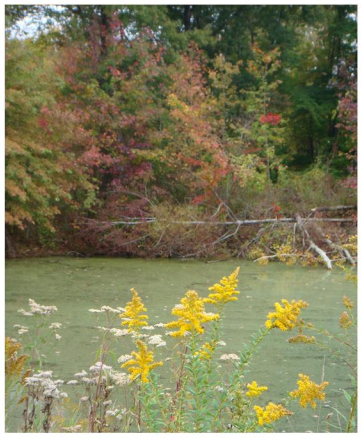
September 2014

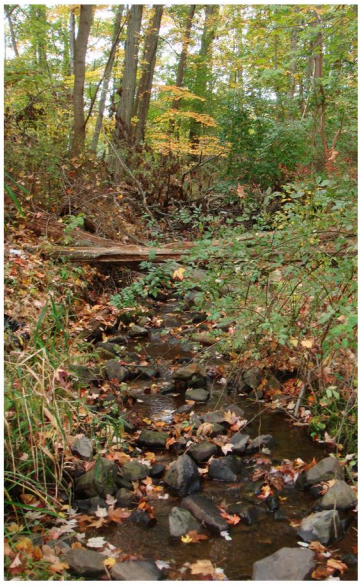


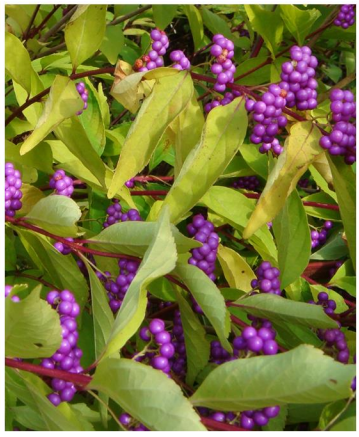
Environmental Resource Inventory

for

North Brunswick Township

Middlesex County, NJ





Prepared for:

North Brunswick Township

Kratzer Environmental Services

Written by:
Deborah J. Kratzer

ENVIRONMENTAL RESOURCE INVENTORY

North Brunswick Township

Middlesex County

New Jersey

Prepared By

Deborah J. Kratzer, Kratzer Environmental Services

For

The Township of North Brunswick Township

FINAL

September 2014

This plan was prepared with the assistance of a Smart Growth Planning Grant from the Association of New Jersey Environmental Commissions

Kratzer Environmental Services

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"We should act like this is the only planet we have because it is." (Honachevsky, 2000)

Acknowledgements

This report was authored by Deborah J. Kratzer. Funding for this report was provided by a grant from the Association of New Jersey Environmental Commissions and the Township of North Brunswick.

2014 North Brunswick Mayor and Council Members	
Francis M. Womack, III, Mayor Cathy Nicola, Council President Ralph Andrews Bob Corbin	Bob Davis Shanti Narra Carlo Socio
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Andrew Besold Tom Brys, Chairman Laura Dodge Donna Fennell Angela Foster	Karen Iorio William Krause, Planning Board Rep. Ameila Mate, Secretary Dev Sachdev
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Special Acknowledgements:

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Photo Credits:

Page 174: Glenn Sandor. Invasive species photos on pages 164-168: Bodner, Britton & Brown, bugwood.org and Mohlenbrock. All other photos by Deborah J. Kratzer.

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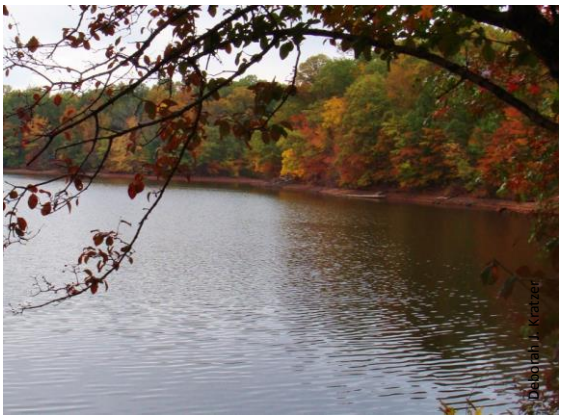
1: INTRODUCTION

A. About This Report

Ecologically Based Planning



Farrington Lake

Ecology is defined as the science of the relationships between organisms and their environments. The relationships between and among the physical factors of the environment, including the air, geology, topography, soils, and water, and the biotic environment, including plants, animals and decomposers, are a complex web. Humans are a significant part of the ecosystem of the Township of North Brunswick, both affecting and being affected by many physical and biological factors. With North Brunswick's population of 40,742, or (3,320 persons/mi^2 [1] (US Census, 2010), the cumulative effects of many individual decisions have altered and have the potential to impact the environment in ways that cause harm directly to the environment and human health, and indirectly through complex environmental functions.

> "The scientific community needs to articulate more clearly for local decision makers the underlying ecological processes and the consequences resulting from interference or truncation of those processes." (Honachefsky, 2000, p. 32)

Assembling an inventory of the Township's environmental and biological infrastructure is the first step in a proactive and ecological approach to protecting and preserving human and ecological health. Analyzing the data, gaining an understanding of the ecological processes involved, and considering the consequences of ignoring them, will help local land planners create and maintain an ecologically healthy community.

Goal of the Environmental Resource Inventory

The goal of the *Environmental Resource Inventory (ERI)* is to provide objective, reliable environmental data in one document so that Township officials (the Mayor, Township Council, Planning Board, Board of Adjustment, Environmental Commission, Depratment of Parks, Recreation and Community Service (DPRCS) and the Construction Office) can make more informed decisions by taking numerous variables into consideration in order to better protect the township's natural resources and the overall health and welfare of the community. Similarly, it is a tool for the public to use.

The Municipal Land Use Law requires municipalities' Master Plans to have a land use plan including, but not necessarily limited to, topography, soil conditions, water supply, flood plains, wetlands, and woodlands (Municipal Land Use Law, 2002).

The Environmental Commission Enabling Legislation gives environmental commissions the authority to conduct such research for inclusion in the Master Plan, and then to use this information to help evaluate development applications.

[1] The population of Middlesex County as a whole is 809,858 persons (2,507 persons/mi^2) and for the entire State of New Jersey, the population is 8,791,894 (1,008 persons/mi^2) (US Census, 2010).

The Association of New Jersey Environmental Commissions (ANJEC) defines "Environmental Resource Inventory" in its Resource Paper, The Environmental Resource Inventory: ERI, as follows:

> "The Environmental Resource Inventory (ERI), or Index of Natural Resources, is a compilation of text, tables, maps and other visual information about the natural resource characteristics and environmentally significant features of an area. Traditionally called "Natural Resources Inventory," the title "Environmental Resources Inventory" is now commonly used, reflecting the addition of manmade features to the inventory, such as historic sites, brownfields and contaminated sites. An ERI provides baseline documentation for measuring and evaluating resource protection issues. It is an objective index and description of features and their functions, rather than an interpretation or recommendation. Identifying significant environmental resources is the first step in their protection and preservation and in assuring that future development or redevelopment protects public health, safety and welfare." (ANJEC, no date).

The ERI will principally be used by the Planning Board and Environmental Commission, but will provide valuable information to anyone interested in the natural resources of the Township of North Brunswick. This objective information may facilitate resource-sensitive development decisions. In addition, familiarity with environmental concerns enables residents to appreciate and to learn how to maintain our valuable natural resources. Areas of specific concern may emerge which require additional protection strategies, such as further research and monitoring, public outreach and education, habitat restoration, easements, volunteer projects, and/or revised or new ordinances.

Methods

Funding for this project was obtained through a grant from the Association of New Jersey Environmental Commissions (ANJEC), with 50% cost share provided by the Township of North Brunswick.

What is GIS?

"A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts." (GIS.com, 2011)

An inventory of what is currently known about the physical and biological environment and the human influence on the environment of North Brunswick has been compiled for this document. The most current GIS data have been obtained from the New Jersey Department of Environmental Protection GIS Data Web Site and other sources (see **Appendix A** and **Appendix B)**. A total of 97 GIS data layers from 28 sources were used for this report's 58 maps.

Further sources include the internet, and federal, state, county and local databases and contacts. All digital inventory data used in this report will be provided to the North Brunswick Environmental Commission. The public can also use GIS data by using either the New Jersey Department of Environmental Protection's NJ-GeoWeb website or obtain relevant data layers (most are free on the internet), and download the free software, ArcExplorer to view the data (see **Internet Resources**, at the end of this section).

When viewing the digital document (as opposed to a printed copy) maps in PDF[2], clicking on the tab "Layers" at the left side of the screen will allow users to turn on or off the various data layers. Viewing the separate layers in this way is often helpful, especially for complex maps[3].

References and related Internet resources (with links) are listed at the end of each section, so that readers may find more information and updates. Please note that Internet sites may change or be temporarily out of service. If an Internet link doesn't work, try using an Internet search engine.

The following chapters present objective information about the Township of North Brunswick's natural resources, including climate, geology, soils, water, floodplains, wetlands, and forests, and cultural resources such as infrastructure, open space and historic and architecturally interesting structures. Environmental concerns in North Brunswick include air and water pollution, rare, threatened and endangered species, invasive species and potential loss of remaining wetlands and forests.

Limitations of the ERI

It should be noted that the ERI is not meant to replace the primary data sources upon which it is based. Some new data was created for this project. Details about each data layer, including the date, scale and methods of developing the data, are provided in **Appendix B**. The ERI is intended for preliminary assessments of projects and *cannot substitute for on-site testing and evaluations*. Most maps are presented at a scale of 1:18,000 in order to fit on 8.5 x 11 inch paper. "Zooming in" to better view individual lots is possible, but should not exceed the scale at which the data was created. Most data layers used for this report were created at 1:24,000 scale (with an accuracy of $\pm$ 40 feet). Data mapped at 1:100,000, such as the geology data layer, have an accuracy of $\pm$ 166.7 feet (Garie, 1998).

Sometimes mapped features don't line up exactly, since different data producers may have used different methods of acquiring and analyzing the data, used different scales or coordinate systems, and because of differences or errors in the base data.

GIS data from NJDEP and Middlesex County are used with permission (see the Terms of Agreement in **Appendix A**), with the required "disclaimer" printed on each map which uses their data.

Some components of the environment may have been studied or presented in detail, while other important factors may have been minimally addressed. When new or updated information becomes available, or new issues emerge, *updates should be appended to the ERI*.

Following the guidelines provided by ANJEC, management recommendations are not included in the ERI.

B. General Description of the Township of North Brunswick

North Brunswick is located in Middlesex County, NJ (see **Figure 1a**) and is bordered by the City of New Brunswick to the north; East Brunswick Township and Milltown Borough to

[2] PDF stands for "Portable Document Format," a digital format which allows the document to appear the same to everyone, requiring only the download of the free Adobe® Reader® at http://www.adobe.com/products/acrobat/readstep2.html.

[3] A few maps are so large in this format that they are included as a simple graphic in the report, but are available separately in PDF.

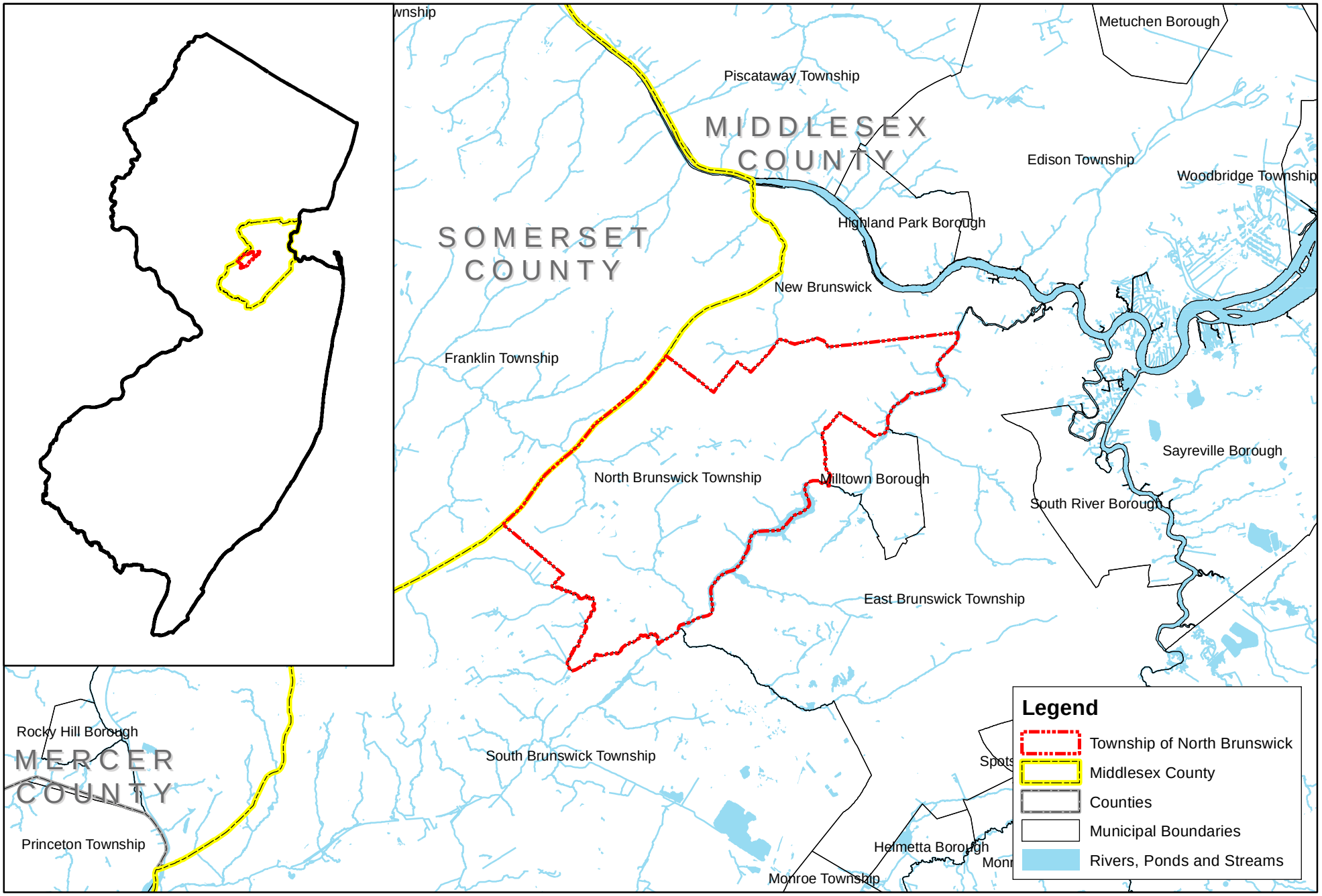


Figure 1a: Location of the Township of North Brunswick

0 0.5 1 2 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

the east; by South Brunswick Township to the south; and Franklin Township (Somerset County) to the west. Six Mile Run crosses the township's boundary into Franklin near Woodmere Road. Part of the eastern boundary of the township is formed by the Lawrence Brook and Farrington Lake, while part of the southern boundary is formed by Oakeys Brook, a tributary of Lawrence Brook. The Lawrence Brook joins the Raritan River approximately 1.2 miles to the northeast, which flows another 6 miles to reach the Atlantic Ocean. The western boundary, where North Brunswick meets Franklin, is also the boundary between Middlesex and Somerset Counties.

The township was incorporated in 1798, one of the state's original 104 townships. Later, portions of the township separated to become East Brunswick and Milltown Borough. North Brunswick encompasses 12.272 square miles (7,854 acres) with a population of 40,742 living in 15,045 housing units (Wikipedia, 2013; US Census, 2010).

C. Land Use and Land Use Change

Figures 1b through **1e** show aerial photographs of North Brunswick and the surrounding areas. In **Figure 1b**, aerial photography taken in 1930, although not very high resolution and not georeferenced,[4] illustrates the existence of many acres of agricultural land within North Brunswick, as well as a large forested area in the center of the township, at the time. Aerial photographs taken in 1995, 2002, 2007 and 2012 are shown in **Figure 1c, 1d, 1e and 1f**[5] respectively. These aerial photographs are georeferenced. Other options for viewing aerial photos online are listed in **Internet Resources**, at the end of this section.

The New Jersey Department of Environmental Protection (NJDEP) used aerial photography taken in 1986, 1995, 2002 and 2007 to determine land use and land use change. NJDEP has not yet produced land use data based on the 2012 aerial photography.

The *Land Use Type* is the generalized category of six land uses: agriculture, barren, forest, urban, water and wetlands. Definitions are as follows (USGS, 2010):

Agriculture includes all lands used primarily for the production of food and fiber and associated farm structures.

Forest land is covered by woody vegetation (excluding wooded wetlands, which are included in the wetlands category). These areas are capable of producing timber and other wood products, and of supporting many kinds of outdoor recreation. Forests are important environmentally, because they affect air quality, water quality, wildlife habitat and climate.

Any areas periodically covered with water are included in the *water* land use type.

Wetlands are those areas that are inundated or saturated by surface or ground waters at a frequency and duration sufficient to support vegetation adapted for life in saturated soil conditions. Included in this category are naturally vegetated swamps, marshes, bogs, etc., as well as formerly natural wetlands that have been altered (sometimes filled) and are now part of a managed recreational area, but which still show signs of soil saturation on the aerial imagery. These areas do not currently support typical wetland vegetation, but are vegetated primarily by grasses and other planted vegetation that may be routinely mowed. Wetlands are further discussed in **Section 6C** of this report.

Barren Land includes areas being developed or cleared at the time the photos were taken.

[4] Georeferencing involves defining the location of something in physical space using map coordinates and assigning a coordinate system. This is the strength of GIS, because features can be defined in relation to other features.

[5] The 2002, 2007 and 2012 aerial photography data are high resolution, with pixels of 1 square foot. This is much more detail than can be shown in this report. See NJ-GeoWeb in **Internet Resources**, below .

The *Urban Land* type is characterized by intensive land use where the landscape has been altered by human activities. It encompasses various categories of residential, commercial, educational and industrial land.

The 2007 land use types within the Township of North Brunswick are illustrated in **Figure 1f**, and summarized in **Table 1.1**. North Brunswick is 69% urban, 14% wetlands and only 9% forested. Detailed categories of land use/land cover are shown in **Section 7 (Figures 7a, 7b and 7c)** of this report.

Table 1.1: 2007 Land Use Type

2007 Land Use Type	Acres	Percent
Agriculture	319.14	4.05
Barren Land	92.94	1.18
Forest	745.40	9.47
Urban	5458.99	69.34
Water	180.83	2.30
Wetlands	1075.26	13.66
Total	7872.58	100.00

Sources: NJDEP, Bureau of Geographic Information Systems (BGIS), July 12, 2010a; July 12, 2010b

Table 1.2 shows the percentages of North Brunswick in each land use type in 1986, 1995, 2002 and 2007 and the changes in percent cover. **Figure 1g** show the areas that have changed to urban or barren land over this time period. Clearly, the most significant changes in land use occurred prior to 1986, the first year for which detailed land use information is available. Since then, there has been a small but steady conversion of agriculture, forest and wetlands to urban land uses within the township.

As previously mentioned, 2012 land use change data is not yet available. Therefore, recent changes (since 2007) are not mapped. One example is highlighted on **Figure 1h**. In this example, 0.4 acres of wooded wetlands at the intersection of Fleetwood Avenue and Danny Court were converted to a mulch storage area sometime between 2007 and 2010.

Table 1.2: Change in Land Use Type

Land Use Type	1986 Percent	1995 Percent	% Change '86-'95	2002 Percent	% Change '95-'02	2007 Percent	% Change '02-'07
Agriculture	8.84	6.69	-2.15	4.99	-1.70	4.05	-0.94
Barren Land	0.90	1.61	0.71	2.39	0.78	1.18	-1.21
Forest	14.14	10.86	-3.28	10.16	-0.70	9.47	-0.69
Urban	57.79	62.84	5.05	65.92	3.09	69.34	3.42
Water	1.86	1.93	0.07	2.18	0.25	2.30	0.11
Wetlands	16.47	16.07	-0.41	14.35	-1.72	13.66	-0.69
Total	100.00	100.00	0.00	100.00	0.00	100.00	0.00

Sources: NJDEP, Bureau of Geographic Information Systems (BGIS), July 12, 2010a; July 12, 2010b; October 2009; January 1, 2007a; January 1, 2007b; December 1, 2000a; December 1, 2000b

References: Introduction

Association of New Jersey Environmental Commissions (ANJEC). No Date. The Environmental Resource Inventory: ERI. Mendham, NJ: ANJEC. 12 pages. http://anjec.org/pdfs/ERI2013.pdf

Garie, Henry L. and Lawrence L. Thornton. September 1998. New Jersey State Agency Partnership GIS Technical Mapping Standards: Enhancing GIS Technology for Multi-Agency Cooperation. Standards Subcommittee State Mapping Advisory Committee: Trenton, NJ. http://www.state.nj.us/dep/gis/standinter.html

GIS.com. 2011. ESRI. http://gis.com/content/what-gis

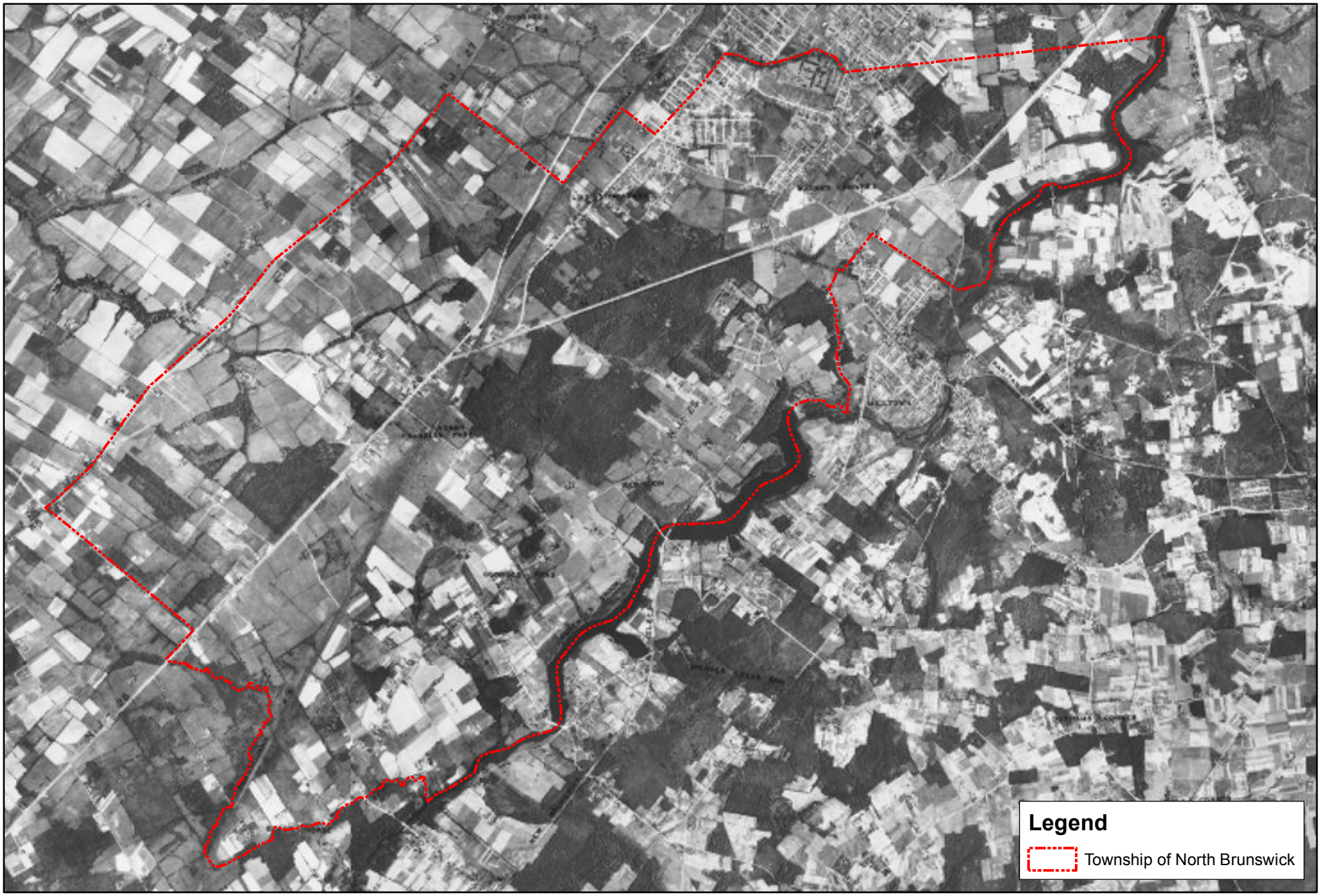


Figure 1b: 1930 Aerial Photography

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

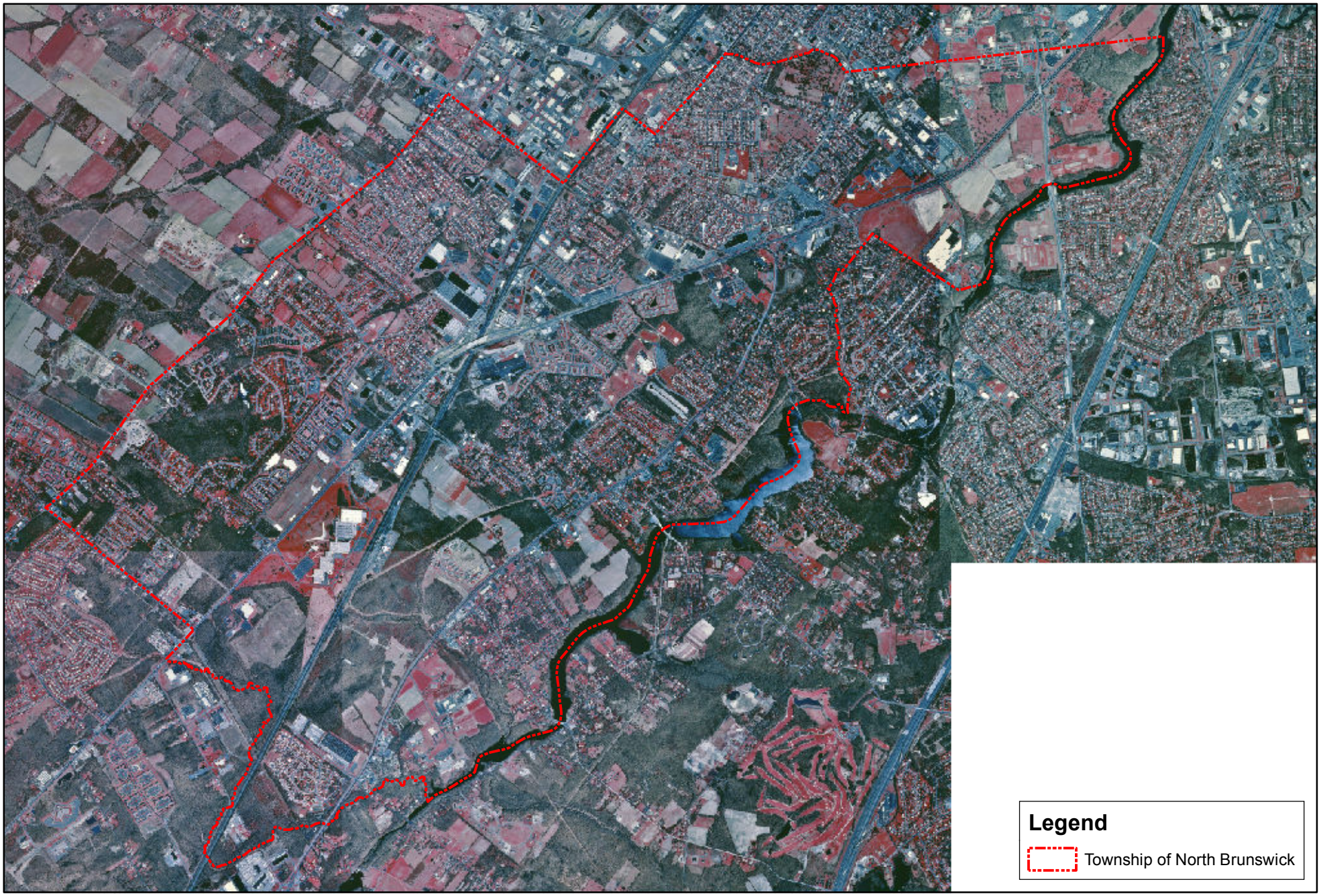


Figure 1c: 1995 Aerial Photography

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
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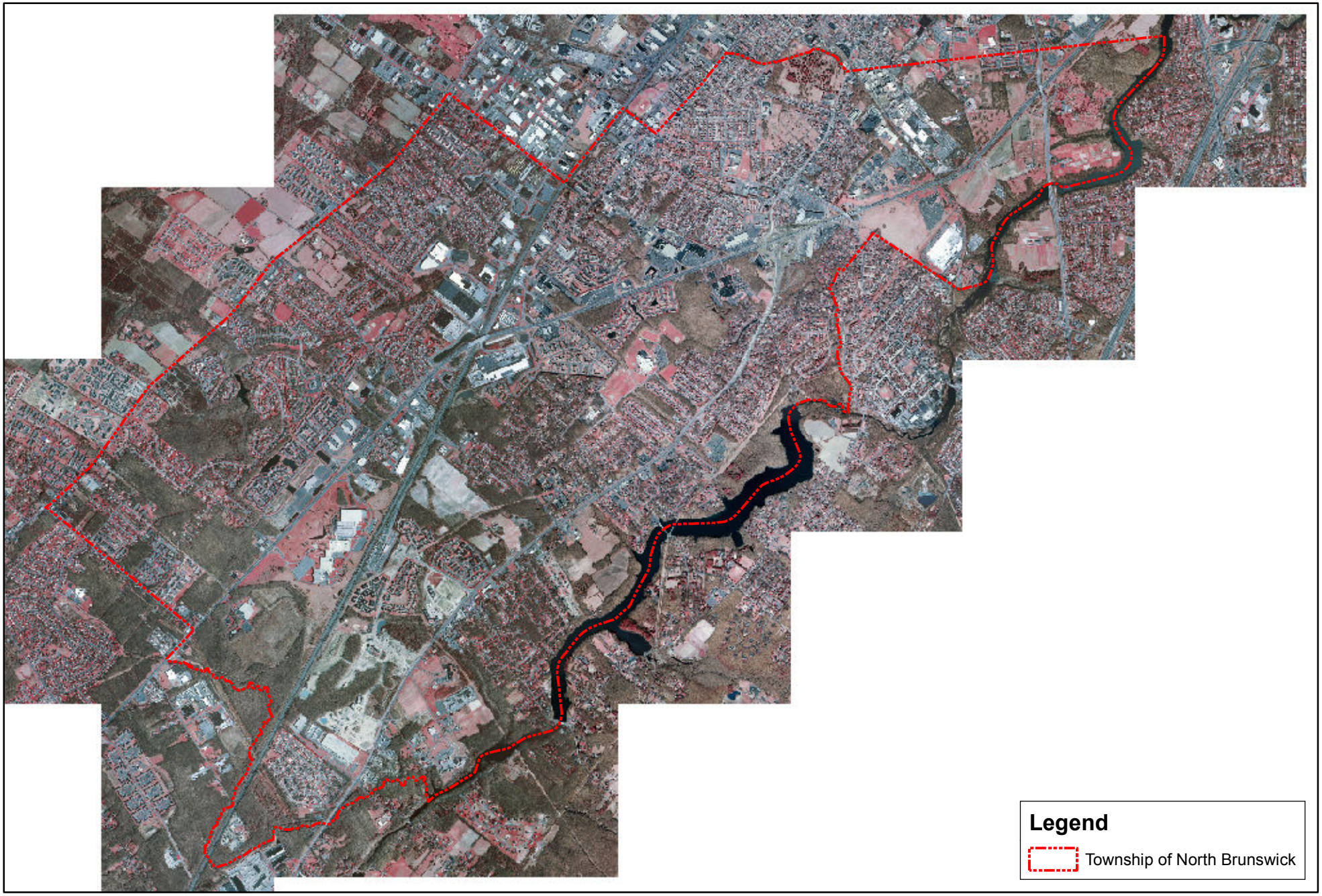

Figure 1d: 2002 Aerial Photography

0 0.25 0.5 1 Miles

N

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

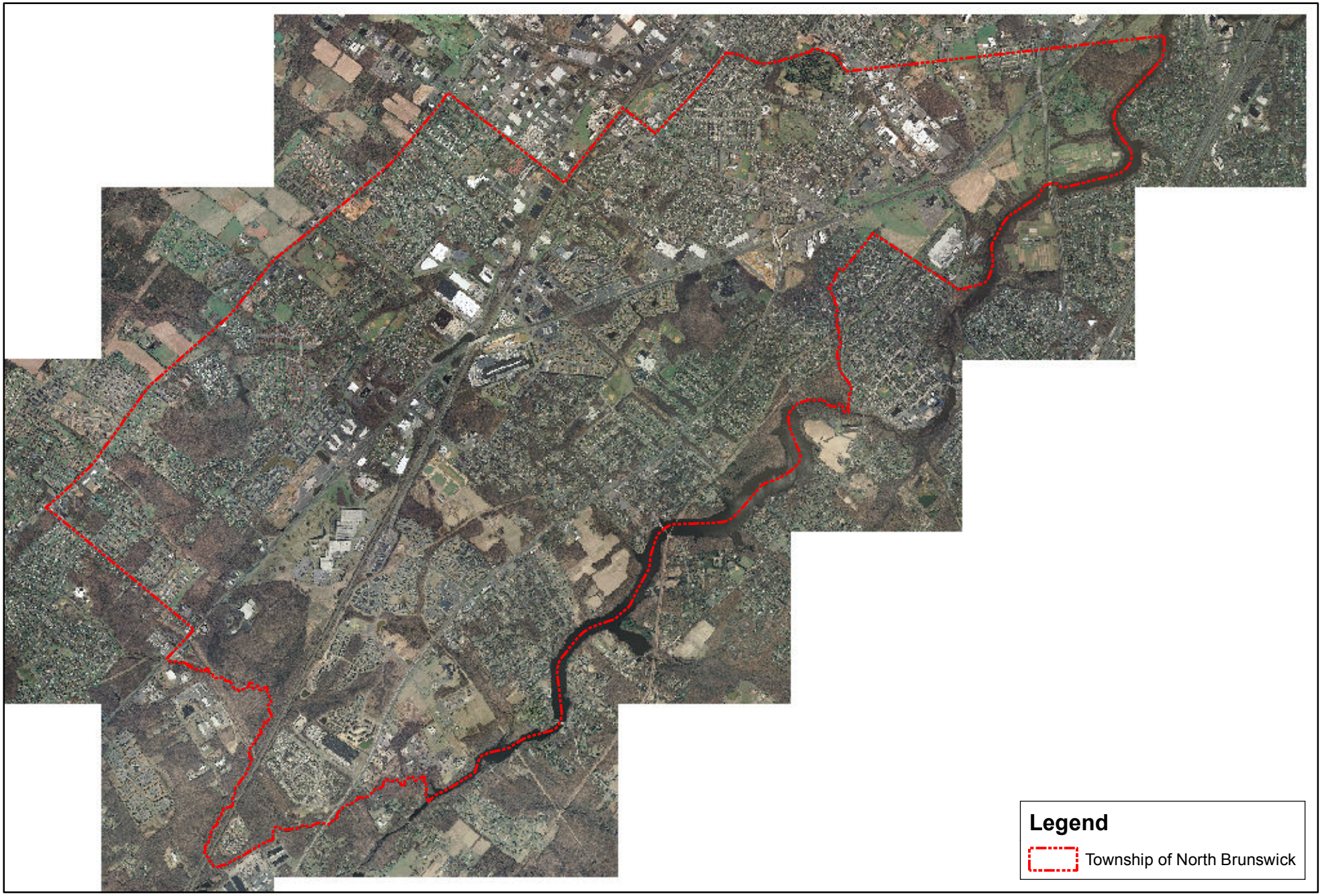

Figure 1e: 2007 Aerial Photography

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

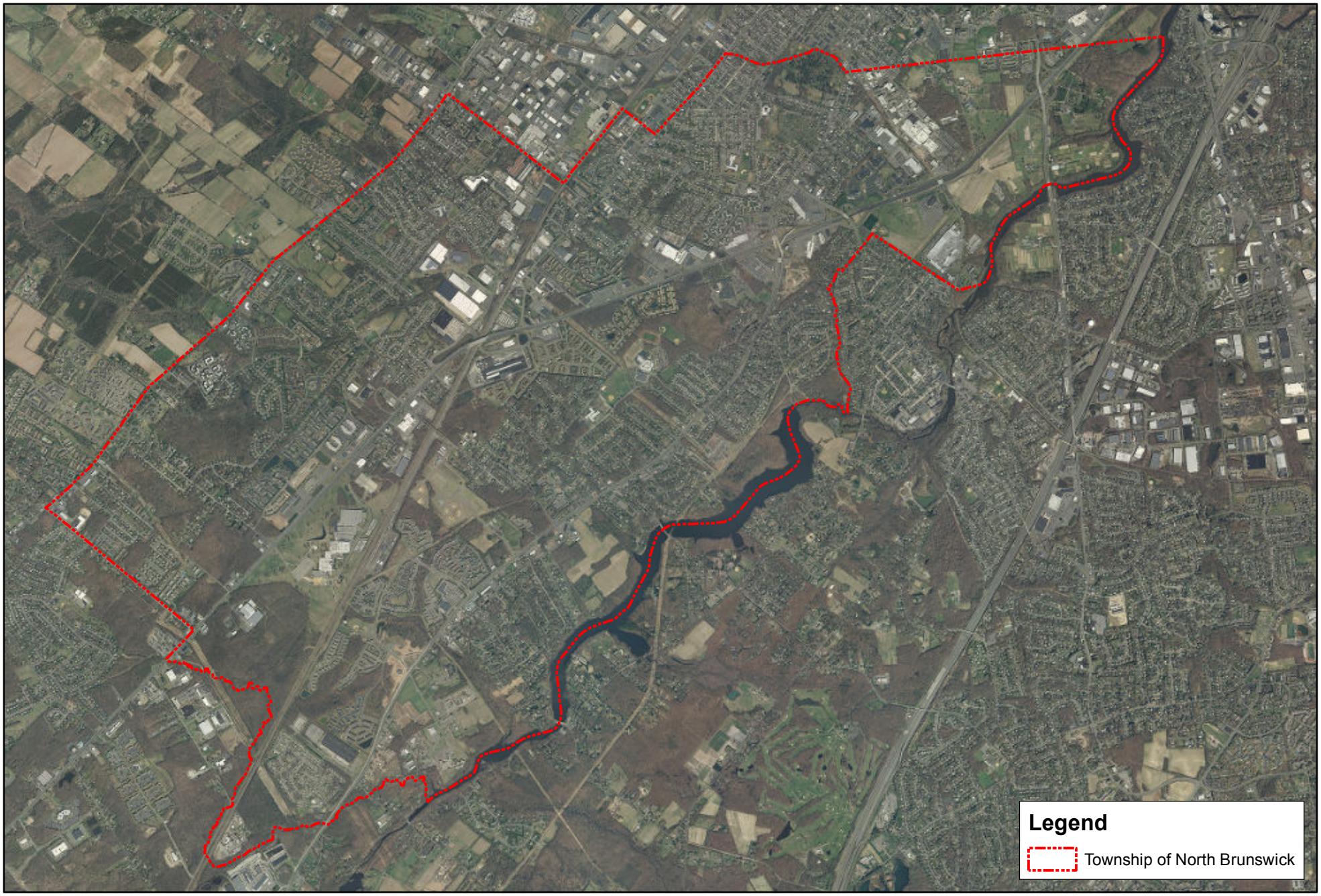

Figure 1f: 2012 Aerial Photography

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

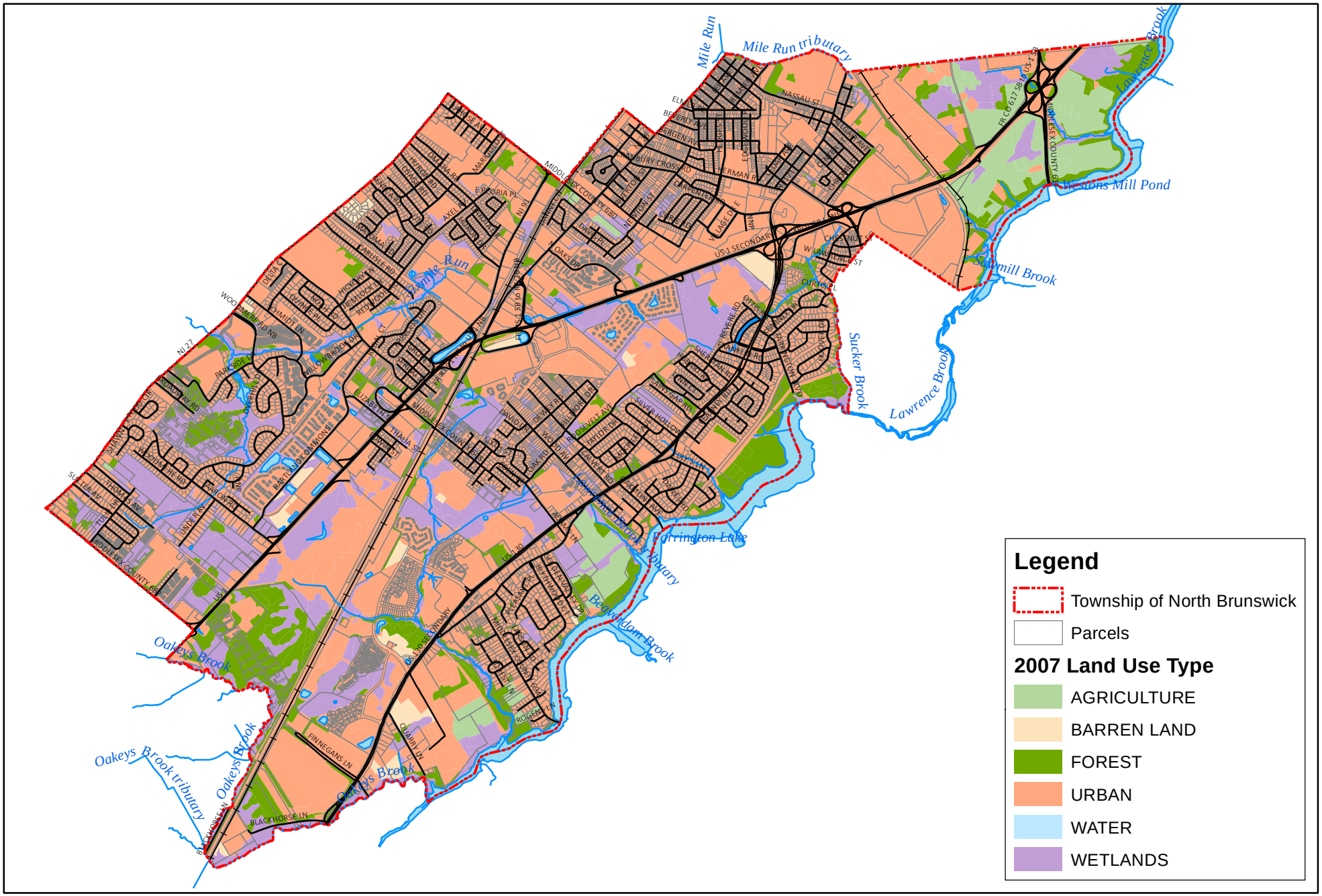

Figure 1g: 2007 Land Use Type

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Notes:
1. Land use types are general categories as defined and identified by NJDEP from aerial photography taken in 1986, 1995, 2002 and 2007. Areas of change from previous land use types are shown here.
2. Changes since 2007 are not shown, except one example noted by the arrow.

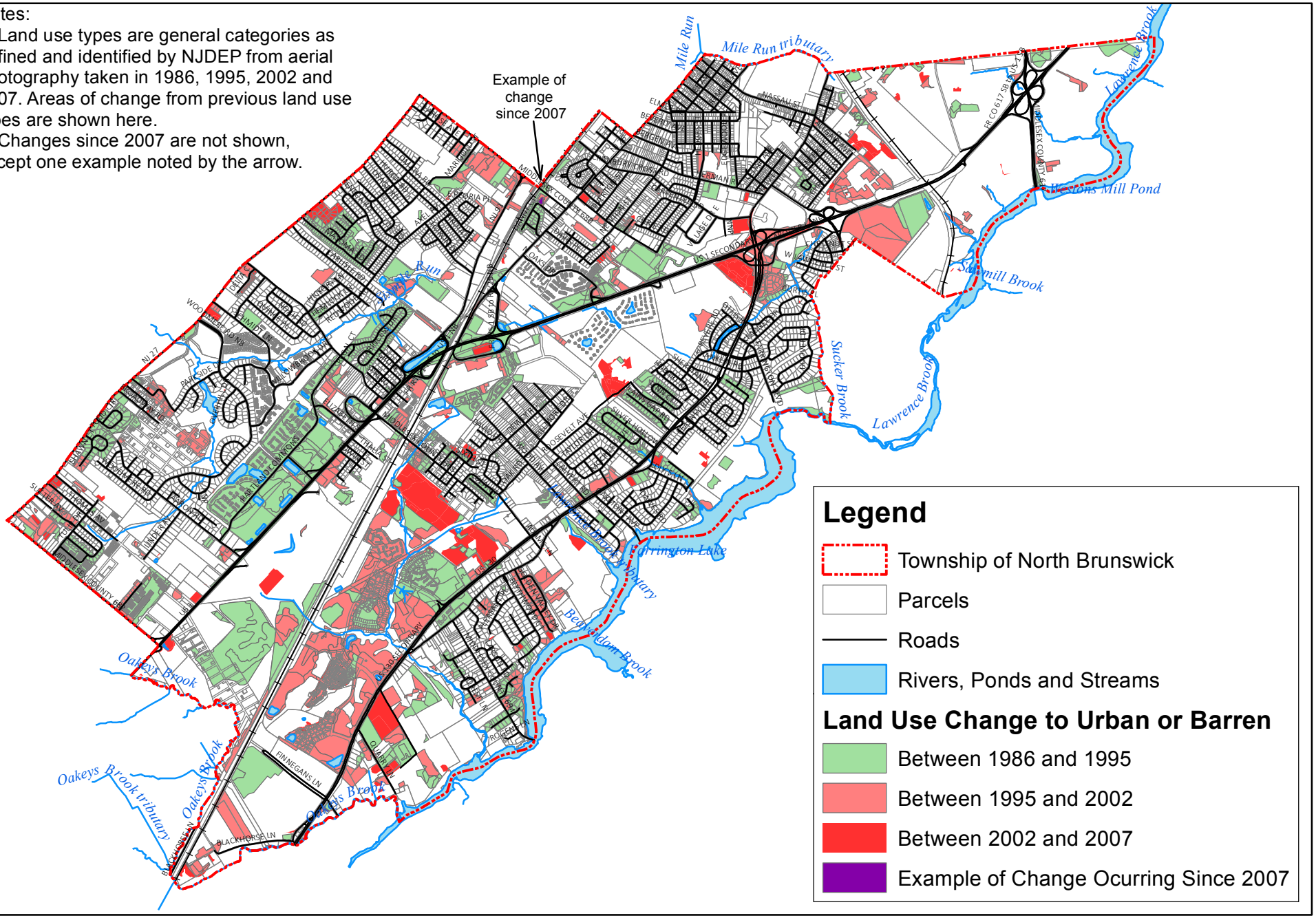

Figure 1h: Land Use Changes to Urban or Barren Type

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Honachefsky, William B. 2000. Ecologically Based Municipal Land Use Planning. Lewis Publishers: New York. 255 pages.

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NJDEP, Bureau of Geographic Information Systems (BGIS). July 12, 2010b. NJDEP 2007 Land use/Land Cover Update, Millstone Watershed Management Area, WMA10. Edition: 20100712. GIS data. http://www.state.nj.us/dep/gis/digidownload/zips/lulc07/w10lu07.zip

NJDEP, Bureau of Geographic Information and Analysis (BGIA). October 2009. 1930s Aerial Photography of New Jersey Web Map Service (WMS). GIS data. https://njgin.state.nj.us/NJ_NJGINExplorer/full_metadata.jsp

NJDEP, Bureau of Geographic Information Systems (BGIS). January 1, 2007a. NJDEP 2002 Land use/Land cover Update, Lower Raritan, South River and Lawrence Watershed Management Area, WMA-9. Edition: FINAL. GIS data. http://www.state.nj.us/dep/gis/digidownload/zips/lulc02/w09lu02.zip

NJDEP, Bureau of Geographic Information Systems (BGIS). January 1, 2007b. NJDEP 2002 Land use/Land cover Update, Millstone Watershed Management Area, WMA-10. Edition: 20080304. GIS data. http://www.state.nj.us/dep/gis/digidownload/zips/lulc02/w10lu02.zip

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NJDEP, Bureau of Geographic Information and Analysis (BGIA). December 1, 2000b. NJDEP 1995/97 Land use/Land cover Update, Millstone Watershed Management Area, WMA-10. Edition: 1.3; (FINAL). GIS data. http://www.state.nj.us/dep/gis/digidownload/zips/lulc95/w10lu95.zip

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US Geological Survey (USGS). 2010. Edited by NJDEP, Bureau of Geographic Information Systems (BGIS) 1998, 2000, 2001, 2002, 2005, 2007, 2010. NJDEP MODIFIED ANDERSON SYSTEM 2007 derived from: A Land Use and Land Cover Classification System for Use with Remote Sensor Data, USGS Professional Paper 964, 1976. 35 pages. http://www.state.nj.us/dep/gis/digidownload/metadata/lulc07/anderson2007.html

Wikipedia. Accessed July 2, 2013. North Brunswick, NJ. http://en.wikipedia.org/wiki/North_Brunswick,_NJ

Internet Resources: Introduction

Aerial photography and online mapping:

Google Earth[6]: http://www.google.com/earth/index.html (free download, restrictions on map image use)
HistoricAerials.com[7]: http://historicaerials.com (free to use, but maps have watermark unless purchased)
NJ-GeoWeb (NJDEP): http://www.state.nj.us/dep/gis/geowebsplash.htm (free to use, many data layers available)

Environmental Education

NJDEP SEEDS: The State Environmental Education Directory Website: http://www.state.nj.us/dep/seeds/index.html

[6] Users of Google Earth may also view several years of historic imagery of North Brunswick from 1995 through 2012. On the menu bar, click View, then click Historical Imagery and use the slider bar to choose the year.
[7] HistoricAerials.com allows viewing of historic aerial photography between 1931 and 2007.

Free GIS Software

ArcExplorer (free GIS software): http://www.esri.com/software/arcexplorer/explorer.html

GIS Data from New Jersey Department of Environmental Protection
(For a complete list of data sources used in this report, see Appendix B.)

NJ GIS Home Page: http://www.state.nj.us/dep/gis/index.html
Download GIS data: http://www.state.nj.us/dep/gis/downloadintra.html
NJ Geographic Information Network: https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp

Middlesex County's Official Home Page: http://www.co.middlesex.nj.us/

North Brunswick's Official Home Page: http://www.northbrunswicknj.gov/

2: LOCAL & REGIONAL CONDITIONS

A. Climate & Meteorology

Climate

Climate is a major factor in determining the kinds of plants and animals found in an ecosystem. New Jersey has a temperate climate because it has mild average temperatures, four seasons, and rainfall distributed throughout the year. The dominant atmospheric circulation is the prevailing westerlies, the broad, undulating flow of air from west to east across the middle latitudes of North America. Prevailing winds are from the southwest in summer and from the northwest in winter (Office of the New Jersey State Climatologist, No Date).

According to the NJ State Climatologist,

> "Amidst growing evidence that our global climate is changing as a result of human activities, are specific concerns regarding the local and regional impacts such changes may be having or may eventually have on nature and society. Such worries are justified around the globe, including New Jersey, the most densely populated of the United States. Changes in our State's climate are likely to impact natural flora and fauna, human health and safety, agricultural productivity, fresh-water resources, tourism, transportation, and business and commerce in general. It is imperative that we better understand the nature of the climate of New Jersey in order to recognize the significance of its possible ongoing or future behavior." (Robinson, 2010)

The NJ State Climatologist evaluated data from 19 stations for the NJ Climate Report Card in order to begin to document and understand climate change within NJ. While statistical trends were not developed for this study, over 600 time-series graphs were created that chart weather variables over the past century (e.g. min. and max. temperature, precipitation). One weather station evaluated for this climate study was in North Brunswick, although it's called "New Brunswick." This station, located at Cook College, has been monitored since 1847 (Robinson, 2010; Hartman, 2002).

According to the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC), the temperature trend (annual average) in New Jersey is +0.2 °F per decade, and the precipitation trend is +0.41 inches per decade (for the period of record 1895 to 2012) (NOAA, June 13, 2013).

In addition, the NCDC calculates state *normals* (three-decade averages) of climatological variables, including temperature and precipitation. The normal maximum temperature for NJ has increased between 0.5 to 0.7°F for 1981-2010 compared to the 1971-2000 period. Normal minimum temperature for the state has increased 0.3 to 0.5°F (NOAA, July 5, 2011).

State and Federal laws regulate greenhouse gas emissions that cause climate change (see **Internet Resources**).

NJDEP Sustainability and Green Energy (SAGE) "promotes and supports programs that both reduce greenhouse gas emissions and preserve and expand natural carbon sinks such as forests, soils and wetlands to ensure compliance with the NJ Global Warming Response Act. In addition, SAGE promotes and supports initiatives designed to help New Jersey to adapt to climate-related impacts that are unavoidable" (SAGE, 2013).

North Brunswick Township received a *Sustainable Jersey Community Bronze Certification* in 2009, with 110 points. Sustainable actions include a Natural Resource Inventory, Environmental Commission, municipal carbon footprint, green team, sustainability programs, recycling, solar energy, and energy audits (North Brunswick, 2009).

Precipitation and Temperature

As the prevailing westerlies shift north and south and vary in strength, they bring wet, dry, hot, and cold airstreams. These influence the weather throughout New Jersey, resulting in highly variable daily weather. The Office of the New Jersey State Climatologist (ONJSC) divides New Jersey into five distinct climate regions. North Brunswick is included in the Central Zone, which extends diagonally from Bergen to Mercer Counties (ONJSC, No Date).

This region has many urban areas and the intensity of buildings and paved surfaces serve to retain more heat. Local nighttime temperatures in heavily developed parts of the zone are regularly warmer than surrounding suburban and rural areas, a phenomenon known as an urban heat island. The difference between freezing and non-freezing precipitation during the winter often occurs at the northern edge of the Central Zone. In the summer, the Central Zone usually has 15-20 days with temperatures above 90 °F, half as many as areas to the south (ONJSC, No Date).

The ONJSC's New Jersey Weather and Climate Network maintains weather stations which transmit real-time data and weather forecasts on the Internet. Of these stations, the New Brunswick station is actually in North Brunswick. **Table 2.1** displays monthly average highs and lows and mean temperature, average monthly precipitation, and record highs and lows (and the year it occurred in parentheses).

Measurable precipitation falls in this area on approximately 120 days per year (ONJSC, No Date). Annual precipitation has averaged 45.72 inches in New Brunswick (for the period 1912-2013)(see **Table 2.1**).

