	0.06	0.10	0.03	0.05	0.09

1996 - 1997

SITE	Summer BOD5			Winter BOD5			Summer TSS			Winter TSS			Summer NH3-N			Winter NH3-N		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
Hopewell	1.95	2.97	4.40	1.65	2.16	3.05	0.60	1.70	3.00	0.60	1.15	2.00	0.04	0.06	0.13	0.03	0.04	0.06

1997 - 1998

SITE	Summer BOD5			Winter BOD5			Summer TSS			Winter TSS			Summer NH3-N			Winter NH3-N		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
Hopewell	2.20	2.54	3.00	1.30	1.99	2.70	0.50	1.27	2.00	0.60	0.80	1.30	0.04	0.06	0.09	0.04	0.04	0.05

1998 - 1999

SITE	Summer BOD5			Winter BOD5			Summer TSS			Winter TSS			Summer NH3-N			Winter NH3-N		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
Hopewell	1.40	1.82	2.05	1.00	1.47	1.80	0.80	1.07	1.70	0.60	1.22	2.80	0.05	0.07	0.10	0.04	0.05	0.08

1999 - 2000

SITE	Summer BOD5			Winter BOD5			Summer TSS			Winter TSS			Summer NH3-N			Winter NH3-N		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
Hopewell	1.35	2.22	3.00	0.90	1.79	2.95	0.60	0.89	1.40	0.65	1.02	2.00	0.04	0.05	0.06	0.05	0.06	0.10

2000 - 2001

SITE	Summer BOD5			Winter BOD5			Summer TSS			Winter TSS			Summer NH3-N			Winter NH3-N		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
Hopewell	0.78	1.85	2.86	NA	NA	NA	0.70	1.21	1.90	NA	NA	NA	0.04	0.07	0.10	NA	NA	NA

APPENDIX C:
Known Contaminated Sites and Point Source Dischargers

KNOWN CONTAMINATED SITES IN BEDEN BROOK WATERSHED

Note: Descriptions are provided only for sites that have been researched, either by doing a full file review or by speaking with site managers and getting summary information from them.

ANDY'S AUTO REPAIR
130 Broad St. W, Hopewell Boro

SITE DESCRIPTION:
This could be one of the sources of Ground water contamination for Hopewell Municipal well #4. In 1997 several underground storage tanks and some soil were removed, including: A 1000 gal gasoline tank, 2 –4000 gal gasoline tanks, 2 – 550 gal waste oil tanks. Soil and Ground water contamination was identified. Ground water near the tanks contained contamination by benzene at 825 ppb (stds = 1 ppb), MTBE at 2090 ppb (stds = 70 ppb) and TBA (Tetrabutyl alcohol) at 3540 ppb (stds = 100 ppb).

The responsible party submitted a report that requested NJDEP to allow natural attenuation of the contamination, based on modeling they performed that indicates that the cleanup standards may be achieved in about 19 years, through natural attenuation.

BELLE MEAD LUMBER COMPANY, INC.
28 Reading Boulevard, Montgomery Township

SUPERFUND? NO
RESPONSIBLE PARTY: Belle Mead Lumber Company

MEDIA AFFECTED	CONTAMINANTS	STATUS
Ground Water	Petroleum hydrocarbons	Confirmed
Potable Water	Petroleum hydrocarbons	Clean
Soil	petroleum hydrocarbons	Removed

SITE DESCRIPTION
In 1995, this site had both a spill of fuel oil and a leaking underground storage tank (UST) on site. Contaminated soil was removed. Two local potable wells do not show any contamination. However, monitoring wells show petroleum hydrocarbon contamination migrating in a plume across the road to the lumber property on the other side. No remedial action has been taken or planned for this site.
Updated information May 2001:
MOA (Memorandum of Agreement) was made with the company, which means they are working cooperatively under the voluntary cleanup program. Gasoline tanks and soil were removed but ground water remained contaminated. They removed additional soil in the Spring 2001 - NJDEP is

awaiting the results of sampling for the soil and ground water to determine if the cleanup is complete.