Rainfall is distributed fairly evenly throughout the year, with February being the driest month. On average, July, August and September have the most precipitation, but appear drier because evapotranspiration exceeds precipitation (ONJSC, 2012-2013). Record rainfalls are more likely to occur between July and September, due to tropical storms (see **Table 2.2**).

In the past 100 years, an average of 25.5 inches of snow has fallen annually measured at the New Brunswick station (about 10" of snow equals 1" of rain); while the amount of snow has ranged from 3.1 to 76.5 inches (ONJSC, 1912-2013). Each winter, about 9 to 10 days receive snowfall greater than or equal to 0.5" in North Brunswick. Days with snowfall greater than 4" occur only about twice per winter in this area (ONJSC, 1971-2000). Measured in New Brunswick, the earliest snow on record was on October 19 (in 1972, with 0.6"), and the latest was April 23 (in 1986, with 1.2") (ONJSC, 1912-2012).

According to NOAA, the freeze-free period in New Brunswick is an average of 182 days. The average date for the last spring frost (32^{o}F) is April 20th (although there is a 10% probability that the last freeze may be May 1st or later). The first frost in fall is usually around October 20th (although there is a 10% probability that the first frost may be October 7th or earlier). The exact dates vary within the county as well as from one year to another (NOAA, February 26, 2005).

During the winter, temperatures are not generally cold enough to keep the soil frozen for the whole winter. Winter rains are frequently warm enough to thaw the soil. Heavy rain on partly thawed soils is very erosive.

Table 2.1: Temperature & Precipitation at New Brunswick, NJ

Month	*Based on data from 1912-2013*			*Based on data from 1912-2012*		*Based on data from 1912-2013*
	Temperature					Mean Precipitation
	Avg. High	Avg. Low	Mean	Record High	Record Low	
January	39.2 °F	22.4 °F	30.8°F	73 °F (1916)	-14 °F (1935)	3.43 in.
February	41.2 °F	23.1 °F	32.1°F	76 °F (1930)	-16 °F (1934)	2.89 in.
March	50.4 °F	30.7 °F	40.5°F	88 °F (1998)	2 °F (1967)	3.82 in.
April	61.6 °F	39.9 °F	50.8°F	95 °F (2002)	11 °F (1923)	3.71 in.
May	72.2 °F	49.5 °F	60.9°F	96 °F (1962)	30 °F (1983)	3.97 in.
June	80.7 °F	58.9 °F	69.8°F	99 °F (1967*)	38 °F (1938)	3.89 in.
July	85.2 °F	64.1 °F	74.7°F	105 °F (2011*)	45 °F (1982)	4.79 in.
August	83.4 °F	62.7 °F	73.0°F	106 °F (1918)	40 °F (1982)	4.61 in.
September	77.1 °F	55.5 °F	66.3°F	102 °F (1953)	33 °F (1942)	4.08 in.
October	66.4 °F	44.3 °F	55.3°F	94 °F (1941)	22 °F (1936)	3.44 in.
November	54.5 °F	35.6 °F	45.1°F	82 °F (2003*)	6 °F (1938)	3.49 in.
December	42.8 °F	26.3 °F	34.6°F	76 °F (1998)	-15 °F (1917)	3.65 in.
					Average Annual Precipitation:	45.72 in.

*Temperature reached in one or more previous years.
Sources:
Averages: ONJSC, 1912-2013. http://climate.rutgers.edu/stateclim_v1/monthlydata/index.html
Extremes: ONJSC, 1912-2012. http://climate.rutgers.edu/stateclim_v1/dailynormalsextremes.html

Extreme Weather

Most areas of New Jersey receive 25 to 30 thunderstorms per year, with fewer storms near the coast than farther inland. In addition, each year between 1 and 10 nor'easters bring strong winds and heavy rains to the state. Approximately five tornadoes appear each year in New Jersey (usually relatively weak ones) (ONJSC, No Date). From 1996 to the present, two tornadoes have been documented in Middlesex County; Both F0 on the Fujita Scale, one in East Brunswick on September 8, 1996 and one in Highland Park October 27, 2003. During the same period, 25 hail events were recorded in Middlesex County. Hail which fell specifically in North Brunswick was recorded on May 24, 2004 and July 18, 2012 (NOAA, 1996-2013).

Table 2.2 lists some of the highest snow and rainfall received in one day at New Brunswick (although multiple day storms can have higher totals), for the period 1912 to 2012.

Tropical storms and hurricanes can contribute significant rainfall and can cause flooding. Some of the major storms that have affected North Brunswick are described here.

Hurricane Irene, the first hurricane to make landfall in NJ since 1903, brought the highest one-day precipitation measured at New Brunswick, 7.96 inches, on August 28, 2011. Tropical Storm Doria dropped the second highest one-day rainfall recorded at the New Brunswick station on August 28, 1971. An intense nor'easter that brought the third highest one-day rainfall at New Brunswick (6.43 inches) caused widespread flooding on April 15-16, 2007. Nearly every municipality in Middlesex County

Table 2.2: Highest Daily Precipitation Measured at New Brunswick

Rank	Greatest one-day snowfall		Greatest one-day rainfall	
	Amount	Date	Amount	Date
1st	19.8	2/12/2006	7.96	8/28/2011
2nd	19.5	1/8/1996 12/27/2010	7.66	8/28/1971
3rd	19.0	2/4/1961	6.43	4/16/2007
4th	17.9	2/12/1983	6.24	7/25/1997
5th	16.1	1/27/2011	5.78	9/17/1999

Note: Multiple-day storms may have storm totals greater than some of the one-day storms listed.
Source: ONJSC, 1912-2012

suffered flood damage or had roads closed due to flooding. It produced the worst flooding in the Raritan Basin since Hurricane Floyd, and, combined with high winds, was the second-worst rainstorm (not related to a hurricane) in the state's history (ONJSC, 1912-2012; NOAA, 1996-2013; Barry, 2013).

Hurricane Danny, which made landfall on July 19, 2007 in Alabama, quickly weakened to a tropical depression after landfall. Despite its small size, Danny produced record rain amounts in many areas, including 6.24 inches at New Brunswick on July 25, 2007, the fourth highest one-day rainfall recorded here (Wikipedia, July 7, 2013).

Hurricane Floyd battered New Jersey on September 16, 1999 and brought with it record breaking amounts of rain and damaging winds. For this multiple-day storm, a total rainfall of 7.04 inches was recorded in New Brunswick (higher in some areas), resulting in the worst flooding of the Raritan basin on record, exceeding previous records set during Tropical Storm Doria on August 28, 1971 (ONJSC, 1912-2012; NOAA, 1996-2013; Barry, 2013).

Hurricane Sandy, which made landfall near Atlantic City on October 29, 2012, was notable not for rain totals, but for sustained wind and wind gusts (52 mph at New Brunswick; many sites even higher) (Robinson, November 7, 2012) and in North Brunswick, devastating damage to power lines and trees, and some damage to homes (Glenn Sandor, personal communication, March 2014).

Historical floods are discussed in **Section 6a.** Flood forecasts and gage height of the Raritan River at Bound Brook are available in real-time on the internet from USGS and NOAA (see **Internet Resources**).

At the other extreme, extended periods of time with less than normal amounts of precipitation result in drought; agriculture suffers, wells can fail, reservoir levels fall and water supplies can be threatened.

The lowest annual precipitation measured at New Brunswick was 27.51 inches, which occurred in 1965. The five lowest precipitation years are shown in **Table 2.3**. The month with the lowest rainfall on record at New Brunswick occurred in June 1949, when just 0.02 inches of rain was recorded (ONJSC, 2014).

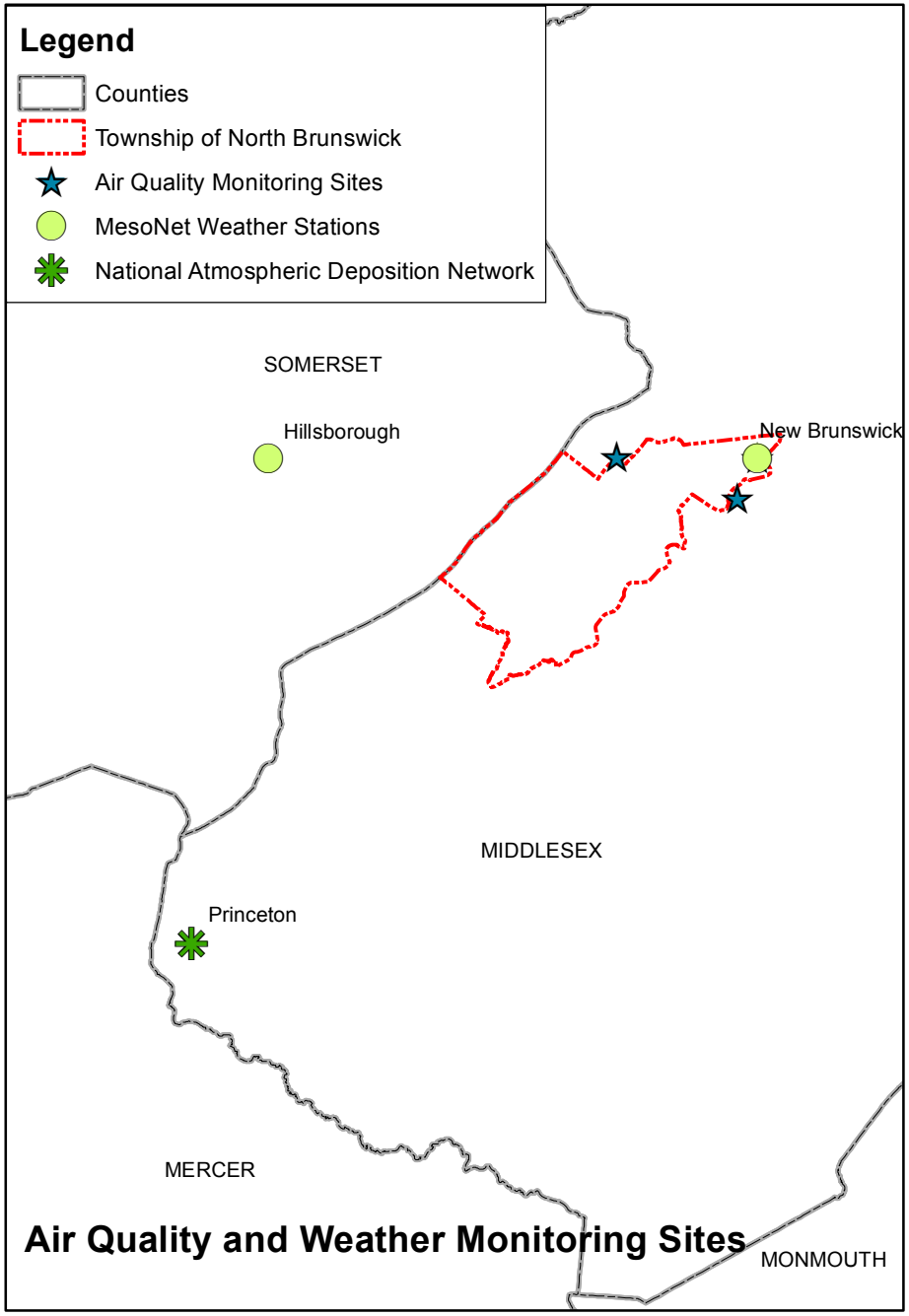
Table 2.3: Lowest Annual Precipitation at New Brunswick

Rank	Year	Amount (inches)	Deviation from Mean (inches)
1st	1965	27.51	-18.21
2nd	1930	32.90	-12.82
3rd	1963	32.95	-12.77
4th	1957	35.00	-10.72
5th	1923	35.18	-10.54
Based on data from 1912 to 2013, with a mean annual precipitation equal to 45.72 inches.			
ONJSC, 2014			

NJDEP provides information about droughts according to Drought Region, using indicators of 90-day precipitation, 90-day stream flow, reservoir levels and ground water levels for each region. North Brunswick lies within the Central Drought Region (see **Figure 2a** and **Internet Resources**).

During a *drought watch*, voluntary water conservation measures are encouraged. During a *drought warning*, measures are taken to manage water supplies in order to avert a *drought emergency*. A water supply emergency results in mandatory restrictions on water use in order to curtail water demand.

Significant droughts in recent years included 1997-1999 and 2001-2002. A drought spanning September 1997 through September 1999 included a "snow drought" – one of the least snowy seasons on record. This drought was ended by Tropical Storm Floyd. Another year-long drought occurred between October 2001 and November 2002, when the drought was ended by a series of nor'easters that resulted in a wetter than normal November. The drought of record for the region, however, is considered 1963-1965, when three consecutive years included 3 of the 4 driest years (statewide) since record-keeping began in 1895 (NJDEP, 2012).



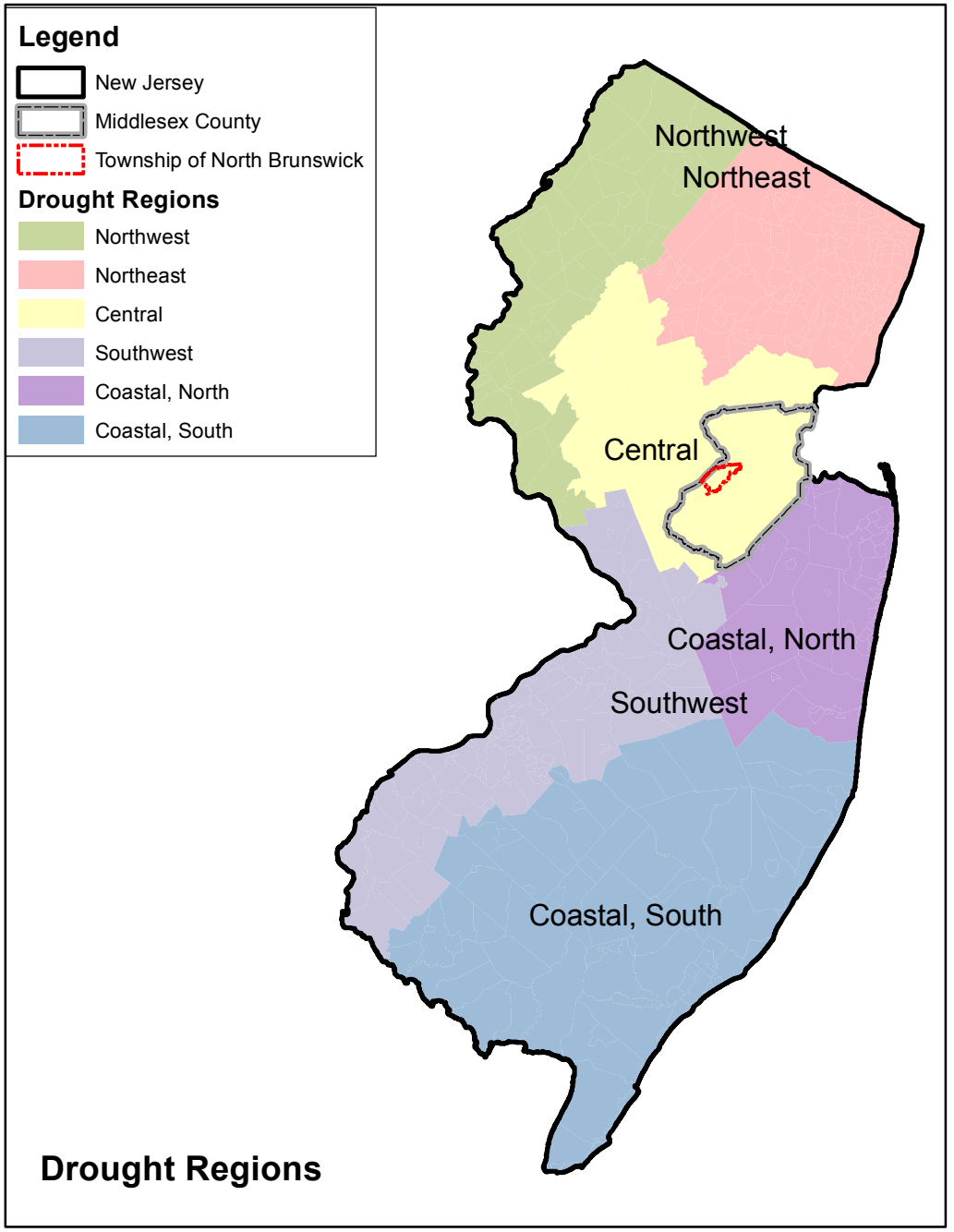


Figure 2a: Drought Regions, Air Quality and Weather Monitoring

0 10 20 40 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

B. Air Quality

The New Jersey Comparative Risk Project (March 2003), funded by the United States Environmental Protection Agency (USEPA) and the NJDEP, combined the efforts of 73 experts to analyze and rank 88 chemical, physical and biological factors ("stressors") according to their relative negative impacts on human health, ecological quality, and socioeconomic conditions (monetary cost). The study ranked several air pollutants among the highest risks to human health, including ground-level ozone, particulate matter, radon[8], secondhand tobacco smoke, and volatile organic compounds (VOCs). Air pollution is estimated to have medium to medium-high socioeconomic impact, and lesser impacts to ecological quality (Steering Committee of the NJ Comparative Risk Project, 2003).

Exposure to air pollution is a widespread problem that occurs throughout the entire state. Airborne pollutants come from a wide variety of sources, including industry, utilities, manufacturing and commercial sources, vehicles and residential activities (such as oil burning for home heating, and painting houses). On hot summer days, when pollutant levels are worst, winds in New Jersey are usually blowing from the southwest, carrying air pollution from the Washington, Baltimore and Philadelphia metropolitan areas to New Jersey. In turn, these winds carry the pollution created here to New York, Connecticut and further to the northeast.

National Ambient Air Quality Standards (NAAQS)

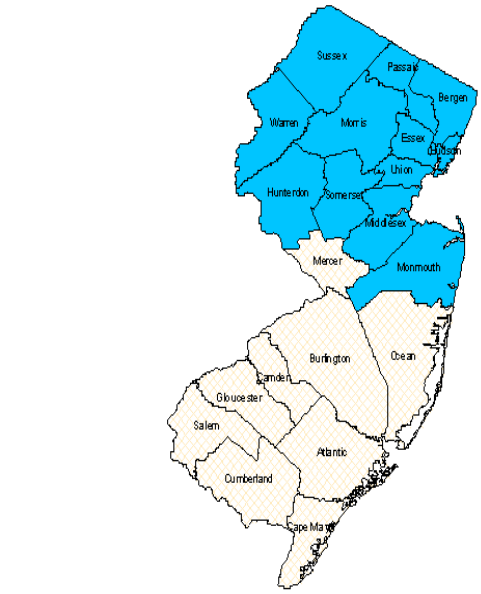
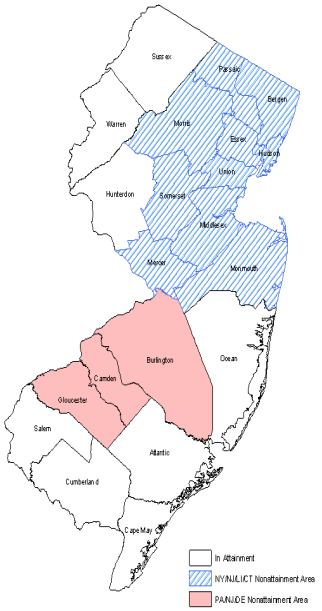
After the passage of the Clean Air Act in 1970, the USEPA set National Ambient Air Quality Standards (NAAQS) for six pollutants, known as the *Criteria Pollutants*, (ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, particulate matter, and lead). These pollutants are addressed throughout the country through a planning process and the concentrations of these pollutants in air have been monitored for compliance with the air quality standards. Since 1970, concentrations of these six pollutants have been significantly reduced throughout the country (USEPA, July 24, 2012; USEPA, February 14, 2012). Areas of the country where air pollution levels persistently exceed the NAAQS are designated *nonattainment*.

NJ has never exceeded the NAAQS for nitrogen dioxide (NO_2), and has not exceeded the standard for lead since the early 1970s. Only Warren County exceeds the SO_2 standard. The air quality in Middlesex County does not exceed the 8-hour carbon monoxide standard. Middlesex County is part of the Northern New Jersey/New York/Connecticut nonattainment area for both the particulate matter ($PM_{2.5}$) annual standard of 15 $\mu g/M^3$, [9,10] as well as for the 24-hour 35 $\mu g/M^3$ standard (see **Table 2.4**). Middlesex County is also part of the New York-Northern New Jersey-Long Island (NY-NJ-CT) nonattainment area for the ozone standard. In 1997 the 8-hour ozone standard was 0.08 ppm, but was revised in 2008 to 0.075 ppm (both primary and secondary) (see **Table 2.4**) (NJDEP Bureau of Air Quality Planning, January 25, 2013).

The USEPA requires New Jersey to report the emissions from major sources annually. To accomplish this, the Emission Statement Rule (N.J.A.C. 7:27-21) requires the annual reporting of emissions from stationary sources for the following air contaminants; carbon monoxide (CO), sulfur dioxide (SO_2), ammonia (NH_3), total suspended particulate matter (TSP), respirable particulate[11] matter (PM_{10} and $PM_{2.5}$), lead (Pb), volatile organic compounds (VOC), oxides of nitrogen (NO_x), carbon dioxide (CO_2), methane (CH_4) and the 36 Toxic Air Pollutants (TAPs).

[8] Radon is discussed in **Section 3D**.
[9] M^3= cubic meters
[10] $\mu g/M^3$ = micrograms per cubic meter of air (a microgram is one millionth (10^{-6}) of a gram).
[11] See Particulates, below in this section, for more information.

Table 2.4: National Ambient Air Quality Standards Nonattainment

New Jersey 8-Hour Ozone Nonattainment Areas	New Jersey Annual Fine Particulate Matter ($PM_{2.5}$) Nonattainment Areas
	
Designated 8-Hour Ozone Nonattainment Areas Northern New Jersey - New York- Conn. Area Southern New Jersey - Philadelphia - Delaware Area **Standards:** ***Ozone*, *8-hour*** [73 FR 16436, Mar 27, 2008] Primary & secondary: Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years = 0.075 ppm	**Standards:** ***Particle Pollution*, $PM_{2.5}$** [as of Dec 14, 2012] Primary: Annual mean, averaged over 3 years=12 µg/M^3; Secondary: Annual mean, averaged over 3 years=15 µg/M^3; Primary & Secondary: 24-hour 98th percentile, averaged over 3 years=35 µg/M^3
Sources: NJDEP Bureau of Air Quality Planning, January 25, 2013 and US EPA, December 14, 2012	

Air Quality Index (AQI)

NJDEP developed the Air Quality Index (AQI) to provide a descriptive rating and a color code (e.g. green=good) in real-time on the internet for many sites. For the AQI, $PM_{2.5}$ is monitored continuously at the New Brunswick monitoring site (Cook College, Log Cabin Road in North Brunswick Township), while nitrogen dioxide (NO_2) and ozone (O_3) are monitored continuously at Rutgers University (Ryders Lane, East Brunswick Township). In addition, $PM_{2.5}$ speciation, Volatile Organic Compounds (VOCs), carbonyls, and mercury are measured at the New Brunswick station, and Photochemical Assessment Monitoring Station (Ozone Precursors, known as PAMS) and meteorology parameters are measured at Rutgers University (Ryders Lane) (see **Figure 2a**) (NJDEP Bureau of Air Monitoring, 2012).

New Jersey is divided into 9 regions for the purpose of reporting the AQI. Middlesex County is located in Region 3: *Suburban*. In 2011 (the most recent year for which the AQI summary is available), the Suburban Region's AQI was Good on 305 days, Moderate on 48 days, Unhealthy for Sensitive Groups on 12 days and had 0 Unhealthy or Very Unhealthy days (NJDEP Bureau of Air Monitoring, 2012).

Ground-level Ozone

Ground-level ozone (O_3) causes serious adverse health effects, including respiratory and cardiovascular disease, and environmental effects by damaging foliage. It forms in the air from volatile organic compounds (VOCs) and nitrogen oxides (NO_x) under conditions of high temperature and bright sunlight. Sources include vehicles, power plants and factories. The hottest days of summer can yield unhealthy levels of ozone. In 2012, ozone was monitored at 16 locations throughout the state, including the Rutgers University station.

The National Ambient Air Quality Standards (NAAQS) for ozone were revised in 2008 because the USEPA determined that the 1997 standard was inadequate to protect public health. The standard of 0.075 ppm is calculated as an average over 3 years of the annual fourth-highest daily maximum 8-hour concentration. The national 1-hour ozone standard was revoked June 15, 2005 (USEPA, December 14, 2012). New Jersey's primary standard for 1-hour ozone is 0.12 ppm and secondary standard is 0.08 ppm (NJDEP Bureau of Air Monitoring, 2013). The graph below (**Figure 2b**) presents a summary of the number of days the ozone standards were exceeded per year at the New Brunswick Station (from 1980-1997) and Rutgers University station (1998 to 2012). To better view the trends, the 0.075 ppm 8-hour standard is applied to the past 10 years, even though it was not in effect until 2008 (USEPA, May 3, 2013).

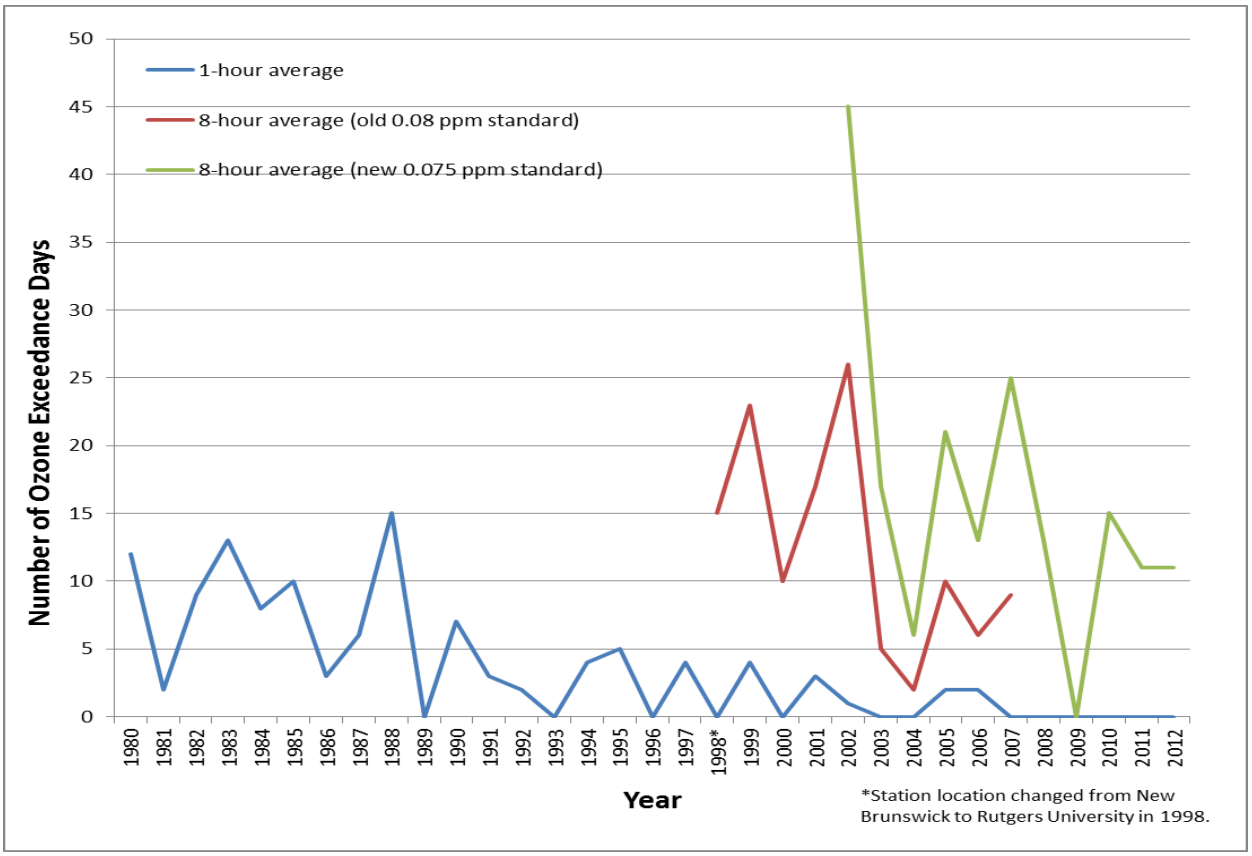


Figure 2b: Ozone Exceedance Days (Source: USEPA, May 3, 2013)

The 1-hour ozone standard has not been exceeded at the New Brunswick station since 2006. However, the new 8-hour ozone standard of 0.075 ppm was exceeded 11 times in both 2011 and 2012. The Clean Air Act requires that all areas of the country be evaluated and then classified as attainment or non-attainment areas for each of the National Ambient Air Quality Standards. The New Jersey non-attainment area is shown above in **Table 2.4**. The 2012 Air

Quality Report states that significant further improvements will require reductions in both VOCs and NOx, which will have to be achieved over a large region because levels in New Jersey are impacted by emissions from upwind sources (NJDEP Bureau of Air Monitoring, 2013).

Particulates

Particulate air pollution consists of both solid particles and liquid droplets suspended in the atmosphere, usually less than 70µ [12] in diameter. Particulate matter smaller than 2.5µ diameter ($PM_{2.5}$) are considered *Fine Particulates*, while larger particles are considered *Coarse Particulates*. Coarse Particulates are made up of Total Suspended Particulates (TSP) and Inhalable Particulates (PM_{10}). All sizes reduce visibility and are harmful to the environment, but coarse particles smaller than 10µ (PM_{10}) and fine particles less than 2.5µ ($PM_{2.5}$) are inhalable, therefore are considered harmful to human health, causing heart and lung conditions, such as asthma and heart attacks. Coarse particle sources include windblown dust and industrial sources, while fine particles come from combustion sources or are formed in the atmosphere from gaseous emissions.

The nearest monitoring site for fine particulates is in New Brunswick (Cook Campus), where $PM_{2.5}$ is monitored continuously (every minute). In 2011, neither the annual standard of 15.0µg/M^3 [13,14] nor the 24-hour standard of 35µg/M^3 was exceeded at any monitoring site in the state. The 2011 annual mean at the New Brunswick station was 8.2µg/M^3, and the highest 24-hour concentration was 34.7µg/M^3 (NJDEP Bureau of Air Monitoring, 2012).

PM_{10} is monitored at only 2 sites in the state: Camden and Jersey City-Firehouse. In 2011, neither site exceeded the PM_{10} 24-hour maximum standard of 150µg/M^3 or the annual average standard of 50µg/M^3. At the Camden site, the 24-hour maximum was 77µg/M^3 and the annual average was 33µg/M^3. At the Jersey City site, the 24-hour maximum was 63µg/M^3 and the annual average was 30µg/M^3 (NJDEP Bureau of Air Monitoring, 2012).

At 4 sites, including the New Brunswick site, Fine Particulate Speciation Data is collected. $PM_{2.5}$ samples are analyzed for 39 different chemicals to determine the composition of the particulate pollution. The most prevalent species are organic carbon, sulfate, nitrate, sulfur, ammonium and elemental carbon (NJDEP Bureau of Air Monitoring, 2012).

Air Toxics

In addition to ozone and particulates, there is increasing concern about a group of air pollutants termed *air toxics*. These include all other chemicals released into the air that have the potential to cause adverse health impacts in humans. Toxic pollutants may also be deposited on soil and water, taken up by plants and consumed by animals.

The list of potential air toxics is very large and includes many different types of compounds from heavy metals to volatile organic compounds (VOCs) such as benzene. In 1979, NJDEP adopted a regulation that specifically addressed air toxics emissions. This rule (Control and Prohibition of Air Pollution by Toxic Substances, N.J.A.C. 7:27-17) listed 11 Toxic Volatile Organic Substances (TVOS) and required that sources emitting those TVOS to the air should register with the Department and demonstrate that they were using state-of-the-art controls to limit their emissions (NJDEP Air Toxics in NJ, July 24, 2012).

Under the Clean Air Act Amendments of 1990, USEPA is required to begin to address a list of 188 of these air toxics (known as *Hazardous Air Pollutants*, or HAPs). NJDEP works with USEPA to implement these various strategies to reduce air toxics throughout the state.

[12] µ=microns, equal to 0.001 millimeter
[13] M^3= cubic meters
[14] µg/M^3 = micrograms per cubic meter of air (a microgram is one millionth (10^{-6}) of a gram).

The USEPA prepared a comprehensive inventory of air toxics emissions for the entire country as part of the National-Scale Air Toxics Assessment (NATA) in 1996, which was updated several times, most recently in 2005. The 2005 study update determined that on-road mobile sources are responsible for 33% of the toxic emissions, non-road mobile sources (airplanes, trains, construction equipment, lawnmowers, boats, dirt bikes, etc.) account for 29%; nonpoint sources contribute 31% (residential, commercial, and small industrial sources), and point sources account for the remaining 7% (NJDEP Bureau of Air Monitoring, 2012).

The NATA study also estimated levels of pollutants geographically. Benchmarks are developed based on health risks, and compared to predicted exposure to the chemicals, e.g. the risk of exposure to Acetaldehyde in Middlesex County is 4.5 times the health benchmark. Middlesex County is expected to have concentrations exceeding the health benchmark for a number of chemicals, particularly diesel particulate matter, formaldehyde, benzene, carbon tetrachloride, acetaldehyde and chromium (see **Table 2.5**) (NJDEP Air Toxics in NJ, March 28, 2011).

The NJDEP has established three comprehensive air toxics monitoring sites. They are located in Elizabeth, New Brunswick and Chester. Pollutant concentrations are trending downward, but many of them still exceed the NJDEP health benchmarks. At New Brunswick, some VOCs of concern include acetaldehyde, acrolein, acrylonitrile, benzene, 1,3-Butadiene, chloroform, chloromethane, ethylbenzene and formaldehyde. Toxic metals (measured by the $PM_{2.5}$ speciation monitors) above the health benchmarks include arsenic, cadmium, and cobalt (NJDEP Bureau of Air Monitoring, 2012).

Atmospheric Deposition

Pollution that is deposited on land or water from the air is called *atmospheric deposition.* Wet deposition is washed from the air by precipitation, while dry deposition refers to particulates that settle out of the atmosphere during dry weather. Sources include motor vehicles, power plants, and incinerators. The major pollutants of concern are sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury (Hg), and volatile organic compounds (VOCs). In addition, the presence of these pollutants changes the pH of the precipitation which can harm plants and aquatic life (trout are particularly sensitive) and deplete nutrients from soils.

Of the 3 sites where atmospheric deposition is monitored in New Jersey, the one in Washington Crossing is closest to North Brunswick. This site is also part of the National Atmospheric Deposition Program (NADP), and has been monitored since 1981. Results for 2011 (the most recent available) show a mean pH value of 4.94 (normal rainfall has a pH of about 5.6). This is very acidic, but is a slight improvement from the 1980's, when pH averaged around 4.3. Trends show decreasing concentrations of SO_4, NO_3 and Mg; but no improvement in NH_4, Ca, K, Na, Cl and N (NJDEP Bureau of Air Monitoring, 2012; NADP, 2012a).

Mercury (Hg) is a highly toxic heavy metal. Human health concerns of mercury include neurotoxicity (low-level exposure is linked to learning disabilities in children) and interference in reproduction, while both methyl mercury and mercuric chloride are listed by EPA as possible human carcinogens. Environmental effects have not been adequately studied, but animals, especially fish-eaters, experience effects similar to humans. The exposure to mercury is not from ambient air, but from deposition of airborne mercury onto surface water, vegetation and soil, which can then enter the food and water supply. On the basis of preliminary data from the New Jersey Air Deposition Network, the deposition of mercury from the air is higher than the national average of 10 $\mu g/m^2$/year. In NJ, the major sources of mercury are steel and iron manufacturing, coal combustion, products (such as broken fluorescent tubes), and municipal and sludge incineration. Mercury persists in the atmosphere up to two years and reaches the surface through atmospheric deposition, where it may persist as methyl mercury in the soil for decades. Mercury is never

Table 2.5: 2005 NATA Predicted Concentrations in Middlesex County

Chemical Name	Health Benchmark	Risk Ratio in Middlesex County◆	Primary Source(s) of Pollutant in Middlesex County◈
Acetaldehyde	0.45 µg/M^3	4.5 times	Background & Secondary
Acrolein	0.02 µg/M^3	3 times	Background & Secondary; non-road; on-road mobil
Arsenic Compounds	0.00023 µg/M^3	3.1 times	Background & Secondary
Benzene	0.13 µg/M^3	11 times	Background & Secondary On-road mobile sources
1,3 Butadiene	0.033 µg/M^3	2.9 times	On-road mobile sources Background & Secondary; non-road mobile
Cadmium Compounds	0.00024 µg/M^3	0.4 times	Background & Secondary; nonpoint
Carbon Tetrachloride	0.067 µg/M^3	9.1 times	Background & Secondary
Chloroform	0.043 µg/M^3	3 times	Non-point sources; Background & Secondary
Chromium VI	0.000083 µg/M^3	3.9 times	Background & Secondary; point
Cobalt Compounds	0.00011 µg/M^3	0.4 times	Non-point Sources
1,4-Dichlorobenzene	0.091 µg/M^3	1.1 times	Non-point sources; Background & Secondary
1,3-Dichloropropene	0.25 µg/M^3	0.4 times	Non-point sources
Diesel Particulate Matter	0.0033 µg/M^3	381 times	On-road & Non-road mobile sources
Ethylbenzene	0.4 µg/M^3	1 times	On-road mobile sources; Non-point; Non-road mobile sources
Ethylene Oxide	0.011 µg/M^3	0.9 times	Background & Secondary; Point Sources
Formaldehyde	0.077 µg/M^3	29 times	Background & Secondary
Methyl Chloride	0.56 µg/M^3	2.2 times	Background & Secondary
Naphthalene	0.029 µg/M^3	4.8 times	Non-point sources; Background & Secondary
Nickel Compounds	0.0021 µg/M^3	0.6 times	Background & Secondary Point & Non-point sources
PAH/POM *	0.0072 µg/M^3	1.7 times	Non-point sources
Perchloroethylene	0.17 µg/M^3	1.7 times	Background & Secondary
1,1,2-Trichloroethane	0.063 µg/M^3	<0.5 times	Point Sources

◆Risk Ratio is Ratio of the Modeled Air Concentration to the Health Benchmark. Chemicals in grey have a Risk Ratio less than 1, therefore are not expected to be harmful to human health.

◈**Sources of Toxics:**

Background concentrations can be attributed to long-range pollutant transport, unidentified emission sources and past emissions.

Secondary formation is a process by which air pollutants are transformed in the air into other chemicals.

Point Sources are stationary facilities or processes whose location could be identified with latitude and longitude coordinates, including manufacturing, power generation, heating, incineration, and other facilities that are required to report their emissions under the federal Toxic Release Inventory program and the state's Community Right-To-Know program.

Nonpoint/Area Sources : These are small stationary sources of air pollution which by themselves may not emit very much, but when their emissions are added together, they account for a significant portion of the total emissions of air toxics. They are also referred to as area sources and are generally too small or too numerous to be inventoried individually, including: Consumer products (personal care products, adhesives, sealants, automotive products, paints etc.); residential heating and fuel use; pesticide use; gas stations; dry cleaners; and institutional and commercial heating.

On-road mobile sources are vehicles found on roads and highways, including cars, trucks, buses & motorcycles.

Non-road mobile sources include aircraft, trains, lawnmowers, boats, dirt bikes, construction & farm vehicles, etc.

*PAH/POM is polycyclic aromatic hydrocarbons/polycyclic organic matter

Source: NJDEP Air Toxics in NJ, March 28, 2011

removed from the environment, but accumulates in biological tissue (bioaccumulation) (see **Section 6.I for Fish Consumption Advisories**) (NJDEP New Jersey Mercury Task Force, December 2001; NADP, 2012b).

In New Jersey, three sites are monitored as part of the Atmospheric Mercury Network (AMNet) for mercury: NJ54 Elizabeth Lab, NJ30 New Brunswick and NJ32 Chester, but the data is not publicly available. The New Brunswick site is also part of the Mercury Deposition Network (MDN) (NADP, 2012b; NADP, 2012c). **Figures 2c and 2d** display the New Brunswick data for wet deposition, also presenting a linear regression line showing a downward trend in mercury concentration and total mercury deposition (National Atmospheric Deposition Network, July 2013).

A study of mercury in lake sediment cores (which may be representative of atmospheric deposition over time) throughout New Jersey demonstrated that, while mercury levels have decreased, they are still present at levels far higher than natural levels (Kroenke et al, 2003; Schuster et al, 2004).

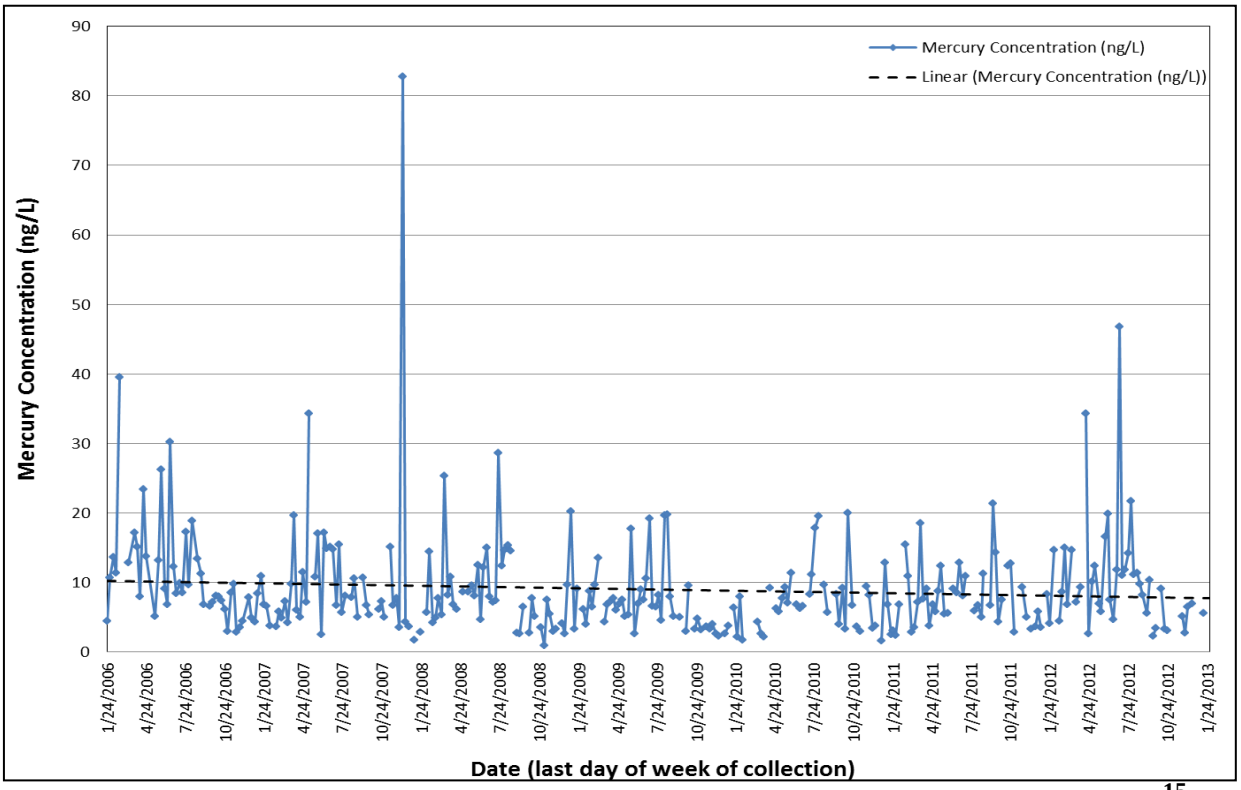


Figure 2c: Mercury Concentration in Wet Deposition at New Brunswick[15]

[15] in ng/L = nanograms per liter, or parts per trillion

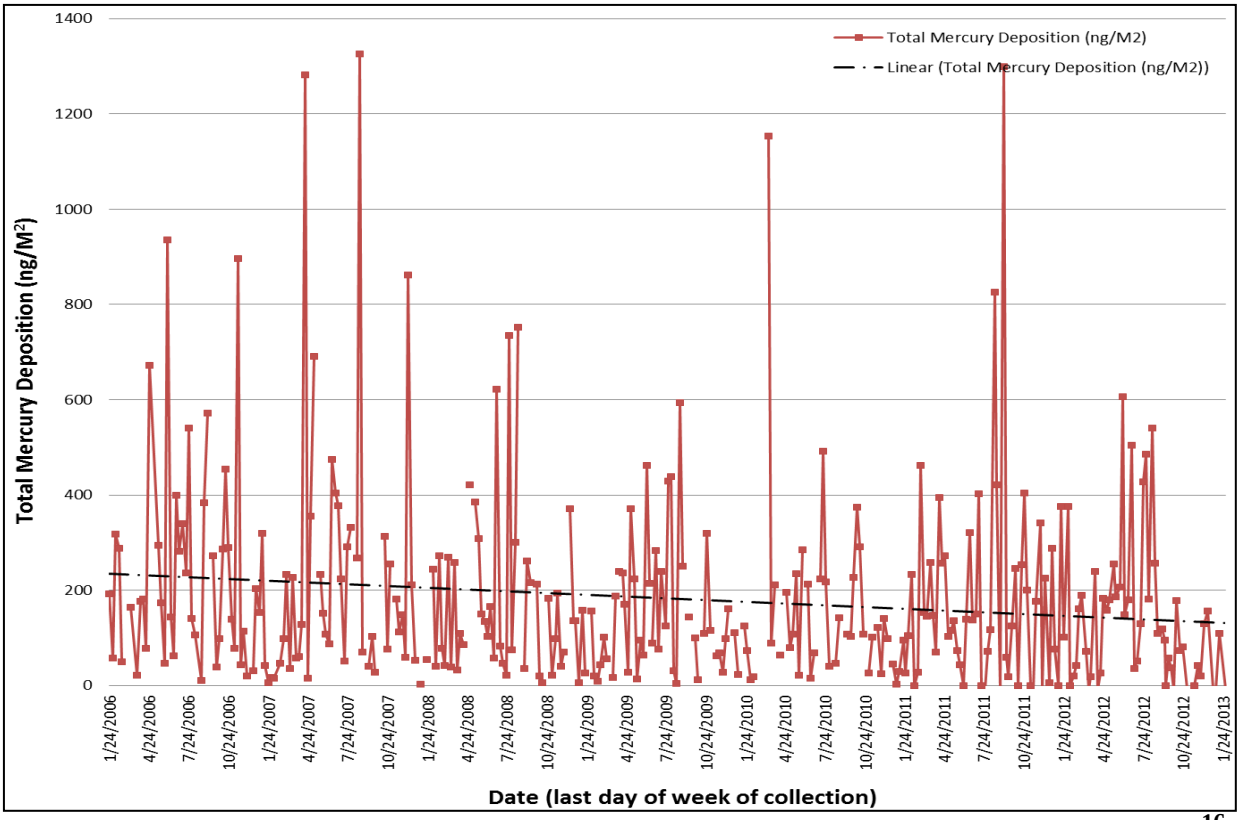


Figure 2d: Total Mercury Deposition in Wet Deposition at New Brunswick[16]

C. Existing Infrastructure

Public Water

Public water purveyors may be government agencies, private companies, or quasi-government groups. Water purveyors are regulated by the NJDEP Bureau of Safe Drinking Water, under the Safe Drinking Water Act.

According to the 2006 Master Plan (Heyer, Gruel & Associates, May 2006), the Township of North Brunswick obtains all its water supply from the Delaware and Raritan Canal, which is owned and operated by the New Jersey Water Supply Authority (NJWSA). The township is permitted to withdraw 8 million gallons a day (MGD) from the canal. The water is treated at the township-owned and operated Water Treatment Plant located in Franklin Township at Suydam and Canal Roads. Treatment capacity is approximately 10 MGD. Three elevated storage tanks located at the Water Treatment Plant, at Nassau Street and at Adams Lane store a total of approximately 9 million gallons of water (Heyer, Gruel & Associates, May 2006).

Public Community Water Supply (PCWS) wells are wells that supply potable water to public communities, and serve at least 15 connections used by year-round residents or which serve at least 25 year-round residents. There are no PCWS wells within North Brunswick (NJDEP Bureau of Environmental Assessment, July 7, 2011).

[16] in ng/M^2 = nanograms per square meter; result of multiplying rain amount times mercury concentration

Sanitary Sewers

North Brunswick relies on sanitary sewers for wastewater disposal. **Figure 2e** shows the sewer infrastructure within North Brunswick, including the force mains, mains, pump stations and manholes. The township's sanitary sewage is collected through the Mile Run Interceptor and transported to the Middlesex County Utility Authority's (MCUA) Raritan Trunk Sewer for treatment at the regional treatment plant in Sayreville. After treatment, the effluent is discharged into the Raritan Bay. The North Brunswick transmission system currently has 9 pumping stations: How Lane, Church Lane, Edly's Lane, South Brunswick (on Edly Cove Court), Schmidt Lane, Princess Drive, West Lawrence Brook, Farrington Boulevard, and Johnson & Johnson (Heyer, Gruel & Associates, May 2006).

Water Quality Management Planning and Wastewater Management planning are discussed in **Section 10D**.

Stormwater

The NJDEP Municipal Stormwater Regulations (N.J.A.C. 7:14A-25) require each municipality to create a Municipal Stormwater Management Plan (MSWMP). This documents the strategy for North Brunswick Township to address stormwater-related impacts (Township of North Brunswick, February 24, 2006).

North Brunswick is a *Tier A* municipality, because it is located within the more densely populated regions of the state. This stormwater permit addresses stormwater quality issues related to both new and existing development (NJDEP, Bureau of Nonpoint Pollution Control, April 30, 2012). The township has mapped the stormwater infrastructure, which is shown in **Figure 2f** (Township of North Brunswick, 2013).

Brownfields

NJ Department of State, Office for Planning Advocacy defines *brownfields* as any former or current commercial or industrial site, currently vacant or underutilized, on which there has been, or there is suspected to have been, a discharge of a contaminant. The purpose of the Brownfields and Contaminated Site Remediation Act (N.J.A.C. 58:10) is to develop strict remediation standards in order to protect public health and safety and the environment. In order to encourage clean-up of contaminated sites, NJDEP provides financial incentives, liability protection, cleanup procedures that are cost effective and regulatory action that is timely and efficient (NJDEP Site Remediation Program, September 22, 2011).

The Brownfields SiteMart was developed to highlight and denote locations of brownfield sites in order to promote the redevelopment of brownfields throughout the State. The 36 brownfield sites currently located within North Brunswick are listed in **Table 2.6** and shown on **Figure 2g**.

Table 2.6: Brownfields

Site ID❖	PI Number*	Site Name	Address	City
2418		US Gas	865 Route 130	North Brunswick Twp.
8024	012385	North Brunswick Maintenance Yard	Route 1 & College Farm Road	North Brunswick Twp.
8025	006678	Hess Station 30318	Route 1 & Apache St	North Brunswick Twp.
8026	016513	Sunoco 0007-6653	770 786 Route 1 N	North Brunswick Twp.
8027	012572	North Brunswick American Exxon LLC	686 Livingston Ave	North Brunswick Twp.
8028	005226	Shell Service Station	1300 Lincoln Hwy	North Brunswick Twp.
8029	006913	Luna Inc. D.B.A US Gas	865 Georges Road	North Brunswick Twp.
8030	012721	Adult Correctional Facility Annex	Apple Orchard Lane	North Brunswick Twp.
8031	008529	Permacel	Route 1 N	North Brunswick Twp.
8032	000965	BP Service Station 3682	923 Livingston Ave	North Brunswick Twp.
8033	G000061386	Sliver Line Building Products Corporation	1 Silverline Drive	North Brunswick Twp.
8034	002828	Webcraft Technologies Inc.	Route 1 & Adams Station Road	North Brunswick Twp.
8035	002838	Abb Turbocharger Inc.	1460 Livingston Ave	North Brunswick Twp.
8036	000867	Johnson & Johnson Incorporated	RT 1 N & Aaron Road	North Brunswick Twp.
8037	023061	North Brunswick Foreign Car Serv	590 Georges Road	North Brunswick Twp.
8038	018291	Parker Seals Incorporated	601 Nassau Street	North Brunswick Twp.
8039	013737	The Coca Cola Bottling Co of NY	1500 Livingston Ave	North Brunswick Twp.
8040	G000004598	Ward Products Corp	633 Nassau Street	North Brunswick Twp.
8041	002763	Brogan Cadillac	1100 Livingston Ave	North Brunswick Twp.
8042	G000035759	Hood Finishing Products	14901510 Jersey Ave	North Brunswick Twp.
8043	013779	Malouf Ford	RT 1 S & Georges Road	North Brunswick Twp.
8044	018796	Adams Maintenance Of Way Facility	788 Adams Lane	North Brunswick Twp.
8045	003663	Central Transport	1305 Livingston Ave	North Brunswick Twp.
8046	006068	Graybar Elec Co Inc.	1300 Livingston Ave	North Brunswick Twp.
8047	003270	Pepsi Cola Bottling Group	1007 Livingston Ave	North Brunswick Twp.
8048	022977	North Brunswick High School/Veterans Park	1648 Route 130	North Brunswick Twp.
8049	026186	George Logan Towing Inc.	1979 Old Georges Road	North Brunswick Twp.
8050	030988	Joe's Service Center	814 Livingston Ave	North Brunswick Twp.
8051	G000003935	North Brunswick Coatings & Chemicals	1430 Jersey Ave	North Brunswick Twp.
8052	G000039586	Finnegan Plaza	1550 Finnegan Lane	North Brunswick Twp.
8053	G000062569	Jersey Avenue	Jersey Ave	North Brunswick Twp.
8054	171771	Route 1 & Thomas Avenue	RT 1 & Thomas Ave	North Brunswick Twp.
8055	010004	USA Detergents Incorporated	1600 Route 1	North Brunswick Twp.
8056	248860	Otken Farm	20512053 Georges Road	North Brunswick Twp.
8057	227097	Elmwood Place Road Improvement	Elmwood Place	North Brunswick Twp.
8058	221418	The Shops At Commerce Plaza	2219 Route 1	North Brunswick Twp.

Notes:
❖Identification number used on NJ SiteMart.
*Program Interest ID used by NJDEP.

Sources: NJ Department of State, Office for Planning Advocacy, January 12, 2013; NJ Office for Planning Advocacy, July 2013

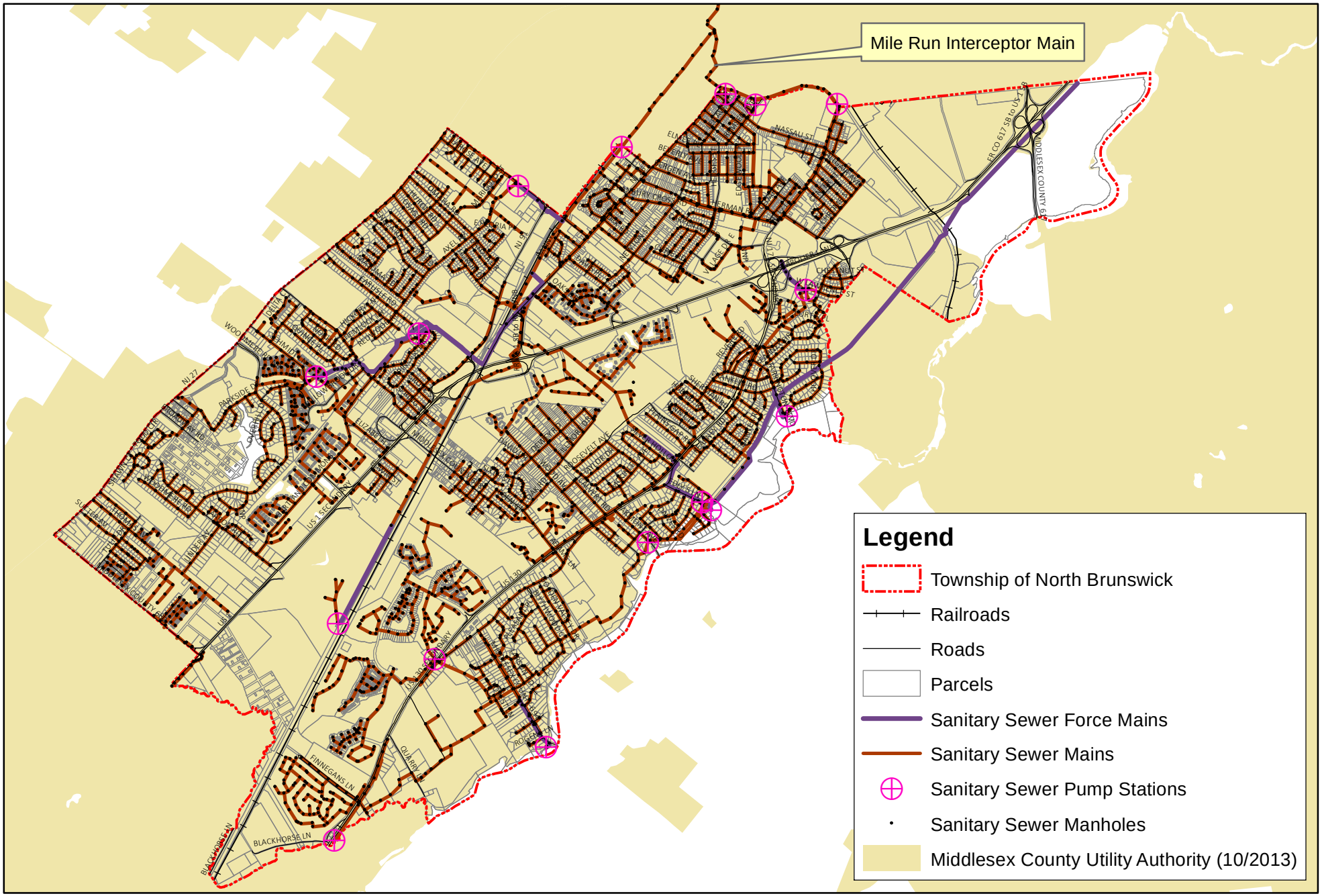


Figure 2e: Sanitary Sewers

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

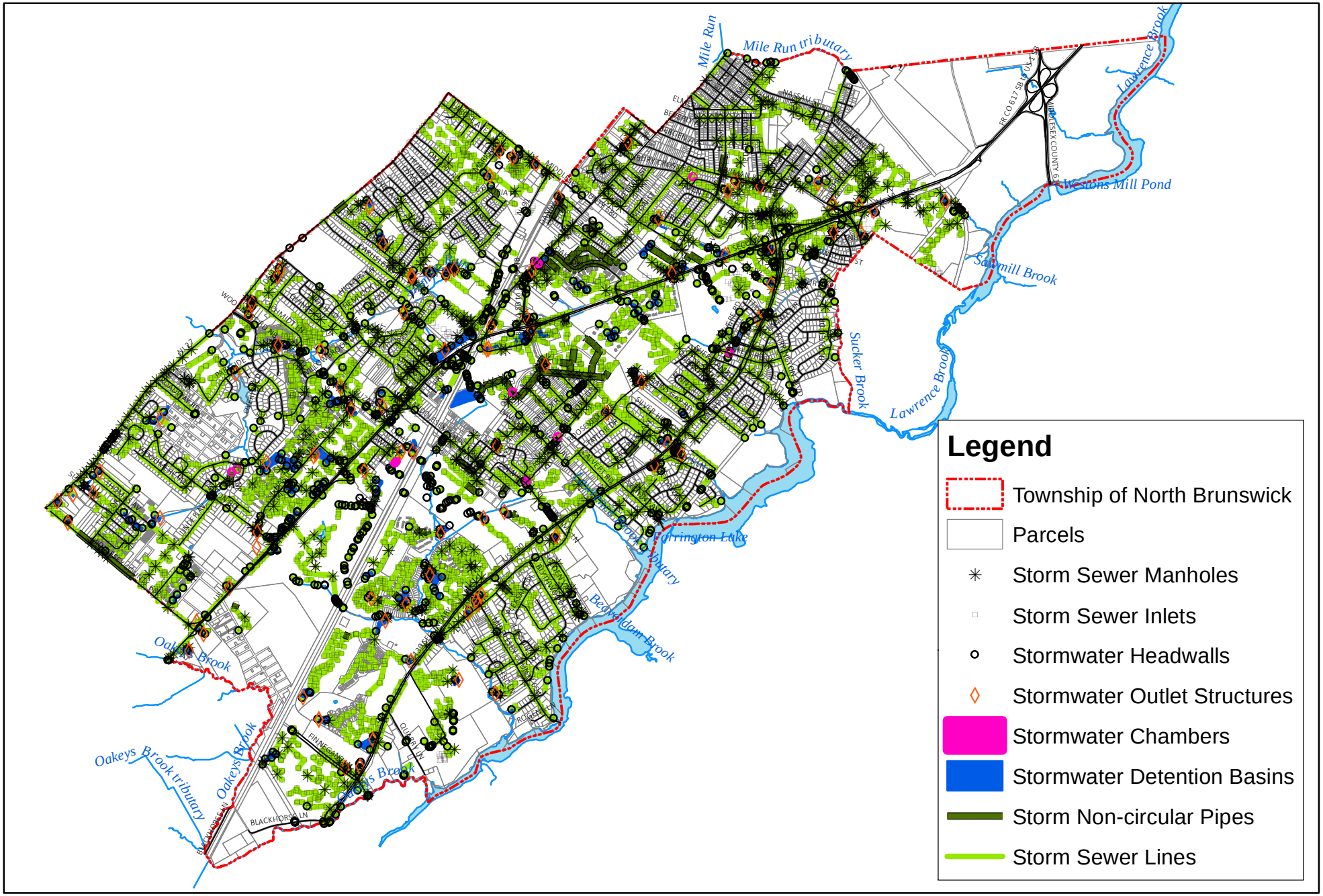


Figure 2f: Stormwater System

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

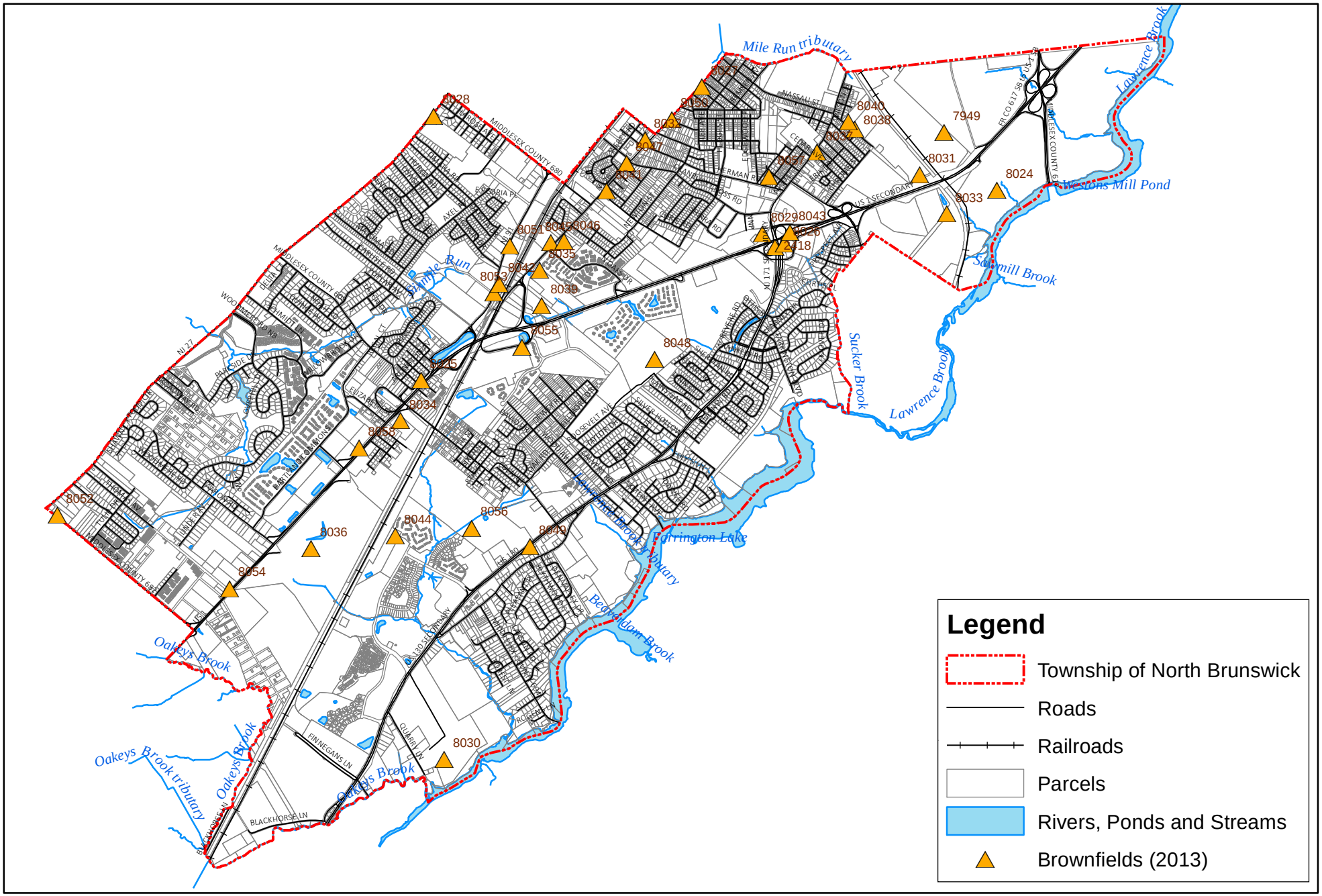


Figure 2g: Brownfields

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

D. Noise and Light Pollution

Light pollution is defined as excess or obtrusive light created by humans. Light pollution obstructs views of stars and planets, disrupts ecosystems and impacts human health and safety. Thousands of stars should be visible in the night sky, but as few as 10% of Americans live in areas where they can view them (Bower, 2000). Ecological impacts of light pollution range from contributing to algal blooms, disrupting feeding and mating of nocturnal animals such as frogs, bats, fireflies and moths, and killing migrating birds. Most migrating birds navigate at night by the moon and stars, and artificial lighting short-circuits their ability to navigate, causing millions of fatalities from collisions annually (Guynup, 2003; Bower, 2000).

At least 1/3 of our lighting is wasted because it shines upward or sideways, most of which was created by burning fossil fuels, thereby wasting energy and contributing to global warming and polluting air and water. Links between artificial light and human health, such as cancers, have also been documented. Finally, reduced and non-glaring lighting has been shown to decrease crime (Bower, 2000).

North Brunswick is impacted by a number of sources of light pollution. First, the general glow from the New York and central New Jersey metropolitan areas is visible in the night sky. Local sources include light from housing developments, businesses, residences and street lights.

Noise pollution, defined as unwanted or excessive sound, is another undesirable by-product of modern life. It can be a nuisance, interfere with activities, and can cause physical damage. Transportation noise is among the most pervasive noise sources in our environment today, particularly for people who live within 500 feet of heavily traveled highways or within 100 to 200 feet of lightly traveled roads (Washington County Task Force, 2005).

Federal highway noise criteria (which apply only to federal highways) range from 57 to 72 decibels (depending on adjacent land use) (USDOT, FHA, 2006). New Jersey's Noise Control Act of 1971 authorized the NJDEP to develop regulations relating to the control and abatement of noise. While these regulations do not specify noise criteria, a sample municipal ordinance is provided with sound level standards of 50 decibels during nighttime (10:00 p.m. to 7:00 a.m.) and 65 decibels during daytime (NJDEP, 2008). The Middlesex County Public Health Department (MCPHD) is authorized by NJDEP to enforce noise pollution regulations in the State Noise Pollution Code (N.J.A.C. 7:29) (Middlesex County Public Health Department, 2007-2011).

North Brunswick is subjected to noise pollution from cars and trucks on the state and interstate roads. The Middlesex County Public Health Department's annual reports revealed no noise complaints in North Brunswick in 2009, 2010 or 2011; noise data was not provided for 2008, while 5 noise complaints were reported in 2007 (Middlesex County Public Health Department, 2007-2011).

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2011 Air Quality Index Summary. 7 pages. http://www.njaqinow.net/App_Files/2011/Index%202011.pdf
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2011 Ozone Summary. 11 pages. http://www.njaqinow.net/App_Files/2011/ozone%202011.pdf
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Internet Resources: Local & Regional Conditions

Climate and Meteorology

Office of the New Jersey State Climatologist (ONJSC)

- ONJSC Home Page: http://climate.rutgers.edu/stateclim/
- NJ Drought Watch: http://www.njdrought.org/
- Drought Status of Central Region: http://www.njdrought.org/status.html#central
- Weather and Climate Network Index: http://climate.rutgers.edu/njwxnet
- Weather and Climate Network - New Brunswick: http://climate.rutgers.edu/njwxnet/station.php?s=1101

National Weather Service Advanced (NOAA) Hydrologic Prediction Service (flood predictions Raritan River at Bound Brook): http://water.weather.gov/ahps2/hydrograph.php?wfo=phi&gage=bdkn4&view=1,1,1,1,1,1,1,1"

National Weather Service Forecast North Brunswick, NJ
http://forecast.weather.gov/MapClick.php?lat=40.4525163&lon=-74.4766712&site=all&smap=1&searchresult=North%20Brunswick%2C%20NJ%2C%20USA#.UdnuSqTD9pg

NJDEP Sustainability and Green Energy: http://www.nj.gov/dep/sage/climate-energy.html

State of New Jersey Global Warming Home Page: http://www.state.nj.us/globalwarming/index.shtml

US Environmental Protection Agency (USEPA) Climate Change: http://epa.gov/climatechange/index.html

USGS Real-Time Stream Flow Stations:
01403060 Raritan River below Calco Dam at Bound Brook NJ:
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01403060&PARAmeter_cd=00065,00060

Index of NJ sites: http://waterdata.usgs.gov/nj/nwis/current/?type=flow

Air Quality

Current Air Quality: Closest Stations for the following parameters:
$PM_{2.5}$: (New Brunswick (Cook Campus)) - http://www.njaqinow.net/StationInfo.aspx?ST_ID=21
O_3, NO, NO_2: (Rutgers University (Ryders Lane)) - http://www.njaqinow.net/StationInfo.aspx?ST_ID=25
SO2 (also O_3, NO, NO_2 Chester) - http://www.njaqinow.net/StationInfo.aspx?ST_ID=6

What you can do to reduce air toxics? http://www.state.nj.us/dep/airmon/airtoxics/youcan.htm

NJDEP Radon Information: http://njradon.org or call 1-800-648-0394

NJDEP Rules and Regulations (current and proposed): http://www.nj.gov/dep/rules/

United States Environmental Protection Agency Air Topics: http://www.epa.gov/agriculture/air.html

Existing Infrastructure

Water:
American Water: http://www.amwater.com/
NJ Statewide Water Supply Plan (1996): http://www.nj.gov/dep/watersupply/pdf/swsp-execsummary.pdf
NJ Water Supply Authority: http://njwsa.org

Sewer:
Middlesex County Wastewater Management Plan: Future Sewer Service Map
http://www.co.middlesex.nj.us/planningboard/wastewater_plan.asp
Middlesex County Utility Authority: http://www.mcua.com/

Brownfields SiteMart Search:
http://www.njbrownfieldsproperties.com/Search.aspx

Light: NJ Astronomical Society - Light Pollution: http://www.njaa.org/light.html
Simple Scale for evaluating sky darkness:
http://www.skyandtelescope.com/resources/darksky/3304011.html?page=1&c=y

Railroad:
NJ Transit Northeast Corridor: http://www.njtransit.com/pdf/rail/R0070.pdf

3: PHYSIOGRAPHY, TOPOGRAPHY & GEOLOGY

A. Physiography

New Jersey can be divided into four regions, known as *physiographic provinces*, which are areas with a common geologic history and similar sequences of rock types and geologic structures (see **Figure 3a**). The geologic history of New Jersey is summarized in **Table 3.1**.

During the Precambrian and Paleozoic Eras, the land that is now New Jersey was at the bottom of the sea, close to the equator. About 400 million years ago, the continents Europe and North America collided, forming the Appalachian Mountains, which at that time reached far higher and were more rugged than the Rocky Mountains are now (Gallagher, 1997).

The long, parallel ridges and valleys that characterize the northwestern section of New Jersey form the *Valley and Ridge Province*. The ridges are composed of erosion-resistant sandstone and siltstone bedrock while easily-eroded shale and limestone underlie the valleys (NJGS, 1999). No rocks of Precambrian or Paleozoic age are found within Middlesex County (Dombroski, 1980).

Bordering the Valley and Ridge Province to the southeast, the *Highlands Province* consists of metamorphic rocks of Precambrian age (the oldest rocks in the state). The granites and gneisses are resistant to erosion and create a hilly upland with deep, steep-sided valleys carved by streams.

The Highlands Province is separated from the *Piedmont Province* by a series of major faults. The Piedmont Province, covering roughly the northwest half of Middlesex County, is characterized by gently rolling hills. The rocks of the Piedmont are of Late Triassic and Early Jurassic age. As sediments eroded from adjacent uplands, and were deposited along rivers and lakes within the basin, they became compacted and cemented to form conglomerate, sandstone, siltstone and shale.

Roughly 200 million years ago, the supercontinent Pangaea broke apart, and the Atlantic Ocean was born. This was accompanied by volcanic activity, which resulted in magma flowing at or near the surface. When the diabase[17] intruded, the surrounding sedimentary rocks were hardened by heat and pressure, and are known as hornfels rocks, or traprock, some of which have been quarried commercially. These exist today as the erosion resistant outcrops and hills found in the Palisades, the Sourland Mountains, Sand Hills (Middlesex County), and Little Rocky Hill and Rocky Hill (both in Somerset County) (Gallagher, 1997; Dombroski, 1980). North Brunswick lies entirely within the Piedmont Province (NJGS, 2002) (see **Figure 3a**).

Overlapping the Piedmont Province to the southeast, diagonally bisecting Middlesex County just southeast of North Brunswick, the relatively flat terrain of the *Coastal Plain Province* consists of unconsolidated sedimentary formations, such as sands, clays, and marls (NJGS, 1999).

Within the past two million years, the climate alternated between cool and warm. During periods of glaciation, the glaciers came as far south as Perth Amboy, NJ, while the area below that, including North Brunswick, became a cold tundra. At times, the location of North Brunswick was under the Atlantic Ocean, although at other times, the shore may have extended a hundred miles beyond the present shore (NJGS, 1999).

[17] *Diabase* is a rock formed by the cooling of magma at some depth in the crust (i.e. the magma did not erupt at the surface), while basalt formed when the magma was extruded onto the surface.

Table 3.1: Summary of New Jersey's Geologic History

Period	Million Years Ago	Description of Climate and Fossils Found in Corresponding Bedrock
Precambrian Era		
	Up to 544	**Climate:** New Jersey was under the sea. **Fossils:** stromatolites; most life forms were soft bodied and left no fossils
Paleozoic Era		
Cambrian Period	544 – 505	**Climate:** New Jersey was close to the equator, covered by warm tropical seas. **Fossils:** trilobites, brachiopods, stromatolites, worm burrows
Ordovician Period	505 – 440	**Climate:** New Jersey continued to be underwater, as the sea above deepened to oceanic depths. **Fossils:** trilobites, brachiopods, coral, nautiloids, clams, crinoids, and snails
Silurian Period	440 – 410	**Climate:** The sea level rose and fell, with New Jersey remaining at the sea floor. **Fossils:** coral, brachiopods, clams, brine shrimp, primitive fish, eurypterids (sea scorpions), arthrophycus (fossilized feeding burrow made by a worm-like animal)
Devonian Period	410 – 360	**Climate:** Europe collided with North America, forming the mountains which are now the Ridge and Valley and Highlands provinces of New Jersey. The fossils found continued to be aquatic life forms. **Fossils:** brachiopods, clams, trilobites, nautiloids, crinoids, coral, snails, stromatoporoids, ostracodes, bryozoa
Mississippian, Pennsylvanian & Permian Periods	360-248	**Climate:** No geologic record of these time periods is present in New Jersey. At some point, the sea subsided, and New Jersey became dry land, at least in part. **Fossils:** none
Mesozoic Era		
Triassic Period	248 – 200	**Climate:** New Jersey was next to Morocco, part of the supercontinent Pangaea. In the dry interior of the continent, the area experienced greater daily and seasonal fluctuations than the coasts. The rugged landscape consisted of high young mountains and deep valleys formed by faults. The brief rainy seasons' flashfloods dropped mud and silt in low areas, where playa lakes formed. In the end of the Triassic the climate became desert-like. The lakes began to dry up and became salty, resulting in an environment where brine shrimp flourished. When a lake went dry, some fish and other aquatic life became fossils. **Fossils:** dinosaur footprints, thecodonts, fish (including coelacanths), phytosaurs, amphibians, insects, plants
Jurassic Period	200 – 145	**Climate:** The breakup of Pangaea resulted in the beginning of the Atlantic Ocean. Igneous intrusions (molten rock forced into earlier rock formations) formed diabase and basalt bedrock. Because the terrain was mountainous, the net geologic action was erosion, not deposition. **Fossils:** There are no late Jurassic deposits in New Jersey; therefore no fossils exist from this period. However, the fauna probably consisted of the same dinosaurs as the American West, including sauropods, armored dinosaurs, ornithopods (forerunner of hadrosaurus), tenontosaurus (relative of the iguanadon). True flowering plants (angiosperms) appeared at this time.
Cretaceous Period	145 – 65	**Climate:** Northern New Jersey was above sea level, while southern New Jersey experienced flooding and ebbing. The sea level changed cyclically from deeper to shallower water in this tropical environment. During flooding, greensand marl (glauconite) was formed. During ebbing, clay and sand were deposited. **Fossils:** Fossil phytoplankton, clams, snails, crustaceans, ammonites, oysters, reptiles, sharks, burrows, worm tubes and vertebrates such as mosasaurs have been found in New Jersey's coastal plain. The fossil dinosaurs found include hadrosaurus (which probably washed downstream during a flood), ornithomimus, *Dryptosaurus aquilunguis* (a 17' predator with a great hand claw), *Hadrosaurus foulkii*, and *Hadrosaurus minor*.

Continued on next page

Cenozoic Era		
Tertiary Period	65 – 1.8	**Climate:** The climate was warm, and the sea level was higher, covering the much of the Coastal Plain (see **Figure 3a**). **Fossils:** Fossils of land animals include birds, such as the diatryma (a giant flightless bird), tillodont (an extinct mammal the size of a bear, but with rodent-like teeth) and possibly others similar to those found in the South Dakota badlands, such as brontotherium, ancestral horses, entelodonts (resembled giant warthogs), diceratherium (semi-aquatic rhinoceros), peccary, prosynthetoceras (a camal), anchitherium (horse), and a primitive doglike carnivore. Fossils found in the Outer Coastal Plain include brachiopods, corals, sponges, clams, sharks, mollusks, crinoids, mammals (probably washed to the sea in floods), crocodiles, snakes, and early whales.
Quaternary Period	1.8 - present	**Climate:** The climate alternated between cool and warm, resulting in four intervals of glaciation. The glaciers covered northern New Jersey, reaching as far south as Belvidere on the Delaware River. South of the glacial ice, treeless, frozen tundra existed. When water was frozen in glaciers, the sea level was lower, resulting in a shoreline over a hundred miles east of the present coast. **Fossils:** Fossils of many familiar and some extinct animals have been found in nearby areas. There were insects, turtles, and snakes. Herbivores included squirrels, groundhogs, porcupines, beaver, muskrats, voles, mice, eastern cottontail rabbits, white-tailed deer, peccaries, tapirs, giant ground sloth, the elk-moose, giant beaver, American mastodon, and mammoth. Carnivores included otters, skunks, bobcats, foxes, black bears, coyotes, jaguars, jaguarundi, short-faced bear and a saber-toothed cat.
Sources: Gallagher, 1997; University of California Museum of Paleontology et al., 2003; USGS, 2002		

B. Topography

Topography depicts the relief features of an area. The elevation in North Brunswick ranges from about 10 meters (32.8 feet) (on the northeast edge of the township along the Lawrence Brook) to 30 meters (98.4 feet) above mean sea level (most of the township)(see **Figure 3b**). In **Figure 3b**, each line represents 10 meters of elevation, and is drawn to follow the contour of the land. **Figure 3c** uses shaded colors to illustrate elevation in North Brunswick. Steep topography can be seen in **Figure 3c** where the color contrasts are the greatest.

Slopes greater than 10 or 15% are generally considered "steep slopes." Steep slopes present difficulties for driveway construction and for usable areas around a house. In addition, steeper slopes are more vulnerable to erosion. As the gradient or percent of slope increases, the velocity of runoff water increases, which increases its erosive power. A doubling of velocity of runoff water increases the erosive power fourfold and causes 32 times the amount of material of a given particle size that can be carried (Foth, 1978).

Erosion causes a number of harmful effects on the environment: loss of soil upon which plants and wildlife depend; loss of soil fertility, because the nutrients and organic material are more easily eroded; gully formation; loss of water that might have been useful for plant growth or ground water recharge; sedimentation of streams; and deposition of soil in navigable waters, creating the need for dredging to maintain navigability. Eroded sediment, and the nutrients, pesticides, and other chemicals carried with it, affects aquatic life in many ways. The sediments may bury fish eggs, reduce light available to aquatic plants, and reduce recreational quality and aesthetics.

General areas of steep slopes are depicted in **Figure 3d**. North Brunswick has very few steep slopes, almost all of which are located along the Lawrence Brook, Sucker Brook, Six Mile Run and other streams.

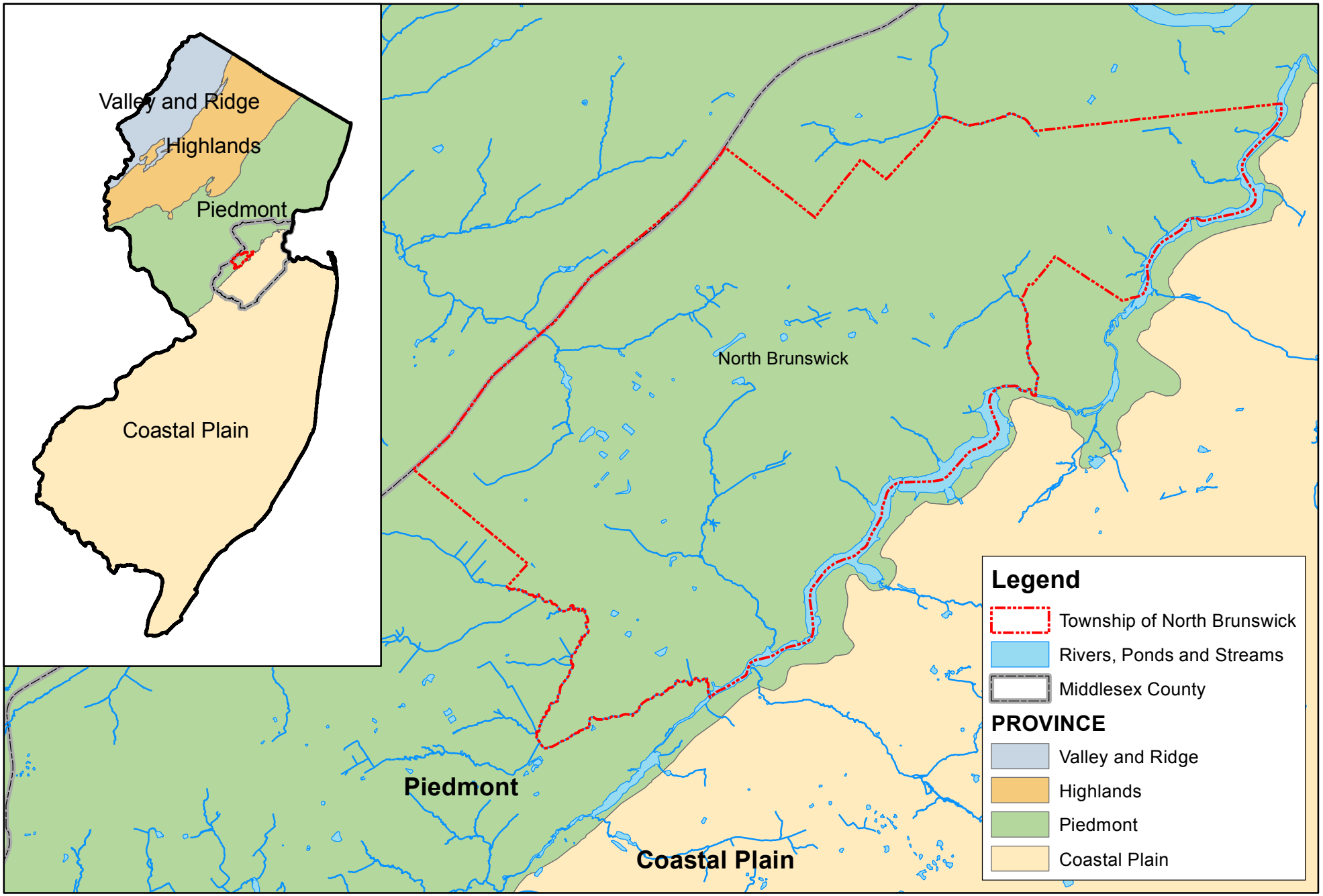

Figure 3a: Physiographic Provinces

0 0.25 0.5 1 1.5 Miles

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N

Data Sources: NJDEP
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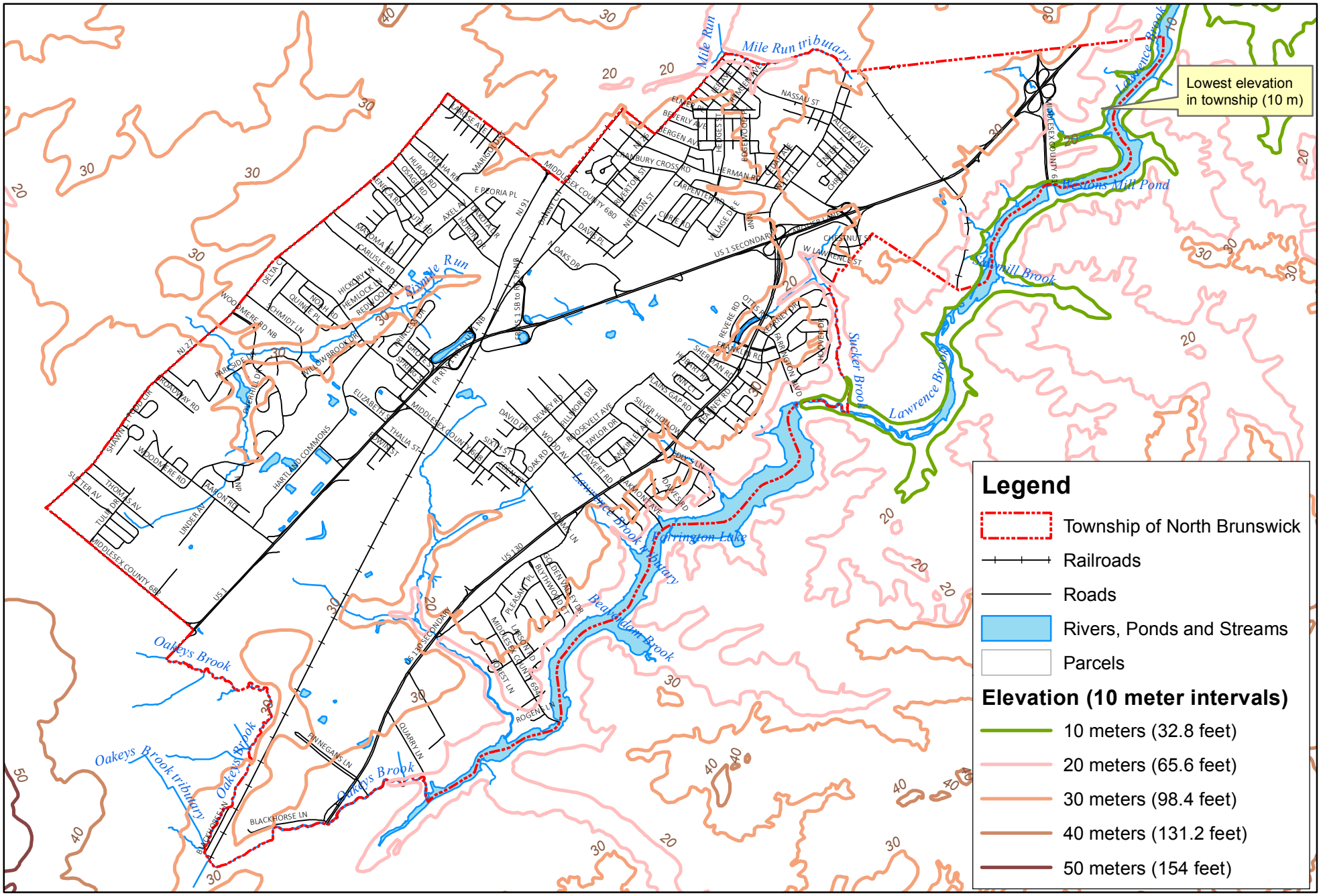

Figure 3b: Elevation

0 0.25 0.5 1 Miles

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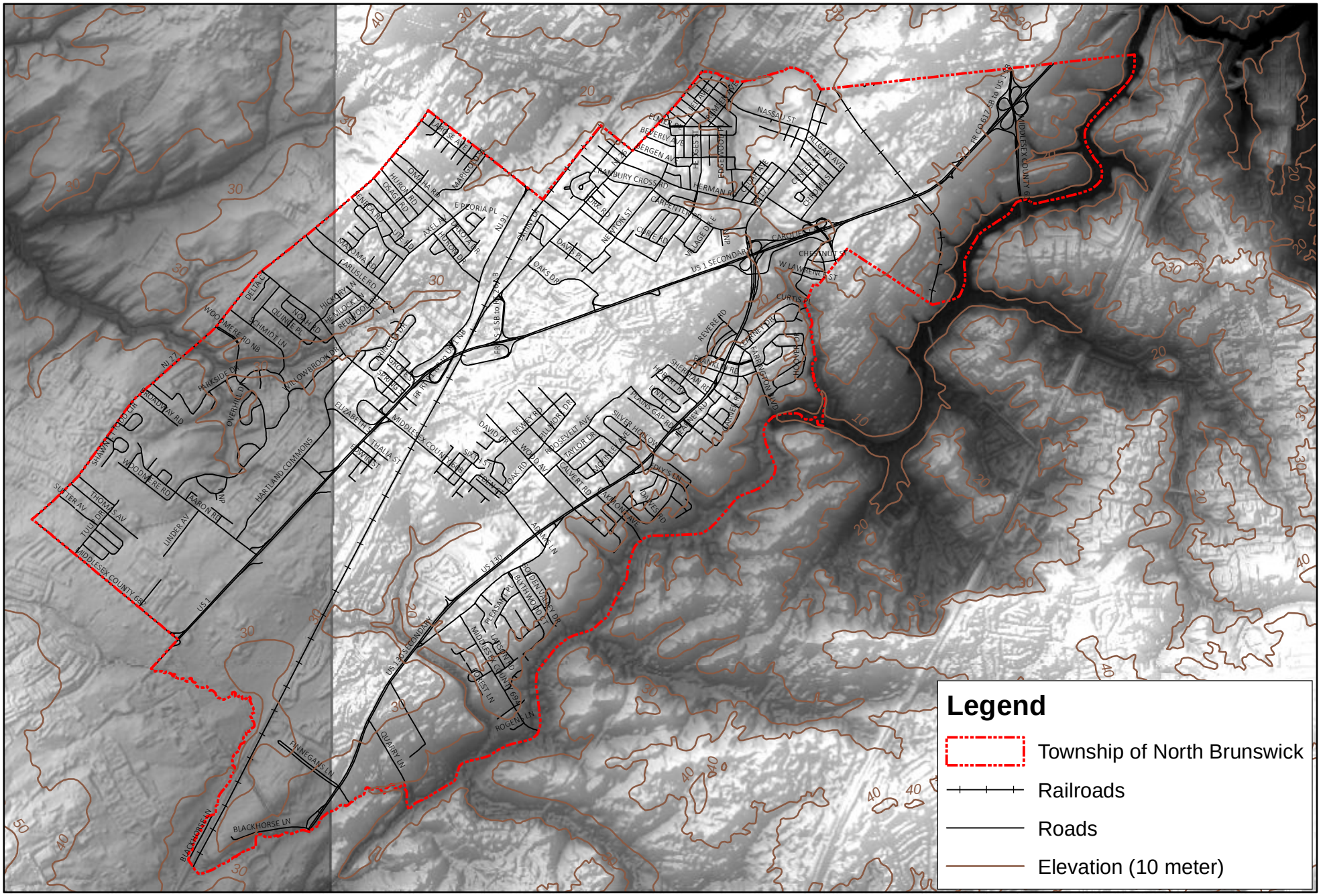

Figure 3c: Shaded Elevation
National Elevation Dataset - 3 meter

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
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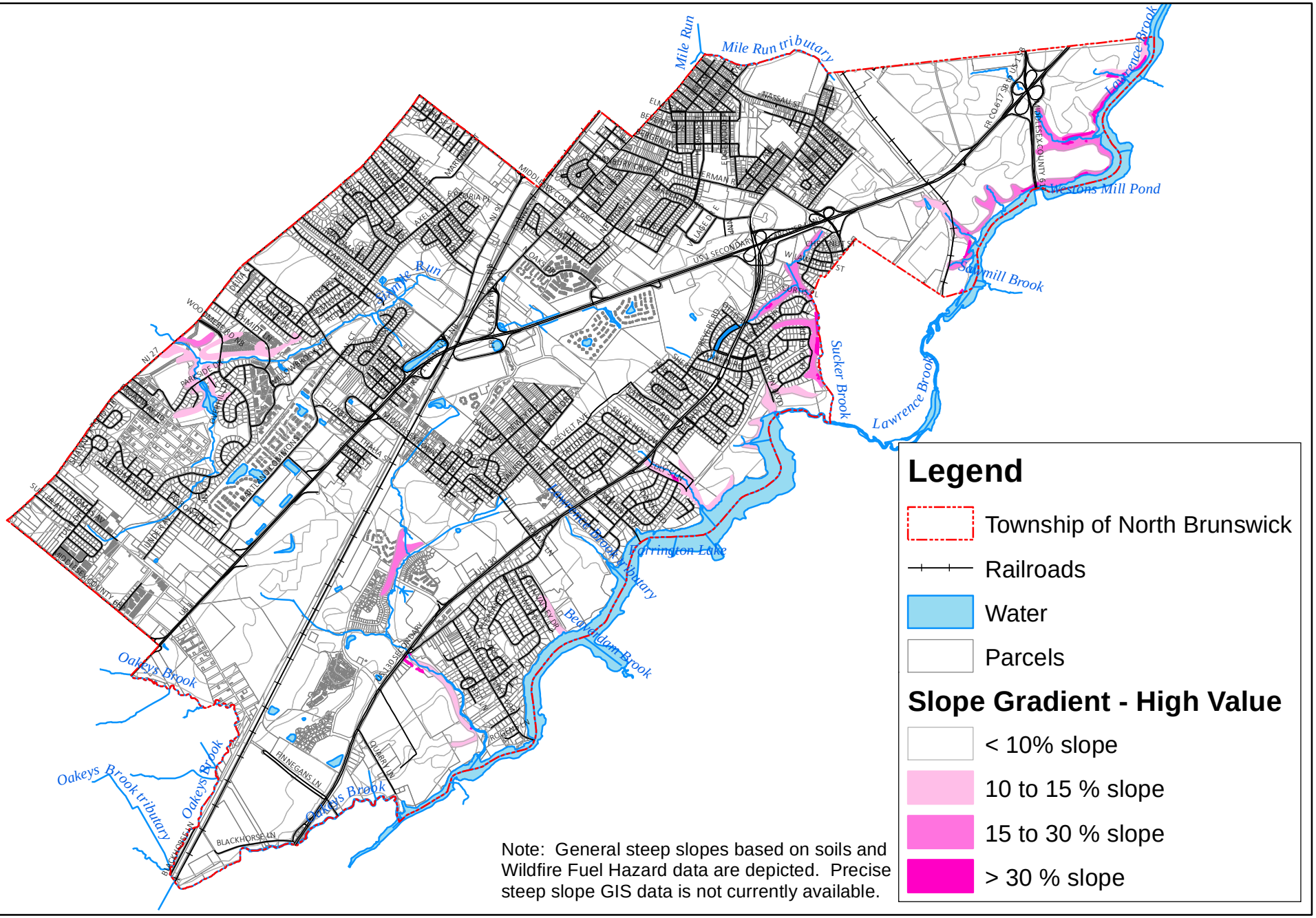

Figure 3d: Steep Slopes

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
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C. Bedrock Geology

Bedrock is the solid rock beneath the soil and surficial rock. The shales, siltstones, and sandstones of the *Passaic Formation* underlie the Township of North Brunswick (see **Table 3.2** and **Figure 3e**).

During the Mesozoic Era (252 to 66 million years ago, the time of the dinosaurs), streams eroded the high Appalachian mountains, dropping larger particles closer to the base of the mountains while carrying the smaller particles farther from the mountains. As the rivers reached flat plains, the water slowed and spread out into a fan shape. This alluvial fan deposited fine sands and clays, which, with time and pressure, became the sedimentary rocks of the Passaic Formation.[18] The Passaic shales were deposited during wet periods when the valleys drained to the sea (Dombroski, 1980; Walker et al, 2012).

There is no exact boundary between the Triassic and Jurassic periods; that is, the deposition was continuous during these time periods, and the sequence of deposition is not clear-cut, resulting in interfingering of the *Passaic* and *Lockatong Formations*. The sediment layers compacted to hard sedimentary rocks (lithified), resulting in a maximum bedrock thickness of 6,000 meters (19,685 feet) (Dombroski, 1980; Olsen, 1980).

During the Triassic-Jurassic Periods, there were three or more periods of volcanic activity as Pangaea continued to break apart, forming the Atlantic Ocean. Intrusive igneous rock called *Diabase* formed when lava cooled slowly beneath the surface, forming a hard, coarse grained, durable rock, commonly known as traprock (Dombroski, 1980).

Later, crustal movement caused the *Passaic* and *Lockatong Formations*, that originally were laid down in nearly horizontal beds dipping[19] slightly to the south, to dip about 15° northwestward (Dombroski, 1980; Olsen, 1980). These Triassic-Jurassic sedimentary rocks exhibit two types of fracturing. Bedding fractures resulted from changes in the characteristics of the sediments at the time of deposition. In addition, fracturing occurred when weak sedimentary layers were pulled apart as the continents separated. Often these fractures have a vertical or near vertical orientation and extend a few inches to a few feet across (Van Houten, 1969).

Table 3.2: Characteristics of Bedrock Types Found in North Brunswick

Abbre-viation	Geologic Formation	Geologic Period (Million Years Ago, Ma)	Lithology (physical character of the rocks)	Area (acres) in Township	Percent of Township
Kmg	Magothy Formation	Late Cretaceous, Turonian to Santonian Ages (93.9 to 83.6 Ma)	quartz sand, fine- to coarse-grained, interbedded with thin-bedded clay or clay-silt as much as 180 feet thick	1646.58	20.92
Jd	Jurassic Diabase	Early Jurassic (201 to 174 Ma)	diabase, medium- to coarse-grained	32.36	0.41
JTrp	Passaic Formation	Early Jurassic (201 to 174 Ma) to Late Triassic (237 to 201 Ma)	siltstone and shale	4745.03	60.27
Trpg	Passaic Formation Gray Bed		sandstone, siltstone and shale	845.74	10.74
Trl	Lockatong Formation	Late Triassic (237 to 201 Ma)	dolomitic or silty argillite, mudstone, sandstone, siltstone, and minor silty limestone	602.88	7.66
			Total:	**7872.58**	**100.00**
Source: NJGS, 2009; Walker et al, 2012.					

[18] The Passaic Formation was formerly known as the Brunswick Formation.
[19] In geology, dip means the inclination of the rock layer in reference to the plane of the horizon.

During the Cretaceous Period (145 to 66 million years ago), northern New Jersey was uplifted, while southern New Jersey was depressed. The coastline changed several times as the land rose and fell. A succession of sands and clays were deposited on the changing Coastal Plain, including the *Magothy Formation*.

Passaic Formation (JTrp)

The Passaic Formation is characterized by interbedded sequences of reddish-brown to maroon and dusky grayish-red siltstone, reddish-brown shaly siltstone to mudstone, separated by interbedded olive-gray to dark-gray siltstone and lesser silty argillite. Reddish-brown siltstone is medium to fine grained, and is thin to medium bedded planar (having flat layers) to cross-bedded (having irregular layers). It contains mica (an aluminum silicate mineral), mud cracks, ripple cross-laminations, root casts, load casts and evaporate minerals. Together with the Passaic Formation Gray Beds (described below), the thickness is approximately 5,422 to 5,475 feet (Stanford et al, 1998).

Passaic Formation Gray Beds (JTrpg)

Passaic Formation Gray Beds are similar to the Passaic Formation, with sequences of medium to fine grained thin to medium bedded, planar to cross bedded layers. In places, desiccation features and pyrite can be found. Gray bed sequences vary from less than 1 foot to approximately 40 feet thick. The division between the Passaic and the Lockatong Formations is gradational, and placed where the proportion of gray beds (Lockatong) is greater than reddish brown beds (Passaic). Beneath Cretaceous deposits (the Magothy, described below), weathers to a red, reddish-brown, gray, or olive clay as much as 20 feet thick (Stanford et al, 1998).

The Passaic and Passaic Formation Gray Beds interfinger with one another, and together underlie about 71% of North Brunswick Township (see **Figure 3e**). The Passaic Formation is exposed along Westons Mill Pond and nearby along the Raritan River (Stanford et al, 1998).

Lockatong Formation (Trl)

The Lockatong Formation was cyclically deposited forming sequences that are mainly gray to greenish-gray and in upper part of unit, locally reddish-brown siltstone to silty argillite and dark gray to black shale and mudstone. The siltstone is medium to fine grained thin bedded planar to cross bedded with mud cracks, ripple cross laminations, and locally abundant pyrite. Shale and mudstone are very thin-bedded to thinly laminated, platy, locally containing desiccation features. This formation can be about 1,800 feet thick (Stanford et al, 1998).

The Lockatong Formation underlies about 8% of the southern portion of North Brunswick Township (see **Figure 3e**). The Lockatong Formation is best exposed southeast of Farrington Lake (Stanford et al, 1998).

Jurassic Diabase (Jd)

Lower Jurassic Diabase rocks are lava flows intruded between layers of the sedimentary Passaic and Lockatong Formations, which cooled slowly beneath the surface. This formation is composed of fine grained to dense homogenous dikes and sills and medium grained, discordant, sheet-like intrusions of dark-gray to dark greenish-gray diabase containing elongate crystals (plagioclase embedded in pyroxene). It is massive textured, hard and sparsely fractured. Contacts are typically fine grained, and have sharp margins and may have vesicles (bubbles) adjacent to the enclosing sedimentary rocks. Diabase is not exposed in North Brunswick, but

can be seen in several locations, including along the Raritan River east of Highland Park. This sheet may be the southern extension of the Palisades sill and is approximately 1,325 feet thick (Stanford et al, 1998).

Within North Brunswick, the Jurassic Diabase is found in a small area near Quarry Lane, where Oakeys Brook joins the Lawrence Brook, beneath less than 1% of the township (see **Figure 3e**).

Mogathy formation (Kmg)

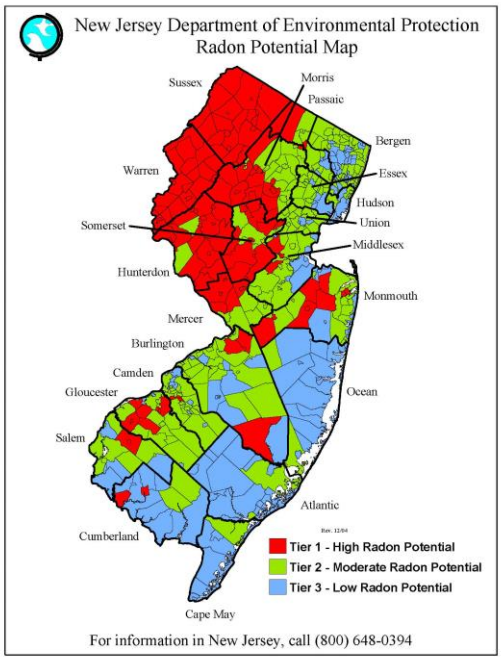
The *Magothy Formation* is the youngest formation found in North Brunswick. It is made up of quartz sand, and is white to yellow in color, contains mica, and is commonly interbedded with gray carbonaceous clay and silt. In some places the clay is oxidized to white, red and pink. Locally, the clay contains pyrite (fool's gold) and lignite (a low grade of coal). This sequence was formerly included in the Raritan Formation. It was formed in the Late Cretaceous (Turonian-Coniaccium to Santonian Ages) and is as much as 180 feet thick (Stanford et al, 1998).

The Magothy is found in the middle of North Brunswick, south of Route 1, and overlies portions of the Passaic and Passaic Gray Bed formations within the township (see **Figure 3e**).

Radon

Radon is a radioactive gas that is naturally occurring in New Jersey rocks, soil and ground water. The Triassic-Jurassic rocks of the Piedmont Province can be high in radon. Radioactive minerals are more concentrated in granite, near faults, and in lake-bed formations. The natural decay of uranium and thorium produce *radon gas*, which has been shown to cause lung cancer, as discussed in **Section 2B**. Radon can become concentrated indoors, where it can increase risks of lung cancer. Because there is no known safe level of exposure to radon, the USEPA strongly recommends taking measures to reduce indoor radon if your radon test shows 4 pCi/L (picocuries per liter of air) or more, and to consider remediation if your test shows between 2 and 4 pCi/L (USEPA, February 2013; NJDEP, February 6, 2012).

The southern Piedmont Province has elevated radon, with 32% of homes having radon above 4 pCi/L. In contrast, only 6% of homes in the northern Piedmont exceed the recommended radon limit, partly because glacial materials cover the bedrock (Muessig et al, 1992). Therefore, the Township of North Brunswick is considered to be *Tier 1 - High Radon Potential* (see Radon Potential Map to the right). New homes built in Tier 1 areas must include radon preventative features (N.J.A.C. 5:23-10.1 et seq.) (NJDEP Radon Section, February 6, 2012).



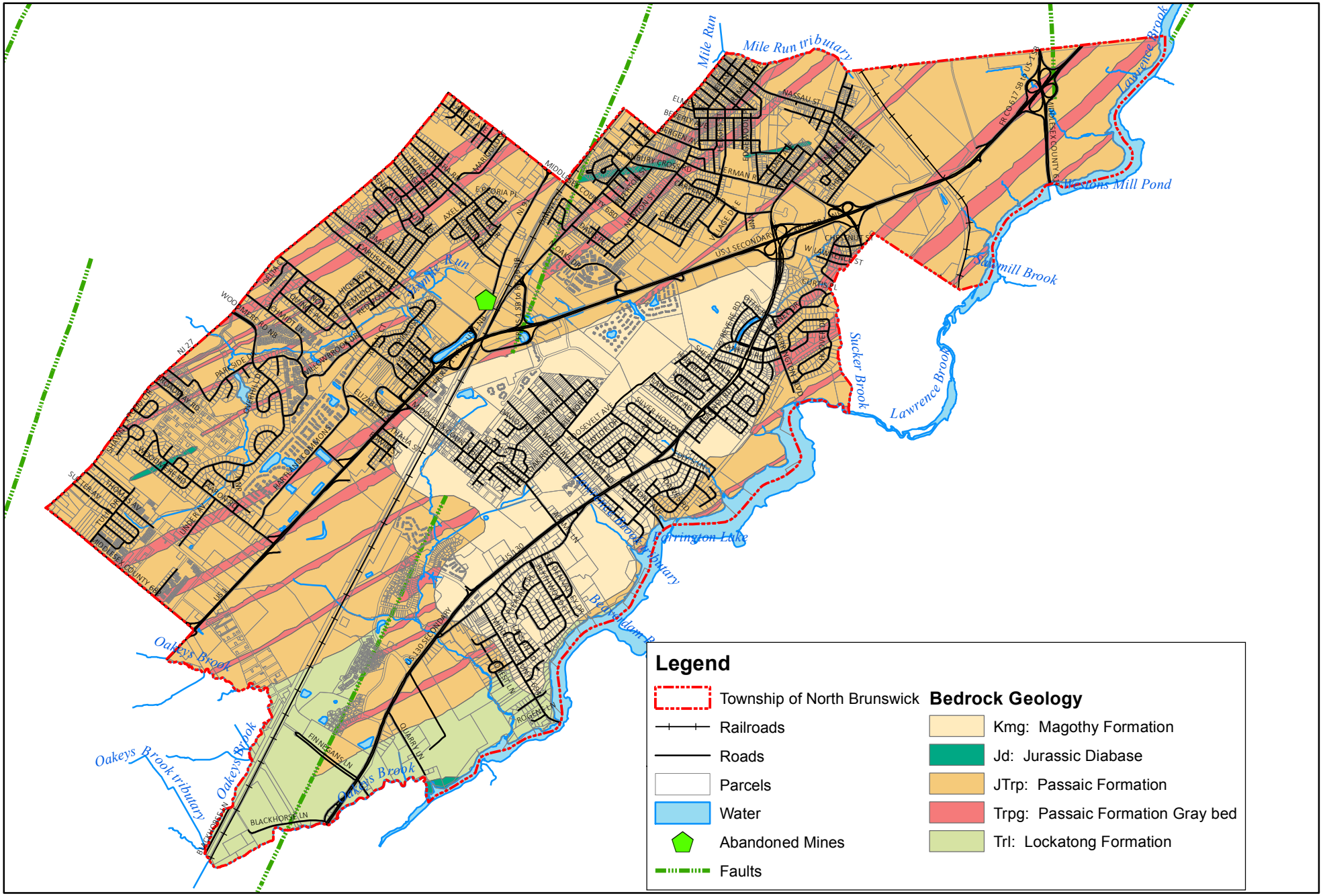


Figure 3e: Geology

0 0.25 0.5 1 Miles

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Mining & Quarrying

There is one abandoned mine in North Brunswick, a copper mine called the Raritan Mine (NJGS, 2006). Nearly all copper-bearing minerals and copper mines in New Jersey are found in Triassic rocks, especially the Passaic (formerly Brunswick) formation. The copper ore zones (chalcocite and secondary copper carbonate) may be related to diabase intrusions. A relatively large amount of money has been spent on copper mining in the state, but few, if any, of them were profitable. The Raritan Mine was no exception. It was worked prior to 1840, and around 1847, a main shaft was sunk 160 feet and a short tunnel ran north-northeastward. However, problems with water and the low grade of the ore made mining unprofitable, and the mine has been inactive since at least 1868 (Woodward, 1944; Stanford et al, 1998).