CARRIER FOUNDATION
East Mountain Rd. and Great Rd., Montgomery Township

SUPERFUND? NO
RESPONSIBLE PARTY: Carrier Foundation

MEDIA AFFECTED	CONTAMINANTS	STATUS
Soil	petroleum hydrocarbons	Removed
Ground Water	petroleum hydrocarbons; base neutral organics; xylenes	Extent unknown; more wells planned in 2000

SITE DESCRIPTION
The Carrier Foundation is a private rehabilitation facility. This site contained 14 USTs, which have all been closed and removed. Monitoring wells have shown no contamination in ground water except at one site, where a monitoring well showed contamination by BTEX (gasoline additives) at the time of removal. The extent of this contamination is unknown. Carrier requested a decision of No Further Action (NFA) on soils in 1998, after contaminated soil had been removed. Carrier has requested closure of several monitoring wells, which have not recorded any contamination to date. As of September 2000 NJDEP recorded that there were no sensitive receptors, but remediation was required. Carrier Foundation is complaint with the remediation process requiring soil sampling.

CASTORO & CO., Inc.
71 E. Broad St., Hopewell Borough

SUPERFUND? NO
RESPONSIBLE PARTY Castoro & Company, Inc.

MEDIA AFFECTED	CONTAMINANTS	STATUS
Soil	2 underground storage tanks	Removed

SITE DESCRIPTION
On Aug 18, 2000 - 2 underground storage tanks were removed - contents of tanks is unknown by NJDEP case manager. "Evidence of a discharge" was noted and the removal contractor notified NJDEP hotline phone number. This could mean many things: that the tank could have noticeable holes, a strong odor was present, or oil was observed on soil or in the ground water.
The report was due to NJDEP on Dec 2000 - but has not been submitted.

CHEMICAL BANK
52 E. Broad St., Hopewell Borough

SUPERFUND? NO
RESPONSIBLE PARTY: Chemical Bank of New Jersey

MEDIA AFFECTED	CONTAMINANTS	STATUS
Soil	#2 fuel oil	Removed

SITE DESCRIPTION
This site contained one leaking UST, containing 1000 gallons of #2 fuel oil. The tank was excavated, and contaminated soil was removed in 1993. As of May 2001, NJDEP suspects ground water contamination but the company has not submitted any lab data.

GSA SUPPLY DEPOT
Route 206 & Mountain View Road, Franklin Township

SUPERFUND? YES, but not on National Priority List
RESPONSIBLE PARTY: US Army Corps of Engineers
PROPERTY SIZE: 890 acres

FUNDING SOURCES:	AMOUNT AUTHORIZED:
SUPERFUND	N.A.

MEDIA AFFECTED	CONTAMINANTS	STATUS
Ground Water	VOCs, metals	Confirmed
	Pb, Ba, TCE (confirmed in septic fields)	Possible
Surface Water	Bis (2-ethylhexyl) phthalate*	Confirmed
Offsite Sediment	PAHs, metals	Confirmed
Soil	PAHs, Pb, Be, Cd, Fe, Mn, As, petroleum hydrocarbons, PCB, pesticides, DDT, DDE, organic contaminants	Confirmed
Air (soil dust)	Same as soil	Possible

* A plasticizer

SITE DESCRIPTION
The United States Government, General Services Administration (GSA) for troop training, internment, and supply storage, previously used this site. The original property is divided into three adjacent sections: the GSA Federal Supply Center; a parcel to the north owned by Chemical Bank;

and a parcel to the south owned by Bridgefield Associates. Activities on the site previously included packing and shipping of arms, a car wash, gasoline transfer and distribution, septic fields, railroad lines, and an incinerator. In addition, a "drum trench" was found during the initial clearing of the site. A Site Inspection was completed in 1994, but no remedial action will be taken until after further study is complete (several years). The site is located on a perched water table. There were a total of 29 USTs and above ground storage tanks (ASTs) on the property. The tanks contained diesel, gasoline, water, and kerosene supplies. The tanks were closed and removed. Ground water and soil tests shown no exceedances of standards, so the Army has requested a decision of NFA from NJDEP. NJDEP is waiting on a new round of ground water data to confirm that ground water is not contaminated by contents of these tanks.