There are no active or former quarries in North Brunswick.

Earthquakes

Damaging earthquakes are rare in North Brunswick, but possible. Soils influence the potential for damage from earthquakes. Some areas of North Brunswick have relatively shallow depth to bedrock, which dampens the movement of earthquakes (USDA NRCS, November 21, 2012). However, soft soils (e.g. silt, clay, and fine sand) amplify the motion of earthquake waves, increasing ground shaking, while wet sandy soils can liquefy (Stanford, 2003).

No recorded earthquakes have had their epicenter in North Brunswick; while 6 have occurred within 10 miles (see **Figure 3f)**. The closest, an earthquake of magnitude 2.3, was epicentered near Princeton in 1997. The most recent nearby earthquake occurred in 2011 near South Plainfield, with a magnitude of 1.6 (NJDEP NJGS, June 24, 2013).

Table 3.3: Earthquakes within 10 miles of North Brunswick

Quad	Date	Depth	Magnitude	Location
South Amboy, NJ-NY	9/1/1895	0	4.1	Near South Amboy, NJ
Freehold, NJ	1/9/1992	8	3.1	New Brunswick, NJ
Monmouth Junction NJ	3/11/1997	10	0	3 km W of Kendall Park, NJ
Monmouth Junction NJ	7/15/1997	5	2.3	12 km NE of Princeton, NJ
South Amboy, NJ-NY	6/6/2010	5	2.3	6 km SE of Sayreville, NJ
Plainfield, NJ	6/9/2011	5	1.6	2 km SE of S. Plainfield, NJ
Source: NJDEP NJGS, June 24, 2013				

D. Surficial Geology

Surficial materials are the unconsolidated sediments that overlie bedrock formations, and that are the parent material for soils. In Middlesex County they include fluvial (deposited by rivers), glacial, eolian (transported by wind), swamp, beach and estuarine deposits; weathered mudstone, sandstone and diabase material; and man-made fill. The surficial materials may be as much as 140 feet thick, although typically are less than 50 feet thick. They vary widely, leading to differences in the ability to transmit ground water to aquifers, to support structures and to provide sand and gravel resources (Stanford, 1999). The characteristics of surficial geology types found in North Brunswick are provided in **Table 3.4** and illustrated in **Figure 3g**.

About 5 to 2 million years ago, a large southwesterly flowing river (the Pensauken River, which most likely drained a large area including what is now the Hudson River valley and southwestern New England) eroded a broad valley. When sea levels rose, sediments were deposited, building up the level of the streambed and filling the floodplain in a process known as

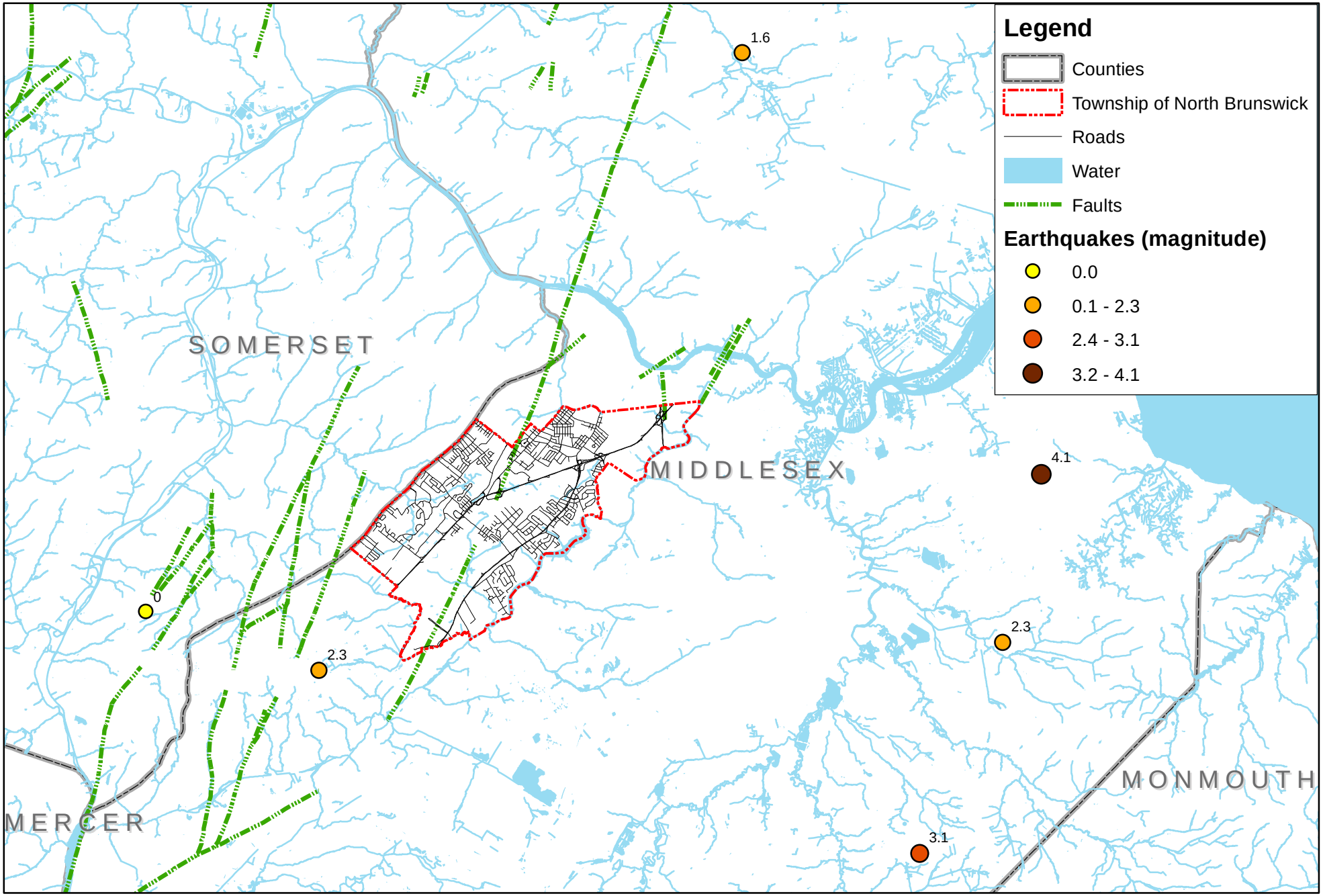

Figure 3f: Earthquakes and Faults

0 1 2 4 Miles

N

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aggradation. These deposits comprise the Pennsauken Formation (Tp)20, which is found in about 39% of North Brunswick, in a broad band roughly following the southeast border of the township (Stanford, 1999; NJGS, 2006).

About 2 million years ago, glaciation likely changed the course of the Pensauken River, and the Raritan River was established on the former Pennsauken Plain (although no glaciers reached as far south as North Brunswick). Melting glaciers resulted in sea level rise, causing the sea to encroach on the Raritan River, bringing about the creation of the Raritan Bay. Because the environment in the area that is now North Brunswick was cold tundra, there was little vegetation to stabilize the soils. Permafrost impeded subsurface drainage, causing waterlogged soils to erode easily. These sediments were transported by nonglacial streams and deposited as *Lower and Upper Stream Terraces (Qtl and Qtu)*. These deposits are found on the slopes above the Lawrence Brook. At the same time, the action of gravity resulted in loose rock debris to be deposited at the base of steep hillsides (*Colluvium, Qcs*), which is found in North Brunswick in a small area on Westons Mill Pond (Stanford, 1999).

Weathered Diabase (Qwd), Weathered Shale, Mudstone, and Sandstone (Qws) and *Weathered Coastal Plain Formations (Qwcp)* are primarily of Quaternary age (2.6 Ma to the present), which are rocks of the respective types that have been affected by exposure to the action of the weather (water, wind, frost, heat) (Stanford, 1999; Stanford 2009).

The warming climate then allowed vegetation to grow and stabilize the ground, resulting in less erosion. Streams carved deeper into the stream banks, and later deposited *Alluvium (Qal)* (floodplain and channel sediments), and continue to do so to the present (Stanford, 1999). Alluvium is found along the Lawrence Brook, Six Mile Run and Oakeys Brook.

Table: 3.4: Characteristics of Surficial Geology Found in North Brunswick

Deposit Type	Lithology	Geologic Age	Notes	Acres	Percent of Twp.
Qal Alluvium	Sand, gravel, silt, minor clay and peat; reddish brown, yellowish brown, brown, gray. As much as 20 feet thick.	Holocene and Late Pleistocene 1.8 Ma to present	Contains variable amounts of organic matter. Deposited in modern floodplains and channels.	287.35	3.65
Qtu Upper Stream Terrace Deposits	Sand and pebble gravel, minor silt and cobble gravel; yellow, reddish yellow, yellowish brown. As much as 20 feet thick.	Middle to Late Pleistocene 1.8 to 0.01 Ma	Forms nonglacial stream terraces 20 to 50 feet above the modern floodplain. Topographic position and weathering characteristics are similar to Illinoian glaciofluvial deposits. Terraces grade to, or are onlapped by Cape May Formation, unit 2.	50.05	0.64
Qtl Lower Stream Terrace Deposits	Sand, pebble gravel, minor silt and cobble gravel; reddish brown, yellowish brown, reddish yellow. As much as 30 feet thick.	Late Pleistocene To Late Wisconsinan 1.8 to 0.02 Ma	Forms nonglacial stream terraces with surfaces 5 to 20 feet above modern floodplains. Terraces grade to late Wisconsinan glaciofluvial deposits in the Delaware, Millstone, and Raritan valleys.	61.97	0.79

[20] Tp, Qal, Qcs etc. are standard abbreviations, with the first letter referring to the geologic period. See **Table 3.4**.

Deposit Type	Lithology	Geologic Age	Notes	Acres	Percent of Twp.
Qcs Shale, Mudstone, And Sandstone Colluvium	Sandy silt to clayey silt with shale, mudstone, or sandstone fragments; reddish brown, yellow, light gray. As much as 30 feet thick.	Pleistocene 2.6 to 0.01 Ma	Forms aprons at the base of slopes on weathered shale, mudstone, and sandstone.	1.87	0.02
Qwd Weathered Diabase	Clayey sand to silty clay with diabase fragments and boulders; reddish yellow, yellow, brown, light gray. As much as 20 feet thick.	Pleistocene 2.6 to 0.01 Ma		1.33	0.02
Qws Weathered Shale, Mudstone, and Sandstone	Silty sand to silty clay with shale, mudstone, or sandstone fragments; reddish brown, yellow, light gray. As much as 10 feet thick on shale and mudstone, 30 feet thick on sandstone.	Pleistocene 2.6 to 0.01 Ma		4,361.21	55.40
Qwcp Weathered Coastal Plain Formations	Fine to medium sand, clayey coarse sand, minor clay; yellow, white, pink and red; as much as 10 feet thick.	Chiefly Pleistocene 2.6 to 0.01 Ma, locally Miocene and Pliocene 23 to 2.6 Ma	Exposed sand and clay of Coastal Plain bedrock formations. Includes thin, patchy alluvium and colluvium, and pebbles left from erosion of surficial deposits.	49.52	0.63
Tp Pensauken Formation	Sand, clayey sand, pebble gravel, minor silt, clay, and cobble gravel; yellow, reddish yellow, white. Sand typically includes weathered feldspar. Locally iron-cemented. As much as 140 feet thick.	Pliocene 5.3 to 2.6 Ma	In erosional remnants of a former river plain that occupied the broad valley between South Amboy and the Salem area. Elevation of the top of the deposit grades from 160 feet at South Amboy to 80 feet in the Salem area.	3059.28	38.86
			Total	7,872.58	100.01
Source: NJGS, 2006; Stanford 2009					

Historic Fill

Historic fill is defined by NJDEP as non-indigenous material placed on a site in order to raise the topographic elevation of the site. Large areas (over 5 acres) of historic fill have been mapped by NJDEP, as required by the Brownfield and Contaminated Site Remediation Act (N.J.S.A. 58:10B-1 et seq.). While most urban and suburban areas are underlain by an irregular layer of excavated indigenous soil mixed with various amounts of non-indigenous material, this material generally does not meet the definition of historic fill. Also, there may be historic fill areas that were not detectable on aerial photography or by archival map interpretation, particularly along streams in urban and suburban areas. Areas of historic fill in North Brunswick are all associated with highways (US Routes 1 and 130, County Routes 617, 680 and 694, and Oakmont Avenue), as shown on **Figure 3g** (NJGS, February 17, 2009)**.**

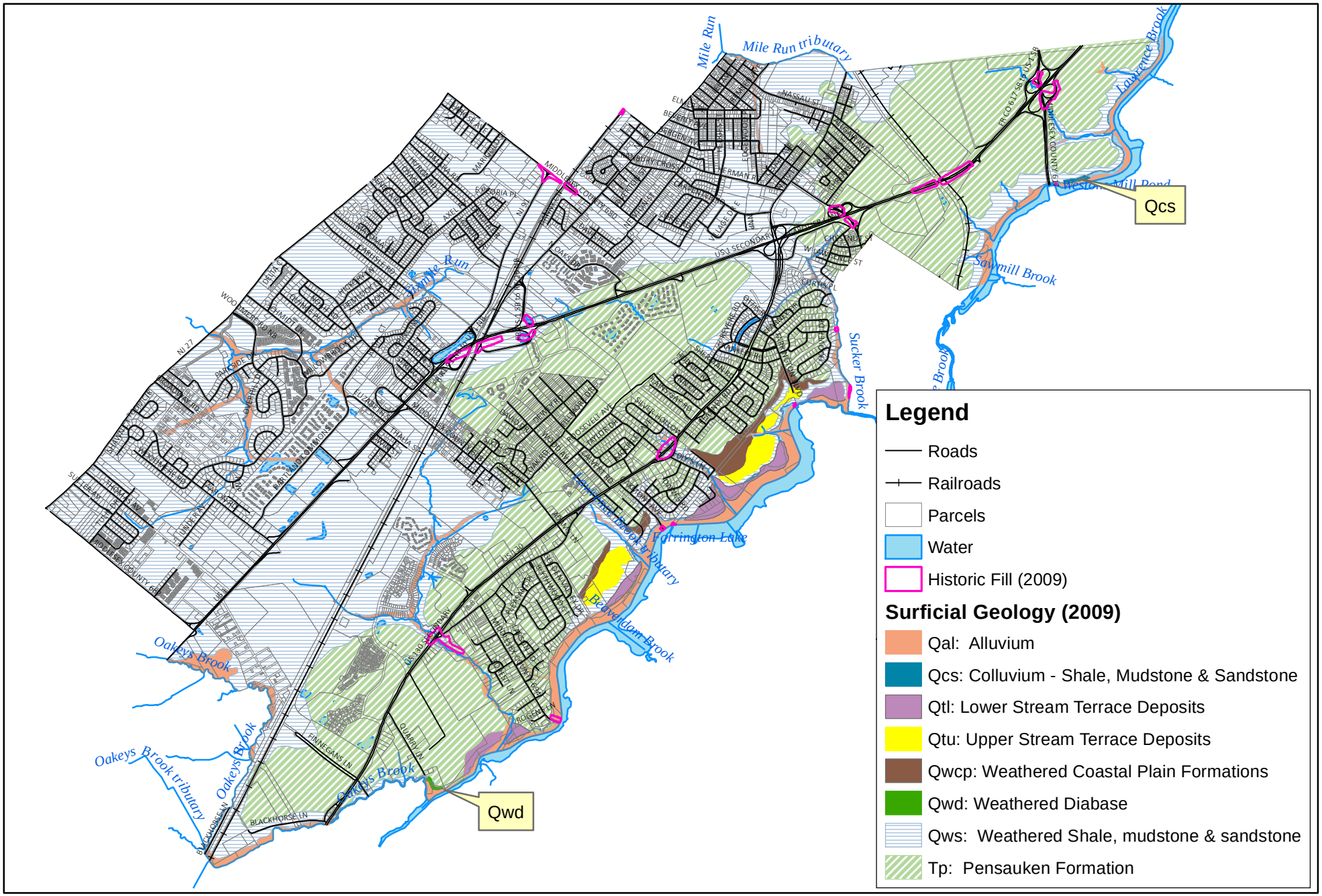

Figure 3g: Surficial Geology

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

This artificial fill is generally composed of sand, silt, gravel, clay and rock fragments, and can include a variety of man-made materials, including concrete, brick, asphalt, cinders, ash, wood, slag, metal, glass and trash. Color is variable but generally gray, brown, white or yellow. Urban and suburban areas generally have a thin layer of fill or mixed fill and natural material overlying the mapped surficial material. Only large areas of fill, which can be as much as 20 feet thick, are mapped (Stanford, 1999).

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The Geology of New Jersey (NJ Geological Survey): http://www.state.nj.us/dep/njgs/index.html

The Paleontology Portal: http://www.paleoportal.org

The Physiographic Provinces of NJ (NJ Geological Survey): http://www.state.nj.us/dep/njgs/enviroed/infocirc/provinces.pdf

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4: SOILS

A. Soil Survey Maps

The *soil* is the unconsolidated mineral material on the immediate surface of the earth and which serves as the medium for growth of land plants. The characteristics of each soil type have developed over time (usually many thousands of years) under the influence of the parent material (the bedrock that has broken down into small fragments to form the soil), climate (including moisture and temperature regimes), macro- and microorganisms, and topography. Soil is a basic resource for food production, in addition to its essential role in collecting and purifying water before it enters the ground water (Soil Science Society of America, 2013). However, soil itself can be a pollutant as dust in the air or as sediment in water.

The US Department of Agriculture Natural Resources Conservation Service (USDA NRCS) is the science-based agency which provides technical assistance based on sound science in the conservation and management of soil, water, and other natural resources to private land owners and local, state, and federal agencies and policy-makers (USDA NRCS, July 9, 2013).

One of these technical services is the soil survey. A *soil survey* is an inventory of the country's soil resources to determine soil characteristics and capabilities and to help people understand soils and their uses. Soil surveys help identify the best way to protect soil and water quality through the use of conservation practices and to identify which sites are suitable (and the degree of suitability) for various land uses (e.g. septic systems, roads, agriculture).

The objective of soil mapping is to separate the landscape into segments that have similar use and management requirements. Therefore, this data set is not designed for use as a primary regulatory or management tool, but may be used as a broad scale reference source. According to the Soil Survey Geographic Database (also known as SSURGO) information, field investigations and data collection were carried out in sufficient detail to name map units and to identify accurately and consistently areas of about 5 acres. As with other GIS data sets, enlargement of the maps to a scale greater than the accuracy of the data can cause misinterpretation of the data. Onsite sampling, testing, and detailed study of specific sites is essential for determining intensive uses, and managing farms and wetlands (USDA NRCS, February 15, 2013).

Beginning in 2005, the NRCS made its soil surveys available online (USDA NRCS, February 15, 2013). This provides the means for keeping the information current and available to the public. The newest version of the gSSURGO (Gridded Soil Survey Geographic Database) spatial data and tabular data were downloaded for use in this report (USDA NRCS, Soil Survey Staff, November 21, 2012) [21].

B. Soil Series and Map Units

Soil characteristics vary from place to place in slope, depth, drainage, erodibility and other characteristics that affect management. A *soil series* is a basic unit of soil classification consisting of soils that are essentially alike, except that they may differ in surface texture, stoniness, slope or some other attribute. A *map unit* is the area delineated on a soil map, representing an area dominated by one major kind of soil, and is named according to the classification of the dominant soil or soils. However, soils are natural systems, with natural

[21] The maps in this report use the most recent data available: US Department of Agriculture, NRCS, Soil Survey Staff. November 21, 2012.

variability, and the range of some observed properties may extend beyond the limits defined for the class. In addition, small areas of contrasting soils may not be visible on the maps. The databases included with the soils data describe the characteristics of each soil map unit. The NRCS has included both estimated and measured data on the physical and chemical soil properties and soil interpretations for engineering, water management, recreation, agronomic, woodland, range and wildlife uses of the soil.

There are 27 soil series' found in North Brunswick, such as Elkton, Fallsington and Nixon. A total of 51 different map units are present in North Brunswick. These map units are described below and listed in **Table 4.1** (found on pages 65 to 69), along with several important properties of these soils, and shown on **Figure 4a**. **Figures 4b** through **4i** illustrate the distribution of some soil characteristics (descriptions, tabular data and GIS data are from USDA NRCS, Soil Survey Staff. November 21, 2012).

Map Unit Descriptions

Map unit: BhnB - Birdsboro silt loam, 2 to 6 percent slopes

The Birdsboro series consists of very deep, well to moderately well drained soils on terraces and alluvial fans. They formed in stream deposits washed from uplands underlain by red sandstone, shale and siltstone. Typically these soils have a dark brown silt loam surface layer about 10 inches thick. The subsoil between 10 and 46 inches is reddish brown and brown silty clay loam, loam and sandy clay loam. The substratum from 46 to 70 inches is reddish brown very gravelly clay loam.

Map unit: EkaAr - Elkton loam, 0 to 2 percent slopes, rarely flooded

The Elkton series consists of very deep, poorly drained soils formed in loamy (silty)/ clayey deposits of the Mid-Atlantic coastal plain. They are on lowlands, depressions, and ancient floodplains. Typically the surface layer is dark olive gray silt loam 1 inch thick. The subsurface layer is gray silt loam 9 inches thick. The subsoil from 10 to 14 inches is gray silty clay loam with prominent mottles. The substratum from 40 to 65 inches is gray very fine sandy loam.

Map unit: FapA - Fallsington loam, 0 to 2 percent slopes

The Fallsington series consists of very deep, poorly drained soils on upland flats and in depressions. They formed in stratified coastal plain sediments of marine or alluvial origin. Typically these soils have a dark gray sandy loam surface layer 10 inches thick. The subsoil, from 10 to 40 inches is mottled gray sandy clay loam to 32 inches and mottled light gray loamy sand to 40 inches. The substratum is stratified light gray sandy clay loam and sand.

Map unit: HumAt - Humaquepts, 0 to 3 percent slopes, frequently flooded

Humaquepts, frequently flooded consists of deep, somewhat poorly drained to very poorly drained soils adjacent to perennial streams in the coastal plain province that are subject to frequent stream overflow. These soils formed in sediments that are quite variable in texture.

Map unit: KemD - Keyport sandy loam, 10 to 15 percent slopes

The Keyport series consists of very deep, moderately well drained soils on uplands. They formed in northern coastal plain sediments. Typically these soils have a dark brown silt loam surface layer 10 inches thick. The subsoil layers from 10 to 44 inches are yellowish brown and dark yellowish brown silty clay loam. The upper substratum from 44 to 60 inches is dark gray silty clay loam and the lower substratum from 60 to 72 inches is dark gray stratified clay to loamy sand.

Map unit: KeoA - Keyport loam, 0 to 2 percent slopes
Map unit: KeoB - Keyport loam, 2 to 5 percent slopes
Map unit: KeoC - Keyport loam, 5 to 10 percent slopes

The Keyport series consists of very deep, moderately well drained soils on uplands. They formed in northern coastal plain sediments. Typically these soils have a dark brown silt loam surface layer 10 inches thick. The subsoil layers from 10 to 44 inches are yellowish brown and dark yellowish brown silty clay loam. The upper substratum from 44 to 60 inches is dark gray silty clay loam and the lower substratum from 60 to 72 inches is dark gray stratified clay to loamy sand. These three map units differ in percent slope.

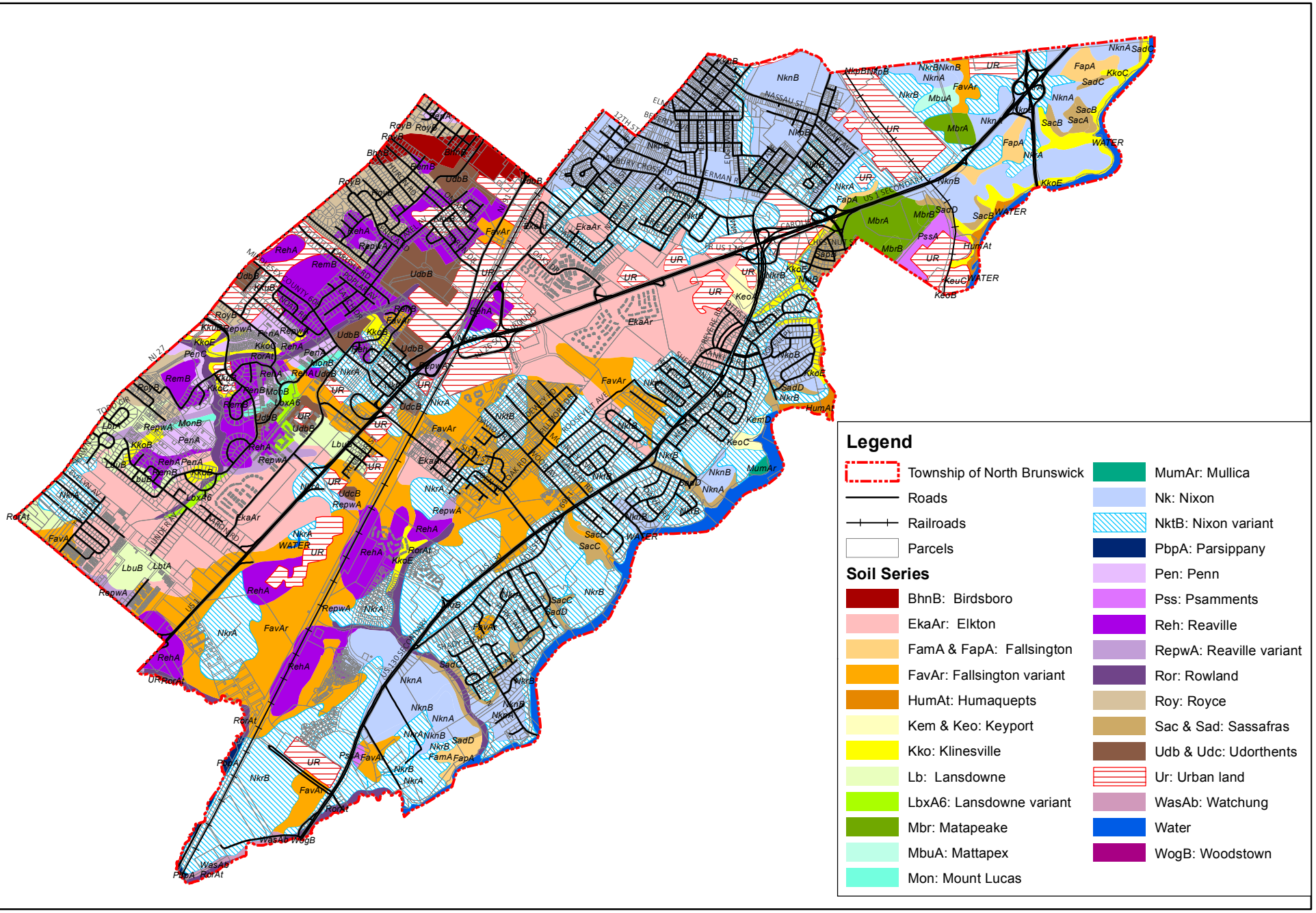

Figure 4a: Soils
Gridded Soil Survey Geographic (gSSURGO)
(NRCS, 2012)

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Map unit: KeuC - Keyport-Urban land complex, 0 to 10 percent slopes
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas. Otherwise, this map unit is similar to the Keyport loams described above.

Map unit: KkoB - Klinesville channery loam, 2 to 6 percent slopes
The Klinesville series consists of shallow, somewhat excessively drained soils on uplands. They formed in material weathered from shale, siltstone, and sandstone. Typically these soils have a dark reddish brown very channery silt loam surface layer 5 inches thick. The subsoil from 5 to 15 inches is reddish brown very channery silt loam. The substratum from 15 to 19 inches is weak red weathered shale fragments. Bedrock is found at a depth of 19 inches.

Map unit: KkuB - Klinesville-Urban land complex, 0 to 6 percent slopes
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas. Otherwise, this map unit is similar to the previous one.

Map unit: LbtA - Lansdowne silt loam, 0 to 2 percent slopes
The Lansdowne series consists of deep, moderately well to somewhat poorly drained soils on uplands. They formed in old alluvium and glacial till. Typically these soils have a dark reddish brown loam surface layer 9 inches thick. The mottled subsoil is mainly yellowish red. From 9 to 14 inches it is silty clay loam, from 14 to 25 inches it is silty clay, from 25 to 38 inches it is clay, and from 38 to 44 inches it is dark red silty clay. The substratum from 44 to 55 inches is dusky red shaly clay loam. Bedrock is found at a depth of 55 inches.

Map unit: LbuB - Lansdowne-Urban land complex, 0 to 6 percent slopes
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas. Otherwise, this map unit is similar to the previous one.

Map unit: MbrA - Matapeake silt loam, 0 to 2 percent slopes
Map unit: MbrB - Matapeake silt loam, 2 to 5 percent slopes
The Matapeake series consists of very deep, well drained soils on coastal plain uplands. They formed in a silty mantle and the underlying sandy sediments. Typically, these soils have grayish-brown and light yellowish-brown silt loam surface layers to a depth of 11 inches. The subsoil, from 11 to 34 inches, is yellowish-brown and strong brown silt loam. From 34 to 38 inches, the subsoil is strong brown sandy loam. The substratum layers, from 38 to 62 inches, are light yellowish-brown sandy loam and pale yellow loamy sand. These two map units differ in percent slope.

Map unit: MbuA - Mattapex silt loam, 0 to 2 percent slopes
The Mattapex series consists of very deep, moderately well drained soils formed in silty sediments overlying coarser sediments of marine or alluvial origin. Typically, these soils have a dark grayish-brown loam surface layer, 11 inches thick. The subsoil from 11 to 15 inches is brown loam, from 15 to 26 inches is yellowish-brown silty clay loam, and from 26 to 36 inches is mottled light olive brown silty clay loam. The mottled substratum from 36 to 60 inches is yellowish-brown fine sandy loam.

Map unit: MumAr - Mullica sandy loam, 0 to 2 percent slopes, rarely flooded
The Mullica series consists of very deep, very poorly drained soils on flats and in depressions. They formed in coastal plain sediments. Typically, these soils have a black sandy loam surface layer 10 inches thick. The subsurface layer from 10 to 18 inches is gray sandy loam. The subsoil from 18 to 28 inches is mottles gray sandy loam. The substratum from 28 to 60 inches is gray or grayish brown gravelly sand or sand.

Map unit: NknA - Nixon loam, 0 to 2 percent slopes
Map unit: NknB - Nixon loam, 2 to 5 percent slopes
The Nixon series consists of deep, well drained soils on uplands. They formed in material weathered from old alluvium containing red shale and siliceous coastal plain sediments. These soils have a dark brown loam surface layer, 10 inches thick. The subsoil from 12 to 40 inches is strong brown and reddish brown loam and sandy clay loam. The substratum from 40 to 60 inches is yellowish red loamy sand. These two map units differ in percent slope.

Map unit: NkpB - Nixon-Urban land complex, 0 to 5 percent slopes
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas. Otherwise, this map unit is similar to the previous one.

Map unit: NkrA - Nixon moderately well drained variant loam, 0 to 2 percent slopes
Map unit: NkrB - Nixon moderately well drained variant loam, 2 to 5 percent slopes
The Nixon Variant consists of deep, moderately well or somewhat poorly drained soils on uplands. They formed in material weathered from old alluvium containing red shale and siliceous coastal plain sediments. These soils have a dark brown loam surface layer, 11 inches. The subsoil from 11 to 38 is mottled strong brown and yellowish red silt loam and loam. The substratum from 38 to 60 inches is mottled. These two map units differ in percent slope.

Map unit: NktB - Nixon moderately well drained variant-Urban land complex, 0 to 5 percent slopes
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas. Otherwise, this map unit is similar to the previous one.

Map unit: PbpA - Parsippany silt loam, 0 to 3 percent slopes
The Parsippany series consists of deep, poorly drained soils in old lake basins and near streams. They formed in water-laid sediments. Typically these soils have a dark gray silty clay loam surface layer 9 inches thick. The mottled subsoil layers from 9 to 29 inches are gray and reddish brown silty clay and from 29 to 50 inches the subsoil is brown and strong brown silty clay loam. The substratum from 50 to 70 inches is reddish brown stratified silt loam and very fine sand.

Map unit: PssA - Psamments, 0 to 3 percent slopes
Psamments are excessively drained to well drained sandy fill land that has been smoothed. The thickness of the fill ranges from 24 to 48 inches but is dominantly 36 inches. Gravel content ranges from 0 to 50 percent.

Map unit: RehA - Reaville silt loam, 0 to 2 percent slopes
Map unit: RehB - Reaville silt loam, 2 to 6 percent slopes
The Reaville series consists of moderately deep, moderately well, and somewhat poorly drained soils on uplands. They formed in material weathered from interbedded Triassic red shale and siltstone. Typically, these soils have a reddish brown, channery silt loam surface layer 9 inches thick. The mottled subsoil from 9 to 15 inches is reddish brown channery silt loam. The mottled substratum from 15 to 25 inches is dusky red, very channery silt loam. Bedrock is found at a depth of 25 inches. These two map units differ in percent slope.

Map unit: RemB - Reaville-Urban land complex, 0 to 6 percent slopes
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas. Otherwise, this map unit is similar to the previous one.

Map unit: RepwA - Reaville poorly drained variant silt loam, 0 to 2 percent slopes
The Croton series consists of deep, poorly drained soils on uplands. They formed in medium or moderately-fine textured materials over argillite, siltstone or shale. Typically these soils have a dark grayish brown very stony or extremely stony silt loam surface layer 9 inches thick. The subsoil from 9 to 18 inches is gray silty clay loam. From 18 to 36 inches is a very firm and brittle fragipan that is light brownish gray and yellowish brown silty clay loam. The substratum from 36 to 48 inches is a very firm yellowish brown channery silty clay loam. Shale is at a depth of 48 inches.

Map unit: RorAt - Rowland silt loam, 0 to 2 percent slopes, frequently flooded
The Rowland series consists of very deep, moderately well to somewhat poorly drained soils on floodplains. They formed in alluvial sediments. Typically these soils have a dark reddish brown silt loam surface layer 10 inches thick. The subsoil from 10 to 28 inches is reddish brown silt loam mottled in the lower part. The substratum from 28 to 44 inches is weak red silty clay loam. Below 44 inches is stratified sand and gravel.

Map unit: RoyB - Royce silt loam, 3 to 8 percent slopes
The Royce series consists of deep, well drained soils on uplands. They developed in a thin mantle of reddish weathered outwash materials underlain by weathered red shale, sandstone or siltstone bedrock. Typically these soils have a dark reddish-brown silt loam surface layer 8 inches thick. The subsoil between 8 and 48 inches is dark reddish-brown and reddish-brown silt loam, clay loam, and channery loam. The underlying red shale bedrock is found at a depth of 48 inches or more.

Map unit: SacA - Sassafras sandy loam, 0 to 2 percent slopes
Map unit: SacB - Sassafras sandy loam, 2 to 5 percent slopes
Map unit: SacC - Sassafras sandy loam, 5 to 10 percent slopes
The Sassafras series consists of very deep, well drained soils on uplands. They formed in marine or alluvial coastal plain sediments. Typically, these soils have a brown sandy loam surface layer, 9 inches thick. The subsoil, from 9 to

21 inches, is yellowish-brown loam, from 21 to 32 inches, is brown sandy clay loam, and, from 32 to 40 inches, is strong brown sandy loam. The substratum, from 40 to 52 inches, is strong brown gravelly sandy loam and, from 52 to 70 inches, is brownish-yellow loamy sand. These three map units differ in percent slope.

Map unit: SadC - Sassafras gravelly sandy loam, 5 to 10 percent slopes
Map unit: SadD - Sassafras gravelly sandy loam, 10 to 15 percent slopes
The Sassafras series consists of deep, well drained soils on uplands. They formed in marine or alluvial coastal plain sediments. Typically, these soils have a brown gravelly sandy loam surface layer, 9 inches thick. The subsoil, from 9 to 21 inches, is yellowish-brown loam, from 21 to 32 inches, is brown sandy clay loam, and, from 32 to 40 inches, is strong brown sandy loam. The substratum, from 40 to 52 inches, is strong brown gravelly sandy loam and, from 52 to 70 inches, is brownish-yellow loamy sand. These two map units differ in percent slope.

Map unit: SapB - Sassafras-Urban land complex, 0 to 5 percent slopes
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas. Otherwise, this map unit is similar to the previous one.

Map unit: UdbB - Udorthents, bedrock substratum, 0 to 8 percent slopes
Udorthents, bedrock substratum are filled and smoothed pits in rippable bedrock. The original soil formed in shallow to moderately deep residuum or glacial till. Drainage classes range from moderately well to poorly drained. Pits have been backfilled with approximately four feet thick layer of the original surface and subsoil material.

Map unit: UR - Urban land
Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas.

Map unit: WasAb – Watchung silt loam, 0 to 2 percent slopes, very stony
The Watchung, very stony component is found on depressions on piedmonts. The parent material consists of fine-silty residuum weathered from diabase. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is poorly drained. This soil is not flooded or ponded. A seasonal zone of water saturation is at 6 inches during January, February, March, April, May, June, and December. Organic matter content in the surface horizon is about 85 percent. This soil meets hydric criteria. Slopes are 0 to 2 percent.

Map unit: WogA - Woodstown loam, 0 to 2 percent slopes
The Woodstown series consists of deep, moderately well drained soils on uplands and terraces. They formed in marine and alluvial coastal plain sediments. Typically, these soils have a dark grayish-brown sandy loam surface layer, 7 inches thick, and a subsurface layer, from 7 to 11 inches, of light yellowish-brown sandy loam. The light olive brown sandy clay loam subsoil, from 11 to 29 inches, is mottled in the lower part. The substratum layers, from 29 to 70 inches, are sandy loam and loamy sand.

C. Soil Quality and Soil Degradation

Soil is arranged in horizontal layers called horizons. These horizons have technical designations largely useful for soil scientists to distinguish one soil series from another. The descriptions in the NRCS soil survey are done using soil in its native state where possible, so a soil profile which has been disturbed may not match the written description for the series. This is the way the degree of disturbance is assessed—by comparing the soil in its native condition to the profile observed at a specific site. For example, the upper horizon is often an *A horizon*, commonly known as "*topsoil*." An A horizon typically exhibits increased organic matter, reduced clay percentage, a more granular structure of the soil aggregates, and a lower bulk density than the *B horizon* below it. If the A horizon is removed (a common practice in construction), this is evident to a trained observer and the soil would be described as having the A horizon missing. The material on the new surface does not automatically become an A horizon merely as a result of its position. It is possible over time for the newly exposed surface to acquire the characteristics of an A horizon; however this is not automatic and is highly management dependent. In technical writing, in particular guidance documents intended for post-construction remediation, the use of the term "topsoil" should be used with caution if at all

because there is no legal definition of topsoil and the materials available in commerce are highly variable in quality (Muldowney, 2011).

Soils vary naturally in their capacity to function. *Soil quality* is defined as the capacity of a specific kind of soil to function to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. *Inherent* or *intrinsic soil qualities* or characteristics of the soil are determined by factors of soil formation (climate, parent material, topography, time and biota). These are properties which cannot be altered by management except by actually replacing the present material with a different material altogether. An example is the soil's percent sand. The inherent soil quality is used to evaluate the suitability of soils for specific uses (buildings, roads, agriculture, septic systems, etc.). An example is soil particle size: A loam soil will have higher water holding capacity than a sandy soil, therefore will have a higher inherent quality for storing water (USDA NRCS, November 2010).

Contrasting with intrinsic soil properties are management-dependent soil properties, also known as *dynamic soil qualities*. As the term suggests, these can be altered significantly (for better or for worse) by the management of a specific parcel of land and they can have significant consequences for overall environmental quality. Dynamic quality is determined by soil characteristics that are affected by human use and management practices, including physical, chemical and biological properties. Soil quality or health may be evaluated by either comparing to a reference condition that represents full capacity of a soil for a specific function, or to a baseline for the management-dependent soil properties (such as before and after a land use change) (USDA NRCS, November 2010).

Degradation of soil quality occurs in many forms. In urban areas, the significant issues are cutting and filling, compaction, excess salt content and organic matter content. *Cutting and filling* operations actually remove, bury, or invert existing horizons such that they no longer behave in a hydrologically coherent way, with precipitation and gases readily able to enter the soil surface and transmit to horizons lower in the profile. *Compaction*, the increase of bulk density as a result of compression from the surface, is another common form of soil degradation. Compaction can be avoided by not working soil at too high a moisture content. Even foot traffic on a near saturated soil can result in lasting damage which does not resolve itself naturally. A compacted soil can have runoff characteristics more similar to pavement than to the soil in good condition (Muldowney, 2011).

Excess salt content often results from deicing salts but sometimes from fertilizer preparations. It is especially common on roadside verges. The remedy is to either prevent or to wash the salt from the profile with excess water. Sodium salts are especially damaging because sodium causes the clays to disperse. Calcium chloride is relatively harmless to plants and soil (Muldowney, 2011; Wikipedia, July 19, 2013).

Organic matter content is another dynamic soil property. Rutgers New Jersey Agricultural Experiment Station (see **Internet Resources**) provides a chart for interpretation of organic matter percentages in New Jersey soils. Soils with a high organic content are better able to resist other forms of degradation than soils with depleted organic matter. Organic matter in the upper horizons of soil is a measure of carbon storage in soil. Soil is the largest terrestrial reservoir of carbon and has the greatest potential for long term storage if degraded soils are managed in a way that builds up carbon. The silt loams found in most of North Brunswick are able to store more carbon in the form of organic matter than sandier soil. Keeping soil in good condition reduces runoff, produces cleaner runoff, requires less irrigation, grows more robust plantings, and sequesters more atmospheric carbon than a damaged soil (Muldowney, 2011).

D. Characteristics of North Brunswick Soils

Soil properties contained in the NRCS soil survey and mapped in **Figures 4b through 4i** and summarized in **Table 4.1** (found on pages 65 to 69) are *intrinsic* soil properties. These are properties which cannot be altered by management except by actually replacing the present material with a different material altogether.

Depth to Bedrock (Figure 4b)

According to NJDEP (April 2, 2012), bedrock is defined as "any solid body of rock, with or without fractures, which is not underlain by soil or unconsolidated rock material."

The *depth to bedrock* is the distance from the land surface to bedrock. Each soil map unit is characterized by a range of depths to bedrock that is typical for the majority of that soil type. Depth to bedrock is an important factor when determining the suitability of land for building roads, foundations and septic systems.

Figure 4b shows the range of depths to bedrock for the majority of each soil unit in North Brunswick. Much of the township, however, is Not Rated (i.e. no data is available) for depth to bedrock (see **Figure 4b**).

Depth to Seasonal High Water Table (Figure 4c)

The *depth to seasonal high water table* (SHWT) is the distance between the ground surface and the top of the water surface in the saturated part of a water bearing zone. A SHWT of less than one foot severely constrains development, while SHWT between 1 and 3 feet also provides obstacles to development. On-site investigation will often reveal that these areas are actually wetlands or floodplains. High water tables impact the effectiveness of septic systems, and the freeze/thaw cycles cause frost heaving, which damages structures and roads.

Only a small area of North Brunswick has a SHWT < 1 foot (see **Figure 4c**), while about 25% of the township has SHWT less than 2 feet (also see **Figures 6d** and **6e** for floodplains and wetlands maps).

Hydrologic Soil Group (Figure 4d)

The *hydrologic soil grouping* describes a group of soils having similar runoff potential under similar storm and cover conditions (how much water would runoff compared to the rate that water would infiltrate into the ground). The definitions of the hydrologic soil groups are shown below in **Table 4.2**. Only a very small portion (0.3%) of North Brunswick has a low runoff potential (A). About 44% of the township has a moderate runoff potential (B), and 0.9% is rated B/D, or low to high. The remainder of the township has high runoff potential (C, 16%; D, 17%; C/D, 11%) (see **Figure 4d**).

Table 4.1: Characteristics of Soil Types Found in North Brunswick[22]

Map Unit Symbol	Map Unit Name	Component Name	Depth to Bedrock (inches)	Seasonal High Water Table Depth (inches)	Annual Flood Frequency	Ponding Frequency - Presence	Drainage Class	Potential Frost Action	Hydrologic Group✳	Hydric Soil?	Farmland? ◆	Septic Suitability★	Percent of Township
BhnB	Birdsboro silt loam, 2 to 6 percent slopes	Birdsboro	-	-	None	0-14%	Well drained	Moderate	B	No	P	VL	0.88
EkaAr	Elkton loam, 0 to 2 percent slopes, rarely flooded	Elkton	-	15	Rare	75-100%	Poorly drained	Moderate	C/D	Yes	SI	VL	10.97
FamA	Fallsington sandy loam, 0 to 2 percent slopes	Fallsington	-	15	None	0-14%	Poorly drained	High	B/D	Yes	SI	VL	0.06
FapA	Fallsington loam, 0 to 2 percent slopes	Fallsington	-	15	None	0-14%	Poorly drained	High	B/D	Yes	SI	VL	0.84
FavAr	Fallsington bedrock substratum variant loam, 0 to 2 percent slopes, rarely flooded	Fallsington variant	-	15	Rare	75-100%	Poorly drained	High	D	Yes	No	VL	11.25
HumAt	Humaquepts, 0 to 3 percent slopes, frequently flooded	Huma-quepts	-	15	Frequent	75-100%	Poorly drained	High	D	Yes	No	VL	0.32
KemD	Keyport sandy loam, 10 to 15 percent slopes	Keyport	-	61	None	0-14%	Moderately well	High	C	No	No	VL	0.05
KeoA	Keyport loam, 0 to 2 percent slopes	Keyport	-	76	None	0-14%	Moderately well	Moderate	C	No	P	VL	0.25
KeoB	Keyport loam, 2 to 5 percent slopes	Keyport	-	61	None	0-14%	Moderately well	High	C	No	P	VL	0.00
KeoC	Keyport loam, 5 to 10 percent slopes	Keyport	-	76	None	0-14%	Moderately well	Moderate	C	No	SI	VL	0.07

[22] The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation.

Map Unit Symbol	Map Unit Name	Component Name	Depth to Bedrock (inches)	Seasonal High Water Table Depth (inches)	Annual Flood Frequency	Ponding Frequency - Presence	Drainage Class	Potential Frost Action	Hydrologic Group✳	Hydric Soil?	Farmland? ◆	Septic Suitability★	Percent of Township
KeuC	Keyport-Urban land complex, 0 to 10 percent slopes	Urban land	-	61	None	0-14%	Moderately well	-	-	No	No	VL	0.15
KkoB	Klinesville channery loam, 2 to 6 percent slopes	Klinesville	30	-	None	0-14%	Somewhat	Mod.	D	No	No	VL	0.35
KkoC	Klinesville channery loam, 6 to 12 percent slopes	Klinesville	28	-	None	0-14%	Somewhat	Mod.	D	No	No	VL	0.33
KkoE	Klinesville channery loam, 18 to 35 percent slopes	Klinesville	36	-	None	0-14%	Somewhat	Mod.	D	No	No	VL	1.21
KkuB	Klinesville-Urban land complex, 0 to 6 percent slopes	Urban land	30	-	None	0-14%	Well drained	None	-	No	No	VL	1.43
LbtA	Lansdowne silt loam, 0 to 2 percent slopes	Lansdowne	152	53	None	0-14%	Somewhat poorly	High	C	No	SI	VL	0.92
LbuB	Lansdowne-Urban land complex, 0 to 6 percent slopes	Lansdowne	152	53	None	0-14%	Somewhat poorly	High	C	No	No	VL	1.06
LbxA6	Lansdowne moderately deep variant silt loam, 0 to 2 percent slopes	Lansdowne variant	64	53	None	0-14%	Somewhat poorly	High	C	No	No	VL	0.29
MbrA	Matapeake silt loam, 0 to 2 percent slopes	Matapeake	-	-	None	0-14%	Well drained	High	B	No	P	VL	1.20
MbrB	Matapeake silt loam, 2 to 5 percent slopes	Matapeake	-	-	None	0-14%	Well drained	High	B	No	P	VL	0.17
MbuA	Mattapex silt loam, 0 to 2 percent slopes	Mattapex	-	76	None	0-14%	Moderately well	High	C	No	P	VL	0.16
MonB	Mount Lucas silt loam, 2 to 6 percent slopes	Mount Lucas	142	46	None	0-14%	Moderately well	High	C	No	P	VL	0.27

Map Unit Symbol	Map Unit Name	Component Name	Depth to Bedrock (inches)	Seasonal High Water Table Depth (inches)	Annual Flood Frequency	Ponding Frequency - Presence	Drainage Class	Potential Frost Action	Hydrologic Group✳	Hydric Soil?	Farmland? ◆	Septic Suitability★	Percent of Township
MumAr	Mullica sandy loam, 0 to 2 percent slopes, rarely flooded	Mullica	-	8	Rare	0-14%	Very poorly drained	High	D	Yes	SI	VL	0.06
NknA	Nixon loam, 0 to 2 percent slopes	Nixon	-	-	None	0-14%	Well drained	Mod.	B	No	P	VL	3.13
NknB	Nixon loam, 2 to 5 percent slopes	Nixon	-	-	None	0-14%	Well drained	Mod.	B	No	P	VL	3.56
NkpB	Nixon-Urban land complex, 0 to 5 percent slopes	Nixon	-	-	None	0-14%	Well drained	Mod.	B	No	No	VL	6.27
NkrA	Nixon moderately well drained variant loam, 0 to 2 percent slopes	Nixon variant	-	76	None	0-14%	Moderately well	High	B	No	P	VL	10.49
NkrB	Nixon moderately well drained variant loam, 2 to 5 percent slopes	Nixon variant	-	76	None	0-14%	Moderately well	High	B	No	P	VL	6.58
NktB	Nixon moderately well drained variant-Urban land complex, 0 to 5 percent slopes	Nixon variant	-	76	None	0-14%	Moderately well	High	B	No	No	VL	9.85
PbpA	Parsippany silt loam, 0 to 3 percent slopes	Parsippany	-	15	None	0-14%	Poorly drained	High	D	Yes	No	VL	0.14
PenA	Penn silt loam, 0 to 2 percent slopes	Penn	76	-	None	0-14%	Well drained	Mod.	C	No	P	VL	1.02
PenB	Penn silt loam, 2 to 6 percent slopes	Penn	76	-	None	0-14%	Well drained	Mod.	C	No	P	VL	0.11
PenC	Penn silt loam, 6 to 12 percent slopes	Penn	76	-	None	0-14%	Well drained	Mod.	C	No	SI	VL	0.20

Map Unit Symbol	Map Unit Name	Component Name	Depth to Bedrock (inches)	Seasonal High Water Table Depth (inches)	Annual Flood Frequency	Ponding Frequency - Presence	Drainage Class	Potential Frost Action	Hydrologic Group✳	Hydric Soil?	Farmland? ◆	Septic Suitability★	Percent of Township
PssA	Psamments, 0 to 3 percent slopes	Psam-ments	-	122	None	0-14%	Well drained	Low	A	No	No	VL	0.34
RehA	Reaville silt loam, 0 to 2 percent slopes	Reaville	71	46	None	0-14%	Somewhat poorly	High	C	No	SI	VL	4.03
RehB	Reaville silt loam, 2 to 6 percent slopes	Reaville	58	46	None	0-14%	Somewhat poorly	High	C	No	SI	VL	0.08
RemB	Reaville-Urban land complex, 0 to 6 percent slopes	Reaville	71	46	None	0-14%	Somewhat poorly	High	C	No	No	VL	3.74
RepwA	Reaville wet variant silt loam, 0 to 2 percent slopes	Reaville variant	51	15	None	0-14%	Poorly drained	High	D	Yes	No	VL	0.99
RorAt	Rowland silt loam, 0 to 2 percent slopes, frequently flooded	Rowland	-	61	Frequent	75-100%	Moderately well	High	C	No	No	VL	1.66
RoyB	Royce silt loam, 3 to 8 percent slopes	Royce	122	-	None	0-14%	Well drained	Mod.	C	No	P	VL	2.28
SacA	Sassafras sandy loam, 0 to 2 percent slopes	Sassafras	-	-	None	0-14%	Well drained	Mod.	B	No	P	VL	0.11
SacB	Sassafras sandy loam, 2 to 5 percent slopes	Sassafras	-	-	None	0-14%	Well drained	Mod.	B	No	P	VL	0.20
SacC	Sassafras sandy loam, 5 to 10 percent slopes	Sassafras	-	-	None	0-14%	Well drained	Mod.	B	No	SI	VL	0.25
SadC	Sassafras gravelly sandy loam, 5 to 10 percent slopes	Sassafras	-	-	None	0-14%	Well drained	Mod.	B	No	SI	VL	0.33
SadD	Sassafras gravelly sandy loam, 10 to 15 percent slopes	Sassafras	-	183	None	0-14%	Well drained	Mod.	B	No	No	VL	0.64

Map Unit Symbol	Map Unit Name	Component Name	Depth to Bedrock (inches)	Seasonal High Water Table Depth (inches)	Annual Flood Frequency	Ponding Frequency - Presence	Drainage Class	Potential Frost Action	Hydrologic Group✳	Hydric Soil?	Farmland? ◆	Septic Suitability★	Percent of Township
SapB	Sassafras-Urban land complex, 0 to 5 percent slopes	Sassafras	-	-	None	0-14%	Well drained	Mod.	B	No	No	VL	0.28
UdbB	Udorthents, bedrock substratum, 0 to 8 percent slopes	Udorthents	152	77	None	0-14%	Moderately well	Mod.	D	No	No	VL	1.78
UdcB	Udorthents, clayey substratum, 0 to 8 percent slopes	Udorthents	-	31	None	0-14%	Somewhat poorly	High	D	No	No	VL	0.14
UR	Urban land	Urban land	-	-	None	0-14%	-	-	-	NR	No	NR	7.77
WasAb	Watchung silt loam, 0 to 2 percent slopes, very stony	Watchung	-	15	None	0-14%	Poorly drained	High	D	Yes	No	VL	0.12
Water	Water	Water	-	-	-	0-14%	-	-	-	-	No	NR	1.60
WogB	Woodstown loam, 2 to 5 percent slopes	Woodstown	-	77	None	0-14%	Moderately well	Mod.	C	No	P	VL	0.00

✳**Hydrologic Group:** see **Table 4.2**
◆**Farmland:** **P**=Prime; **SI**=Statewide Importance; **No**=Not Prime Farmland
★**Septic Suitability:** **VL**=Very Limited; **NR**=Not Rated

Source: US Department of Agriculture, NRCS, Soil Survey Staff. November 21, 2012

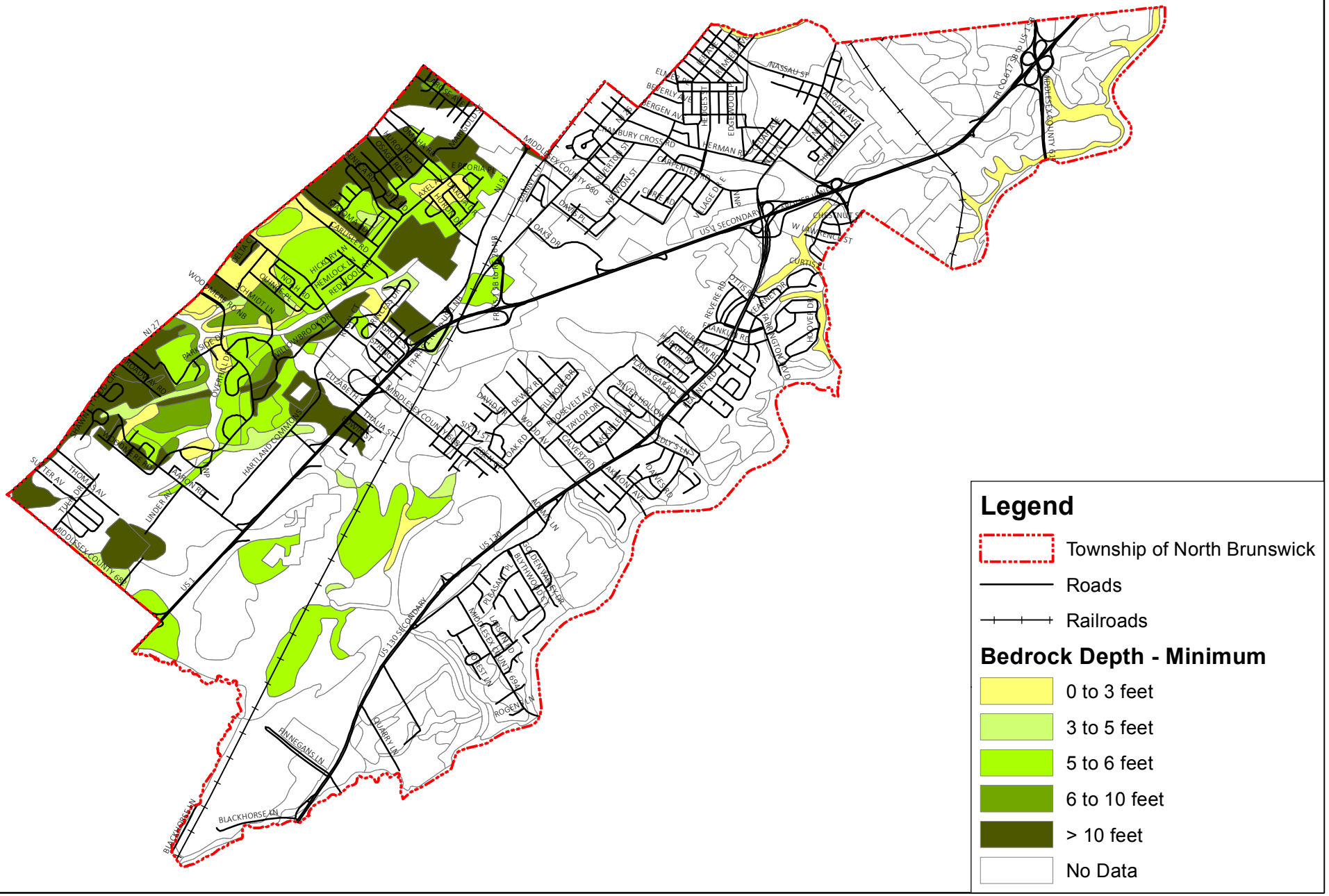

Figure 4b: Soils - Depth the Bedrock (minimum) (NRCS, 2012)

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

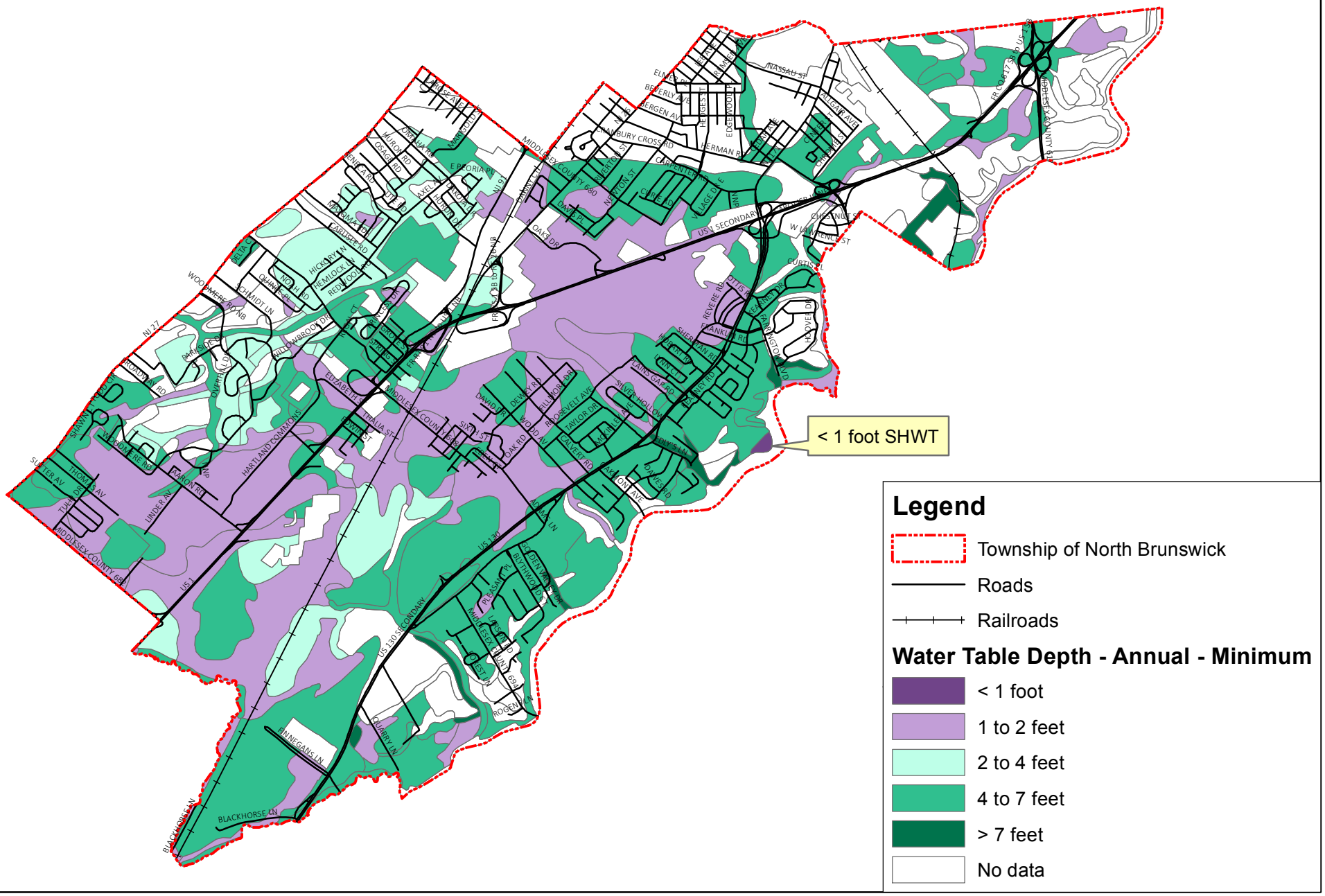

Figure 4c: Soils - Depth the Water Table (minimum) (NRCS, 2012)

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Table 4.2: Hydrologic Soil Grouping

Class	Definition
A	Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil.
B	Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded.
C	Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted.
D	Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted.
B/D	These soils have moderately low runoff potential when drained and high runoff potential when undrained.
C/D	These soils have moderately high runoff potential when drained and high runoff potential when undrained.
Source: USDA NRCS, June 25, 2012	

Septic Suitability (Figure 4e)

The NRCS gSSURGO database provides an interpretation of limitations of each soil for *septic suitability*. The interpretation shown in **Figure 4e** is based on the N.J.A.C. 7:9A Standards for Individual Subsurface Sewage Disposal Systems, Subchapter 10 Disposal Fields. Factors which may affect the functioning of the system, and therefore limit septic suitability, are excessively coarse substratum (which allows effluent to percolate to ground water too rapidly); presence of water (including depth to high water table, flooding, ponding, slow water movement and hydric soils); depth to restrictive layer (bedrock or restrictive substratum) and steep grades over 25%. N.J.A.C 7:9A prohibits septic systems in soils subject to flooding. In addition, septic disposal fields are prohibited in locations with the combination of slope greater than 10% and less than 50 feet upslope of any bedrock outcrop where signs of ground water seepage can be detected (NJDEP, April 2, 2012).

Figure 4e illustrates that North Brunswick's soils are very limited for use of septic systems (except a few areas that are "not rated"); therefore the township does not rely on any on-site septic systems.

Potential Acid Producing Soils (Figure 4f)

Soil pH is a measurement of the acidity or alkalinity level in the soil. Soil pH is important because it affects the availability of nutrients to plants and the toxicity of certain elements or ions. The element aluminum, for example, becomes toxic to many plants at soil pH < 5. While some plants require acid soils, such as blueberries, cranberries and rhododendrons, most plants prefer a pH of 6.0 to 6.8. Most soils in New Jersey are naturally acidic; i.e. they have a pH less than 7.0 (Murphy, no date). However, extreme acidification of the soil can occur when certain acid-producing sediments are excavated and exposed to air. These include Cretaceous and Cenozoic marine and estuarine sediments which contain sulfide minerals, such as pyrite and elemental sulfur. Rainwater combines with these chemicals and the sulfuric acid leachate can result in a pH to < 4, creating conditions unsuitable for plant growth, impacting nearby bodies of water, and damaging concrete structures (NJGS, May 24, 2010).

In the geologic units that are capable of producing acid conditions, including the Magothy Formation in North Brunswick, the New Jersey Department of Agriculture requires that land disturbances (such as construction) must have and implement erosion-control plans under the Standards for Soil Erosion and Sediment Control Act (P.L. 1975, chapter 251, N.J.S.A. 4:24-39 et seq.) (NJGS, May 24, 2010) (See **Figure 4f)**.

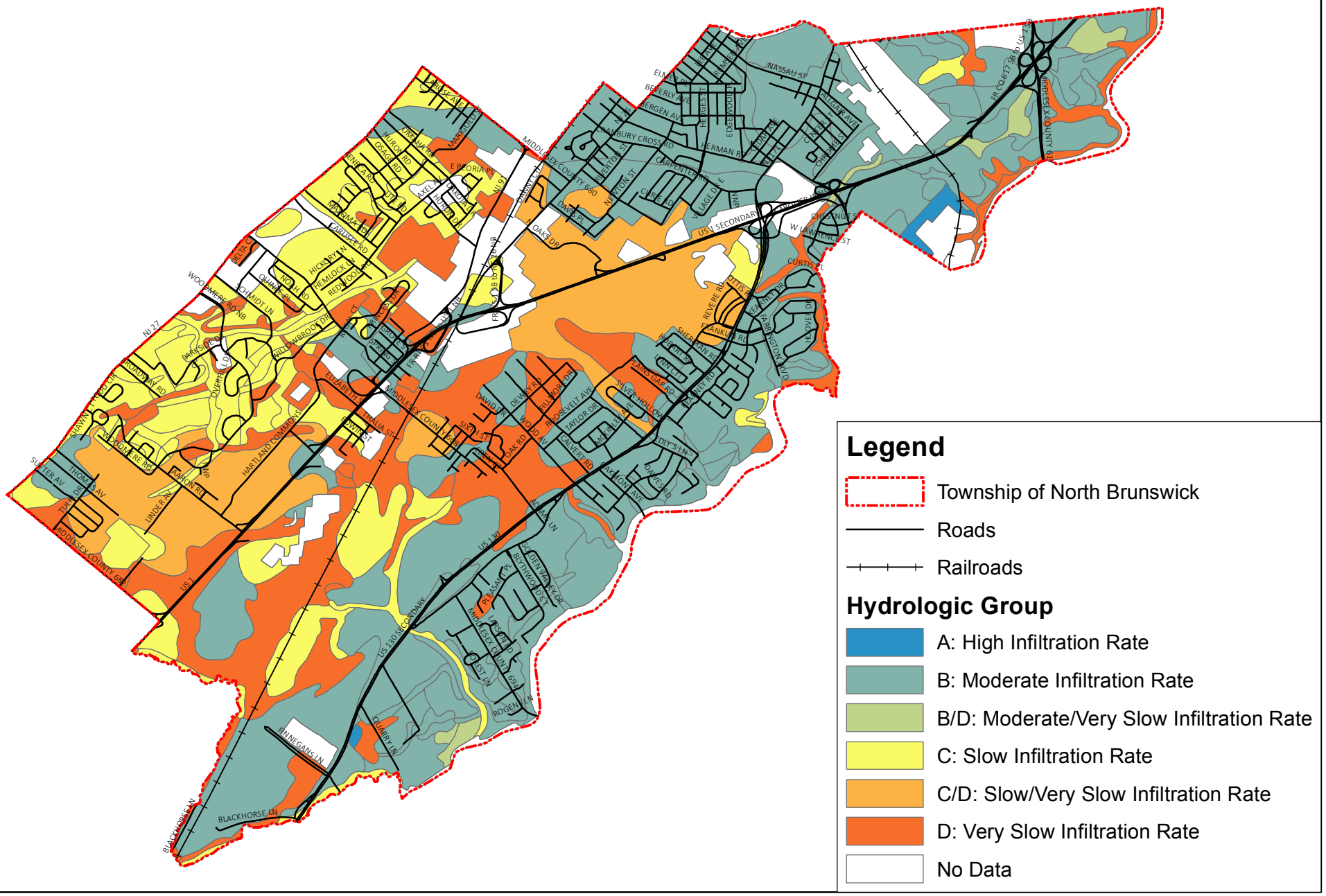

Figure 4d: Soils - Hydrologic Group (NRCS, 2012)

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Soil Drainage Class (Figure 4g)

Soil Drainage Class is a code identifying the natural drainage condition of the soil and refers to the frequency and duration of periods when the soil is free of saturation or partial saturation during soil formation, and does not refer to saturation due to recently altered drainage (manmade or natural). The categories are as follows: well drained, moderately well drained, excessively drained, somewhat excessively drained, poorly drained, and somewhat poorly drained. About 22% of North Brunswick is well drained, and 31 % moderately well drained. Generally speaking, the less well drained soils are found in the higher elevations of the township (10% somewhat poorly drained and 25% poorly drained). A very small area of very poorly drained soil can be found adjacent to the Lawrence Brook in the vicinity of Edly's Lane. The 2% of the township with somewhat excessively drained soils corresponds to the steeper slopes (see **Figure 4g).**

Agricultural Soils (Figure 4h)

Under the Federal Crop Insurance Reform and Department of Agriculture Reorganization Act, NRCS has responsibility for conducting inventories of farmland and is concerned about any action that may harm the productivity of American agriculture. *Prime Farmland Soils* include soils that have the best combination of physical and chemical characteristics for economically producing sustained high yields of crops when treated and managed according to acceptable farming methods and is also available for these uses. These soils have the soil quality, growing season, and moisture supply needed; they are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding. *Farmlands of statewide importance* include those soils with characteristics that are nearly Prime Farmland. They economically produce high yields of crops when treated and managed according to acceptable farming methods. Some may produce yields as high as Prime Farmland if conditions are favorable (USDA NRCS NJ, July 2013).

While 52% of North Brunswick does not have prime agricultural soil, 30% of the township does (2,394 acres), and 18% has soils that are of statewide importance (1,402 acres) (see **Figure 4h**). Not surprisingly, the agriculture that still exists in the township, such as Cook College, is found on prime agricultural soils. The Pulda Farm, now preserved open space, is mostly farmland of statewide importance and partially prime agricultural soils.

Potential Frost Action (Figure 4i)

Potential Frost Action is an interpretation rating of the susceptibility of the soil to frost heaving. Most soils within North Brunswick have high potential frost action, many have moderate, while only the Psamments has low and only the Klinesville-Urban Land complex has no potential frost action.

Flooded and Hydric Soils

Annual flood frequency is a descriptive term used to describe the frequency of flooding that is likely to occur in a year. **Frequent** is > 50% chance of flooding in a given year; **occasional** is 5 to 50%; **rare** is 0 to 5% chance of flooding. In North Brunswick, the Humaquepts and the Rowland silt loam soils bordering the Lawrence Brook, Oakeys Brook and Six Mile Run frequently experience flooding (see **Table 4.1** (found on pages 65 to 69); **Figure 6c** shows floodplains).

Hydric soils are those soils that are wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants. For delineation of hydric soils the ponding

event must last greater than seven days. The Elkton, Falsington, Humaquepts and Mullica soils are hydric soils found within North Brunswick.

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http://soils.usda.gov/survey/geography/ssurgo/description_gssurgo.html

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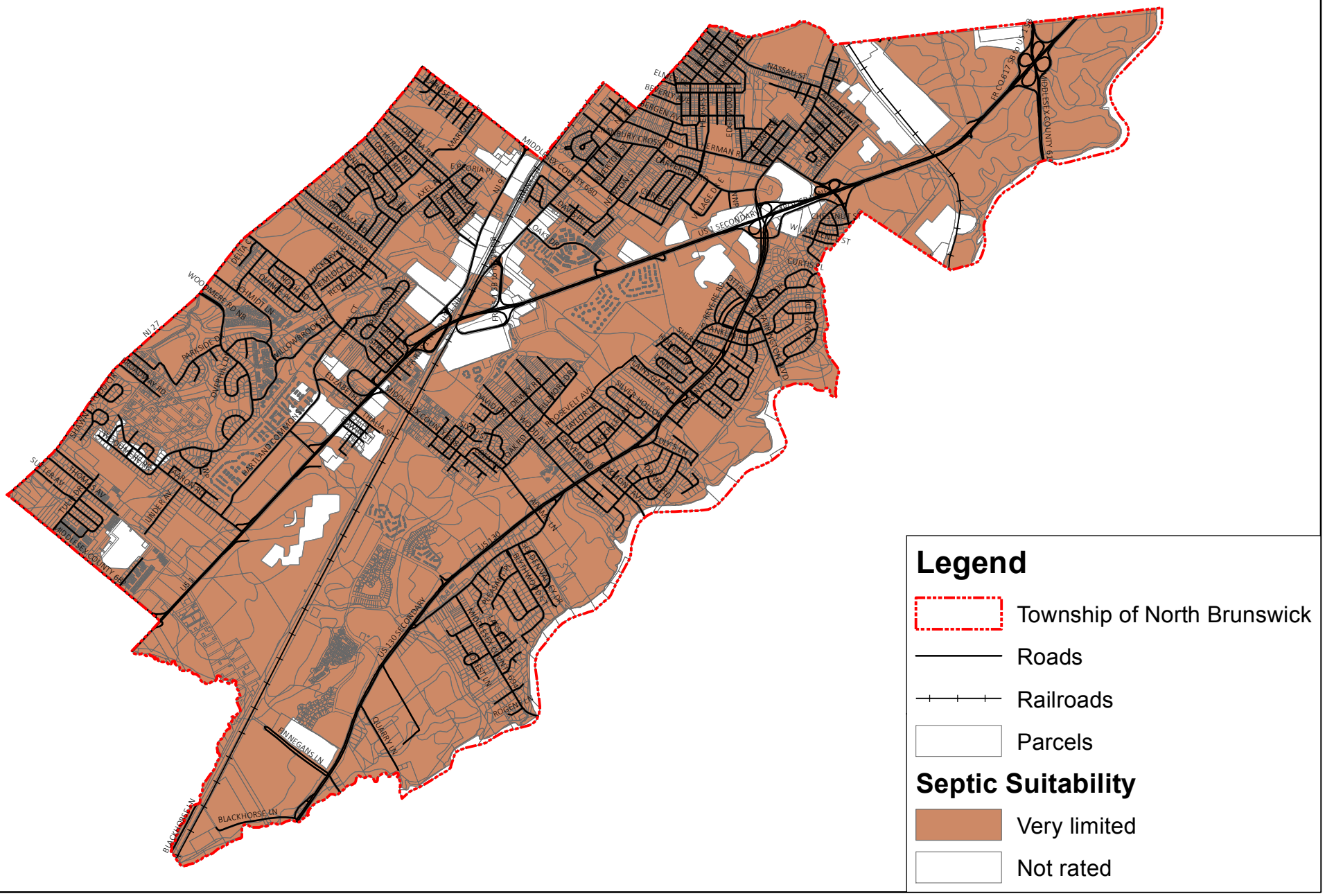

Figure 4e: Soils - Septic Suitability (NRCS, 2012)

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
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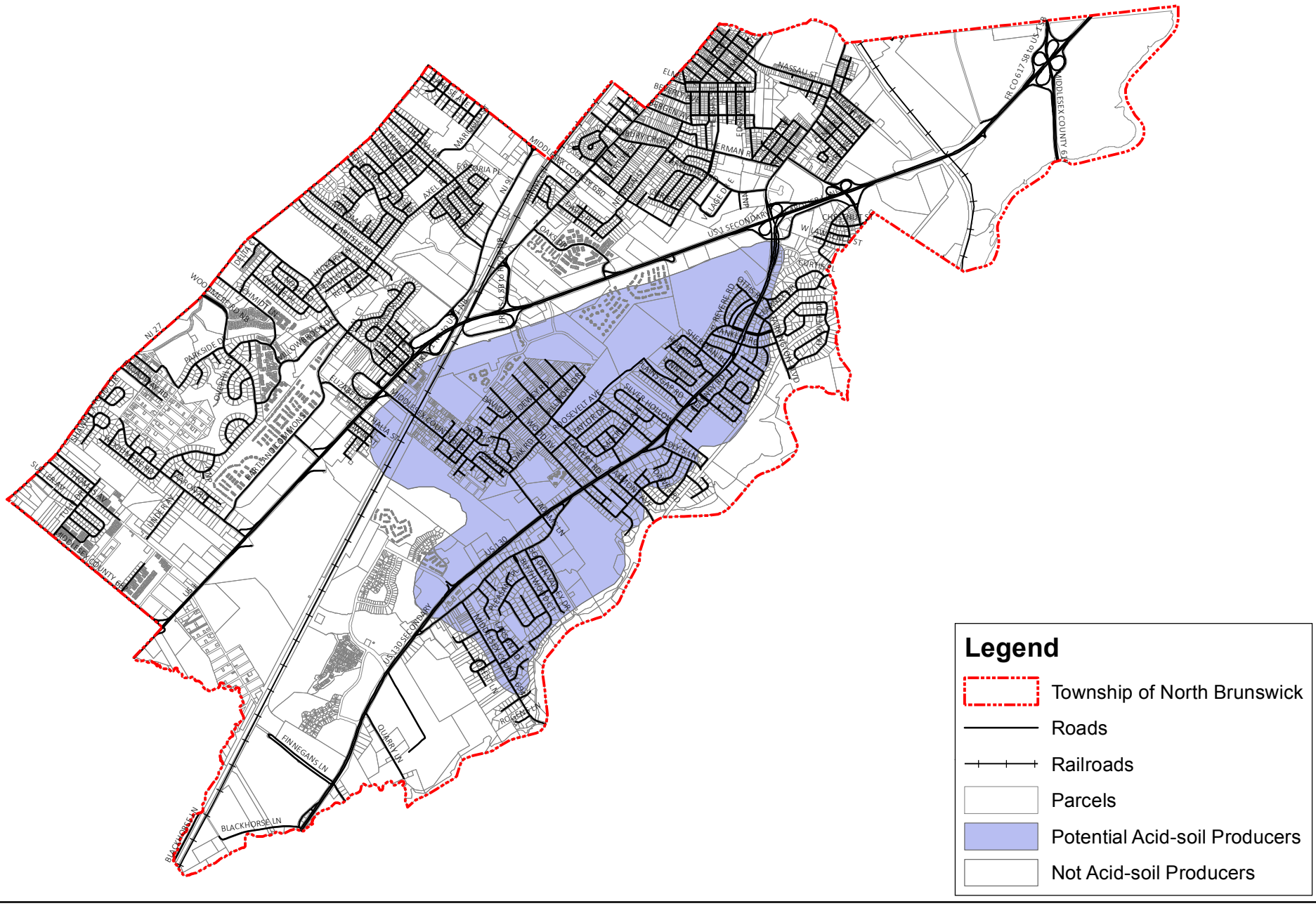

Figure 4f: Potential Acid Produducing Soils

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
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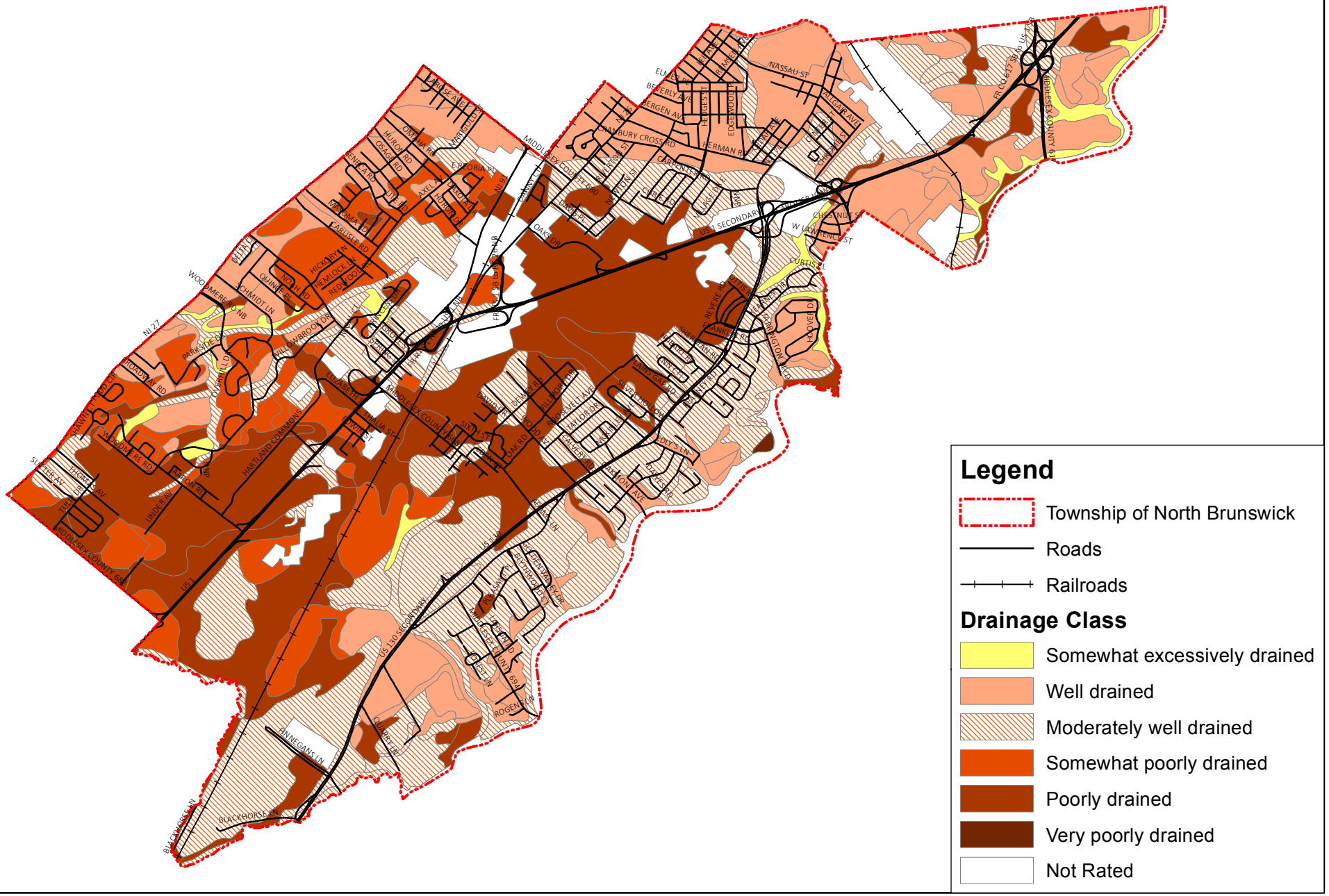

Figure 4g: Soils - Drainage Class (NRCS, 2012)

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
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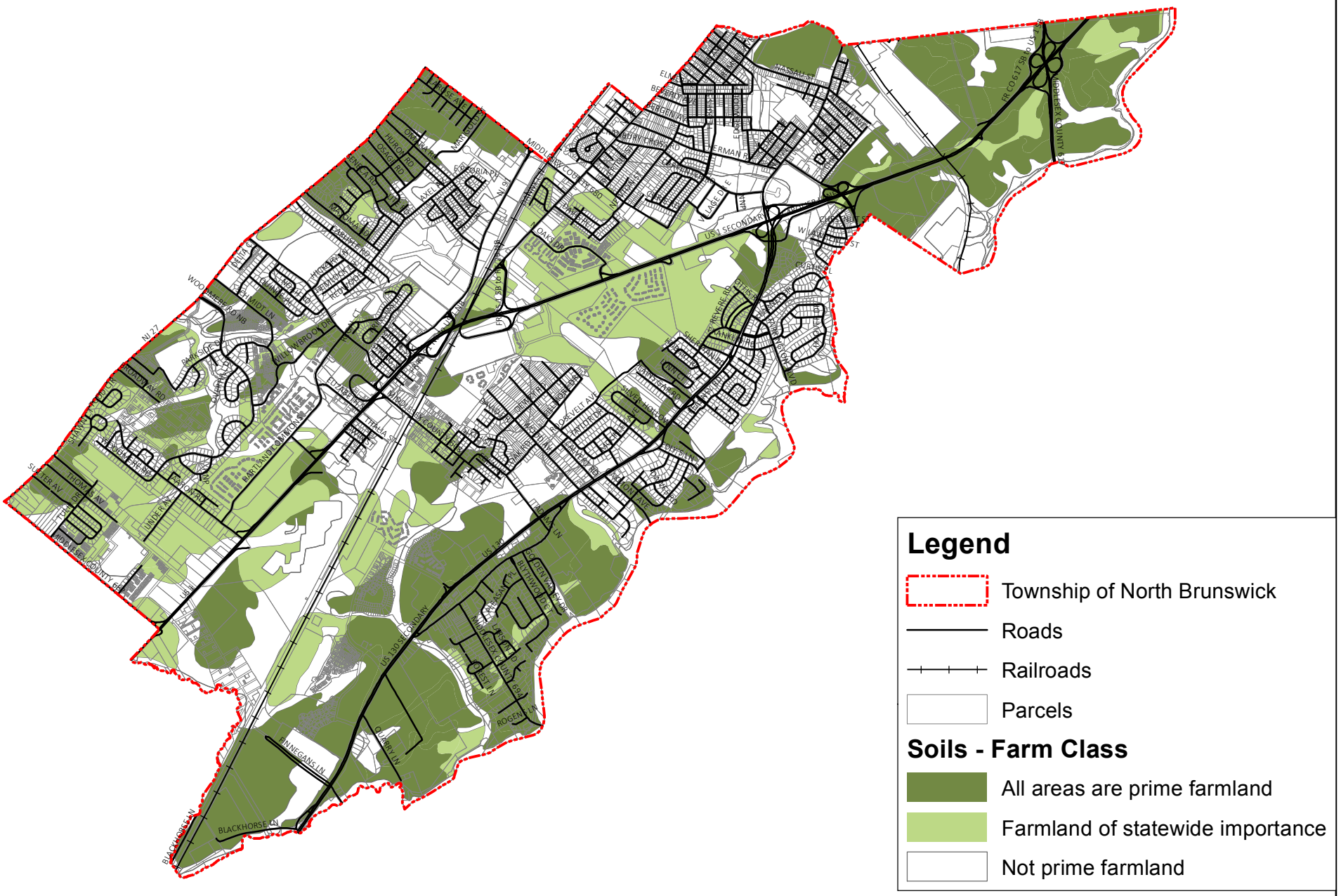

Figure 4h: Agricultural Soils (NRCS, 2012)

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

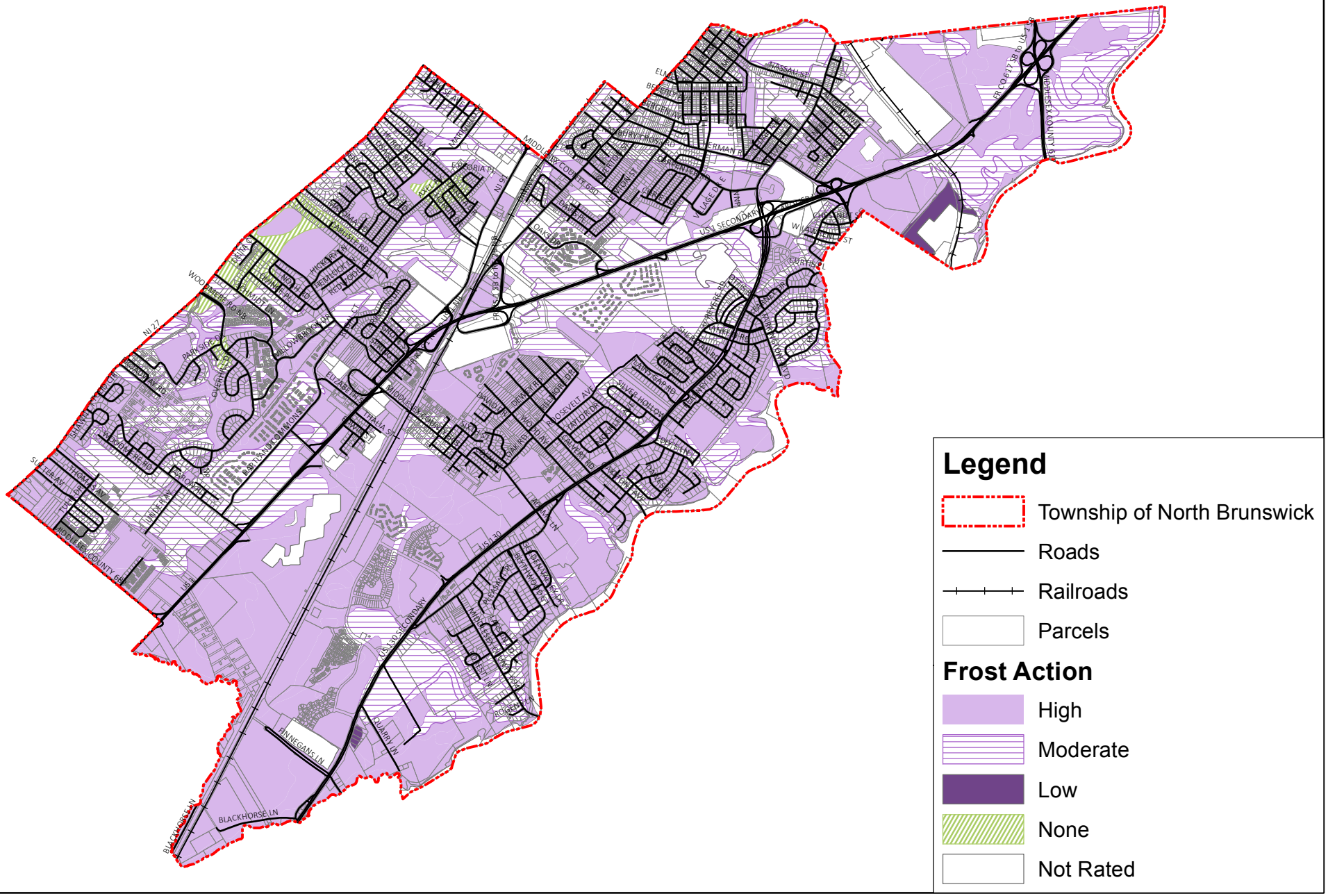

Figure 4i: Soils - Frost Action (NRCS, 2012)

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Internet Resources: Soils

NRCS New Jersey Office: http://www.nj.nrcs.usda.gov/

NRCS Soils Website: Helping People Understand Soils: http://soils.usda.gov/

NRCS Soil Data Mart (download soils data for GIS): http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

NRCS Soils Online Study Guide: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/nj/home/?cid=nrcs141p2_018928

Rutgers New Jersey Agricultural Experiment Station Soil Testing Laboratory Interpretation of Organic Matter Levels in New Jersey Soils: http://njaes.rutgers.edu/soiltestinglab/pdfs/nj-om-interpret.pdf

Web Soil Survey: Instructions: ftp://ftp-fc.sc.egov.usda.gov/NSSC/pub/WSS_brochure.pdf
Web Soil Survey Site (online soils mapping): http://websoilsurvey.nrcs.usda.gov/app/

5: GROUND WATER & DRINKING WATER

A. Water Cycle

Water is essential to all life on Earth. The abundance of water distinguishes the Earth from any other planet, but the amount of water on Earth has remained constant for millennia. Even though the quantity of water is great, only a small portion can be used for drinking water and other human needs. Ninety-seven percent of the world's water supply is saltwater stored in the oceans. The remaining 3% is fresh water. However, most of this is unavailable for human use because it is frozen in the polar ice caps, glaciers, and icebergs; too difficult to tap (below 1.6 miles depth); or too polluted. This leaves 0.003% of water that is available as fresh surface or ground water that humans can use (Miller, 1988).

Surface water is water that is visible above the ground surface, such as creeks, rivers, ponds, lakes, and wetlands. *Ground water* is that portion of water beneath the land surface that is within the zone of saturation (below the water table) where pore spaces are filled with water. An *aquifer* is a water-bearing rock or rock formation where water is present in usable quantities. Water is constantly recycled through the *hydrologic cycle*, also known as the *water cycle* (see **Figure 5a***)*. Precipitation falls on the ground and some travels on the surface of the land (called *surface runoff*), entering streams (where it can be seen as high flows after rain events), and eventually making its way back to the ocean. Some of the water from precipitation enters the ground but remains in the shallow layers where it is available for use by plants, where it returns to the atmosphere through *transpiration* by plants, while some water re-enters the atmosphere directly through *evaporation* from surface water. Evaporation and transpiration combined are known as *evapotranspiration*. The water that migrates below the root zone travels underground and exits the system as stream flow, known as *ground water baseflow* or *ground water recharge*. Ground-water baseflow can be calculated by measuring stream flow during dry weather conditions. A smaller portion of the water penetrates deeper into the ground and enters (or recharges) the saturated zone of the fractured bedrock, called the *aquifer*, where most wells obtain their water.

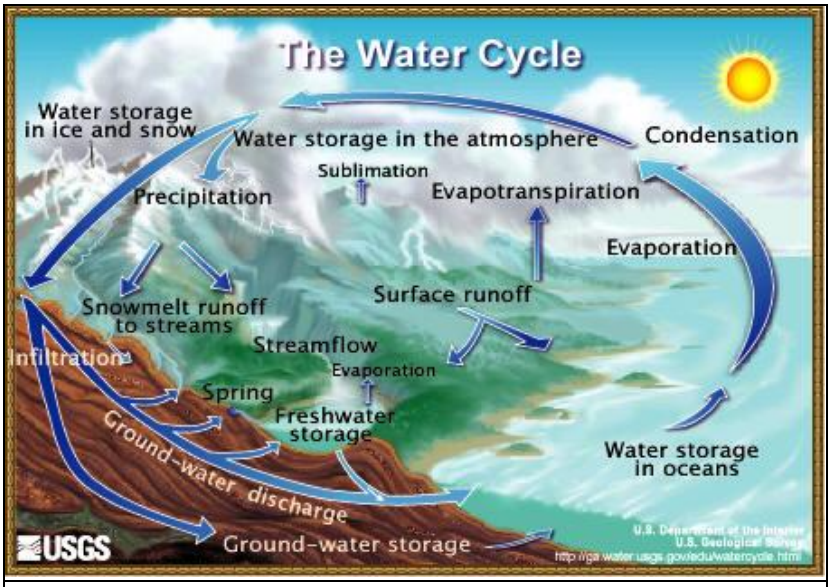

Figure 5a: The Water Cycle

Source: USGS, no date

Pollutants can enter water as it travels the water cycle. Surface runoff can pick up chemicals and soil on its way, depositing these pollutants in waterways. This is especially true of "uncontrolled runoff" on soils that are vulnerable to erosion. Water seeping into the soil can be cleansed of many pollutants by natural soil processes. However, if the pollutant is one that is

resistant to break-down, or if the pollutant doesn't get exposed to the soil long enough (such as by entering a bedrock fracture or by entering the ground water through sub-surface disposal), pollutants can spread underground and pollute sources of drinking water.

Movement of ground water is usually quite slow, on average, ranging from about one foot per day to perhaps ½ inch per month. Therefore, in some areas, it might take days for water to travel from the point where it enters the ground, to a point of discharge into a stream, or it might take millennia (Heath, 1983). However, ground water in North Brunswick, because it is present in fractures, can potentially move much more quickly. The rates of movement in large fractures may approach those observed in surface streams (Heath, 1983; Freeze and Cherry, 1979). A contaminant could also travel quickly through fractures, with little soil contact to allow for filtration or degradation of pollutants. Thus, a well located on a large fracture might have a very good yield, but may be highly susceptible to contamination.

An understanding of the water cycle emphasizes the connections between surface and ground water. While the Township of North Brunswick relies exclusively on public water (not individual wells), the water is no less part of the natural water cycle, and is susceptible to human impacts and the influence of climate and geology.

B. The Aquifers of North Brunswick

Almost half of New Jersey's drinking water comes from ground water. In the northern half of New Jersey, aquifer boundaries roughly correspond to physiographic province boundaries (discussed in **Section 3a** and **Figure 3a**).

The hydrogeologic characteristics of an aquifer are dependent on the type of bedrock. The report Geology as a Guide to Regional Estimates of Water Resources states:

> "The six guiding principles in the application of geology to rock country [bedrock aquifer] wells are: (1) there is no correlation between depth and yield, (2) each drainage basin, no matter how minor, is a surface and ground water entity, (3) water is usable only from fractures, fissures and solution openings, (4) successful industrial wells are completed in the first 200 to 500 feet of rock, (5) porous and permeable Pleistocene or deep weathered rock regolith zones [such as are found in portions of Oakland] above the rock will usually act as a built-in reservoir to increase well capacity and (6) glacial till, heavy clay soil, or bedrock close to the surface will decrease well yields." (Widmer, 1968, p. 11)

The density of housing and impervious surfaces can impact aquifers and may result in reduced recharge, lowered yields, increased interference (wells interfering with each other), and degradation of ground water quality. Furthermore, these changes can alter stream flow dynamics resulting in higher flows after storm events and lowered flows between events.

The Township of North Brunswick is underlain by two types of aquifers: coastal plain and bedrock. There are three different bedrock aquifers in North Brunswick: 71% of the township is underlain by the Passaic[23] aquifer; 8% Lockatong aquifer; and 0.1% Diabase. The Coastal Plain aquifer is underneath 21% of the township. The aquifers are discussed in the paragraphs below and shown in **Figure 5b**, while the aquifers' characteristics are summarized in **Table 5.1**.

Coastal Plain – Potomac-Raritan-Magothy

The Potomac-Raritan-Magothy formation underlays about 21% of North Brunswick.

[23] Also called the Brunswick aquifer.

The Potomac-Raritan-Magothy aquifer system, one of the Coastal Plain aquifers, is considered one of the most productive aquifers in the state. It is a wedge of unconsolidated sedimentary rocks, with the thin edge at the Fall Line in the north (including North Brunswick), and thickening to 6,000 feet beneath the mouth of the Delaware Bay (Richards et al., 1983). It is only as much as 180 feet in depth in the New Brunswick Quadrangle (Stanford et al., 1998). The aquifer consists of alternating layers of sand, gravel, silt, and clay. Water is stored in *primary porosity*[24], and the aquifer is confined except where it outcrops or is overlain by permeable surficial deposits. Recharge comes directly from precipitation in outcrop areas, by vertical leakage through confining beds, and by seepage from surface-water bodies. Water quality is good, except iron and manganese can be high, and some areas are impacted by saltwater intrusion and waste disposal (USGS, January 14, 2013).

According to one study, average yields are 19 GPM for domestic wells, and 327 GPM for industrial wells (Widmer, 1968).

Bedrock Aquifers of the Newark Group – Passaic, Lockatong and Diabase

The majority of North Brunswick is underlain by bedrock aquifers: The Passaic aquifer is beneath 71% of the township; Lockatong aquifer is under 8%; while Diabase is below just 0.1% of the area.

In bedrock aquifers, rocks near the land surface experience weathering, caused by freezing and thawing of water, which has widened fractures and dissolved some of the intergranular cement in the sedimentary rocks. This type of bedrock yields water mostly from *secondary porosity* and permeability provided by fractures. Rocks below the weathered zone, which is usually about 75 feet thick, have no *primary porosity* (Lewis-Brown and Jacobsen, 1995). Therefore, the distribution and orientation of these fractures control the rates and directions of ground water flow. The water bearing structures underground may bear little resemblance to the overlying topography.

Unconfined conditions commonly exist above this level of about 75 feet because pores and fractures in this material are usually well-connected. Below this level, *confined* conditions are caused by the presence of low-permeability layers containing relatively few fractures (Lewis-Brown and Jacobsen, 1995).

The Lockatong and Passaic aquifers are composed of sandstone, siltstone, and shale of the Late Triassic Newark Group of sedimentary rocks. Ground water is stored and transmitted in fractures. The water-bearing units are composed of fissile[25] shale and siltstone, and the confining units are composed of massive siltstone. These formations are characterized by several layers of extensively fractured rocks (water-bearing units) that typically are 1 to 10 feet thick interbedded with layers of sparsely fractured rocks (confining units) that typically are 30 to 100 feet thick. These geologic formations extend thousands of feet below ground, but the density of fractures decreases with depth. Water-bearing, interconnected fractures are present only from the land surface to a depth of about 300-500 feet in the Piedmont (EPA, 1988; Houghton, 1990).

Kasabach (1966) indicates that initial yields in these formations are high and that these yields decrease with time as fractures are dewatered.

The argillite rocks of the Lockatong formation and diabase rocks are among the poorest (lowest yielding) aquifers in New Jersey due to the scarcity of fractures (Kasabach, 1966; USGS,

[24] *Porosity* is the measure of voids in soil or rock, which are available to hold water (like holes in a sponge). *Primary porosity* is due to spaces between the soil or rock particles or within porous rock particles. *Secondary porosity* is found in fractures in bedrock. Aquifers with primary porosity store far more water than those with only secondary porosity.

[25] *Fissile* means capable of being split.

January 14, 2013). In a 1968 study, average yield for Lockatong argillite domestic wells is 9 GPM and industrial wells averaged 32 GPM. Domestic wells in the Brunswick shale averaged 15 GPM and industrial wells yielded 110 GPM. Diabase domestic wells averaged 9 GPM while there were no industrial wells in the diabase (Widmer, 1968).

Table 5.1: Characteristics of Aquifers of North Brunswick

Aquifer	State Rank*	Characteristics	Common Range		Percent of Township
			Depth (ft.)	Yield (gpm)	
AQUIFERS AND CONFINING UNITS OF THE COASTAL PLAIN					
Potomac-Raritan-Magothy Aquifer System (prma)	A	Alternating layers of sand, gravel, silt, and clay. Confined. Highly productive and most used confined aquifer in the Coastal Plain. Aquifer system extends throughout Coastal Plain and attains maximum thickness of 4,100 ft., but only up to 180 feet in the North Brunswick Quadrangle. Salty water increases with depth and in down-dip direction. Excellent water quality but large iron concentrations in some areas.	50-1,800	500-1,000	20.92
FRACTURED-ROCK AQUIFERS					
Passaic (Brunswick) aquifer (ba)	C	Sandstone, siltstone, and shale. Ground water stored and transmitted in fractures. Water is normally fresh, slightly alkaline, non-corrosive and hard. Calcium-bicarbonate type waters dominate. Subordinate calcium-sulfate waters are associated with high total dissolved solids.	30-1,500	10-500	71.30
Lockatong Formation (lf)	D	Silty argillite, mudstone and fine-grained sandstone and siltstone with minor limestone. Ground water stored and transmitted in fractures. Water is normally fresh, slightly alkaline, noncorrosive and hard. Calcium-bicarbonate type waters dominate.	30-1,500	10-500	7.66
Diabase (db)	E	Hard and dense igneous rocks. Ground water stored and transmitted in fractures. Few high-capacity wells. Water is normally fresh, slightly to highly alkaline, moderately hard, and of the calcium-bicarbonate type.			0.12

*** State Rank** is based on High Capacity Wells (such as water-supply, irrigation, and industrial-supply wells sited and tested for maximum yield. Many of the wells have boreholes exceeding the standard six-inch diameter for domestic wells. State Rank is best viewed on a relative basis, with "A" yielding the most water, and "E" the least. Median High Capacity Wells Yield (in gpm): [A] > 500; [B] 251 to 500; [C] 101 to 250; [D] 25 to 100; [E] <25

Sources: Herman et al., 1998; USGS, January 14, 2013a&b

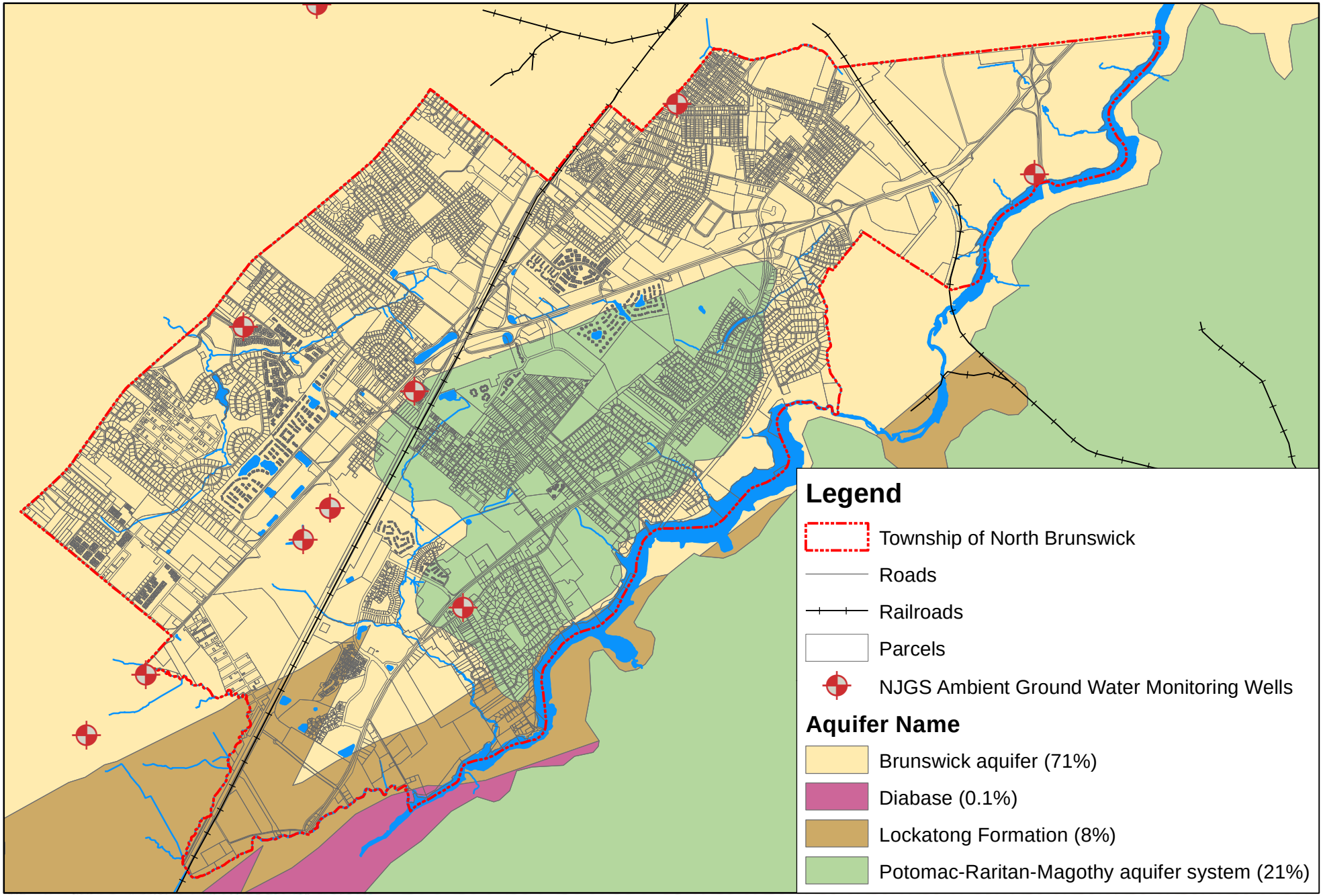

Figure 5b: Aquifers and Ground Water Monitoring

0 0.25 0.5 1 Miles

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N

Data Sources: NJDEP
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C. North Brunswick's Water Source

As discussed in **Section 2C**, the Township of North Brunswick currently obtains its water supply (up to 8 MGD) from the Delaware and Raritan Canal, which is treated at the township-owned Water Treatment Plant, located in neighboring Franklin Township (Heyer, Gruel & Associates Urban Engineers, Inc., May, 2006).

The Delaware and Raritan Canal (D&R Canal) was constructed in 1834 for transporting freight between Philadelphia and New York. A total of 43 miles of the main canal connect Trenton on the Delaware River and New Brunswick on the Raritan River, while 22 miles of feeder canal join Bull's Island in Hunterdon County and Trenton (illustrated in **Figure 5c**). The D&R Canal was taken over by the State of New Jersey in 1934 and was later rehabilitated to serve as a public water supply transmission system (NJWSA, 2013).

The New Jersey Water Supply Authority (NJWSA) was created in 1981 (P.L. 1981, c.293) and was established as a public entity "in but not of" the NJDEP. All water supply facilities owned or operated by the State of New Jersey were transferred to the NJWSA, which is supported by water fees. As a result, the NJWSA now operates the Delaware & Raritan Canal Transmission Complex as part of the Raritan Basin Water Supply System (which also includes Round Valley Reservoir and Spruce Run Reservoir). Water purveyors purchase raw water from NJWSA to distribute to approximately 1.5 million central New Jersey residents for drinking, irrigation, recreation and industrial uses (NJSA, 2013; NJWSA, 2005).

In 2005, NJWSA developed a new model of the Raritan Basin System to assess the safe yield, operational protocols, and future water supply alternatives. The *safe yield* is the amount of water that can be supplied without fail during the drought of record. The safe yield from the Raritan Basin was determined to be 241 million gallons per day (MGD) (176 MGD from the Raritan River and 65 MGD from the D&R Canal) (NJWSA, 2005).