HOPEWELL BOROUGH WATER DEPT. WELL #4
Louellen St. & Model Avenue, Hopewell Boro

SUPERFUND? NO
RESPONSIBLE PARTY: Unknown
PROPERTY SIZE: not applicable

FUNDING SOURCES	AMOUNT AUTHORIZED
Spill Fund	$68,000

MEDIA AFFECTED	CONTAMINANTS	STATUS
Ground Water	VOCs (TCE, PCE)	Confirmed
Potable Water	VOCs (TCE, PCE)	Treating

SITE DESCRIPTION
Routine sampling conducted by the Borough in 1993 revealed that the well was contaminated. Later that year, NJDEP funded the installation of a carbon treatment system as an Interim Remedial Measure. The well was out of service for 1.5 years during 1999 and 2000 while a bubbler system (an "air-stripper") was installed in the uptake mechanism to remove VOCs before the water is mixed into the Borough's distribution system. Well #4 currently operates at about 100 GPM and provides less than 25% of the Borough's public water. No further action is expected to take place. As of 2001 it still remains on the Known Contaminated Site List.

HOPEWELL VETERINARY GROUP
230 Pennington Hopewell Road, Hopewell Township

SITE DESCRIPTION
Diesel and leaded gasoline tanks were removed from this site in 1997. Contaminated soil was removed in 1997; however some soil and ground water contamination remained. NJDEP is concerned that delineation of the extent of contamination was not complete. Ground water contamination included lead and BTEX (Benzene, Toluene, Ethylene and Xylene - common volatile solvent components of gasoline). Two additional monitoring wells were installed. Ground water

contamination was detected in a potable wells, but samples from July 2000 did not detect contamination. In 1998 and 2000, lead was not detected, but MTBE/MTBA gasoline additives were detected in ground water. A Remedial Investigation report was submitted in May 2001.

LEIGH'S SERVICE STATION
59 Princeton Ave, Hopewell Boro

SITE DESCRIPTION
Ten underground storage tanks were removed along with several hundred tons of contaminated soil in 1997. In August 1998, six monitoring wells were installed and evidence of contamination was identified. Ground water flows in a westerly direction and NJDEP requested the installation of additional wells but this was not done.

Tank Summaries

1 Tank	6000 gals leaded gasoline	removed 300 tons of soil
2 tanks	8000 gals leaded gasoline	included above
3 Tanks	3000 gals gasoline	removed 400 tons of soil
1 Tank	1000 gallons gasoline	removed 80 tons of soil
1 Tank	1000 gallons gasoline	removal included below
1 Tank	1000 gals waste oil	removed 100 tons of soil
1 Tank	550 gals waste oil	removed 20 tons of soil
		Total 900 tons of contaminated soil

Facility is now operating as a car repair shop but no longer sells gasoline. In March 1999, NJDEP requested the responsible party to resample the ground water and evaluate possible receptors (i.e. location of all private wells within a mile of the site). This work may not have been completed.

Ground water results from 1998

Compound (Standard)				
Benzene (1ppb)	OW1 = 560 ppb	OW3= 5.1 ppb	OW6= 89	
MTBE (70 ppb)	OW1= 250	OW3= 84	OW6=180	OW2=110
Lead (10 ppb)	OW1=15		OW6=11	OW5=67
Silver (30 ppb)	OW2= 51 ppb			OW5= 67
TICs (500 ppb)	OW1= 1070 ppb			

TICs = Tentatively Identified Compounds

LORD MCCORKLE CORRECTIONAL FACILITY
Burnt Hill Road, Montgomery Township

SUPERFUND? NO
RESPONSIBLE PARTY: NJDOT

MEDIA AFFECTED	CONTAMINANTS	STATUS
Soil	Heating oil and gas	Removed
Ground Water	Heating oil and gas	Investigation in progress

SITE DESCRIPTION
Two underground storage tanks were removed from this site. These were heating oil and gas tanks. Ground water investigation is going on and monitoring wells have been installed. NJDEP is waiting on samples to determine the extent of the contamination.