D. Sole-Source Aquifers

The Safe Drinking Water Act (SDWA) of 1974 contains a provision in Section 1424(e) that provides for designating an aquifer that is the sole or principal drinking water source for an area and that, if contaminated, would create significant hazard to public health. As defined by the U.S. Environmental Protection Agency (EPA), s*ole-source aquifers* (SSA) are those aquifers that contribute more than 50% of the drinking water to a specific area and the water would be impossible to replace if the aquifer were contaminated. Once designated, no Federal financial assistance may be approved for any project that may contaminate the aquifer through a recharge zone so as to create a significant hazard to public health (US EPA, June 1988). Therefore, the EPA must review any federally-funded project in an area that could affect ground water in a sole-source aquifer, including the *aquifer's recharge zone* (the area through which water recharges the aquifer) and its *stream-flow source zone* (the upstream area that contributes recharge water to the aquifer).

In November 1985, NJDEP petitioned the EPA to designate nearly all of the state as a SSA (excluding urban areas around Trenton and in Northeastern NJ). However, some areas did not meet the technical criteria for SSA designation (US EPA, June 1988). As a result, North Brunswick is not part of a SSA.

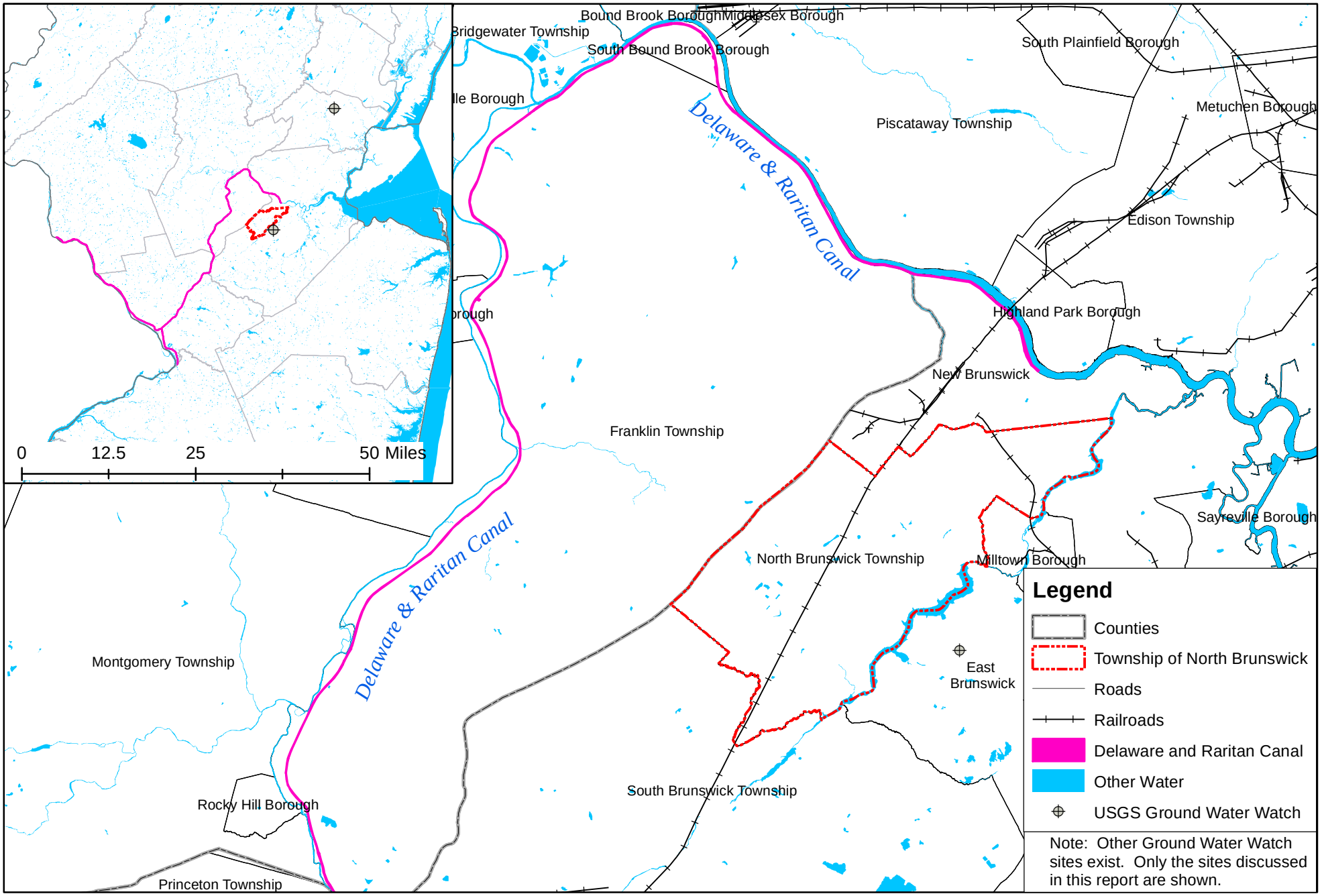

Figure 5c: Delaware & Raritan (D&R) Canal

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
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E. Recharge

Ground water recharge is defined as water added to an aquifer (for example, precipitation that seeps into the ground deep enough to enter the saturated zone of the fractured bedrock). A g*round water recharge area* is the land area that allows precipitation to seep into the saturated zone. These areas are generally at topographically high areas with discharge areas at lower elevations, commonly at streams or other water bodies (i.e. the ground water returns to surface water). In general, ground water divides coincide with, or are slightly offset from, surface water divides (Lewis-Brown and Jacobsen, 1995) (watersheds are described in **Section 6A** and shown in **Figure 6a**). Most ground water flows through the shallow layers of soil and weathered bedrock to the nearest stream. A smaller percentage penetrates deeper and recharges the aquifer.

Recharge rates are expressed in terms of the amount of precipitation that reaches the aquifer per unit of time (e.g. inches/year is used in **Figure 5d**). New Jersey receives an average of 44 inches of precipitation annually, and references vary widely about how much reaches the aquifer (Lewis-Brown and Jacobsen, 1995; Kasabach, 1966; USGS, 2013) in areas like North Brunswick. This is because, while precipitation can be accurately measured, recharge cannot be directly measured. Many factors affect the amount of recharge that will occur in a given area, including climate (e.g. the amount, intensity, and form of precipitation, and the effect of wind, humidity and air temperature on evapotranspiration), soil, surficial geology, and vegetation factors. In addition, recharge of ground water varies seasonally. During the growing season, precipitation is intercepted by plants and returned to the atmosphere through transpiration (part of the hydrologic cycle, see **Section 5A**). Likewise, evaporation is higher during the warmer months. Together, these are known as *evapotranspiration*. Therefore, most recharge occurs during late fall, winter, and early spring, when plants are dormant and evaporation rates are minimal (Heath, 1983). Relative to land use, recharge rates in forests are much higher than those in urban areas (Heath, 1983). This is because urban areas have large areas covered with impermeable surfaces, hastening runoff to surface water, instead of allowing precipitation to percolate into the ground.

To ensure that water is available during all weather conditions for human consumption as well as ecosystems dependent on water, the NJDEP established the Planning Threshold, or *dependable yield,* to be used for planning purposes. *Dependable yield* is defined as "the water yield maintainable by a ground-water system during projected future conditions, including both a repetition of the most severe drought of record and long-term withdrawal rates without creating undesirable effects." The most severe drought on record was in the early 1960's (see **Section 2A**), and this is used in the Statewide Water Supply Plan. However, the Plan acknowledges that there is insufficient long-term precipitation data to prove that this is the worst drought that could occur in the future, in duration or severity, and recommends re-evaluation of safe-yield estimates and development of optimal strategies for severe droughts (NJDEP OEP, 1996). Robert Canace, of the NJ Geological Survey, suggested that 20% of the estimated recharge should be used for planning purposes, representing the portion of recharge actually available for use during drought conditions (Canace, 1995).

In view of the importance of not exceeding the aquifers' safe yield, the New Jersey Geological Survey has completed studies quantifying recharge, as discussed in the following sections.

New Jersey Geological Survey Recharge Method GSR-32

N.J.S.A. 58:11A, 12-16 required the NJDEP to publish a methodology to map and rank aquifer-recharge areas. In addition, the legislation required the development of ground water protection practices designed to encourage ecologically sound development in aquifer-recharge

areas (Charles et. al., 1993). To fulfill the requirements of this legislation, the NJ Geological Survey developed GSR-32, which estimates ground water recharge (but not aquifer recharge), and is useful for evaluating the relative effect of present and future land uses on recharge areas (Charles et. al., 1993). For this method, recharge was calculated based on data for precipitation, soil, land-use/land-cover[26], surface runoff, and evapotranspiration. This method was then applied by NJGS to create a GIS coverage (see **Figure 5d**). There were a number of assumptions made for the calculations and model inputs that limit the accuracy of the method: 1) the calculated ground water recharge includes any water entering the ground (lesser amounts actually enter the aquifer); 2) assumes that all water that migrates below the root zone recharges the aquifer (which doesn't happen); 3) addresses only natural ground water recharge, and does not include artificial recharge, withdrawals or natural discharge; 4) wetlands and water bodies were eliminated from analysis, because the direction of flow between ground water and surface water is site-specific and also varies seasonally, and this level of detail was beyond the scope of the study (these areas were assumed to provide no recharge or discharge); 5) stream baseflows used may not be representative of local streams (Charles et. al., 1993) and 6) does not consider topography, depth to bedrock, presence of impervious surfaces, and/or type of bedrock underlying soils. An additional limitation of the data is that they estimate long-term average annual recharge, which does not represent the reduced recharge during critical summertime conditions (NJ Water Supply Authority, 2002).

The method estimated average annual subsurface recharge rates from 0 to 15 inches per year in North Brunswick (excluding surface water, wetlands and hydric soils) and 0 to 12 inches per year during drought (shown on **Figure 5d**). Applying the 20% consumptive use limit to these figures results in usable recharge from 0 to 2.4 inches per year. As previously mentioned, only a portion of water entering the ground actually recharges the aquifer, but since GSR-32 did not attempt to quantify this amount, this method would be better described as *soil recharge*.

New Jersey Geological Survey Ground Water Potential

In 2005, also in response to N.J.S.A. 58:11A, 12-16, the NJ Geological Survey developed a qualitative representation of the potential for aquifer recharge. This was created by combining ground water recharge rankings and aquifer rankings. NJGS assigned a relative rank based on the inches of ground-water recharge per year (mapped in **Figure 5d**), from A (highest recharge) to E (lowest recharge). Relative values of aquifer yield (based on high yield industrial wells and described in **Table 5.1**) were assigned to each aquifer, from A (highest yield) to E (lowest yield). The State Ranks for the aquifers underlying North Brunswick are A, C, D and E. For both data sets, areas of wetlands, open water and hydric soils were not ranked, since individual areas differ in whether they increase or decrease recharge, which varies seasonally. These two ranks are combined in the format "ground water recharge rank/aquifer recharge rank" and illustrated in **Figure 5e**. For example, A/A would be an area with the highest relative recharge and highest yield, and an area designated E/E would have the lowest recharge and lowest yield, while other combinations would lie somewhere in between (French, 2004a&b).

[26] Land use/land cover data from 1995-1997 were used for this study. Changes in land use/land cover and impervious surfaces affect recharge, but are not shown on **Figures 5d** or **5e**, because this involves complex calculations, and NJGS has not updated this GIS data layer.

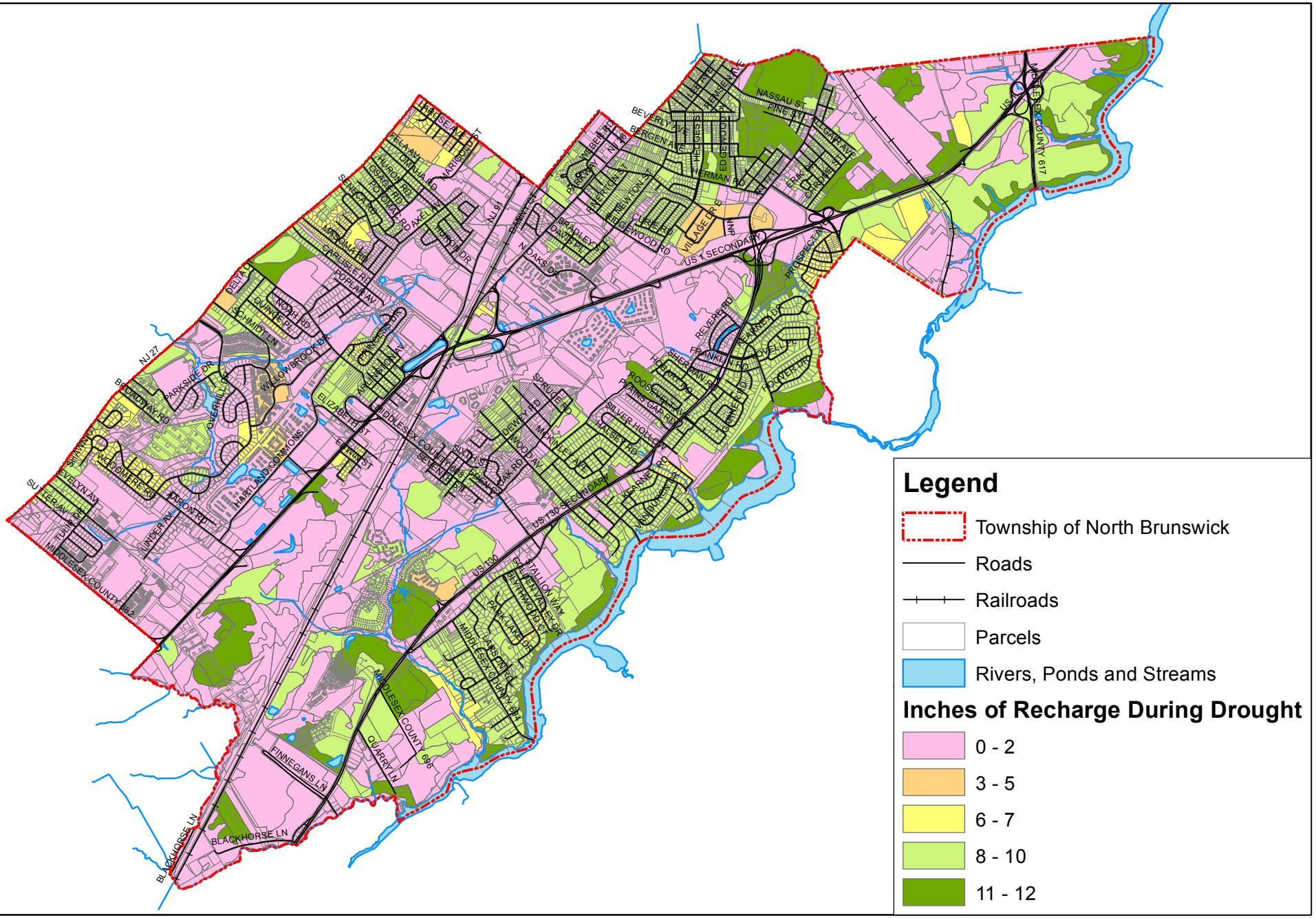

Figure 5d: Recharge (NJGS)

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
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N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
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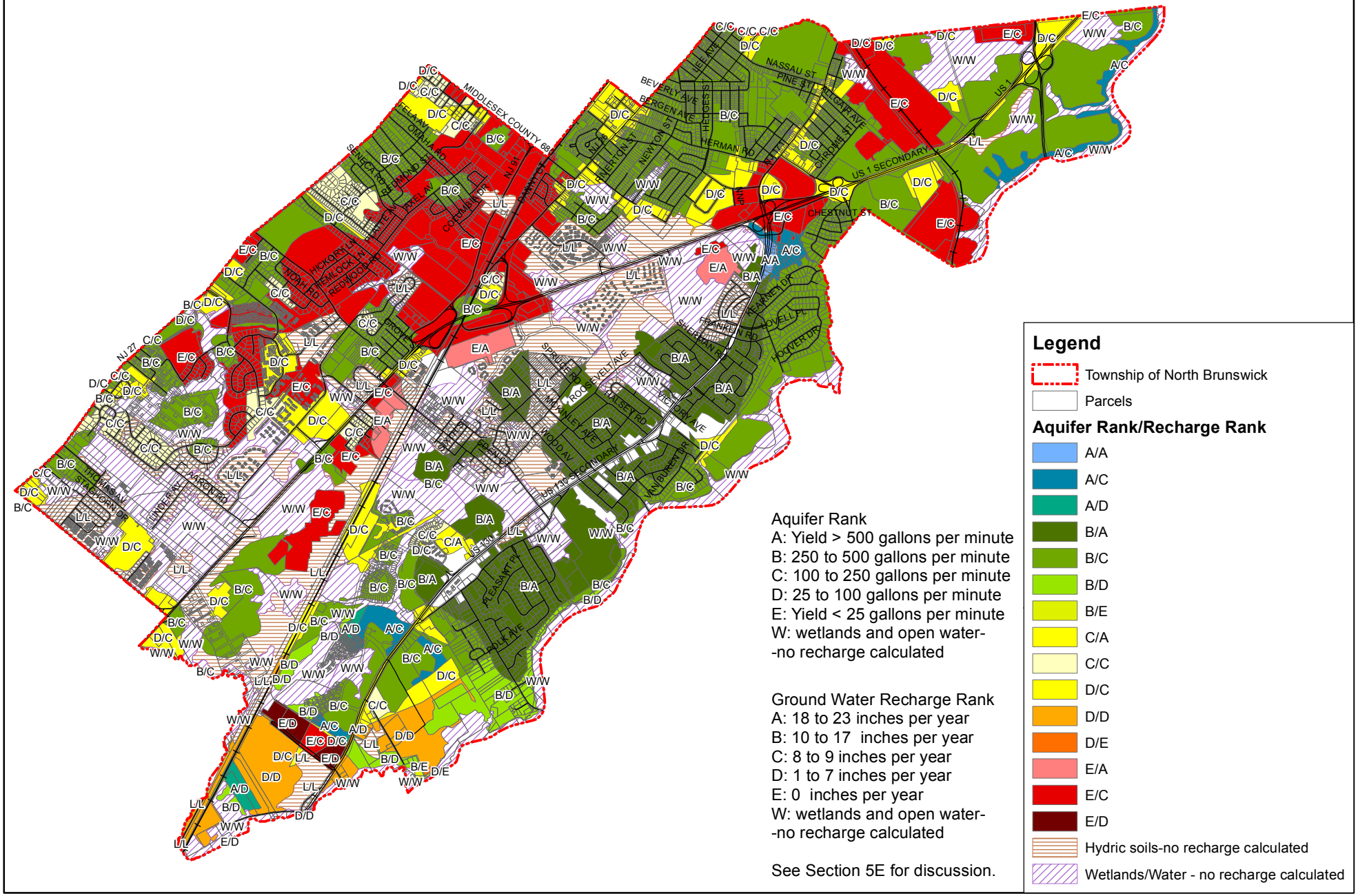


Figure 5e: Aquifer Potential

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

F. Ground Water & Drinking Water Quality

Pollution, such as nitrates, bacteria, metals, pesticides and antibiotics, can enter ground water via non-point sources (including septic systems and runoff from fields and roads), point sources, and rain. The New Jersey Comparative Risk Project (2003) identified a number of possible human health risks from drinking water, including lead (which, when present, is usually from the plumbing (NJDEP, 2004), radon, arsenic, MTBE, nitrates, and waterborne pathogens.

Newark Aquifers

The NJ Geological Survey analyzed data from 150 wells in the Newark Basin in order to characterize the natural range of ground water quality parameters (Serfes, 1994; Serfes and Herman, 1995). There were 8 sites located within North Brunswick (shown on **Figure 5b**). Results showed that ground water in the Newark Basin is normally fresh (total dissolved solids less than 1000 mg/L), somewhat oxidizing, slightly alkaline, non-corrosive, hard and of good natural quality. Calcium bicarbonate waters dominate, but calcium-sulfate waters exist and are associated with high total dissolved solids. Standards were exceeded for manganese in 27% of samples, maximum hardness in 21%, corrosivity 31% of the time, total dissolved solids 14%, sodium 8% and sulfate 8% of the time. The primary drinking water standard for gross alpha particle activity (radon and progeny) was exceeded in 6% of the samples, for radium in 3%, and for lead 1% of the time (Herman et al., 1998; Serfes, 1994). The North Brunswick sites contained particularly high concentrations of iron and manganese. Areas with large ground water withdrawals near bays and estuaries have experienced saltwater intrusion (USGS, 2005a; Serfes, 1994).

Potomac-Raritan-Magothy Aquifer

The NJ Geological Survey compiled water quality data from 330 wells in the Potomac-Raritan-Magothy aquifer, although none of the wells were located in North Brunswick. Cadmium and lead were detected in 25% of the samples, some exceeding the drinking water standards. Iron was found to exceed the secondary drinking water standard in 50% of the wells. Volatile Organic Compounds (VOCs) were found in 5 of 21 samples analyzed for VOCs (Harriman et al., 1989). Water quality is usually satisfactory except for local contamination from saltwater intrusion and waste disposal (USGS, January 14, 2013).

New Jersey Private Well Testing Act

The New Jersey Private Well Testing Act (N.J.S.A. 58:12A-26 et seq.) became effective in September 2002, which mandates private well testing upon the sale of a house. Since North Brunswick has no private wells, none have been tested pursuant to this regulation (NJDEP Division of Science, Research and Technology, 2004).

North Brunswick Water Department

The North Brunswick Water Department serves 38,000 people from withdrawals from the D&R Canal. In 2003, the system experienced a violation of the Safe Drinking Water Act for Total Coliform and in

Deborah J. Kratzer

North Brunswick's water tower

2000, there was a violation of turbidity. There have been no other violations from 2000 to 2012 (NJDEP Division of Water Supply and Geoscience, July 9, 2013). Water quality testing results are available online (see **Internet Resources**).

Radon

Radioactive substances (including uranium, thorium, radium, and radon) from natural sources (see **Section 3D)** are frequently found in ground water in New Jersey (NJDEP Radiation Program, April 2004). However, since North Brunswick's water comes from surface water, this is not a concern in the township.

G. Ground Water Quality Standards

The New Jersey Ground Water Quality Standards (GWQS; N.J.A.C. 7:9C) (last amended July 22, 2010) specify the quality criteria and designated uses for ground water, and serve as the basis for setting ground water discharge standards under the New Jersey Pollutant Discharge Elimination System program (see **Section 5H**), as well as for establishing standards for ground water cleanups and other relevant laws. The criteria are numerical values assigned to each constituent (pollutant). The GWQS also contain technical and general policies to ensure that the designated uses can be adequately protected.

Ground water within watersheds of FW1 surface waters (see **section 6D** for surface water classifications), state-owned Natural Areas, and the major aquifers of the Pinelands Area are designated *Class I*. The designated use for Class I ground water is the maintenance of special ecological resources, with secondary uses being potable, agricultural and industrial water. *Class II* waters are those not specifically designated Class I or Class III. The designated use of Class II ground waters is to provide potable water using conventional treatment. Class II criteria specify the levels of constituents above which the water would pose an unacceptable risk for drinking water. *Class III* ground waters can be used for anything other than for potable water (NJDEP Bureau of Water Quality Standards and Assessment, December 5, 2011).

North Brunswick's waters are designated Class II (to provide potable water with conventional treatment). It should not be assumed that ground water quality everywhere meets the criteria for each classification area in view of natural variability and the possibility of localized pollution. In fact, NJDEP has designated 14 areas within the Township where ground water contamination has been identified (including several service stations, USA Detergents and Route 1 & Thomas Avenue; see **Section 5I** and **Figure 5f** for details).

H. Ground Water Discharges

New Jersey regulates the discharge of pollutants to ground water under the authority of the New Jersey Water Pollution Control Act (WPCA) N.J.S.A. 58:10A. The New Jersey Pollutant Discharge Elimination System (NJPDES) permit program regulations are contained in N.J.A.C. 7:14A (NJDEP, January 5, 2009).

NJPDES permits are required for discharges to ground water of both sanitary and industrial wastes. These permits, which limit the mass and/or concentration of pollutants discharged, are issued to sanitary and industrial facilities that have ongoing, operational discharges of wastewater to ground water. The purpose is to restrict the discharge of pollutants to the ground waters of the state and protect the public health and the environment. Discharges from past activities may continue to be regulated under the Site Remediation Program or the

Division of Solid and Hazardous waste.

There are no ground water discharges within North Brunswick (NJDEP, 2007).

1. Contaminated Sites

On May 7, 2012, NJDEP adopted amendments, repeals, and new rules to implement site remediations through the *Site Remediation Reform Act (SRRA)*, N.J.S.A. 58:10C-1 et seq., and related amendments to the *Brownfield and Contaminated Sites Act (Brownfield Act)* N.J.S.A. 58:10B-1 et seq., the *Spill Compensation and Control Act (Spill Act),* N.J.S.A. 58:23-11 35 seq., the *Industrial Site Recovery Act (ISRA)*, N.J.S.A. 13:1K-6 et seq., and the *Underground Storage of Hazardous Substances Act (UST Act),* N.J.S.A. 58:10A-21 et seq. This major shift requires remediations of contaminated sites to proceed under the supervision of a *Licensed Site Remediation Professional (LSRP)* (hired by the property owner) instead of NJDEP (NJDEP Site Remediation Program, May 7, 2012).

The goal of these changes is to increase the pace of remediation, in order to decrease the threat of contamination to public health and safety and the environment, and to more quickly return properties to productive use that are underutilized due to contamination.

Some key provisions create a licensing board and a code of ethics (including penalties for violations) for LSRPs; establish obligations of each person responsible for conducting remediation; institute mandatory timeframes for the completion of key phases of site remediation; set forth the circumstances under which NJDEP would undertake direct oversight of a remediation; and require NJDEP to establish presumptive remedies for residential development, schools and childcare facilities to ensure that the remediation at these sites is protective of human health and safety and of the environment (NJDEP Site Remediation Program, July 29, 2013).

The LSRP program does not apply to unregulated underground storage tanks (see **Internet Resources**).

Known Contaminated Sites List (KCSL)

The NJDEP Bureau of Planning and Systems compiles a list of Known Contaminated Sites (KCS). The *Known Contaminated Sites List* [27] (non-homeowner) for New Jersey (as required under N.J.S.A. 58:10-23.16-17 and also the New Residential Construction Off-Site Conditions Disclosure Act N.J.S.A 46:3C1 et seq.) contains sites defined as those sites and properties within the state where contamination of soil or ground water has been confirmed at levels equal to or greater than applicable standards. It is important to note that the list may include sites where remediation is either currently under way, required but not yet initiated or has been completed (and no longer considered contaminated). In addition, new contaminated sites may have been identified since the creation of this list and are not included here NJDEP Site Remediation Program, February 2012).

Within the Township of North Brunswick, there are 52 KCSs, none of them on the National Priorities (Superfund) List (see **Table 5.2** and **Figure 5f**). Homeowner sites are not included in the GIS data or in **Table 5.2** because they generally involve small heating oil discharges from leaking underground storage tanks (USTs) that are resolved relatively quickly

[27] The GIS data is updated periodically. The tabular data is updated frequently, with new sites added and remediated ones removed, and is available at: http://datamine2.state.nj.us/DEP_OPRA/OpraMain/categories?category=Site+Case+sub-category

(see **Internet Resources** for a link to NJDEP's grant program for removal and cleanup of USTs) (NJDEP Site Remediation Program, April 12, 2012; USEPA. July 24, 2013).

Classification Exception Area (CEA)

The *Classification Exception Area* (CEA) dataset identifies those sites where ground water contamination has been identified and the NJDEP has established a Classification Exception Area (CEA). CEAs are institutional controls in geographically defined areas within which the New Jersey Ground Water Quality Standards (NJGWQS) for specific contaminants have been exceeded. When a CEA is designated for an area, the constituent standards and designated aquifer uses are suspended for the term of the CEA. This data is intended to provide information to the public regarding areas of contaminated ground water to prevent inappropriate well placement, preventing potential health risks and can minimize unintended contaminant plume migration (NJDEP Site Remediation Program, February 30, 2013). There are 14 CEAs in North Brunswick (see **Table 5.2** and **Figure 5f**).

Deed Notice

A *Deed Notice* is defined by NJSA 58:10B-13a as a "...notice to inform prospective holders of an interest in the property that contamination exists on the property at a level that may statutorily restrict certain uses of, or access to, all or part of that property...." The purpose of the deed notice GIS layer is to minimize any chance of exposure to contaminants remaining on the property (NJDEP Site Remediation Program, January 30, 2012).

There are 2 Deed Notices delineated within the Township of North Brunswick: Route 1 and Thomas Avenue; and USA Detergents – Okonite at 1600 Route 1 North (see **Table 5.2** and **Figure 5f**).

Table 5.2: Contaminated Sites in and Near North Brunswick (See Figure 5f)

Map Id.	Site Id. # PI #	Name*	Address	Block-Lot	Status
	Known Contaminated Sites (KCS) – 52 within North Brunswick				
0	5573 PI# 012721	Adult Correctional Facility Annex	Apple Orchard Lane	224-13.03	Active
1	366088 PI#452551	Truemann Storage Facility	2700 Route 130	N/A	Active
2	5586 PI#031905	North Brunswick DPW Garage	45 Quarry Lane	224-13.02	Active
3	5570 PI#012722	Road Department Complex	Georges Road & Apple Orchard Lane	224-13.03	Active
4	129257 PI#171771	Route 1 & Thomas Avenue	Route 1 & Thomas Ave.	74-30	Active
5	15285 PI#018808	Exxon R/S 39795	2561 Route 1	N/A	Active
6	15967 PI#000867	Johnson & Johnson Incorporated	2300 Route 1	148-5.04	Active
7	55477 PI#026186	George Logan Towing Inc.	1979 Old Georges Road	N/A	Active
8	37363 PI#018796	Adams Lane Maintenance Facility	788 Adams Lane	148-111.04	Active
9	169298 PI#248860	Otken Farm	20512053 Georges Road	148-103	Active
10	5551 PI#016005	BP Service Station 470	2900 Lincoln Hwy.	1-1.01	Active
11	5561	Getty 00254	1700 Georges Road	283-1	Active

Map Id.	Site Id. # PI #	Name*	Address	Block-Lot	Status
	PI#001245				
12	5560 PI#010180	Gulf	1696 Georges Road	282-1	Active
13	225549 PI#294388	1520 Evelyn Avenue	1520 Evelyn Ave.	3-6	Active
14	187217 PI#221418	The Shops at Commerce Plaza	2219 Route 1	4.45-4	Active
15	14352 PI#002828	Webcraft Technologies Inc.	1980 Route 1	148-35.01	Active
16	118592 PI#263605	1445 Route 130	1445 Route 130	143-91.08	Active
17	5545 PI#002268	Route 1 North Brunswick BP LLC	1890 Route 1	143.06-464.01	Active
18	5537 PI#006678	Hess Station 30318	Route 1 & Apache Street	82-7.01	Active
19	27935 PI#020546	Tru Arc Inc.	521 Cozzens Lane	4.41-9	Pending
20	49144 PI#022977	North Brunswick High School/Veterans Park	1648 Route 130	143-69	Active
21	147815 PI#010004	USA Detergents Incorporated	1600 Route 1	143-18.13	Active
22	16730 PI#013737	The Coca Cola Btlg Co Of NY	1500 Livingston Ave.	140.01-3.02	Active
23	391013 PI#488853	1335 Route 1	1335 Route 1	143.04-64	Active
24	88654 PI# G000062569	Jersey Avenue	Jersey Ave.	90-2	Active
25	63095 PI#97837	NJDOT Rte. 1/130 Intersec. Improvements	880 Route 130	259-6.38	Active
26	14842 PI#002838	Abb Turbocharger Inc.	1460 Livingston Ave.	140.01-5.02	Active
27	66214 PI# G000003935	North Brunswick Coatings & Chemicals	1430 Jersey Ave.	90-5	Active
28	42761 PI#003663	Central Transport	1305 Livingston Ave.	90-38	Active
29	66522 PI# G000006366	Penske Truck Leasing Company	777 Ridgewood Ave.	168.02-78	Pending
30	5567 PI#006913	US Gas	865 Georges Road	140-57	Active
31	29332 PI#013779	Malouf Ford	Route 1 South & Georges Road	245-4	Active
32	5539 PI#016513	Sunoco 0007-6653	770 786 Route 1 North	259-10.01	Active
33	91645 PI#129572	Raritan River Garage	740 Route 1 North	N/A	Active
34	68938 PI# G000027834	964 Glenn Avenue	964 Glenn Ave.	N/A	Pending
35	26996 PI#002763	Brogan Cadillac	1100 Livingston Ave.	136-1	Active
36	5518 PI#012385	North Brunswick Maintenance Yard	Route 1 & College Farm Road	252-4.02	Active
37	92370 PI#008530	Personal Products Co.	Route 1 North	194-28	Active
38	125097 PI#165121	NJDOT Route1 Bridge Replacement	Route 1	N/A	Active

Map Id.	Site Id. # PI #	Name*	Address	Block-Lot	Status
39	5593 PI#008529	Permacel	Route 1 North	194-29.01	Active
40	45623 PI#003270	Pepsi Cola Bottling Group	1007 Livingston Ave.	N/A	Active
41	16384 PI#023061	North Brunswick Foreign Car Service	590 Georges Road	202-1	Active
42	5546 PI#000282	Clifford Dry Cleaners	933 Livingston Ave.	98-2	Pending
43	226775 PI#296010	703 Edgewood Place	703 Edgewood Place	N/A	Active
44	12905 PI#000965	BP Service Station 3682	923 Livingston Ave.	98-2	Active
45	5540 PI#008224	ER Squibb & Sons Inc.	1 Squibb Drive	194-18	Active
46	16398 PI#018291	Parker Seals Incorporated	601 Nassau Street	194-30.01	Active
47	20038 PI# G000004598	Ward Products Corp.	633 Nassau Street	194-32	Active
48	56368 PI#030988	Joe's Service Center	814 Livingston Ave.	126-1	Active
49	170930 PI#224642	480 Georges Road	480 Georges Road	N/A	Active
50	358320 PI#443077	54 Abeel Street	54 Abeel Street	126-10	Active
51	178527 PI#233970	5 Linwood Place	5 Linwood Place	N/A	Active
Classification Exception Area (CEA) ★ - 14 in North Brunswick					
0	1181 PI# 002268	Amoco Service Station #84597	1890 Route 1 North	143.06-462.01	
1	1365 PI#008529	Permacel Inc.	Route 1 North	194-29.01	
2	1520 PI#002763	Brogan Cadillac-Oldsmobile, Inc.	1100 Livingston Ave.	136-1	
3	99961 PI#016005	Amoco Service Station #470	2900 Route 27 & Finnegans Lane	1-1.01, 2.01,3	
4	PI#010004	USA Detergents-Okonite	1600 Route 1 North	143-13.1 & 143-18.13	
5	880 PI#006678	Hess Service Station #30318	Route 1 & Apache Street	82-11,12	
6	322 PI#026186	George Logan Towing, Inc.	Route 130 & Georges Road	226-3,4,14,15	
7	1578 PI#009209	Rutgers University, Bldg. 6042	College Farm Road	250-1.01	
8	PI#003270	Pepsi Cola Co. Warehouse	1007 Livingston Ave.	91-18, 19, 20, 21 & 96-2	
9	317 PI#013737	Coca-Cola Bottling Co. of N.Y.	1500 Livingston Ave.	140.01-1, 3.02	
10	759 PI#016513	Sunoco Service Station # 0007-6653	770-786 Route 1 North	259-9.01, 10.01	
11	PI#008224	E. R. Squibb & Sons, Inc.	1 Squibb Drive	194-4, 18, 19, 40	
12	1234 PI#013779	Sansone Auto Network	Route 1 & Route 130	245-4	
13	2245 PI#001611	Getty Service Station #56118	1143 Route 27 & Veronica Ave.	30-5.02, 5.03, 5.04 & 31-1, 5	
	Deed Notice Extent (DNA) - 2 in North Brunswick				
0	171771	Route 1 & Thomas Ave.	Route 1 & Thomas Avenue	74-30	

Map Id.	Site Id. # PI #	Name*	Address	Block-Lot	Status
1	010004	USA Detergents - Okonite	1600 Route 1 North	143-13.1, 18.03	
*Note: The current site name and/or owner may be different from the listed name. Sources: NJDEP SRP, February 2012; NJDEP SRP, February 30, 2013; NJDEP SRP, January 30, 2012					

Remediated Sites

A current Data Miner search revealed that 134 contaminated sites within North Brunswick have been remediated (65 homeowner and 69 non-homeowner) (NJDEP Site Remediation Program (SRP), August 19, 2013). These cases are closed and are not listed**.**

J. Ground Water Level Monitoring

The *ground water level* is the distance from the land surface (i.e. top of well casing) to the water in a well. Ground water level monitoring is critical for determining the current state of the ground water, identifying trends and predicting ground water drought. In addition to drought, over-withdrawal of ground water can occur in areas where more ground water is being pumped out of the aquifer than is replenished through recharge. This could lead to a drop in the ground water level, affecting well performance, and sometimes causing wells to go dry, as well as causing a decrease in the baseflows of adjacent streams. The USGS maintains a nation-wide network of wells to monitor the effects of droughts and other climate variability on ground water levels. The USGS monitoring well currently being monitored nearest to North Brunswick and in the Coastal Plain aquifer system is located in East Brunswick (about 0.6 miles south of North Brunswick). The nearest monitoring well currently being monitored in the Passaic Aquifer is located in Kenilworth Borough (Union County, approximately 16 miles northeast of North Brunswick). Descriptions of these sites and graphs of ground water levels are shown in **Table 5.3**.

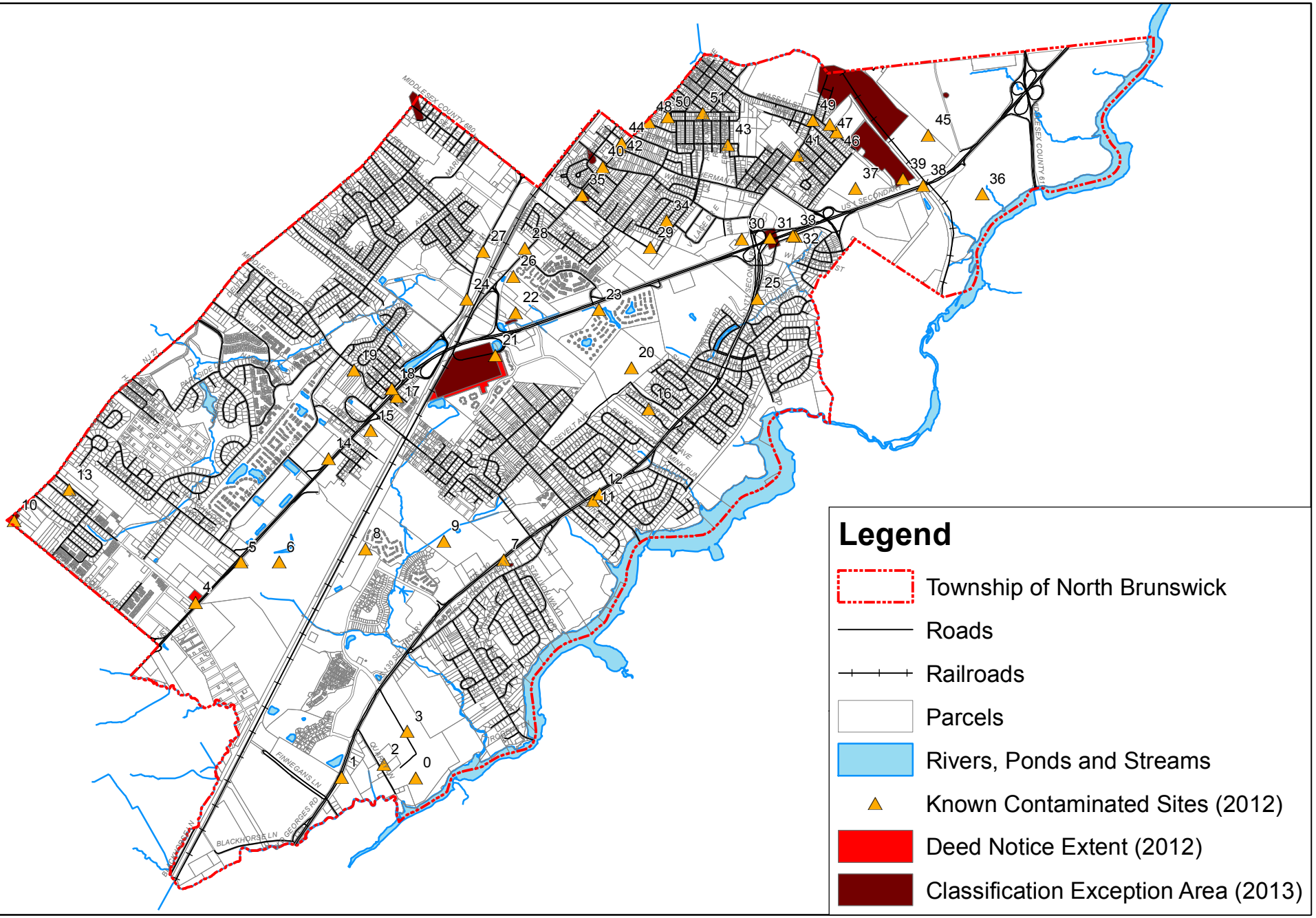


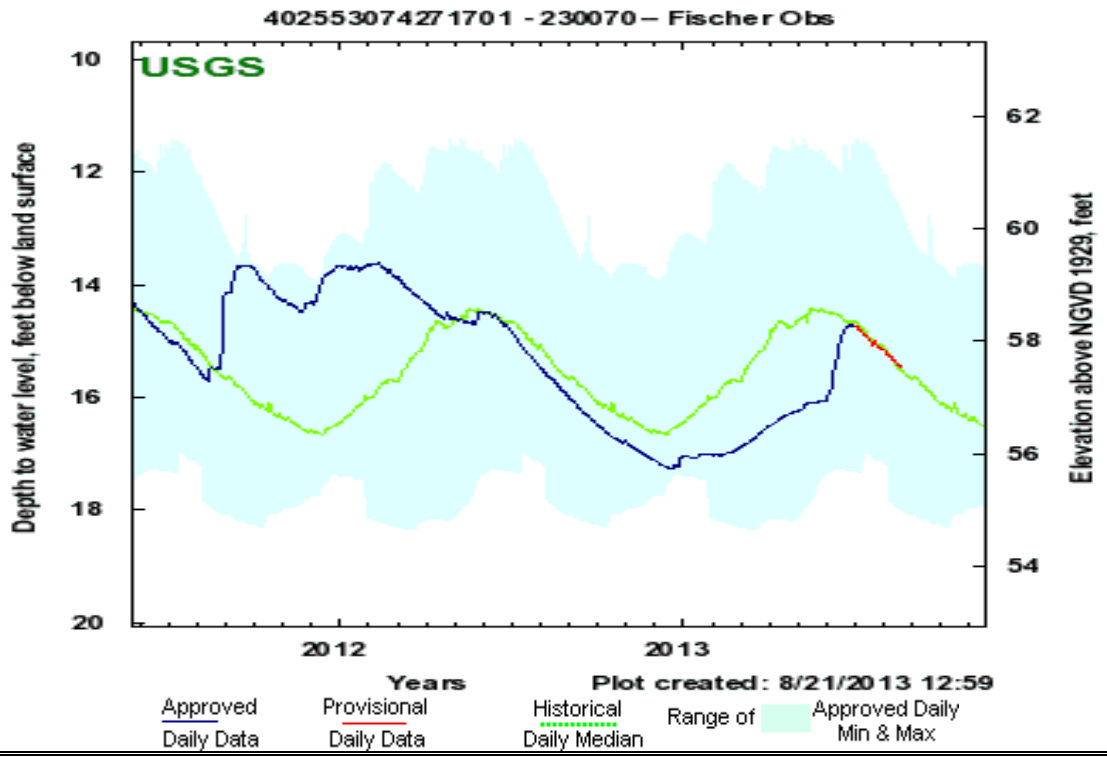
Figure 5f: Contaminated Sites

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Table 5.3: USGS Real-Time Ground Water Level Network – wells near North Brunswick

Site Number:	**402553074271701 - 230070-- Fischer Obs**
Location:	Latitude 40°25'55", Longitude -74°27'19" NAD27 Middlesex County, New Jersey, Hydrologic Unit 02030105
Well Characteristics:	**Depth:** 21 feet **Land surface altitude:** 73 feet above NGVD29
Aquifer:	Well completed in "Northern Atlantic Coastal Plain aquifer system" (S100NATLCP) national aquifer Well completed in "Farrington Sand Member of Raritan Formation" (211FRNG) local aquifer
Begin date (periodic record):	07/31/1936 **Begin date (continuous record):** 10/01/2007
Extremes for Period of Record:	*Highest Water Level*: 11.42 *Average:* 15.6 *Lowest Water Level*: 18.34'
Website:	http://groundwaterwatch.usgs.gov/AWLSites.asp?S=402553074271701&ncd= http://nwis.waterdata.usgs.gov/nwis/uv/?site_no=402553074271701&PARAmeter_cd=72019,72020,62611



Site Number: 404106074171901 - 390119-- Union County Park Obs

Location: Latitude 40°41'06", Longitude 74°17'19" NAD27
Union County, New Jersey, Hydrologic Unit 02030104

Kenilworth Township, Union County, NJ, at Galloping Hill Golf Course

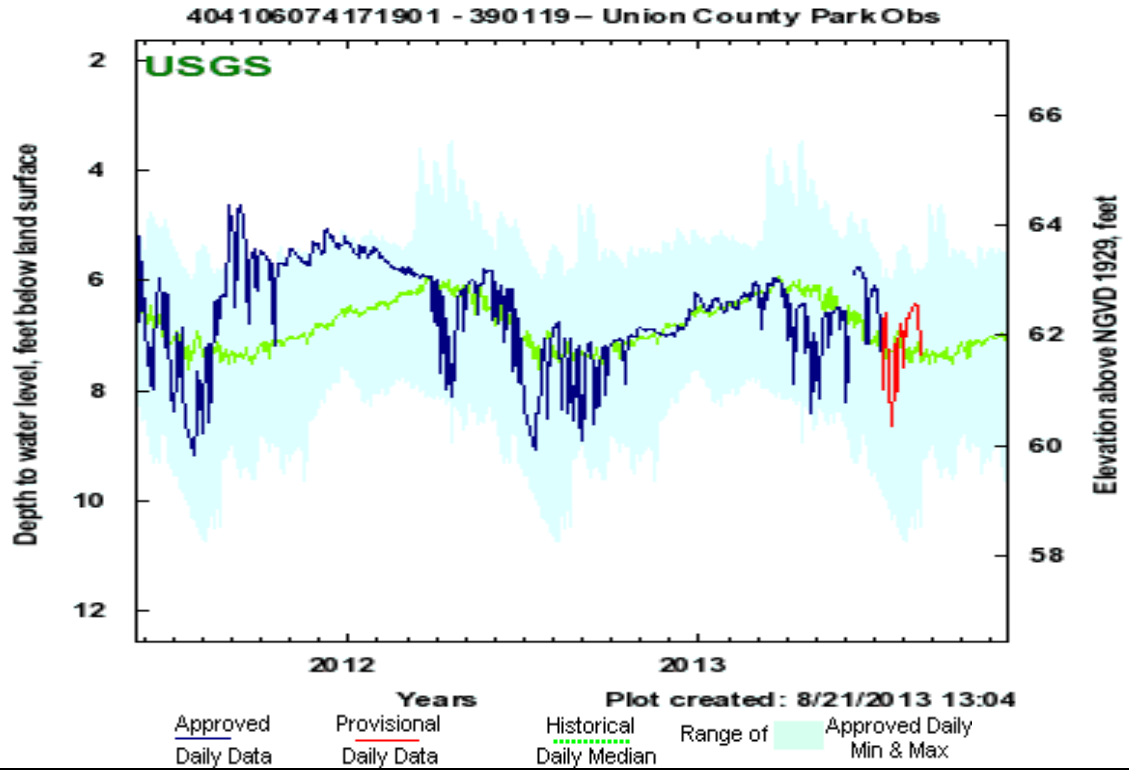
Well Characteristics: Depth: 290 feet **Land surface altitude:** 69.00 feet above NGVD29

Aquifer: Well completed in "Early Mesozoic basin aquifers" (N300ERLMZC) national aquifer.
Well completed in "Passaic Formation" (227PSSC) local aquifer

Begin date (periodic record): 06/30/1943 **Begin date (continuous record):** 11/17/1972

Extremes for Period of Record: *Highest Water Level*: 3.06' *Lowest Water Level*: 15.8'

Website: http://groundwaterwatch.usgs.gov/AWLSites.asp?S=404106074171901&ncd=rtn
http://waterdata.usgs.gov/nwis?program=uv&site_no=404106074171901&agency_cd=USGS



Note: These sites are maintained by USGS New Jersey Water Science Center.
Source: USGS, August 2013

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http://nwis.waterdata.usgs.gov/nwis/uv/?site_no=402553074271701&PARAmeter_cd=72019,72020,62611
Site Number: 404106074171901 - 390119-- Union County Park Obs.
http://groundwaterwatch.usgs.gov/AWLSites.asp?S=404106074171901&ncd=rtn
http://waterdata.usgs.gov/nwis?program=uv&site_no=404106074171901&agency_cd=USGS

Internet Resources: Ground Water

Ground Water Primer (US EPA): http://www.waterscape.org/projects/vanduo/dw_gen/grdshort/src/ground.htm#toc

Groundwater Watch. http://groundwaterwatch.usgs.gov/StateMaps/NJ.html

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- Report Categories: http://datamine2.state.nj.us/dep/DEP_OPRA/index2.html
- Contaminated Sites: http://datamine2.state.nj.us/DEP_OPRA/OpraMain/categories?category=Site+Case+sub-category

NJDEP grants for Underground Storage Tank removal & remediation: http://www.nj.gov/dep/srp/finance/ustfund/

NJDEP Rules & Regulations (current & proposed): http://www.nj.gov/dep/rules/

NJDEP Laws & Rules: http://www.nj.gov/dep/landuse/lawsregs.html
- Site Remediation Reform Act, N.J.S.A. 58:10C-1 et seq.: http://www.nj.gov/dep/srp/regs/statutes/srra.pdf
- Brownfield and Contaminated Sites Act: http://www.nj.gov/dep/srp/regs/statutes/bcsra.pdf
- Spill Compensation and Control Act: http://www.nj.gov/dep/srp/regs/statutes/spill_act.pdf
- Industrial Site Recovery Act: http://www.nj.gov/dep/srp/regs/statutes/isra.pdf
- Underground Storage Tanks: http://www.nj.gov/dep/rules/rules/njac7_14b.pdf

NJDEP Surface & Ground Water Quality Standards and Assessment: http://www.state.nj.us/dep/wms/bwqsa/

NJ Drinking Water Watch – North Brunswick Water Department:
https://www11.state.nj.us/DEP_WaterWatch_public/JSP/WSDetail.jsp?tinwsys=304

NJ Geological Survey Home Page: http://www.state.nj.us/dep/njgs/index.html

Underground Storage Tanks: http://www.nj.gov/dep/srp/bust/

USGS - New Jersey District - Ground Water Information (USGS): http://wwwnj.er.usgs.gov/gw/

USGS - Water Resources of NJ: http://nj.usgs.gov/

USEPA – Region 2: http://www.epa.gov/region02/water/

6: SURFACE WATER

A. Watersheds

Watersheds

Deborah J. Kratzer

Farrington Lake

"Water is vital to life and comprises an invaluable natural resource which is not to be abused by any segment of the State's population or economy." (NJDEP NJAC 7:9B, January 18, 2011).

A *watershed* (or basin) is the land area within the confines of a drainage divide in which all surface runoff will drain into a river, river system, or body of water. North Brunswick is within the Raritan River watershed (see top left inset in **Figure 6a**), the largest river basin located entirely within the State of New Jersey. This watershed covers approximately 1,100 square miles (699,542 acres) and includes parts of seven counties (Hunterdon, Mercer, Middlesex, Monmouth, Morris, Somerset and Union counties) (USDA, Natural Resources Conservation Service, September 14, 2010).

Watershed Management Areas

Watershed management is the process of managing and protecting all of the water resources within the area of a watershed, rather than on a site-specific basis. The NJDEP recognizes that watersheds are "nature's boundaries," and has established a watershed management approach (NJDEP, January 1997). A watershed management approach is based on three key components: 1) a geographic focus; 2) continuous improvement based on sound science; and 3) partnerships/stakeholder involvement. More information concerning watershed management is presented in **Section 10B**. NJDEP has divided the state's watersheds into 20 *Watershed Management Areas (WMAs)*. The Raritan River basin is divided into three WMAs (see bottom left inset in **Figure 6a**). North Brunswick falls mostly within WMA 9, which includes the Lower Raritan River, South River and Lawrence River, but partially within WMA 10, Millstone and Stony Brook.

Hydrologic Unit Codes (HUC)

Sub-watersheds are those smaller drainage areas that make up a larger watershed. North Brunswick is located in a sub-watershed of the Raritan River watershed and is composed of all or portions of several smaller drainage areas whose surface runoff drains directly into the Raritan River (**Figure 6b)**.

The classification system used by the NJDEP assigns each subwatershed a *14-digit Hydrologic Unit Code (HUC14[28]).* The HUC14 is a hierarchical system where the first 2 digits refer to the USGS Water Resources Region and the first 4 digits (also known as a HUC4) refer to the major drainage basin, or sub-region. Therefore, a HUC2 of "02" is in the Mid-Atlantic

[28] The HUC14s have a minimum size of 3,000 acres, although some basins are defined with smaller areas. At other times, small subwatershed units are combined.

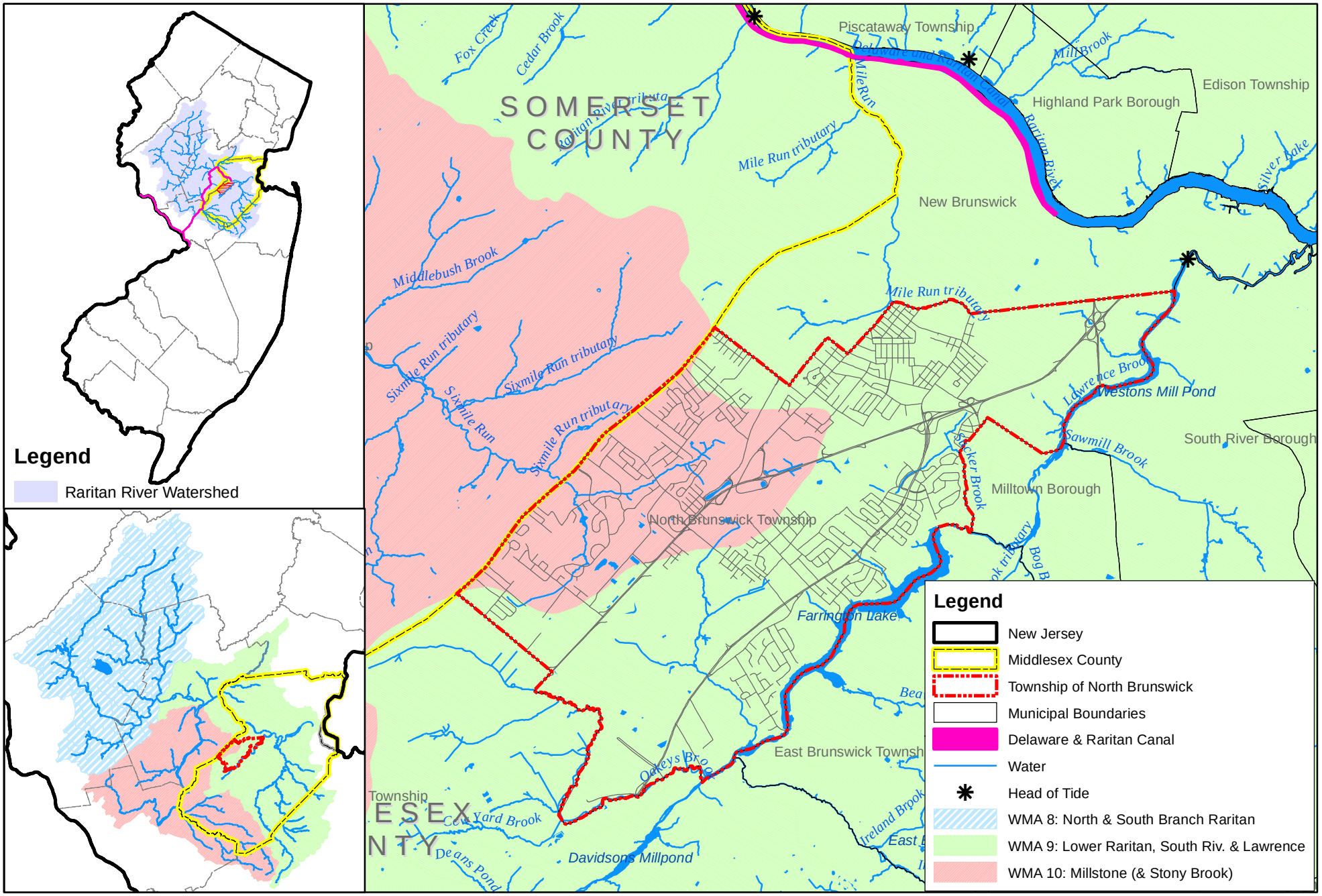

Figure 6a: Raritan Watershed and Watershed Management Areas of North Brunswick

0 0.5 1 2 Miles

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Region, and a HUC4 of "0203" is in the Lower Hudson-Long Island major drainage basin (which includes the Raritan River) (USGS, May 13, 2013).

The Raritan River basin is assigned a HUC8 of "02030105," and every sub-watershed within this basin has a HUC that starts with "02030105."

All of North Brunswick is within the Lower Raritan River watershed, with a HUC11 of "02030105120." HUC14 subwatersheds and streams either within and surrounding the Township of North Brunswick are shown in the lower inset of **Figure 6b**.

Table 6.1 lists the HUC14s for the six subwatersheds encompassing North Brunswick.

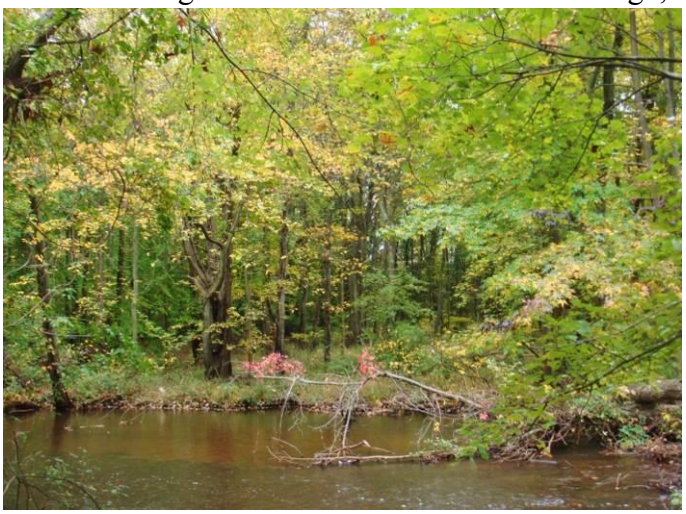
Table 6.1: Hydrologic Unit Codes for North Brunswick's Subwatersheds

HUC14	Watershed Name	Subwatershed Name	Percent of Twp.*
WMA 9: Lower Raritan, South River, and Lawrence			
02030105120150	Raritan R Lower (Lawrence to Millstone)	Mile Run	11.17
02030105130030	Lawrence Brook	Oakeys Brook	11.78
02030105130050	Lawrence Brook	Lawrence Brook (Church Lane to Deans Pond)	18.01
02030105130060	Lawrence Brook	Lawrence Brook (Milltown to Church Lane)	23.72
02030105130070	Lawrence Brook	Lawrence Brook (below Milltown/Herberts Br.)	10.87
WMA 10: Millstone			
02030105110120	Millstone River (below/incl Carnegie Lk)	Six Mile Run (above Middlebush Rd)	24.44
		Total:	100.00
*Percent of the area of North Brunswick that is within each subwatershed.			
Source: NJDEP NJGS, February 25, 2011			

River and Stream Descriptions

Lawrence Brook

The Lawrence Brook is a 10-mile long tributary of the Raritan River, located entirely within Middlesex County (Wikipedia, Accessed August 27, 2013). It arises in South Brunswick and travels northeastward about 6.6 miles before entering North Brunswick. Beginning at the confluence of Oakeys Brook and Lawrence Brook, it then forms the southern boundary of North Brunswick and neighboring South Brunswick and East Brunswick Townships. The Brook crosses through the center of Milltown Borough, therefore doesn't form North Brunswick's boundary in that area.


Deborah J. Kratzer

Lawrence Brook just below Farrington Lake

An unnamed tributary joins the brook in the vicinity of Route 694. South of Milltown, a dam on Lawrence Brook forms an impoundment called Farrington Lake. Farrington Lake covers about 290 acres and has an average depth of 2 meters (6 feet) and a maximum depth of 4 meters (12 feet) (Wikipedia, Accessed August 27, 2013). Sucker Brook follows the border of Milltown Borough and joins Lawrence Brook below Farrington Lake. Downstream

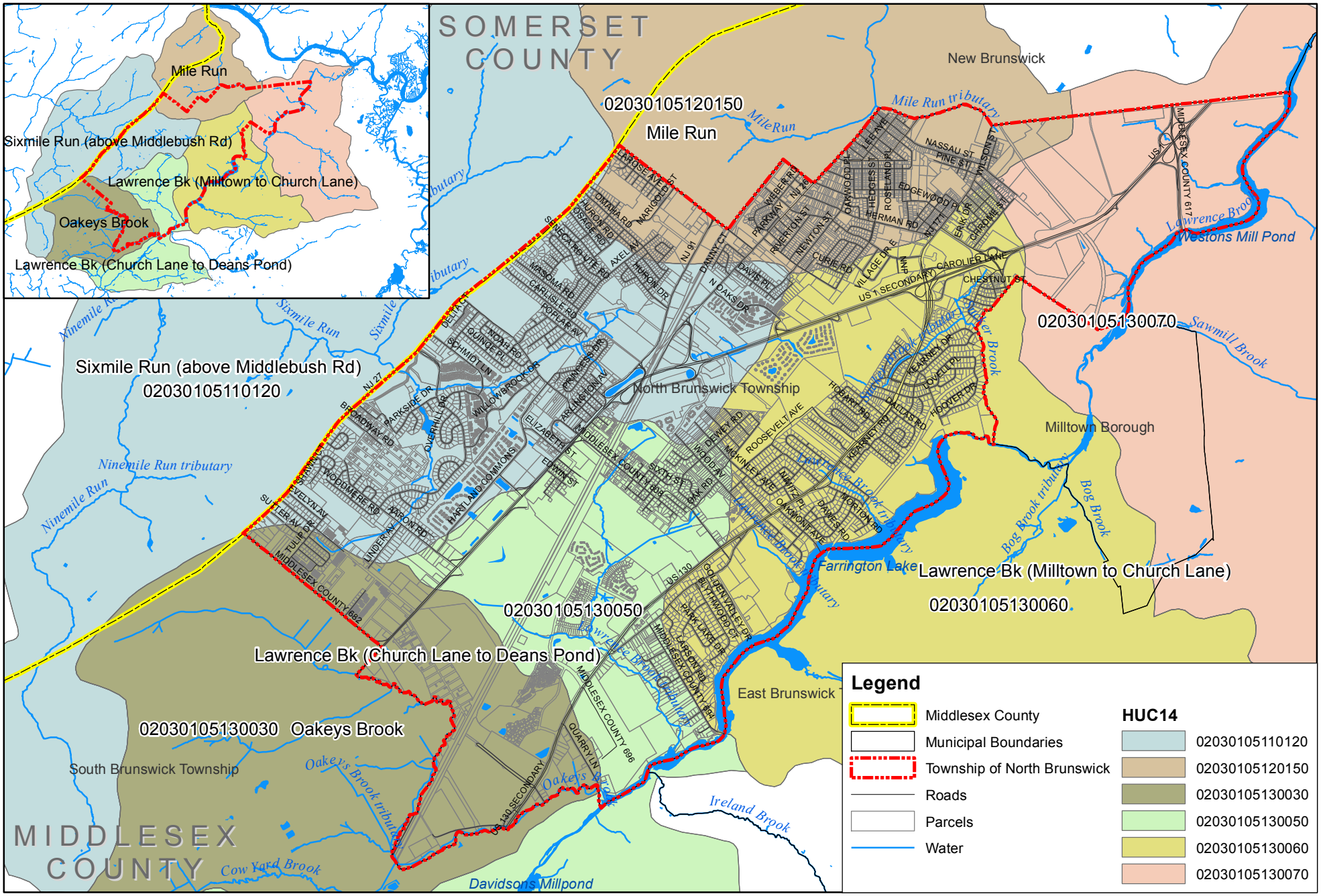


Figure 6b: Subwatersheds of North Brunswick

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
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(north) of Milltown, another dam forms Westons Mill Pond. After exiting North Brunswick's northeast corner, Lawrence Brook flows another 1.8 miles, forming the border between New Brunswick and East Brunswick, before joining the Raritan River (See **Figure 6c**).

Oakeys Brook

The headwaters of Oakeys Brook are in both North and South Brunswick Townships. This stream forms the zigzag portion of North Brunswick's south-western border. It joins the Lawrence Brook near Quarry Lane.

Six Mile Run[29]

Six Mile Run originates in the west-central portion of North Brunswick Township, near Huron Road and Route 91, running roughly southwestward. An unnamed tributary joins the steam from the south near Parkside Drive. Six Mile Run crosses the North Brunswick boundary and runs west-northwest through Franklin Township (Somerset County) approximately 3.5 miles to join the Millstone River.

The Millstone River parallels the D&R Canal, running roughly northward another 6.5 miles before it joins the Raritan River at a point where Manville Borough and Franklin and Bridgewater Townships (Somerset Count) meet.

Mile Run

Mile Run begins in the northern part of North Brunswick. The stream channel forms about ¾ mile of the township's northern boundary with New Brunswick. It flows almost directly northward for about 2.3 miles and then connects with the Raritan River.

Tidal Limit

A *tidal watercourse* is a stream or river affected by tides (the periodic rise and fall of the water surface resulting from the gravitational interaction of the earth, the moon, and the sun). The *Head of Tide* (HOT) is the point on a tidal watercourse at which measurement of the water surface vertical movement at the average high water level becomes negligible. All points seaward of the HOT on a tidal watercourse are tidal. The Lawrence Brook is tidal only to a point about 0.3 miles downstream (northeast) of North Brunswick's boundary. The HOT on the Raritan River is at a point approximately 6 miles upstream of the confluence of the Lawrence Brook and the Raritan River (about 1 mile upstream of the County Route 609 bridge (Landing Lane) (illustrated in **Figure 6a**) (NJDEP, Office of Environmental Analysis, 1986).

Culverted Sections of Streams

Figure 6c illustrates the locations where streams are culverted underground within North Brunswick. Input to these culverted sections comes primarily from stormwater runoff from impervious surfaces within the streams' watersheds. Much of this runoff enters the streams through stormwater outfalls along roadways. Any runoff that feeds to roadways (from parking lots, structures, sidewalks, and other impervious or semi-permeable surfaces such as lawns) increases the volume the culverted portions of streams must carry and can, during heavy storm events, overwhelm the system.

[29] Six Mile Run is spelled "Sixmile Run" by USGS and NJDEP; therefore the map labels reflect the latter spelling.

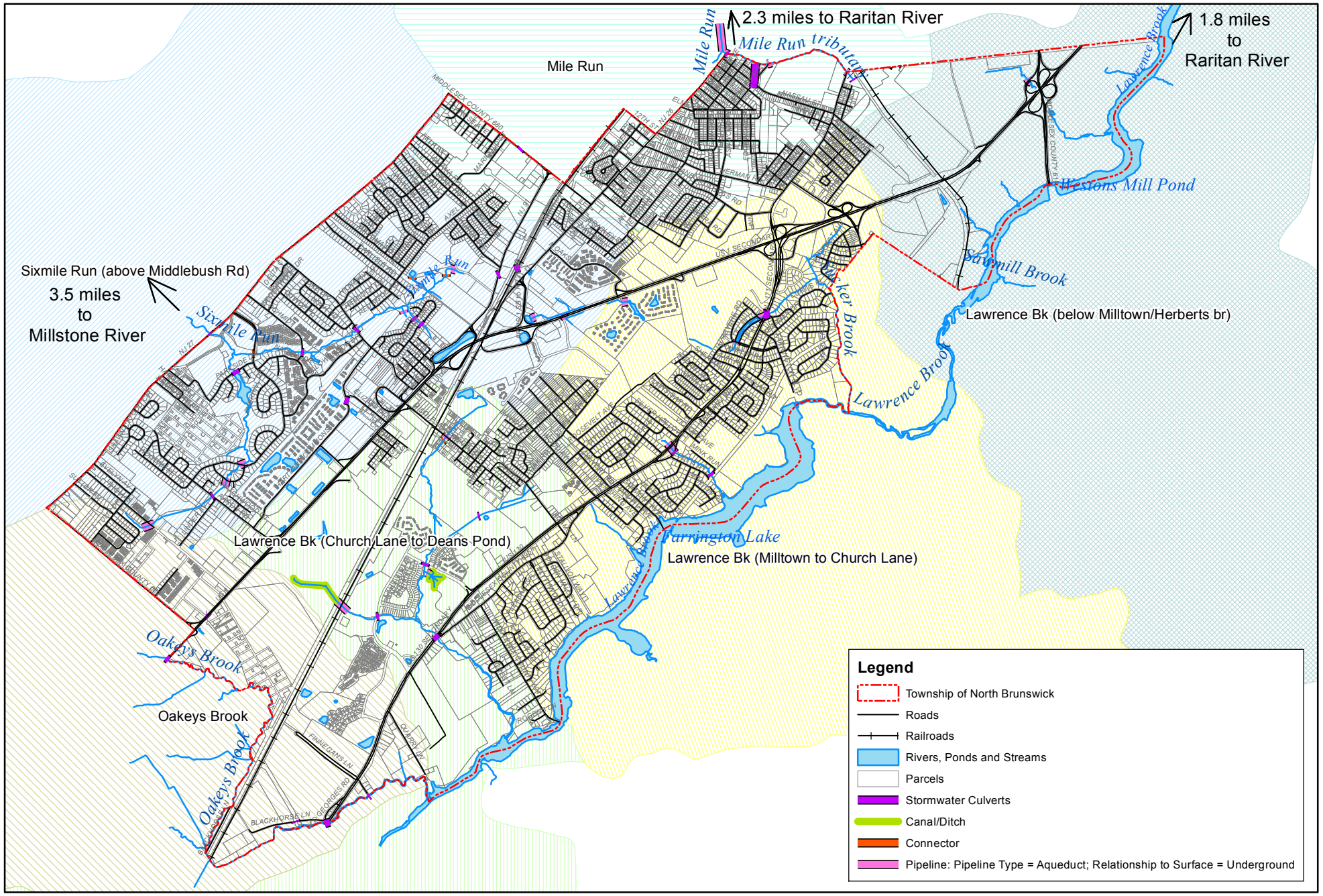

Figure 6c: Streams and Culverts

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
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B. Floodplains & Floods

Floodplains

A *floodplain* is the land along a river or stream that is subject to periodic flooding when the river or stream overflows its banks. As required by the Flood Disaster Protection Act of 1973, the Federal Emergency Management Administration (FEMA) is responsible for delineating floodplains.

According to FEMA, "Everyone lives in some type of flood zone." FEMA defines these geographic areas based on studies of flood risk.

FEMA publishes *Flood Insurance Rate Maps* (FIRMs) that show the flood zone boundaries. FIRMs are the basis for floodplain management, mitigation, and insurance activities for the National Flood Insurance Program (NFIP). Changes to the flood risk information may only be performed by FEMA. The digital FIRM (DFIRM) which are shown in **Figure 6d** are produced by FEMA in conjunction with the hardcopy FIRMs and generally matches the hardcopy map exactly. However, the hardcopy flood maps and flood profiles are the authoritative documents for the NFIP.

Special Flood Hazard Areas (SFHAs) are defined as areas subject to inundation by a flood having, on average, about 1 in 100 chance in any given year, also referred to as the 1% annual chance flood[30] (FEMA, 1996). Below are brief definitions of the FEMA flood zones that occur within North Brunswick.

Flood Facts

- Floods and flash floods happen in all 50 states.
- Hurricanes, winter storms and snowmelt are common (but often overlooked) causes of flooding.
- New land development can increase flood risk, especially if the construction changes natural runoff paths.
- Federal disaster assistance is usually a loan that must be paid back with interest.
- If you live in a Special Flood Hazard Area (SFHA) or high-risk area and have a Federally backed mortgage, your mortgage lender requires you to have flood insurance (FEMA, July 24, 2013).

Areas in *Zone X*, which includes the majority of North Brunswick, have low to moderate risk of flooding and are not in the SFHAs. They correspond to areas outside the 1% annual chance floodplain, areas of 1% annual chance sheet flow[31] flooding where average depths are less than 1 foot, areas of 1% annual chance stream flooding or where the contributing drainage area is less than 1 square mile. No Base Flood Elevations or depths are shown within this zone. Insurance purchase is not required in this zone (FEMA, 2013).

Zones with a high-risk of flooding, or SFHAs, include *Zone A* and *Zone AE*. *Zone A* corresponds to the 1% annual chance floodplains that are determined by approximate methods of analysis (i.e., not with Base Flood Elevations). *Zone AE* corresponds to the 1% annual chance floodplains that are determined by detailed methods of analysis, which includes detailed hydraulic analyses to determine Base Flood Elevations. In communities such as North Brunswick that participate in the NFIP (FEMA, August 22, 2013), all homeowners in Zones A and AE are required to get flood insurance in order to get a loan from a federally regulated lender. These areas have a 26% chance of flooding over the life of a 30-year mortgage (FEMA, 2013).

Areas with a 0.2% annual chance of flooding (typically referred to as the 500 year flood) are not considered high risk, but

[30] Flood designations are based on statistical averages, not the number of years between big floods. The term "100-year flood" does not mean a flood that happens once every 100 years. It is a statistical designation that there is a 1 in 100 chance that a flood of any given size will be equaled or exceeded during any year. Changes and variability in climate and land use over time can change flood frequency (Dinicola, 2005).

[31] Sheet flow, or overland flow, is flow that occurs overland in places where there are no defined channels, so the flood water spreads out over a large area at a uniform depth.

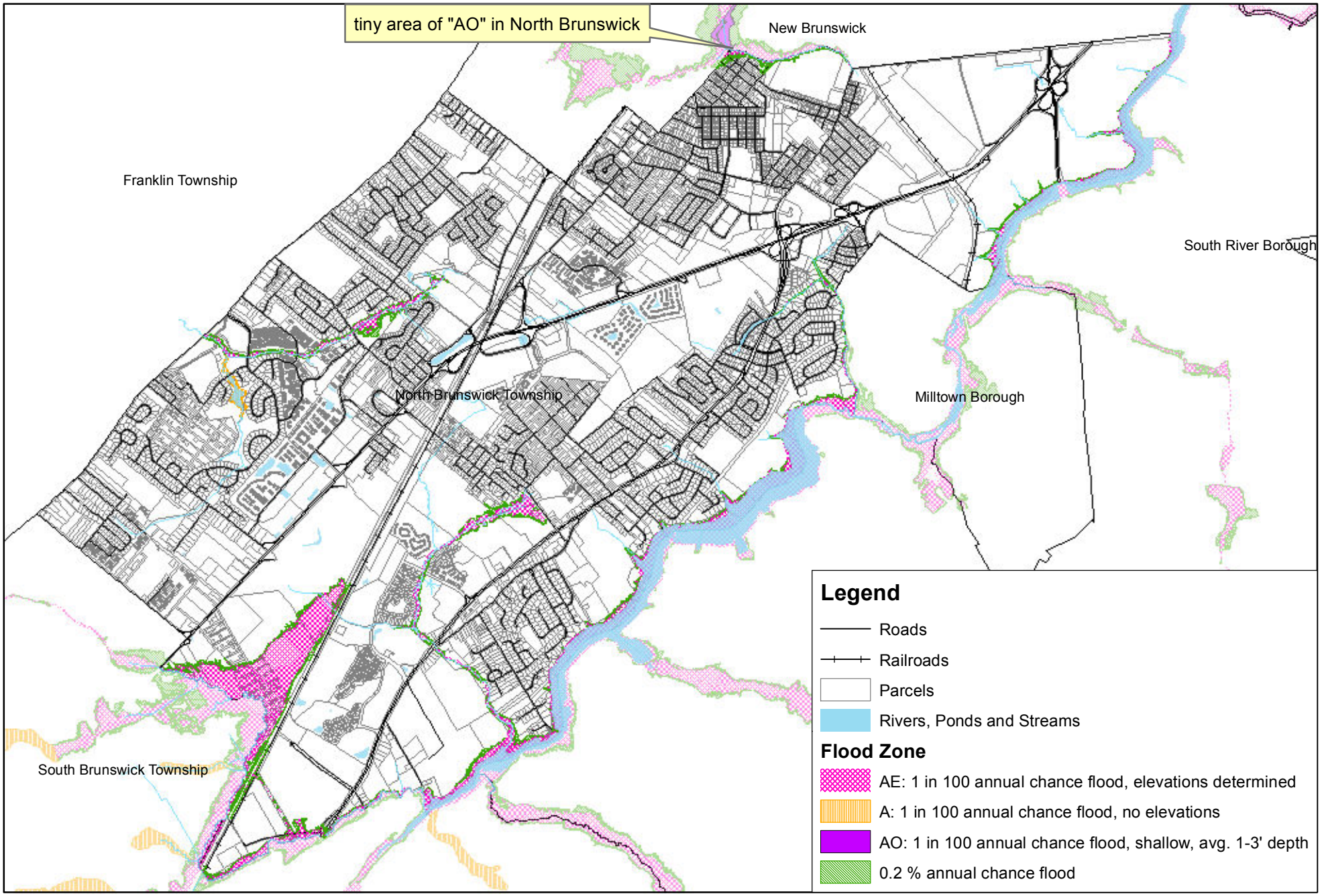

Figure 6d: Floodplains
FEMA Digital Flood Insurance Rate Map
(Date of Most Recent FIRM: July 6, 2010)

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
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are susceptible to periodic flooding.

Floodplains in North Brunswick are shown in **Figure 6d**, based on FEMA determinations (as of July 6, 2010, the most recent GIS data available). Nearly all of the floodplains within the township are wooded, with few manmade structures. The floodway of the Lawrence Brook in the vicinity of Westons Mill Pond averages approximately 100 feet horizontally beyond the normal water level. The floodplain is widest below the Farrington Lake dam, where the floodplain extends as much as about 500 feet into North Brunswick. For the most part, the floodway follows the normal shoreline of Farrington Lake, but extends 50 to 200 feet in a few spots. The floodplain of the Lawrence Brook's unnamed tributary is about 125 to 300 feet wide for its entire length. The Oakeys Brook floodplain extends roughly 50 to 150 feet into the township in its lower segment, but widens to ¾ mile along the railroad corridor, east of Route 1. The 1% annual chance flood zone of Six Mile Run is as much as 500 feet wide, but is generally about 100 feet wide. The northern corner of North Brunswick is within the flood zone of Mile Run, where the 1% chance flood extends about 150 feet into the township, and the 0.2% chance zone extends about an additional 150 feet.

Floodplain management is the operation of a community program of corrective and preventative measures for reducing flood damage. These measures may include zoning, subdivision, or building requirements, and special-purpose floodplain ordinances. North Brunswick adopted an ordinance establishing a Riparian Zone on October 1, 2012 (Township of North Brunswick, NJ, October 1, 2012). Community involvement is an important element in making flood insurance available to home and business owners. Riparian buffer and wetlands protection regulations and ordinances can also reduce flood damage by protecting those areas most susceptible to flooding and providing natural flood control. These efforts benefit downstream areas as well.

Floods

The flow of Lawrence Brook is measured continuously at Westons Mills, just downstream from North Brunswick and is reported in real-time at the USGS National Water Information System and at the NOAA National Weather Service Advanced Hydrologic Prediction Website, although flood forecasts are not available for this site (see **Table 6.3** and **Internet Resources**). Flood stage at this location is 18 feet (2,000 cfs (cubic feet per second)), and the Action Stage is 17 feet (about 820 cfs). Because Lawrence Brook has a relatively small drainage area (44.9 square miles) and because flow is controlled at several impoundments on this stream (including Deans Pond and Davidsons Mill Pond in South Brunswick, and Farrington Lake and Westons Mill Pond in North Brunswick), floods are uncommon. Lawrence Brook has experienced 11 floods since record keeping began at this site in 1989 (see **Table 6.2**).

The worst flood on record for this location was on August 28, 2011, caused by Hurricane Irene, when Lawrence Brook crested at 20.26 feet, or 7,700 cfs. Mean flow is 23 cfs (USGS, August 2013).

C. Wetlands

A *wetland* is a transitional area between aquatic and terrestrial ecosystems. Wetlands are those areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as

Table 6.2: Floods on the Lawrence Brook at Westons Mills

Flood Crests (in order of highest flow first)			
Rank*	**Gage Height (feet)**	**Flow (CFS)****	**Date**
1	20.26	7,700	Aug. 28, 2011
2	19.60	6,070	Apr. 15, 2007
3	19.20	4,850	Sep. 21, 1989
4	18.95	4,280	Sep. 16, 1999
5	18.66	3,710	Mar. 13, 2010
6	18.52	3,020	Oct. 19, 1996
7	18.08	2,890	Dec. 11, 1992
8	18.18	2,700	Sep. 27, 2004
9	18.17	2,420	Aug. 01, 1996
10	17.93	2,250	Dec. 12, 2008
11	17.62	2,200	Jan. 28, 1994
*Rank refers to the relative severity of each flood, i.e. Rank 1 is the highest flood crest on record (1989 - 2013). **Discharge affected to unknown degree by regulation (dams) and diversion (the City of New Brunswick diverts water for municipal supply just upstream of the gage).			
Source: USGS, 2013 http://nwis.waterdata.usgs.gov/nj/nwis/uv/?site_no=01405030&PARAmeter_cd=00065,00060,62614			

hydrophytic vegetation. To determine if an area is a wetland, the vegetation (plants that like wet conditions), soils (wetland types, which often show mottling) and hydrology (low spots or evidence of water) are evaluated. A *transition area*, or buffer, is an area of land adjacent to a freshwater wetland that minimizes adverse impacts on the wetland or serves as an integral component of the wetlands ecosystem (N.J.S.A. 13:9B-3 in NJDEP Division of Land Use Management, July 16, 1998).

In the past, wetlands were often regarded as wastelands – only useful when drained and filled. In contrast, a 1978 Tufts University study showed that one acre of wetland provides at least $153,000 (1978 dollars) of public value, considering proven monetary benefits of flood protection, pollution reduction, water supply, recreation and aesthetics (Fair, 2004). Some of the benefits of wetlands include:

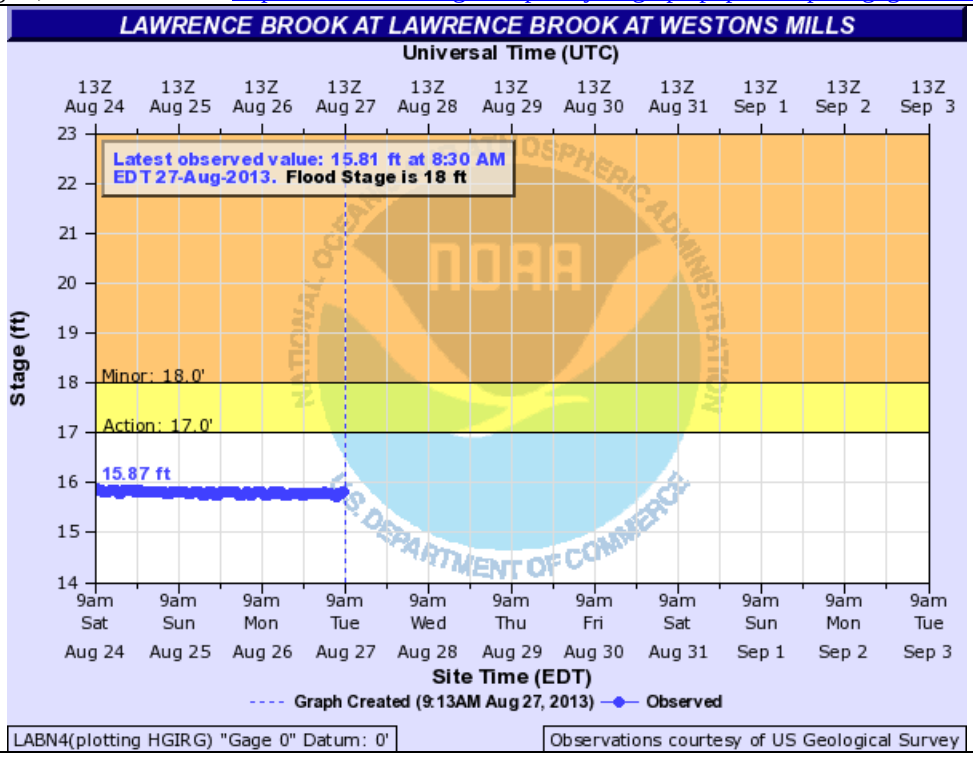
- Wetlands protect drinking water by filtering out pollutants and sediments that would otherwise obstruct and contaminate our waters.
- Wetlands soak up runoff from heavy rains and snow melts, providing natural flood control.
- Wetlands release stored waters during droughts.
- Wetlands provide critical habitats for a major proportion of the state's fish and wildlife, including many endangered, commercial and recreational species.
- Wetlands provide high quality open space for recreation and tourism (NJDEP Land Use Regulation, 2013 and July 16, 1998).

The value of wetlands was not broadly accepted until at least the 1970s and 1980s. By then, more than half of the country's wetlands had been destroyed (NJDEP Land Use Regulation, 2013). Loss of wetlands has resulted in erosion, flooding, sedimentation, and decreased populations of many types of wildlife. Structures built in wetlands suffer from frost heaving and other structural problems.

Table 6.3: Lawrence Brook Flood and Flow Resources

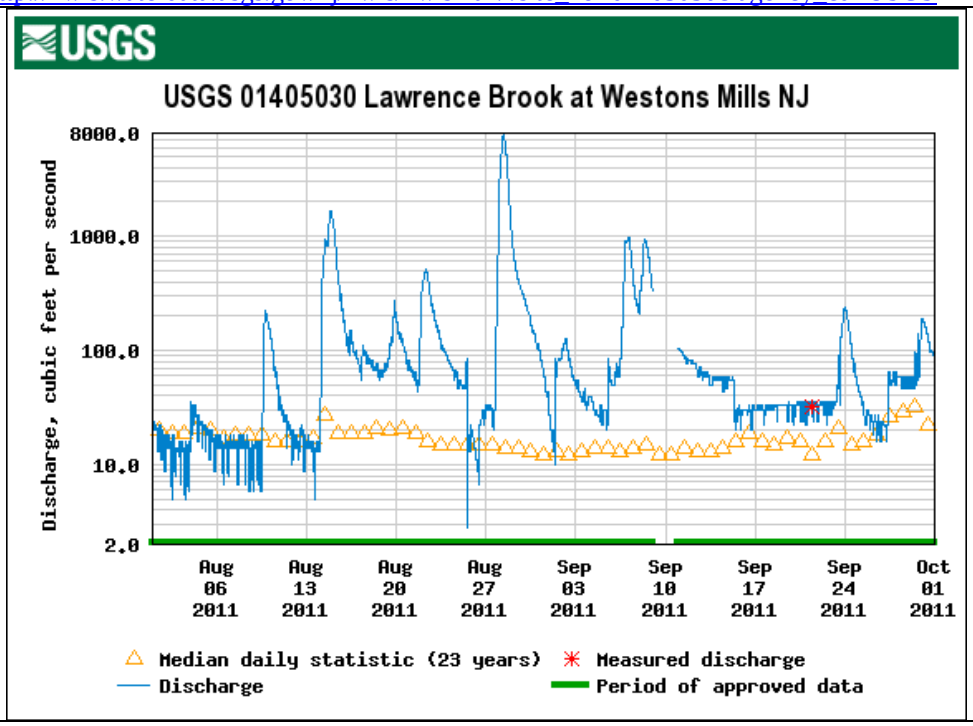
National Weather Service Advanced (NOAA) Hydrologic Prediction Service

Flood predictions are not available for this site. In this example, Lawrence Brook flow remains steady for several days in August, 2013. Website: http://water.weather.gov/ahps2/hydrograph.php?wfo=phi&gage=labn4



USGS National Water Information System Data

By default, the site displays the most recent flow information. In this example, the Lawrence Brook flow for August – September 2011 is shown, illustrating the highest flow on record.
Website: http://nwis.waterdata.usgs.gov/nj/nwis/nwisman/?site_no=01405030&agency_cd=USGS



Source: NOAA National Weather Service, August 2013 and USGS, August 2013

New Jersey protects wetlands under the 1987 New Jersey Freshwater Wetlands Protection Act (N.J.S.A. 13:9B) and Rules (N.J.A.C. 7:7A) (NJDEP Division of Land Use Management, July 16, 1998 and December 7, 2009). Under these, NJDEP regulates virtually all activities proposed within wetlands and transition areas or buffers around freshwater wetlands, including cutting of vegetation, dredging, excavation or removal of soil, drainage or disturbance of the water level, and filling or discharge of any materials. Development that would impair the wetland's ability to provide the values listed above (filtration, flood control, etc.) is prohibited. There are limited exemptions for existing farming, ranching, or forestry operations.

On-site inspection (direct testing and observation of soils, hydrology and vegetation) by a qualified professional is needed prior to making any disturbance within a wetland or transition area. Only an official determination from NJDEP, called a *Letter of Interpretation* (LOI) can verify the presence, absence, or boundaries of freshwater wetlands and transition areas on a site. Copies of these maps are filed at the NJDEP and the township building, but unfortunately, NJDEP does not digitize these determinations into a GIS layer[32].

In addition to defining the boundary of the wetland, the LOI establishes the value of the wetland, which will determine the width of the regulated transition area. *Ordinary Value* wetlands, such as man-made drainage ditches and swales, have a 0 foot buffer. *Intermediate Value* wetlands, which include those wetlands not included in the definitions of Ordinary or Exceptional value, have a 50 foot buffer, and *Exceptional Value* wetlands have a 150 foot buffer width. Exceptional Value wetlands include wetlands that provide habitat for endangered and threatened species and those contiguous with FW-1, FW-2 Trout Production waters and their tributaries, and Category 1 classified streams (see **Section 6D** for descriptions of stream classifications, below). A determination of threatened and endangered species habitat is provided by using the Landscape Project data (see **Section 7F**).

The wetlands shown in **Figure 6e** were determined by selecting all wetlands land use types from NJDEP's 2007 Land Use GIS data. **Figure 6e** provides guidance on where wetlands are found in North Brunswick. This dataset is intended to serve as a resource for analysis rather than regulatory delineations because it is derived from aerial photos rather than on-site surveys. In addition, changes in wetlands that have occurred since 2007, whether permitted by NJDEP or not, are not shown. The transition area widths of 0, 50 and 150 feet are mapped in **Figure 6e**, because the GIS data does not determine the value of each wetland. The actual transition area width required by the NJDEP is determined in the LOI.

There are approximately 1,075 acres of wetlands within North Brunswick, or 14% of the Township (NJDEP, 2010). There are several types of freshwater wetlands in North Brunswick, such as deciduous wooded wetlands, scrub/shrub wetlands and herbaceous wetlands. About 146 acres are disturbed or modified wetlands, such as for agriculture or maintained lawn greenspace (see **Section 7A** and **Figure 7c**).

D. Surface Water Quality Standards

Surface Water Quality Standards (SWQS) are the rules in chapter N.J.A.C. 7:9B that set forth designated uses, use classifications, and water quality criteria for the State's waters based upon the uses, and the NJDEP's policies concerning these uses, classifications and criteria, which are necessary to protect the State's waters. The SWQS operate in conformance with the Federal

[32] Digitizing involves giving latitude and longitude coordinates to areas and lines to depict mapped features.

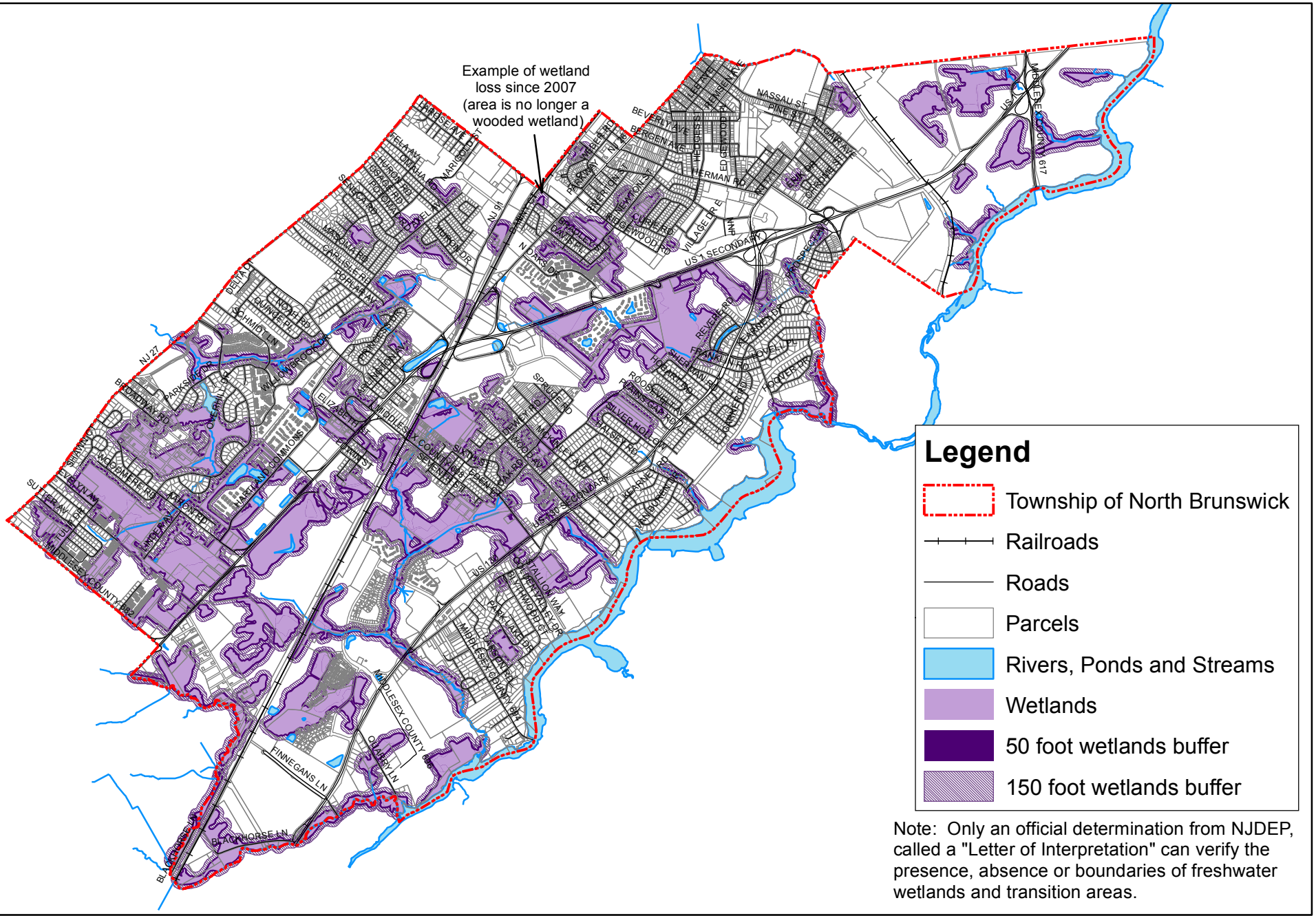


Figure 6e: Wetlands

0 0.25 0.5 1 Miles

N

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Prepared by Kratzer Environmental Services

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Water Pollution Control Act (33 U.S.C. 1313(c)), commonly known as the Clean Water Act (CWA), and the Federal Water Quality Standards Regulation at 40 CFR 131. According to the Surface Water Quality Standards N.J.A.C. 7:9B

> "Water is vital to life and comprises an invaluable natural resource which is not to be abused by any segment of the State's population or economy. It is the policy of the State to restore, maintain and enhance the chemical, physical and biological integrity of its waters, to protect the public health, to safeguard the aquatic biota, protect scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial, agricultural and other reasonable uses of the State's waters.
>
> "The restoration, maintenance and preservation of the quality of the waters of the State for the protection and preservation of public water supplies is a paramount interest of the citizens of New Jersey.... Toxic substances in waters of the State shall not be at levels that are toxic to humans or the aquatic biota, or that bioaccumulate in the aquatic biota so as to render them unfit for human consumption.... Human health-based ambient criteria have been established in freshwaters due to consumption of fish and water, and in saline water due to consumption of fish. For carcinogens, the criteria have been established at levels which would result in no greater than a one-in-one-million lifetime excess cancer risk. For non-carcinogens, the criteria have been established which would result in no appreciable risk of deleterious effect." (NJDEP Land Use Management, Water Monitoring and Standards, April 4, 2011).

According to the designated uses under the SWQS, NJDEP assigns *surface water classifications* to each stream in order to group waters and assign water quality criteria. Designated uses include potable water, propagation of fish and wildlife, recreation, agricultural and industrial supplies, and navigation. The *criteria* are numerical targets for constituent concentrations (such as toxic pollutants) or narratives that describe in-stream conditions to be attained, maintained or avoided, so that the specified uses are protected for the different use classifications.

The SWQS are used by several NJDEP programs, including the New Jersey Pollutant Discharge Elimination System program, Site Remediation program, Stream Encroachment, Land Use Regulation Program and Total Maximum Daily Loads (TMDLs, see **Section 6E**).

Table 6.4 describes the definitions of the surface water classifications, while **Figure 6f** illustrates the stream categories within North Brunswick and the surrounding areas.

The Lawrence Brook and all streams within North Brunswick are designated Freshwater 2 (FW2) and Non-Trout production (NT). Six Mile Run is Category One just outside (downstream) of North Brunswick. The Lawrence Brook becomes saline (FW2-NT/SE1) approximately 2/3 mile downstream (to the east) (NJDEP Land Use Management, Water Monitoring and Standards, April 4, 2011).

Table 6.4: Surface Water Quality Standards Classification

Category	Definition
Freshwater General Surface Water Class	
FW1	**FW1** means those fresh waters, as designated in N.J.A.C. 7:9B-1.15(j), that are to be maintained in their natural state of quality (set aside for posterity) and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance or exceptional fisheries resource(s).
FW2	**FW2** means the general surface water classification applied to those fresh waters that are not designated as FW1 or Pinelands Waters. In all FW2 waters the designated uses are: 1. Maintenance, migration and propagation of the natural and established biota; 2. Primary contact recreation; 3. Industrial and agricultural water supply; 4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation, and sedimentation, resulting in substantial particulate removal but

Table 6.4: Surface Water Quality Standards Classification

Category	Definition
	no consistent removal of chemical constituents) and disinfection; and 5. Any other reasonable uses.
Trout Water Status - this is for information only and does not affect the water quality criteria for those waters.	
TP	***Trout production*** means waters designated at N.J.A.C. 7:9B-1.15I through (i) for use by trout for spawning or nursery purposes during their first summer.
TM	***Trout maintenance*** means waters designated at N.J.A.C. 7:9B-1.15I through (i) for the support of trout throughout the year.
NT	***Nontrout waters*** means fresh waters that have not been designated in N.J.A.C. 7:9B-1.15(b) through (h) as trout production or trout maintenance. These waters are generally not suitable for trout because of their physical, chemical, or biological characteristics, but are suitable for a wide variety of other fish species.
Antidegradation	
ONRW	***Outstanding National Resource Waters*** means high quality waters that constitute an outstanding national resource (for example, waters of National/State Parks and Wildlife Refuges and waters of exceptional recreational or ecological significance). Waters classified as FW1 waters and Pinelands waters are Outstanding National Resource Waters.
FW1/Non-degrada-tion	***Nondegradation waters*** means those waters set aside for posterity because of their clarity, color, scenic setting, other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, or exceptional water supply significance. These waters include all waters designated as FW1.
C1	***Category one waters*** means those waters designated in the tables in N.J.A.C. 7:9B-1.15(c) through (i), for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d), for protection from measurable changes in water quality based on exceptional ecological significance, exceptional recreational significance, exceptional water supply significance or exceptional fisheries resource(s) to protect their aesthetic value (color, clarity, scenic setting) and ecological integrity (habitat, water quality and biological functions).
C2	***Category two waters*** means those waters not designated as Outstanding National Resource Waters or Category One at N.J.A.C. 7:9B-1.15 for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d).
SE	*SE* means the general surface water classification applied to saline waters of estuaries. Unlisted saline waterways and waterbodies are classified as SE1 in the Atlantic Coastal Basin; designated uses are listed in N.J.A.C. 7:9B-1.12(d). In all SE1 waters the designated uses are: 1. Shellfish harvesting in accordance with N.J.A.C. 7:12; 2. Maintenance, migration and propagation of the natural and established biota; 3. Primary contact recreation; and 4. Any other reasonable uses. FW2-NT/SE1 (or a similar designation that combines two classifications) means a waterway in which there may be a salt water/fresh water interface. The exact point of demarcation between the fresh and saline waters must be determined by salinity measurements and is that point where the salinity reaches 3.5 parts per thousand at mean high tide. The stream is classified as FW2-NT in the fresh portions (salinity less than or equal to 3.5 parts per thousand at mean high tide) and SE1 in the saline portions.
Source: NJDEP Land Use Management, Water Monitoring and Standards, April 4, 2011	

E. Integrated List and Total Maximum Daily Loads

States are required by the Federal Clean Water Act (US Federal Water Pollution Control Act, January 4, 2011) to develop a biennial Water Quality Inventory Report (required under Section 305(b) of the act) and a List of Water Quality Limited Segments (required under Section 303(d)). Since 2001, the USEPA has recommended that states integrate these two, producing the *Integrated List*. The goal is to provide an effective tool for maintaining high quality waters where designated uses (designated by the SWQS, discussed above in **Section 6D**) are attained,

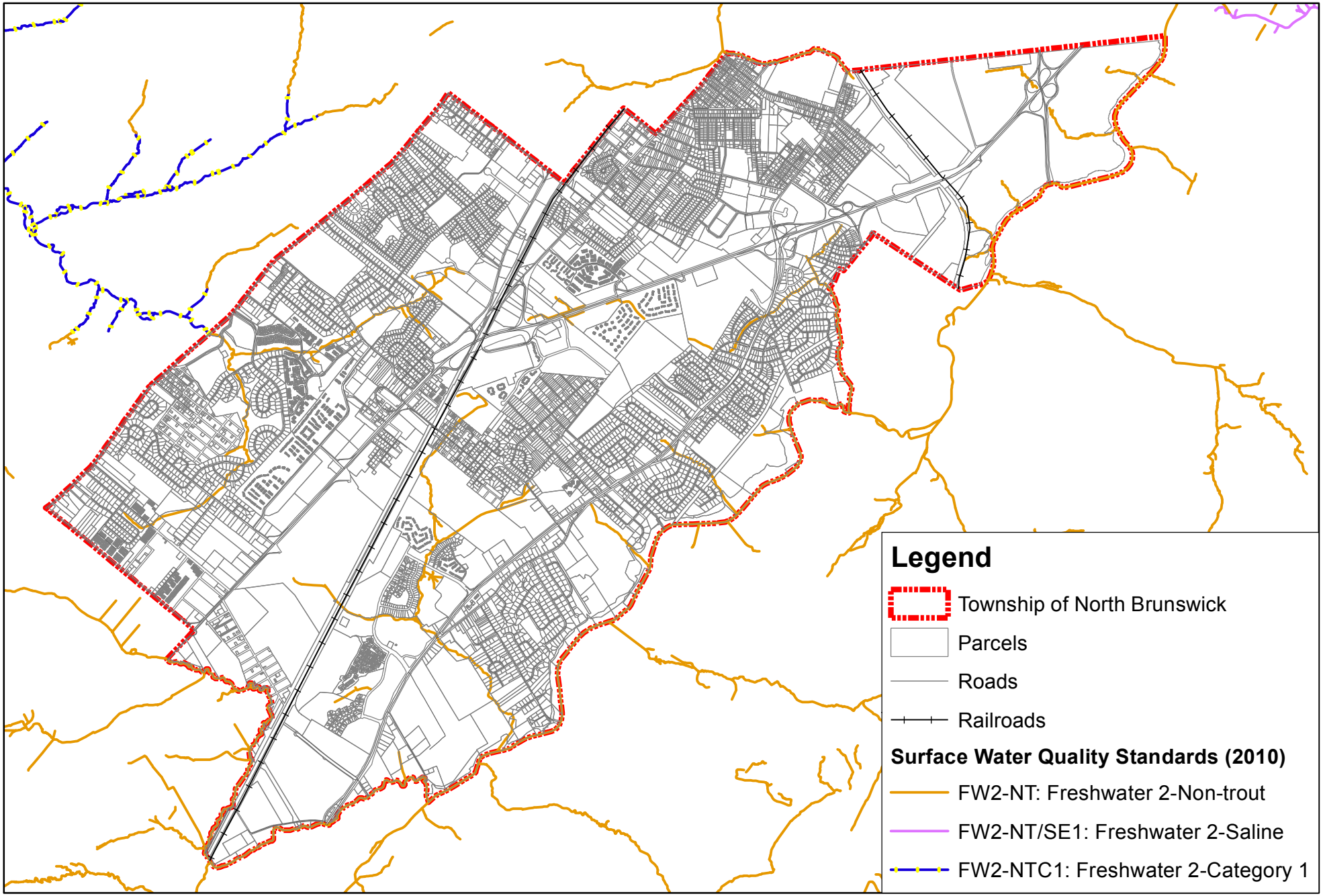


Figure 6f: Surface Water Quality Standards (SWQS) (2010)

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

and improving the quality of surface waters that do not attain their designated uses (NJDEP Water Monitoring and Standards, July 2012a).

The Integrated List is subject to regulatory requirements, which include public participation and submission to the USEPA for approval and adoption. The Integrated List identifies the status of all applicable designated uses for every assessment unit (usually by HUC14 sub-watershed) by labeling the results of each designated use assessment as *Fully Supporting*, *Not Supporting*, or *Insufficient Information* (see **Table 6.5**).

The NJDEP is required to use all existing and readily available data to assess water quality for the Integrated List. As a result, assessment of the HUC14 that encompasses North Brunswick may include sites in South Brunswick, Franklin and New Brunswick, in addition to North Brunswick. A methods document summarizes each step in the assessment process; to evaluate stations and data quality, combine stations to evaluate an assessment unit, assess designated uses, rank and prioritize assessment units that do not attain designated uses, develop a monitoring and assessment plan and provide for public participation (NJDEP Water Monitoring and Standards, July 2012b).

Table 6.5: 2012 Integrated List (Overview)

Assessment Unit (HUC14)	Sub-watershed	Designated Use★					
		Agricultural Water Supply	Aquatic Life General	Fish Consumption	Industrial Water Supply	Primary Contact Recreation	Public Drinking Water Supply
2030105110120	Six Mile Run (above Middlebush Road) *Freshwater Lake 2.3 Acres* *River 22.46 Miles*	F	N	I	F	I	F
2030105120150	Mile Run *River 6.96 Miles*	I	N	I	I	I	I
2030105130030	Oakeys Brook *River 13.71 Miles*	I	F	I	I	I	I
2030105130050	Lawrence Brook (Church Lane to Deans Pond) *Freshwater Lake 62.22 Acres* *River 13.12 Miles*	I	N	N	F	N	N
2030105130060	Lawrence Brook (Milltown to Church Lane) *Freshwater Lake 189.04 Acres* *River 12.14 Miles*	F	N	N	F	N	N
2030105130070	Lawrence Brook (below Milltown/Herberts Br.) *Freshwater Lake 98.56 Acres* *River 12.52 Miles*	I	N	N	I	I	I

★**Designated Uses:** F = Fully Supporting; N = Not Supporting; I = Insufficient Information

Minimum Suite of Parameters Needed to Determine if Water Quality is "Fully Supporting" a Use:

Agricultural Water Supply: Total Dissolved Solids (TDS)
Aquatic Life – General: Biological data
Fish Consumption: Fish tissue data
Industrial Water Supply: Total Suspended Solids (TSS) and pH
Primary Contact Recreation: Pathogenic Indicator Bacteria
Public Drinking Water Supply: Nitrate and Total Dissolved Solids (TDS)

Source: NJDEP Water Monitoring and Standards, May 2012; July 2, 2012a; and July 2012d.

The 2012 Integrated List, which summarizes whether or not the surface water quality of North Brunswick's six sub-watersheds meets the SWQS, is shown in **Table 6.5** and **Figure 6g**. The water quality supports the uses of agricultural water supply, aquatic life (general), industrial water supply, and public water supply in 1 to 3 subwatersheds within the township. The water quality does not support the uses of aquatic life (general), fish consumption, primary contact recreation, or public drinking water supply in 2 to 5 of the subwatersheds. There is insufficient data to evaluate attainment for the other use-subwatershed combinations. **Table 6.6** displays more information about the impaired waters within North Brunswick.

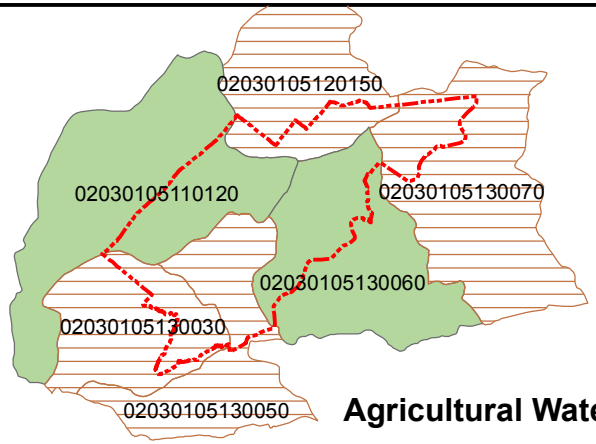
When surface waters do not meet the SWQS, *Total Maximum Daily Loads* (TMDLs) must be developed, as specified under Section 303(d) of the Federal Clean Water Act (US Federal Water Pollution Control Act, January 4, 2011). A TMDL identifies all the contributors to surface water quality impacts and sets goals for load[33] reductions for specific pollutants in order to meet the SWQS. Regulations concerning TMDLs are contained in EPA's Water Quality Planning and Management Regulations (USEPA, June 4, 2013).