MONTGOMERY TWP HOUSING DEVELOPMENT
Rt. 206 and Rt. 518, Montgomery Township

SUPERFUND? YES, and on National Priorities List
RESPONSIBLE PARTY: Princeton Gamma Tech (others)
PROPERTY SIZE: 77 acres

FUNDING SOURCES	AMOUNT AUTHORIZED
Superfund	$1,730,000

MEDIA AFFECTED	CONTAMINANTS	STATUS
Ground Water	VOCs	Confirmed; delineated
Potable Water	VOCs	Alternate supply provided

SITE DESCRIPTION
Approximately 77 homes are affected by this contamination. Originally discovered in Rocky Hill Municipal Well in 1978 and in several private wells the following year, this plume contains various volatile organic compounds (VOCs), primarily TCE. Affected residents were connected to public water supply or to new, clean wells between 1981 and 1990. A separate Superfund site exists for the Rocky Hill Municipal Well. Plans to remediate the still-contaminated ground water are currently underway. The size of the plume and contaminant concentrations have not changed significantly over time. The source of contamination is suspected to be a nearby research facility (Princeton Gamma Tech) on Rt. 518 in Montgomery. Another possibility is the Fifth Dimension facility, where elevated levels of TCE and VOCs have also been detected in soil and ground water. Princeton Gamma Tech believes that TCE contamination of ground water is a regional problem (see Princeton Chemical Research, Inc.) A settlement is being negotiated at the present time.

NORTH PRINCETON DEVELOPMENTAL CENTER
Belle Mead-Blawenburg Road, Montgomery Township

SUPERFUND? NO

RESPONSIBLE PARTY: Dept. of Health and Human Services

MEDIA AFFECTED	CONTAMINANTS	STATUS
Soils	Petroleum hydrocarbons	Extent unknown
Ground water	Petroleum hydrocarbons	Extent unknown
Surface water	Petroleum hydrocarbons	During the 1980s

SITE DESCRIPTION
In 1998, this facility was described as a state facility providing rehabilitation to mentally and physically challenged people. This facility was constructed some time ago, and has 21 underground storage tanks on site, which are at various stages of the processes of examination, closure, and remediation. In 1985, 1986, and 1987, there were significant spills of petroleum hydrocarbons from USTs, one of which required placement of an absorbent boom in Rock Brook, which runs through the property. Nine tanks have been classified NFA by NJDEP at the time of writing. Other tanks are pending ground water monitoring data and soils testing to determine the extent of contamination. Two potable wells belonging to neighbors showed no contamination in 1997.

PRINCETON CHEMICAL RESEARCH
1377 Rt. 206, Montgomery Township

SUPERFUND? NO
RESPONSIBLE PARTY: Princeton Chemical Research (others)

MEDIA AFFECTED	CONTAMINANTS	STATUS
Soil	PCB	Confirmed
Ground Water	TCE	Confirmed

SITE DESCRIPTION
This site was formerly used to manufacture golf balls. Princeton Chemical Research now leases it. Polychlorinated biphenyls (PCBs) are present in the soil, but are not sufficient to mandate removal. Contaminated soil is likely to be consolidated and capped. Some monitoring wells show elevated levels of TCE, which may be part of a larger (regional) ground water contamination problem. (See Montgomery Twp Housing Development). Monitoring wells installed in early 2000 have not produced any results yet, but ground water is being tested for PCBs and TCE.

STERLING DRUG COMPANY, INC.
Rt. 206 North, Hillsborough Township

SUPERFUND? NO
RESPONSIBLE PARTY: Reckitt & Colman, Inc.

MEDIA AFFECTED	CONTAMINANTS	STATUS
Soil	TCE, styrene	Removed
	OPP	Removed
Ground Water	Styrene	Clean
	TCE	Confirmed
	OPP	Clean

SITE DESCRIPTION
This facility manufactures household products. One tank leaked styrene to ground water. Soil was excavated and monitoring wells installed in the late 1980s. In 1998-99 ground water tested OK. The facility now belongs to Reckitt & Colman, Inc.

In addition, the facility experienced a spill on Jan 8 1997, of orthophenylphenol (OPP), which migrated through the foundation of the building and into ground water. This required the installation of 2 more monitoring wells, which found no contamination by OPP. The wells, however, did detect chlorinated solvents (TCE) in ground water and soil, because of an overflow from a neutralization sump in the laboratory 1971-1983. Contaminated soil was removed from the site, and ground water monitoring continues.

SUB & JUG DELI/FORMER CITGO SERVICE STATION
866 Rte. 206, Hillsborough Township

SITE DESCRIPTION
This 1993 case is backlogged and archived as inactive. The site manager doesn't know the details of the project, but an inactive case means it is a low priority and there could be unresolved issues such as an unsatisfactory response from the responsible party (maybe they didn't clean up enough or low levels of GW contamination are still present). Local Construction officials are responsible to issue closure permits when tanks are closed or removed and may have more detailed information. Further research is required.

THE KINGS PATH GROUND WATER CONTAMINATION
The Kings Path, Hopewell Township

SUPERFUND? NO
RESPONSIBLE PARTY: unknown

FUNDING SOURCES	AMOUNT AUTHORIZED
Spill Fund	$5,000
Corporate Business Tax	$12,000

MEDIA AFFECTED	CONTAMINANTS	STATUS
Ground Water	VOCs	Delineating

Potable Water	VOCs	Treating

SITE DESCRIPTION
Sampling of private potable wells in this area by the Hopewell Township Health Department in 1999 revealed that seven wells were contaminated with the volatile organic compounds trichloroethylene (TCE) and tetrachloroethylene (also known as perchloroethylene, or PCE) at levels exceeding New Jersey Drinking Water Standards. NJDEP installed Point-of-Entry Treatment (POET) water filtration systems on the affected wells as an interim remedy to provide potable water for the residents. In late 1999 and early 2000, NJDEP sampled 15 additional private potable wells in the vicinity to further delineate the extent of the ground water contamination. The results of the private well sampling will be used to identify the most cost-effective long-term solution to provide potable water to the affected residences. NJDEP is conducting an area-wide investigation to identify sources that may be contributing to the ground water contamination.

USEF&G REALTY CORPORATION
1434 Rte. 206, Montgomery Township

SUPERFUND? NO
RESPONSIBLE PARTY: USEF&G Realty Corporation
PROPERTY SIZE: unknown

SITE DESCRIPTION
The site had some initial problems with high levels of beryllium, but now it is under control and below the standards. No ground water contamination was found at the site. The case is open because they have some fill-related issues with dumping from farm equipment.

WOODS ROAD GROUND WATER CONTAMINATION
Woods Road Hillsborough Township

SUPERFUND? NO
RESPONSIBLE PARTY: unknown
PROPERTY SIZE: unknown

FUNDING SOURCES	AMOUNT AUTHORIZED
Spill Fund	$50,000

MEDIA AFFECTED	CONTAMINANTS	STATUS
Ground Water	VOCs	confirmed
Potable Water	VOCs	Treating

SITE DESCRIPTION

In 1990, the Hillsborough Township Health Department determined that six private potable wells in this area were contaminated with volatile organic compounds. NJDEP installed Point-of-Entry Treatment (POET) water filtration systems in the affected homes the same year to provide potable water to residents. A further investigation concluded that the most cost-effective action was continued use of the POETs, rather than a clean-up effort. The source of contamination is still unknown. In 1992, a public water line was installed and some homes were taken off ground water supply. Monitoring of ground water continues.

POINT SOURCE DISCHARGERS IN BEDEN BROOK WATERSHED

The table below briefly summarizes the point-source dischargers in Beden Brook Watershed. The following pages describe each facility in more detail. Average flows from 1998 are available for municipal sources only; private sources may or may not have such data available.

FACILITY	AVERAGE FLOW	% CAPACITY	PERMITTED FLOW	# VIOLATIONS
3M Corporation	N.A.	N.A.	0.124 MGD	2
Carrier Foundation	0.0339 MGD	7%	0.5 MGD	11
Johnson & Johnson Personal Products	N.A.	N.A.	0.027 MGD	2
Montgomery High School STP	0.013 MGD	38%	0.035 MGD	1
Burnt Hill STP	0.007 MGD	44%	0.0153 MGD	0
Cherry Valley STP	0.104 MGD	41%	0.251 MGD	5
Pike Brook STP	0.175 MGD	31%	0.7 MGD	13
North Princeton Development Center	<0.1 MGD	<20%	0.5 MGD	2
North Princeton Development Center	0.183 MGD	37%	0.5 MGD	2
Reckitt & Colman	N.A.	N.A.	0.018 MGD	0
Aunt Molly Road STP	0.219 MGD	73%	0.3 MGD	1

3M CORPORATION **NJPDES #0003255**

PERMIT EFFECTIVE	PERMIT EXPIRES:	AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
?	1/31/2000	N.A.	N.A.	0.124 MGD	2

SUMMARY: This is an industrial facility, holding a combined permit for non-contact cooling water discharge and storm water discharge (primarily storm water) to surface water. 3M manufactures roofing granules through mining operations on-site. This facility appears to draw water through wells and discharge sanitary waste to a septic field. No sewer connection and no dedicated STP are on record. The cooling water is treated simply by allowing it to settle. In 1999, 3M was fined $3000 for fine sediment (rock dust from mining operations), which ended up in a tributary to Back Brook. This discharge was still visible in 9/99 and SBMWA is establishing a chemical testing station below the facility this year. A manual clean-up operation was staged in 1999, which removed 5 cu. yards (one dump truck full) of sediment from the stream. 3M believes the fines are due to rock dust settling on building roofs, which then gets carried into gutters and into the stream. In a separate event, leaking underground storage tanks led to a bioremediation effort to remove petroleum hydrocarbons from the soil. The permit for that remediation activity was terminated in 1989, and no further record of it exists at DEP.

VIOLATIONS: TSS violation in 1998. Violation for fines in runoff 3/29/1999. Attempted remediation of #2 fuel oil and "slate oil" leaked from underground storage tanks, and apparently completed in 1989.

CARRIER FOUNDATION **NJPDES #0023663**

PERMIT EFFECTIVE	PERMIT EXPIRES:	AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
8/1/98	7/31/2003	0.0339 MGD	7%	0.5 MGD	11

SUMMARY: This is an STP, which treats waste from on-site. The permit was issued to include an STP, sludge quality assurance reports, and a sanitary surface impoundment. In 1994, the permit for the overland flow field for discharging treated water was terminated. The facility provides secondary treatment only, for waste from residents of the facility. The managers of this facility are considering changing to UV sterilization from chlorine. A mandatory 1-year study of fecal coliform pollution at this site was undertaken in 9/98, but data was deemed insufficient and a 1-year extension was granted.

VIOLATIONS: The overland flow field was terminated in part due to violations in levels of Total Dissolved Solids in ground water from a monitoring well. Feb 1993 total nitrogen violation. Jan-Mar 1994 ammonia-N violation. July-Sep 1996 ammonia-N violation. July 1997 fecal coliform violation. May 1998 serious DO violation. May 1999 pH violation. June 1999 DO violation. Sept 1999 (Hurricane Floyd) entire plant inundated and primary and secondary effluent was lost.

JOHNSON & JOHNSON **NJPDES #0026140**

PERMIT EFFECTIVE	PERMIT EXPIRES:	AVG. FLOW:	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
6/16/95	7/31/2000	?	0.027 MGD	2

SUMMARY: This is an industrial facility, which discharges sanitary wastewater and boiler condensate, as well as cooling water and wastewater from an on-site R&D lab. The facility applied for a renewal of the permit in early 2000. The facility is revamping its entire permit at present, and will no longer be discharging to ground water at all. All discharges will be to surface water. This facility has been consistently negligent in submitting Discharge Monitoring Reports (DMRs), and has had problems with ground water quality from 12/94-2/97.

VIOLATIONS: GW problems recorded for TSS, TDS, and sodium from Dec 1994-Nov 1995. TCE found in GW Nov 1994. June 1997 and August 1997 violations for DO were recorded. (4.1 ppm and 4.8 ppm respectively, while permit requires ≥5 ppm in effluent).

MONTGOMERY HIGH SCHOOL STP **NJPDES # 0023124**

PERMIT EFFECTIVE	PERMIT EXPIRES:	AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
1998	10/30/03	0.010 MGD	38%	0.035	1

SUMMARY: This is an STP serving the high school and middle school. Sludge is hauled to Pike Brook STP for processing. An S-2 operator supervises the plant for 2-3 hours per day. The facility performs advanced treatment.

VIOLATIONS: 1995 one DO violation.

MONTGOMERY TOWNSHIP, BURNT HILL STP **NJPDES #0026891**

PERMIT EFFECTIVE	PERMIT EXPIRES:	1998 AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
7/1/98	6/30/2003	0.007 MGD	44%	0.0153 MGD	0

SUMMARY: This is a municipal STP serving the elementary school. The DEP file on this plant is very sparse. Monitoring is as normal for an STP, except they do not have to test water temperature or pH. An S-2 operator supervises the plant for 2-3 hours per day. This facility performs advanced treatment.

VIOLATIONS: No violations were on file.

MONTGOMERY TOWNSHIP, CHERRY VALLEY STP **NJPDES #69523**

PERMIT EFFECTIVE	PERMIT EXPIRES:	1998 AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
4/1/93	3/31/98	0.104 MGD	41%	0.286	5

SUMMARY: This is a municipal STP, which exports sludge to be treated by the Stony Brook RSA (presumably by incineration at the Princeton facility). The plant is supervised by an S4 operator, and treats residential waste for the township. The permits have been renewed but are not on file at DEP. This facility performs advanced treatment with nutrient removal (N&P)

VIOLATIONS: December 31 1993 chronic toxicity violation. April 1996 toxicity violation, apparently due to road salt. February 1998 violation for total phosphorus. July and Sept 1999 serious violations in chronic toxicity, apparently because sampling was on the same day as a pesticide application by a nearby golf course. Samples from other days in the same period of time showed no pesticides. There was a plant overflow December 1 1996 due to heavy rain.

MONTGOMERY TOWNSHIP STP, PIKE BROOK **NJPDES #0060038**

PERMIT EFFECTIVE	PERMIT EXPIRES:	1998 AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
3/1/97	2/28/2002	0.175 MGD	31%	0.45 MGD	13

SUMMARY: This is a municipal STP. There are two permits existing: sanitary SW discharge and a sludge QA report. An S4 operator staffs the plant. The facility performs advanced treatment with nutrient removal. This is the largest-volume discharger in Beden's Brook, and recently applied to expand to 0.7 MGD.

VIOLATIONS: April 1993 serious total suspended solids (TSS) violation valued at $20,000 was settled for $7500. Four additional violations and two violations for phosphorus occurred at the same time. March 1995 violations for TSS, biological oxygen demand, and phosphorus. March and April 1999 slight violations for P. December 1999 serious violation for phosphorus.

NORTH PRINCETON DEVELOPMENTAL CENTER **NJPDES #0102075**

PERMIT EFFECTIVE	PERMIT EXPIRES:	AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
9/93	9/98	< 0.1 MGD	<20%	0.5 MGD* 13.18 MT/YR**	2

* Permitted capacity of associated STP
** Permitted annual production of sludge fields

SUMMARY: The NPDC facility on Burnt Hill Rd. (on the site of the Skillman Dairy Farm, staffed by Department of Corrections inmates) uses Phragmites beds to break down sewage sludge. There is a small STP performing advanced treatment, with little to no flow going through (except during rain events). Sludge comes from the on-site STP and from the other NPDC STP. This permit may have been renewed, but the renewal is not on file. Supervision at the plant used to be 24-hours, but is now 40 hrs/week plus checkups on the weekends. Montgomery Township is considering assuming responsibility for this discharge (OMNI Nutrient Characterization Study).

VIOLATIONS: High levels of arsenic were detected in a reed core sample taken in April 1998. No other significant violations are on file.

NORTH PRINCETON DEVELOPMENTAL CENTER **NJPDES #0022390**

PERMIT EFFECTIVE	PERMIT EXPIRES:	1998 AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
2/24/86	6/30/2004	0.183	37%	0.5 MGD	2

SUMMARY: This is an STP, which discharges to surface water and is also required to submit sludge quality assurance reports to the DEP. Both permits are issued on and expire on the same date. There is also a landfill permit for this site, issued in 1986, expired 1992. The landfill is no longer operating. The STP expanded to a capacity of 0.5 MGD in 1993 under the ownership of NJ Dept. of Health and Human Services. No data is available on monitoring parameters for the landfill, but those for the STP and sludge appeared to be normal.

VIOLATIONS: In July 1993, excessive fecal coliform in effluent resulted in a $1750 fine. In September 1993, excessive phosphorus in effluent resulted in a $1750 fine. In April 1997, a power outage resulted in a spill of 1000 gallons of untreated sewage.

STONY BROOK RSA, HOPEWELL STP **NJPDES #0035301**

PERMIT EFFECTIVE	PERMIT EXPIRES:	1998 AVG. FLOW:	% CAPACITY	PERMIT ISSUED FOR WHAT LEVEL OF FLOW:	# VIOLATIONS
1984	Renewal in process	0.219	73%	0.3 MGD	0

SUMMARY: A municipal STP. The original permit, issued in 1984, is being updated and renewed at present. Records are meticulously maintained and communicated to DEP by the manager of this facility. The plant is supervised 8 hours a day, 7 days a week.