TMDLs represent the assimilative capacity of surface water for a given parameter of concern. The development of TMDLs includes balancing the impacts from point sources, nonpoint sources and natural background levels of a specific pollutant. The TMDL then quantifies the amount of a pollutant a water body can assimilate without violating a state's water quality standards and allocates that load capacity to known point and nonpoint sources in the form of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, plus a margin of safety (MOS). Load allocations (for nonpoint source pollution) consist of identifying categories of nonpoint sources that contribute to the parameters of concern, followed by recommendations for implementation measures for specific load reductions. Examples include best management practices (BMPs), including structural (stormwater runoff controls) and non-structural (local ordinances for stormwater management and nonpoint source pollution control) mechanisms for addressing the water quality parameter(s) of concern (NJDEP Division of Watershed Management, July 30, 2013).

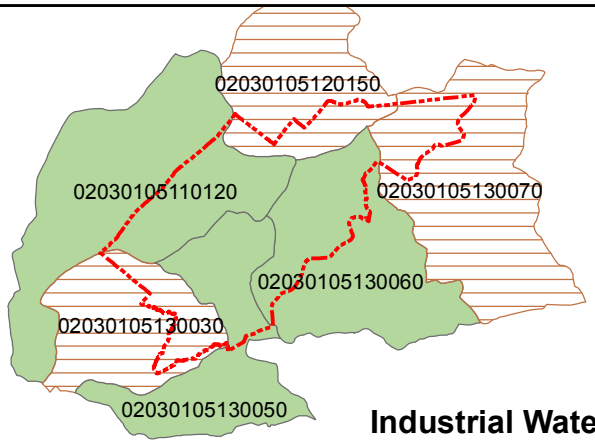
Waters requiring TMDLs are identified in the Integrated List of Waterbodies that combines the 303(d) list of impaired waters and the surface water quality inventory report (305b), which NJDEP prepares every two years. After the Integrated List is approved, the NJDEP writes a TMDL report, which is a proposed Water Quality Management Plan Amendment. When this is published in the NJ Register for public review and comment, the TMDL is considered *proposed*. NJDEP then considers comments received during public comment and finalizes the TMDL report, and the TMDL is considered *established* when it is formally submitted to the US EPA Region 2 for thirty-day review. The TMDL is considered *approved* when the US EPA Region 2 approves it. Next, the TMDL is referred to as *adopted* when the EPA-approved TMDL is adopted by NJDEP as a water quality management plan amendment and the adoption notice is published in the NJ Register (NJDEP Division of Watershed Management, July 30, 2013).

An unnamed tributary within North Brunswick Community Park

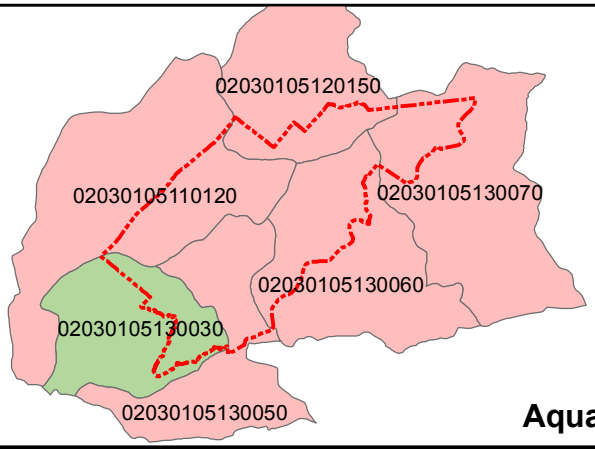
[33] Load is the total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time (USEPA, June 4, 2013).



Agricultural Water Supply



Industrial Water Supply



Aquatic Life

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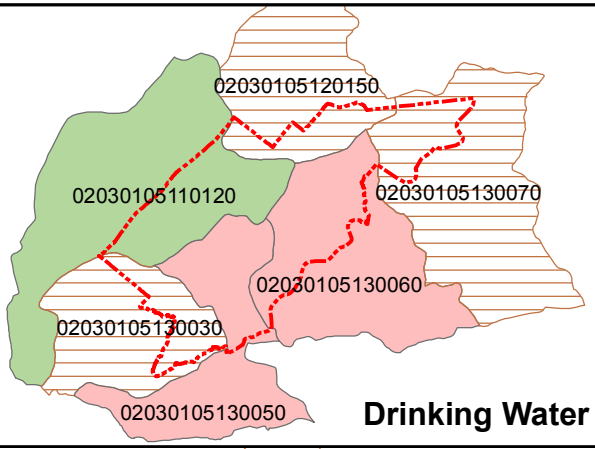
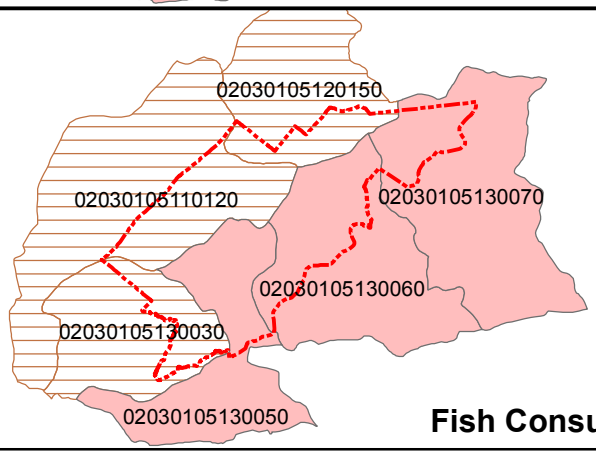
Township of North Brunswick

Integrated List by HUC14

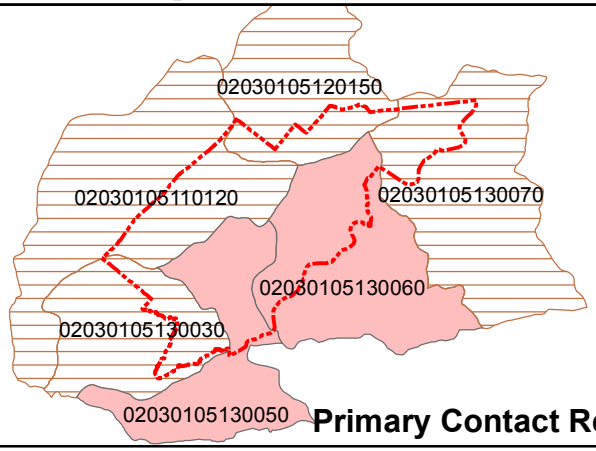
- Fully Supporting
- Not Supporting
- Insufficient Information



Drinking Water Supply



Fish Consumption



Primary Contact Recreation

Figure 6g: 2010 Integrated List (Attainment of Water Quality Standards for Each Designated Use)

0 1.25 2.5 5 Miles

N

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
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In 2009, New Jersey established a TMDL addressing mercury in fish tissue in 122 assessment units, including Lawrence Brook (Church Lane to Deans Pond) and Lawrence Brook (Milltown to Church Lane). It was determined that the source of mercury is primarily atmospheric deposition. Implementation of the TMDL for mercury reduction is being achieved through the actions identified in the New Jersey Mercury Task Force Report. In recent years, New Jersey has substantially reduced mercury through regional and site-specific efforts (USEPA, September 25, 2009; NJDEP Office of Science, November 1, 2010).

Table 6.6: Integrated Water Quality Assessment (Details of Nonsupporting Uses)

Use	Attainment★	Cause	First on 303(d) List	TMDL Priority*	Source
02030105110120: Six Mile Run (above Middlebush Rd)					
Aquatic Life	N	Phosphorus (Total)	2006	High Priority	• Agriculture • Urban Runoff/Storm Sewers
Primary Contact Recreation	N	Escherichia coli	2012	Medium Priority	
2030105120150: Mile Run					
Aquatic Life	N	Cause unknown	2006	Low Priority	• Agriculture • Urban Runoff/Storm Sewers
Primary Contact Recreation	N	Escherichia coli	2012	Medium Priority	
2030105130030: Oakeys Brook					
Aquatic Life	N	Cause unknown	2012	Medium Priority	• unknown
2030105130050: Lawrence Brook (Church Lane to Deans Pond)					
Aquatic Life	N	Cause Unknown	2006	Medium Priority	• Agriculture • Urban Runoff/Storm Sewers
Fish Consumption	N	Mercury in Fish Tissue	2010	Completed	
Primary Contact Recreation	N	Escherichia coli	2008	Medium Priority	
Public Water Supply	N	Arsenic	2006	Low Priority	
2030105130060: Lawrence Brook (Milltown to Church Lane)					
Fish Consumption	N	Mercury in Fish Tissue	2010	Completed	• Natural Sources
Primary Contact Recreation	N	Escherichia coli	2008	Medium Priority	
Public Water Supply	N	Arsenic	2008	Low Priority	
2030105130070: Lawrence Brook (below Milltown/Herberts Br.)					
Aquatic Life	N	Cause Unknown	2006	Medium Priority	• Atmospheric Deposition - Toxics • Package Plant or Other Permitted Small Flows Discharges • Agriculture • Urban Runoff/Storm Sewers
Fish Consumption	N	Dioxin (including 2,3,7,8-TCDD) PCB in Fish Tissue	2006 2006	Low Priority Low Priority	
Public Water Supply	N	Arsenic	2012	Low Priority	

★**Attainment of Designated Uses:** N = Not Supporting;
***Medium** priority = NJDEP expects to complete TMDL in the near future, but not within the next two years.
Low priority = NJDEP does not expect to complete TMDL in the immediate or near future.

Source: NJDEP Water Monitoring and Standards, July 2, 2012a

The Total Phosphorus TMDL for Six Mile Run (above Middlebush Rd) is scheduled for completion within the next two years (NJDEP Water Monitoring and Standards, July 2012d). Excessive phosphorus concentrations in surface water can lead to eutrophication – the excessive growth of algae and/or macrophytes. The normal daily fluctuations in pH and dissolved oxygen due to plant respiration become amplified, which can result in violation of criteria for pH and dissolved oxygen, and can adversely affect the aquatic community (such as macroinvertebrates and fish). In addition, dense plant biomass can physically interfere with designated uses, such as swimming or boating. Algal blooms can also affect taste and odor, which are significant to drinking water quality standards, as well as recreation. As stated in N.J.A.C. 7:9B-1.14(c) of the SWQS for Fresh Water 2 (FW2) waters, the criteria for Total Phosphorus is 0.05 mg/l in any lake, pond or reservoir, and 0.1 mg/l in any stream.

No other TMDLs for North Brunswick's six sub-watersheds are scheduled for completion at least in the next two years (NJDEP Water Monitoring and Standards, July 2012d).

States may remove an assessment unit-pollutant combination from the Integrated List under specific situations, in a process commonly referred to as *delisting*. The Lawrence Brook (Milltown to Church Lane) subwatershed was originally listed in 2010 for pH, but has been delisted for pH because the applicable Water Quality Standard was attained; original basis for listing was incorrect. New data analyzed for the 2012 assessment showed that all samples met the pH criterion (NJDEP Water Monitoring and Standards, July 2, 2012b & July 2012c).

F. Point Source Pollution

Point source pollution (as defined by N.J.A.C. 7:9B Surface Water Quality Standards) refers to discernible, confined, and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture (NJDEP Land Use Management, Water Monitoring and Standards, April 4, 2011).

NJ Pollutant Discharge Elimination System (NJPDES)

Point source discharges are regulated by NJDEP under the New Jersey Pollutant Discharge Elimination System (NJPDES). There are two existing discharges within North Brunswick, and one that was transferred to the Bureau of Nonpoint Pollution Control (see **Table 6.7** and **Figure 6h**) (NJDEP, Division of Water Quality, November 16, 2011).

Aquatic Pesticides

The NJDEP Pesticide Control Program is responsible for issuing permits for aquatic pesticide use for the control of aquatic weeds throughout the state. The purpose of this database is to determine trends in aquatic pesticide use. One site in North Brunswick, Governor's Point Ponds 1 & 2, is in the database (treated with copper) (see **Figure 6h**) (NJDEP, C&E, BPO, October 2009).

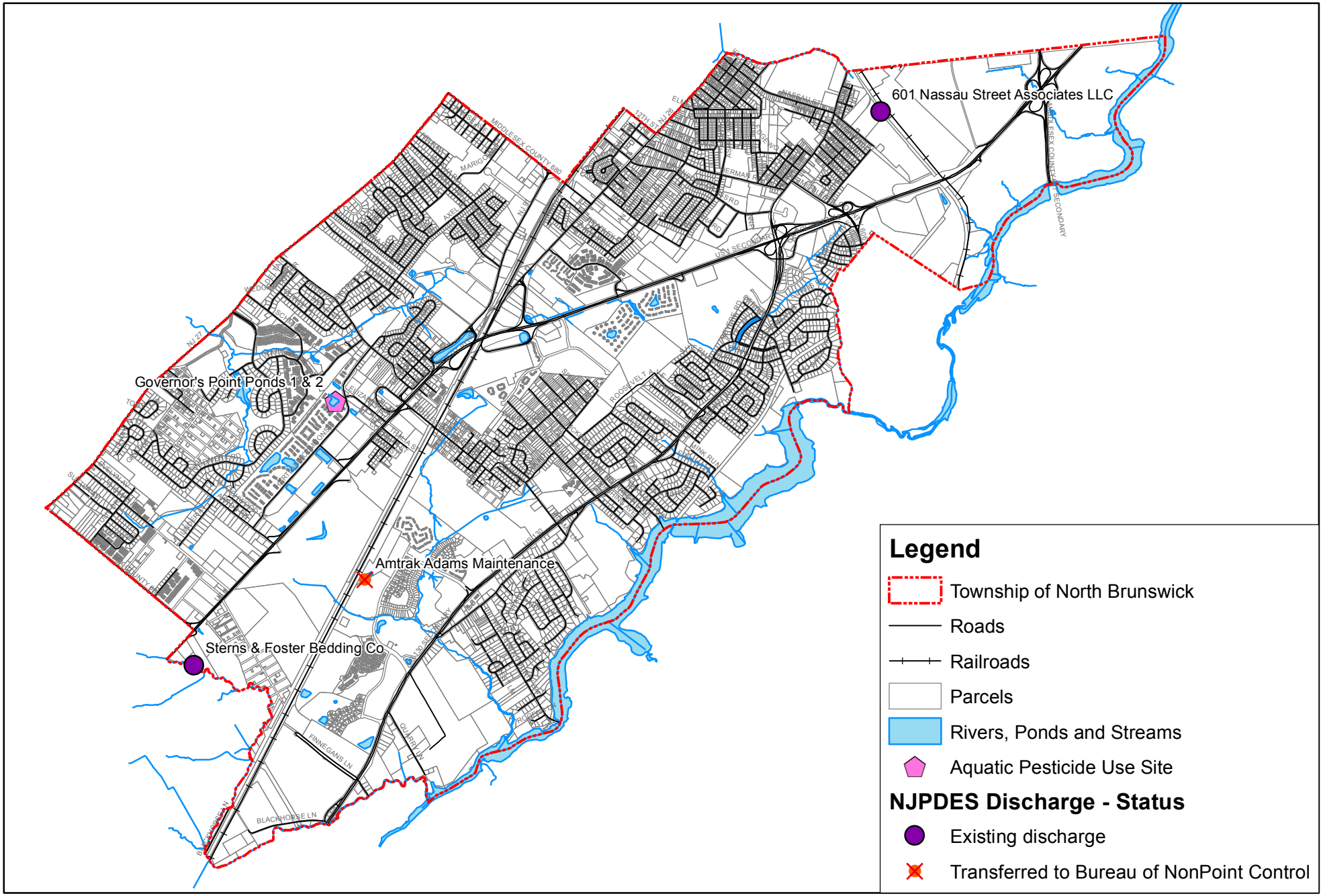

Figure 6h: Surface Water Discharges & Aquatic Pesticide Sites

0 0.25 0.5 1 Miles

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Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
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Table 6.7: NJ Pollutant Discharge Elimination System Surface Water Discharges

PI #⬩	NJPDES ID. #	Facility Name	Status *	Discharge Type*	Receiving Waters
49633	NJG0132829.001A	Sterns & Foster Bedding Co	E	BGR	Oakey's Brook
46067	NJG0033499.001A	Amtrak Adams Maintenance	X	RF	Lawrence Brook via unnamed tributary
49344	NJG0129127.001A	601 Nassau Street Associates LLC	E	BGR	Mile Run via unnamed tributary & storm sewer

⬩PI number corresponds to numbers on **Figure 6h.**
***Notes for Above Codes** (NJDEP's codes and definitions were used):
Status: **E**=Existing in the Point Source Permitting Regions; **X**= Transferred to BNPC - Permits transferred to Bureau of Nonpoint Pollution Control
Discharge type: **BGR**= General Groundwater Remediation; **RF**=Stormwater Discharge

Source: NJDEP, Division of Water Quality, November 16, 2011

G. Nonpoint Source Pollution

Nonpoint source or NPS pollution is any man-made or man-induced activity, factor, or condition, other than a point source, from which pollutants are or may be discharged. Nonpoint pollution may temporarily or permanently change any chemical, physical, biological, or radiological characteristic of water from what was or is the natural, pristine condition of such water.

Impervious surfaces are materials that prevent the infiltration of water into the soil (e.g. parking lots, roads, buildings, sidewalks and compacted soil). The construction of impervious surfaces disrupts the natural water cycle, and is one of the more significant landscape impacts attributable to urbanization (Hasse and Lathrop, 2008). When water flows off impervious surfaces, it is known as *stormwater*. Nonpoint source pollution is directly associated with stormwater.

An increase in impervious surface results in less water infiltrating to the soil and groundwater, which instead runs off the surface and gains velocity. As the velocity of water increases, the amount that can infiltrate into the soil and ground water is reduced and scouring and erosion increase. The stormwater eventually discharges into streams and rivers, carrying pollutants that it has picked up along the way (e.g. trash, used motor oil, sediments, fertilizers, pesticides, pet droppings, etc.). The transport of these pollutants into local water bodies can result in the destruction of fish, wildlife, and habitats; threats to public health due to contaminated food and drinking water supplies; and losses of recreational and aesthetic values. In addition, increased stormwater results in greater frequency and magnitude of floods (Hasse and Lathrop, 2008; Kaplan and Ayers, 2000).

Studies have shown that the level where impacts begin to be seen is above 10% impervious surfaces, and that impacts become severe over 25 to 30% (Kaplan and Ayers, 2000).

NJDEP estimated percent impervious surface based on particular land uses. Approximately 41% of North Brunswick has less than 10% impervious surface; 8% of the

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A stormwater basin on Renaissance Boulevard

township has between 10 and 25% impervious surface, and 51% of the township has greater than 25% impervious surfaces (see **Figure 6i)** (NJDEP, July 12, 2010).

The goals of New Jersey's Stormwater Management Rule (N.J.A.C. 7:8) include reducing runoff, flooding, erosion and non-point pollution for public safety as well as ecological and biological integrity. There are requirements for stormwater management measures and regional and municipal stormwater management planning (NJDEP, April 2010).

The purpose of the Municipal Stormwater Regulation Program is to ensure a consistent approach to stormwater management statewide, reduce costs for regulated entities, and allow for a simple process for requesting authorization. All municipalities within the State are assigned either Tier A (more developed or coastal municipalities, including North Brunswick) or Tier B (less developed and non-coastal) (NJDEP Bureau of Nonpoint Pollution Control, December 2006).

The permits address stormwater quality related issues to new and existing development and redevelopment by requiring the preparation of a stormwater program and implementation of specific permit requirements referred to as Statewide Basic Requirements (SBRs). The Tier B Permit concentrates on new development and redevelopment projects and public education. The Tier A Permit has additional requirements aimed at controlling stormwater pollutants from existing development, such as public education, disposal of waste, solids and floatable controls, maintenance yard operations and employee training (NJDEP Bureau of Nonpoint Pollution Control, April 2004).

In 2006, the Township of North Brunswick adopted a stormwater ordinance (Chapter 205 Article XXXVII of the North Brunswick Code (see **Internet Resources**).

H. Surface Water Quality and Flow Monitoring

The various monitoring programs in the region are discussed below. A list of the sites sampled for each program is provided in **Table 6.8**, grouped by subwatershed, and shown on **Figure 6j**. Data collected through these monitoring programs are used in the Integrated List discussed in **Section 6E.** It is possible that data from other sites might be available, such as any monitoring done by volunteer organizations.

NJDEP Ambient Stream Quality Monitoring Sites for New Jersey (SWpoints)

These data represent ambient stream sites monitored cooperatively by the NJDEP and the USGS for water quality parameters. This network was established in 1976 to determine status and trends of ambient surface waters in New Jersey. The sampling frequency is four times per year. A wide range of conventional parameters, metals, pesticides and sediments are monitored in this program. Metals, pesticides and sediments are monitored on a reduced sampling frequency. Data is available from the following sources: 1.) the USGS computerized data system, NWIS, 2.) EPA's computerized data system, STORET or 3.) USGS's annual reports "Water Resources Data-New Jersey". One site on Oakeys Brook is in North Brunswick, and one site on Lawrence Brook is on the Milltown/East Brunswick border (NJDEP, November 20, 2008).

NJDEP Ambient Supplemental Surface Water Monitoring (SASMN)

This network was established in 2000 to supplement the existing Ambient Surface Water Quality Monitoring Network (described above) to improve spatial coverage by siting an ambient monitoring station in every HUC11. This program measures water quality at only one site within

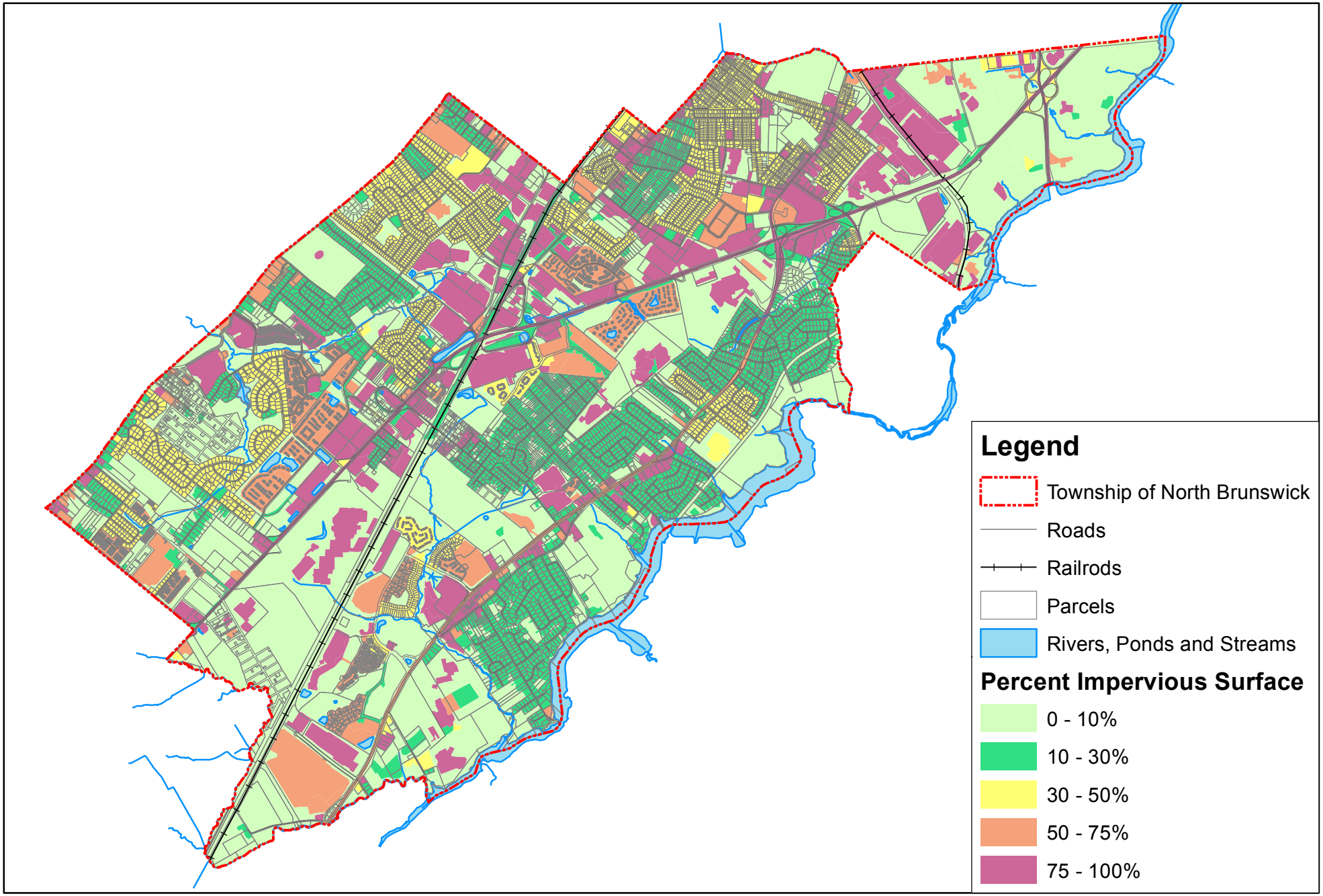

Figure 6i: Percent Impervious Surface

0 0.25 0.5 1 Miles

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the six HUC14s encompassing North Brunswick, which is on Lawrence Brook on the Milltown/East Brunswick boundary (NJDEP, December 21, 2010)

NJDEP Existing Water Quality Stations in New Jersey (EWQPOI)

These data represent sampling points for the EWQ (Existing Water Quality) project at NJDEP. The EWQ Network was designed to provide supplemental data for water quality for the entire state to support water management and monitoring activities within NJDEP, and to be a valuable layer for computerized cartographic products. One location in this sampling network is located within the same HUC14s as North Brunswick, on Lawrence Brook on the Milltown/East Brunswick boundary (NJDEP, October 19, 2007).

NJDEP Ambient Biomonitoring Network (AMNET) (Biopts)

Sites are sampled for benthic aquatic macroinvertebrate using the Rapid Bioassessment Protocol in order to make assessments at three levels of impairment; non-impaired, moderately impaired, and severely impaired. Sites are sampled every 5 years. The data is used as a primary environmental indicator of water quality impairment for New Jersey's Environmental Performance Partnership Agreement (NEPPS) with USEPA. There is one biological monitoring site in each of the six HUC14s covering North Brunswick. The sites on Oakeys Brook and Six Mile Run are located within North Brunswick (NJDEP, November 2010). AMNET is described in more detail below, and results are summarized in **Table 6.9**.

Fish Index of Biotic Integrity Stations (FIBI)

The Fish Index of Biotic Integrity supplements the macroinvertebrate biomonitoring network by assessing the biological health of a stream based on resident fish populations. Like AMNET, sites are sampled once every 5 years. No sites are located within North Brunswick, but there are FIBI sites within two of the surrounding HUC14s; one on Six Mile Run and one on Mile Run (NJDEP, December 15, 2010).

NJDEP/USGS Surface WQ Gage (WQgage)

This network is jointly funded by USGS and NJDEP. USGS maintains a network of gages across NJ at which surface water quality is measured. As project needs and funding levels change, different sites may be active in any given year. The data measured at the active sites are published annually as part of the USGS' series of annual water-data reports. This program includes one site within North Brunswick's six HUC14s; on Lawrence Brook at Westons Mills (USGS, April 17, 2002a).

USGS Continuous-Stream Flow Gaging (Streamgage)

These sites are maintained by the United States Geological Survey (USGS), Water Resource Division (WRD). Two sites in North Brunswick have been discontinued. The only nearby existing site in on the Lawrence Brook at Westons Mills. The gage continuously monitors stream flow and these data are available online in real-time (see **Internet Resources**). In addition, water quality was measured at this location between 1976 and 1982 (USGS, April 17, 2002b).

USGS Stream Crest Gaging (Creststage)

USGS measures gage height (relative height of water level; not actual flow volume) occasionally at these sites. There is one USGS Stream Crest Gage located in North Brunswick,

on Lawrence Brook at Farrington Lake Dam. A second current site is situated on Sawmill Brook in East Brunswick (USGS, April 17, 2002c).

USGS Stream Low Flow Gaging (Lowflow)

USGS measures gage height (relative height of water level; not actual flow volume) occasionally at these sites. There are three inactive low flow stream gaging sites located in the area; on Lawrence Brook in South Brunswick, Oakeys Brook in North Brunswick, and on Beaverdam Brook in East Brunswick (USGS, April 17, 2002d).

STORET Stations

Data collected by some sampling programs and from certain sites are input into EPA's national water quality database. These sites are indicated by an asterisk in **Table 6.8** and by an orange circle on **Figure 6j** (NJDEP, August 2005).

Macroinvertebrate Data (AMNET) (Biopts)

Macroinvertebrates are larger-than-microscopic fauna, which are found in freshwater and estuarine environments, and are an essential part of the aquatic food web. These include insects (primarily immature forms), worms, mollusks (snails, clams) and crustaceans (scuds, shrimp, crayfish, etc.), most of which are bottom-dwelling (benthic). They are more easily collected and quantified than other biological indicators (fish or periphyton communities). Assessments of benthic macroinvertebrates provide a good indication of localized conditions of water quality.

Due to the creatures' limited mobility, they are suitable for the evaluation of site-specific pollution impacts. Different species differ in their sensitivity to pollutants and environmental impacts from both point and non-point sources of pollution. Combined with relevant chemical/physical parameters, benthic macroinvertebrate communities can be used to identify sources of impairment (NJDEP BFBM, December 2012).

The Ambient Biomonitoring Network (AMNET) is the NJDEP's ongoing macroinvertebrate monitoring program. From 1992 to 2004, the New Jersey Impairment Score (NJIS) was used to assign a rating of non-impaired, moderately impaired, or severely impaired. Beginning in 2004, an improved index has been used, which takes into account the different ecoregions in the state. The Highlands, Ridge and Valley and Piedmont regions (including North Brunswick) comprise the region using the *High Gradient Macroinvertebrate Index (HGMI)*. In addition, the HGMI uses genus-level instead of family level identification, which provide four assessment rating levels; excellent, good, fair and poor. NJDEP uses this information in assessing progress toward the goals of the Clean Water Act through the Integrated Water Quality Monitoring and Assessment Report (see **Section 6E**), and for designation of Category 1 waters, based on exceptional ecological significance (see **Section 6D**) (NJDEP BFBM, December 2012).

Locations of monitoring sites are shown on **Figure 6j**, and results of the two sites within North Brunswick are shown in **Table 6.9**.

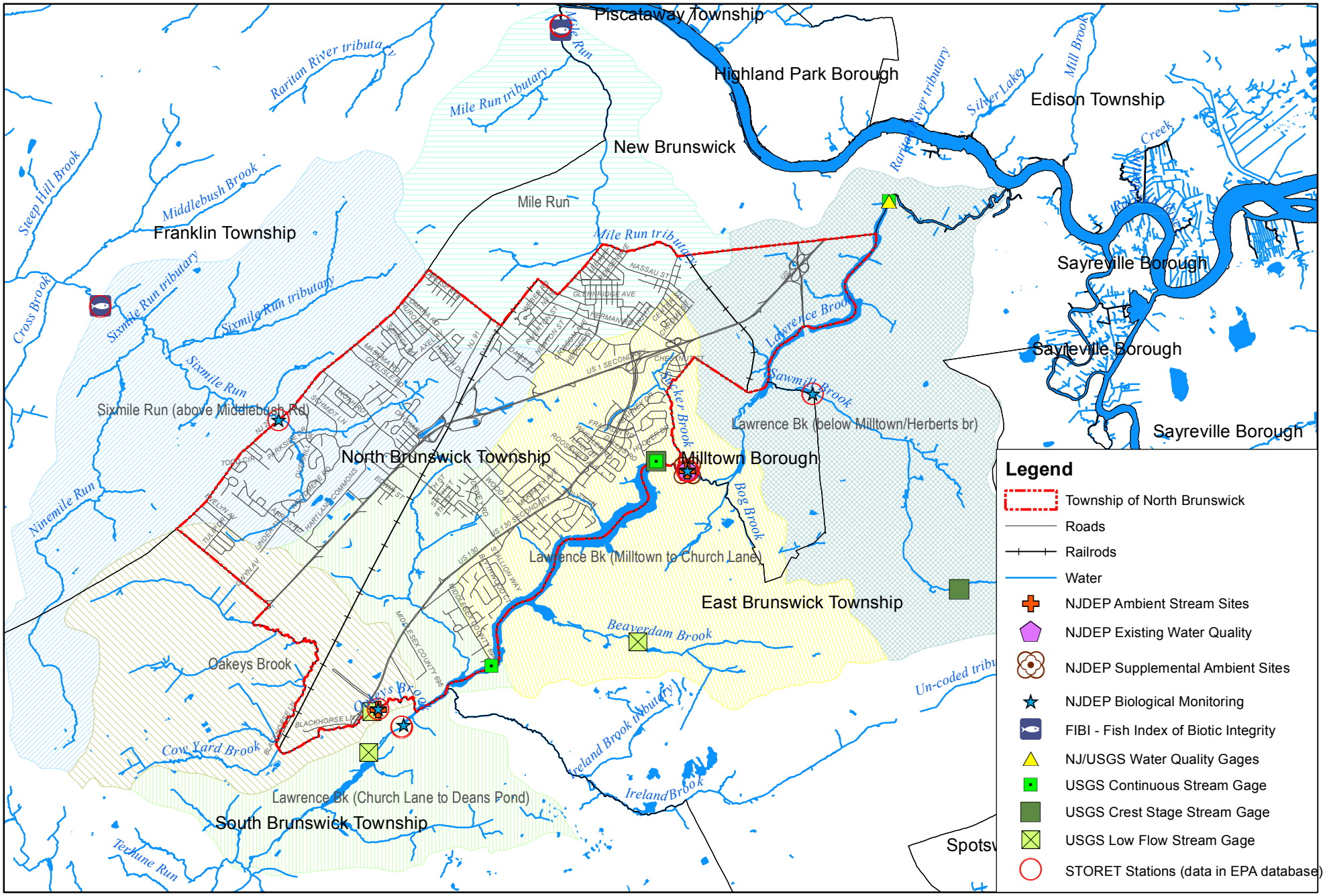

Figure 6j: Surface Water Quality and Flow Monitoring

0 0.45 0.9 1.8 Miles

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Data Sources: NJDEP
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Table 6.8: Surface Water Monitoring Stations

Program Name	Station ID	Name	Municipality	Data Collected
2030105120150: Mile Run				
BIOPTS	AN0429*	Mile Run at Route 527	Franklin Twp. / New Brunswick City	Macroinvert-ebrates & habitat
FIBI	FIBI015*	Mile Run at Route 527	Franklin Twp. / New Brunswick City	Fish Index of Biotic Integrity
2030105130030: Oakeys Brook				
BIOPTS	AN0432*	Oakeys Brook at Davidsons Mill Road	North / South Brunswick	Macroinvert-ebrates & habitat
SWPTS	01404400	Oakeys Brook at South Brunswick Twp.	North / South Brunswick	Water quality
Lowflow	1404400	Oakeys Brook near Patricks Corner NJ	North Brunswick	Stream flow
2030105130050: Lawrence Brook (Church Lane to Deans Pond)				
BIOPTS	AN0431*	Lawrence Brook at Davidsons Mill Road	South Brunswick	Macroinvert-ebrates & habitat
Lowflow	1404300	Lawrence Brook at Outlet of Davidsons Mill Pond NJ	South Brunswick	Stream flow
Streamgage	1404500	Lawrence Brook at Patricks Corner NJ	North Brunswick	Stream flow (continuous)
2030105130060: Lawrence Brook (Milltown to Church Lane)				
BIOPTS	AN0434	Lawrence Brook at Riva Road	Milltown / East Brunswick	Macroinvert-ebrates & habitat
EWQPOI	AN0434*	Lawrence Brook at Riva Road	Milltown / East Brunswick	Water quality
SWPTS	01405003*	Lawrence Brook at Riva Ave at Milltown	Milltown / East Brunswick	Water quality
SASMN	01405003*	Lawrence Brook on Riva Avenue	Milltown / East Brunswick	
Creststage	1405000	Lawrence Brook at Farrington Dam NJ	North/East Brunswick	Stream flow
Lowflow	1404700	Beaverdam Brook near Patricks Corner NJ	East Brunswick	Stream flow
Streamgage	1405000	Lawrence Brook at Farrington Dam NJ	North / East Brunswick	Stream flow (continuous)
2030105130070: Lawrence Brook (below Milltown/Herberts Br.)				
BIOPTS	AN0435*	Sawmill Brook at Ryders Lane	Milltown / East Brunswick	Macroinvert-ebrates & habitat
Creststage	1405010	Sawmill Brook at South River NJ	East Brunswick	Stream flow
Streamgage	1405030	Lawrence Brook at Westons Mills NJ	East Brunswick / New Brunswick City	Stream flow (continuous)
WQGage	1405030	Lawrence Brook at Westons Mills NJ	East Brunswick / New Brunswick City	Water quality and stream flow
2030105110120: Six Mile Run (above Middlebush Road)				
BIOPTS	AN0408*	Six Mile Run at Route 27	Franklin / North Brunswick	Macroinvert-ebrates & habitat
FIBI	FIBI022*	Six Mile Run S Middlebush Road	Franklin	Fish Index of Biotic Integrity
Discontinued or inactive sites are shown in gray.				
*Data from these program sites are input into STORET, EPA's water quality database.				
Sources: NJDEP BFMB, October 2007 November 2008, November 2010, December 2010a, December 2010b; USGS, 2002a, 2002b, 2002c, 2002d				

Table 6.9: Macroinvertebrate and Habitat Scores

Site Code	Site Name	Parameter*	Round 1-3*			Round 4★
			1993	1998	2004	2008
ANO 408	Six Mile Run at Route 27 (North Brunswick & Franklin Townships)	NJIS	15 Moderately Impaired	15 Moderately Impaired	9 Moderately Impaired	11.91 Poor
		Habitat	-	152 Sub-optimal	149 Sub-optimal	147 Sub-optimal
ANO 432	Oakeys Brook at Davidsons Mill Road (North & South Brunswick Townships)	NJIS	21★ Moderately Impaired	15 Moderately Impaired	18 Moderately Impaired	31.87 Fair
		Habitat	-	135 Sub-optimal	167 Optimal	154 Sub-optimal

*** Round 1-3 Parameters**:
NJIS (New Jersey Impairment Score): A composite of 5 scores based on family level taxonomy. **Non-impaired**: score of 24 to 30; benthic community comparable to other undisturbed streams within the region; community characterized by a maximum taxa richness, balanced taxa groups, and good representation of intolerant individuals. **Moderately Impaired**: score of 9 to 21; macroinvertebrate richness reduced, in particular, EPT taxa; reduced community balance and number of intolerant taxa. **Severely Impaired**: score of 0 to 6; benthic community drastically different from those in less impaired situations; macroinvertebrates dominated by few taxa, but with many individuals; only intolerant individuals present.

HABITAT SCORES: **OPTIMAL**= 160 – 200; **SUB-OPTIMAL**=110 – 159; **MARGINAL** = 60 – 109; **POOR** = < 60. Parameters evaluated included in-stream substrate, channel morphology, bank structural features, and riparian vegetation for the sample site and its immediate surroundings (usually 100-200 foot radius).

★ Round 4 Parameters:
HIGH GRADIENT MACROINVERTEBRATE INDEX (HGMI) (Highlands, Ridge and Valley, Piedmont): A composite of 7 scores based on genus level taxonomy.
Excellent 63 to 100; **Good** 42 to <63; **Fair** 21 to <42; **Poor** <21. For Surface Water Quality Standards (SWQS), Excellent and Good scores gain Full Attainment, while Fair and Poor scores are Non-attainment.

HABITAT SCORES: same as above.

Sources: NJDEP BFBM, July 1995, June 2000, February 2008 and December 2012

1. Fish Consumption Advisories

When toxic pollutants are present in surface water, they are consumed by the organisms that live in the water. The process of *bioaccumulation* is when there is an increase in concentration of certain fat-soluble chemicals, such as DDT and PCBs, in successively higher trophic levels of a food chain or web. For example, insects living in contaminated sediments may have accumulated a certain amount of a toxin. Fish, by eating many of these insects, then ingest the toxin into their own bodies. Anything that eats that contaminated fish, including humans and other predators, will absorb the toxin. When the concentration of toxin becomes high enough, the individual's health will be impacted.

The NJDEP samples fish for certain toxic pollutants and, when necessary, issues state and regional *fish consumption advisories*, to reduce exposure to dioxin, PCBs and mercury. This information is intended to help individuals make an informed choice on the number of meals of fish to consume. The 2013 fish consumption advisories for fish caught in Farrington Lake, Westons Mill Pond or anywhere in the state not listed separately are shown in **Table 6.10**. See the **Internet References** for more information, such as fish preparation guidelines and annual updates.

Table 6.10: 2013 Fish Consumption Advisories – Statewide Freshwaters

LOCATION[3]	SPECIES	ADVISORY/PROHIBITION[1]	
		General Population Range of Recommended Meal Frequency	High-Risk Individuals [2]
		DO NOT EAT MORE THAN:	DO NOT EAT MORE THAN:
Farrington Lake at Milltown Middlesex County	Largemouth Bass	One meal per week	Do Not Eat
	Chain Pickerel	No restrictions	One meal per month
	Yellow Perch	No restrictions	One meal per month
	Bluegill Sunfish	No restrictions	One meal per week
	Brown Bullhead	One meal per week	One meal per month
Westons Mill Pond at New Brunswick Middlesex County	Largemouth Bass	One meal per week	One meal per month
	Chain Pickerel	No restrictions	One meal per month
	Yellow Perch	No restrictions	One meal per month
	Black Crappie	No restrictions	One meal per month
	Bluegill Sunfish	No restrictions	One meal per week
	Brown Bullhead	One meal per week	One meal per month
	American Eel	One meal per month	Do Not Eat
New Jersey Statewide – All water bodies *except those listed separately*	*Freshwater species not listed below*	One meal per week	One meal per month
	Trout - (Brown, Brook Rainbow and Hybrid)	One meal per week	One meal per week
	Largemouth bass	One meal per week	One meal per month
	Smallmouth Bass		
	Chain Pickerel		
	Yellow bullhead	No restrictions	One meal per month
	Sunfish [4]	No restrictions	One meal per month
	Brown Bullhead	No restrictions	One meal per week

[1] Eat only the fillet portions of the fish. Use proper trimming techniques to remove fat, and cooking methods that allow juices to drain from the fish (e.g., baking, broiling, frying, grilling, and steaming). See web site for full description. One meal is defined as an eight-ounce serving.
[2] High-risk individuals include infants, children, pregnant women, nursing mothers and women of childbearing age.
[3] Note that only advisories for waterbodies within North Brunswick and Statewide advisories are shown. Advisories exist for other water bodies.
4 Sunfish include bluegill, pumpkinseed, and redbreast sunfish.

Source: NJDEP Division of Science and Research, May 2013 http://www.state.nj.us/dep/dsr/njmainfish.htm

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F. Point Source Pollution

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July 1995. Round 1 (1993-1994 Data): http://www.state.nj.us/dep/wms/bfbm/download/rar94.pdf

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NJDEP Division of Science and Research. May 2013. Fish Smart, Eat Smart: A Guide to Health Advisories for Eating Fish and Crabs Caught in New Jersey Waters. http://www.state.nj.us/dep/dsr/fishadvisories/2013-final-fish-advisories.pdf

Internet Resources: Surface Water

General Water Resources Protection

Home*A*Syst: Evaluate your home and property for pollution and health risks (USDA):
https://prod.nrcs.usda.gov/wps/portal/nrcs/detail/nj/people/partners/?cid=nrcs141p2_018827

SEEDS: The NJ Environmental Education Directory Website: http://www.state.nj.us/dep/seeds/index.html

Basic Watershed Information (Watershed Restoration Section):
http://www.nj.gov/dep/watershedrestoration/info.html

The Clean Water Book: Choices for Watershed Protection:
http://www.nj.gov/dep/watershedrestoration/waterbook_tble.html

NJDEP Laws & Rules: http://www.nj.gov/dep/landuse/lawsregs.html

Water Quality Fact Sheets and Bulletins (NJ Agricultural Experiment Station Rutgers Cooperative Research & Extension): http://njaes.rutgers.edu/pubs/subcategory.asp?cat=6&sub=50&order=LastRevised

Floodplains

Flood Hazard Area Program (NJDEP Land Use Regulation) http://www.nj.gov/dep/landuse/fha_main.html

FloodSmart: The Official Site of the National Flood Insurance Program: http://www.floodsmart.gov

Mid-Atlantic River Forecast Center: http://www.erh.noaa.gov/marfc/

Stream Flow: Lawrence Brook at Westons Mills:

NOAA: http://water.weather.gov/ahps2/hydrograph.php?wfo=phi&gage=labn4
USGS: http://nwis.waterdata.usgs.gov/nj/nwis/uv/?site_no=01405030&PARAmeter_cd=00065,00060,62614

Wetlands
Freshwater Wetlands Program (NJDEP Land Use Regulation): http://www.nj.gov/dep/landuse/fww/fww_main.html

Freshwater Wetlands Program: Before You Buy – Before You Build: http://www.nj.gov/dep/landuse/bybob.html

Integrated List & TMDL
NJDEP Integrated WQ monitoring and Assessment Report: http://www.state.nj.us/dep/wms/bwqsa/generalinfo.htm

NJDEP Total Maximum Daily Load (TMDL): http://www.nj.gov/dep/wms/bear/tmdls.html

USEPA Laws and Regulations: http://www2.epa.gov/laws-regulations

USEPA Watershed Assessment, Tracking & Environmental Results 2010 Waterbody Reports:
TMDL for Mercury: http://www.epa.gov/waters/tmdldocs/NJ-Final_TMDL_09-10-09.pdf

Point Source Pollution
NJPDES Permitting: http://datamine2.state.nj.us/DEP_OPRA/OpraMain/categories?category=NJPDES%20Permitting

Non-Point Source Pollution / Stormwater:
NJDEP's Stormwater Website (includes links to all of the following, and more): http://www.njstormwater.org/
NJDEP Municipal Stormwater Regulation Program: http://www.state.nj.us/dep/dwq/msrp_home.htm
Stormwater Best Management Practices Manual: http://www.njstormwater.org/bmp_manual2.htm
Clean Water NJ: http://www.cleanwaternj.org/index.htm
Multimedia Resources: http://www.cleanwaternj.org/multimedia.html

North Brunswick Code – Chapter 205: Land Use; Article XXXVII: Stormwater Control for Nonresidential Major Development. http://ecode360.com/NO0467

USEPA Nonpoint Source Pollution: http://water.epa.gov/polwaste/nps/index.cfm

Surface Water Quality and Flow
Benthic Macroinvertebrate Sampling: http://www.state.nj.us/dep/wms/bfbm/downloads.html

Lawrence Brook Watershed Partnership: http://www.lbwp.org/

New Jersey Water Supply Authority: http://www.njwsa.org/

Raritan Basin Watershed Management Project: http://www.raritanbasin.org

Sustainable Raritan River: http://www.blueraritan.org/

USEPA STORET Database: http://www.epa.gov/storet

USGS Real-Time Stream Flow:
Lawrence Bk at Westons Mills: http://nwis.waterdata.usgs.gov/nj/nwis/uv/?site_no=01405030&PARAmeter_cd=00065,00060,62614

USGS Real-time flow data index of NJ sites: http://waterdata.usgs.gov/nj/nwis/current/?type=flow

USGS Water Data Mapper (enter year & navigate to location): http://wdr.water.usgs.gov/adrgmap/index.html

USGS Real-time flow data index of NJ sites: http://waterdata.usgs.gov/nj/nwis/current/?type=flow

USGS Water Data Mapper (enter year & navigate to location): http://wdr.water.usgs.gov/adrgmap/index.html

Fish Advisories & Guides
NJ Division of Science & Research Fish Advisories Home Page: http://www.state.nj.us/dep/dsr/njmainfish.htm

Fish Smart Eat Smart: http://www.state.nj.us/dep/dsr/fishsmart.pdf

NJDEP Regulations:
NJDEP Rules & Regulations, current and proposed: http://www.state.nj.us/dep/rules

Phone Contacts:
NJ Drought Hotline: 1-800-4-ITS DRY (1-800-448-7379)

NJ Environmental Incident Hotline (hazardous spill, fire, explosion, illegal dumping, wildlife problem):
1-877-WARNDEP / 1-877-927-6337 (toll-free, 24 hours)

NJDEP – Other Hotlines; http://www.nj.gov/dep/warndep.htm

NJDEP Bureau of Coastal & Land Use Compliance & Enforcement: 1-609-292-1240

NJDEP Division of Land Use Regulation (Wetlands, Streams/Rivers, Flood Hazard Areas):
Technical Support Center: (609) 777-0454
Forms: http://www.nj.gov/dep/landuse/forms.html

7: BIOLOGICAL RESOURCES

A. Dominant Vegetation (Land Cover)

The New Jersey Comparative Risk Project (March 2003) listed habitat fragmentation and habitat loss as the highest ranking stressors of Statewide ecological quality. Certain species that require large expanses of intact habitat are becoming less common. Other factors that impact ecological health include exotic species (e.g. the hemlock wooly adelgid, an insect that causes the decline and death of hemlock trees) and exotic diseases, overpopulations of deer and geese, and pollution.

The 2007 Land Use/Land Cover (LU/LC) data layer was created by a consultant to NJDEP by comparing the 2002 LU/LC layer to 2007 color infrared imagery (2002 and 2007 aerial photos are shown in **Figure 1d** and **Figure 1e**, respectively) and delineating and coding areas of change with a 1 foot pixel resolution. The classification system used was a modified Anderson Classification System (USGS, 2010) that provided the parameters for proper and consistent coding of the LU/LC feature classes and subclasses. It should be noted that 1) changes since 2007 are not shown, and 2) the method is not 100% accurate. In addition, since it is based on interpretation of aerial photographs, it cannot provide information about the particular species found in an area. The land cover classifications are shown in **Figures 7a, 7b, 7c and 7d**. The number of acres of each within North Brunswick is noted on the maps and included in the acreage figures in **Table 7.1** (NJDEP, 2010).

The largest portion of land in North Brunswick has a land cover of *Residential, Single Unit, Medium Density* (22%), followed by *Residential, High Density or Multiple Dwelling* (11%), *Deciduous Wooded Wetlands* (10%) and *Commercial/Services* (8%). Together, these top four land uses make up 51% of the township (NJDEP, 2010).

Table 7.1: 2007 Land Use/Land Cover (Anderson Classification) in North Brunswick

Code	Description	Acres*	Percent
AGRICULTURE			
2100	Cropland And Pastureland	184.38	2.34
2200	Orchards/Vineyards/Nurseries/Horticultural Areas	8.03	0.10
2400	Other Agriculture	126.73	1.61
	Total of all Agriculture Land Uses (excludes agricultural wetlands)	**319.14**	**4.05**
BARREN LAND			
7400	Altered Lands	22.41	0.28
7500	Transitional Areas	70.53	0.90
	Total of all Barren Land Uses	**92.94**	**1.18**
FOREST			
4110	Deciduous Forest (10-50% Crown Closure)	90.98	1.16
4120	Deciduous Forest (>50% Crown Closure)	456.73	5.80
4210	Coniferous Forest (10-50% Crown Closure)	1.04	0.01
4220	Coniferous Forest (>50% Crown Closure)	6.12	0.08
4230	Plantation	2.38	0.03
4312	Mixed Forest (>50% Coniferous With >50% Crown Closure)	6.37	0.08
4321	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	1.55	0.02
4322	Mixed Forest (>50% Deciduous With >50% Crown Closure)	12.92	0.16

4410	Old Field (< 25% Brush Covered)	16.29	0.21
4420	Deciduous Brush/Shrubland	93.24	1.18
4430	Coniferous Brush/Shrubland	6.67	0.08
4440	Mixed Deciduous/Coniferous Brush/Shrubland	51.10	0.65
	Total of all Forested Land Uses	**745.40**	**9.47**
URBAN			
1110	Residential, High Density Or Multiple Dwelling	869.02	11.04
1120	Residential, Single Unit, Medium Density	1764.63	22.41
1130	Residential, Single Unit, Low Density	141.11	1.79
1140	Residential, Rural, Single Unit	65.19	0.83
1200	Commercial/Services	655.71	8.33
1300	Industrial	573.95	7.29
1400	Transportation/Communication/Utilities	35.82	0.45
1410	Major Roadway	195.72	2.49
1411	Mixed Transportation Corridor Overlap Area	0.75	0.01
1420	Railroads	111.04	1.41
1462	Upland Rights-Of-Way Developed	60.61	0.77
1463	Upland Rights-Of-Way Undeveloped	65.67	0.83
1499	Stormwater Basin	54.70	0.69
1500	Industrial And Commercial Complexes	1.85	0.02
1600	Mixed Urban Or Built-Up Land	0.98	0.01
1700	Other Urban Or Built-Up Land	525.28	6.67
1710	Cemetery	130.10	1.65
1800	Recreational Land	159.44	2.03
1804	Athletic Fields (Schools)	47.42	0.60
	Total of all Urban Land Uses (excludes urban wetlands)	**5458.99**	**69.34**
WATER			
1419	Bridge Over Water	0.41	0.01
5100	Streams And Canals	4.51	0.06
5200	Natural Lakes	39.01	0.50
5300	Artificial Lakes	136.90	1.74
	Total of all Water Land Uses	**180.83**	**2.30**
WETLANDS			
1461	Wetland Rights-Of-Way	47.09	0.60
1750	Managed Wetland In Maintained Lawn Greenspace	64.95	0.83
1850	Managed Wetland In Built-Up Maintained Rec Area	22.34	0.28
2140	Agricultural Wetlands (Modified)	40.80	0.52
6210	Deciduous Wooded Wetlands	827.48	10.51
6231	Deciduous Scrub/Shrub Wetlands	28.27	0.36
6233	Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	2.53	0.03
6234	Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	4.62	0.06
6240	Herbaceous Wetlands	17.51	0.22

6241	Phragmites Dominate Interior Wetlands	0.24	0.00
6251	Mixed Wooded Wetlands (Deciduous Dom.)	1.33	0.02
7430	Disturbed Wetlands (Modified)	18.09	0.23
	Total of all Wetland Land Uses	**1075.26**	**13.66**
TOTAL for all Land Use Types:		**7872.58**	**100.00**
* Acreage from the GIS data varies from acreage calculated based on tax maps.			
Source: NJDEP, 2010; USGS, 2010			

B. Wildfire Fuel Hazard

The New Jersey Forest Fire Service (NJFFS), a division of NJDEP, assessed *Wildfire Fuel Hazard* (WFH) throughout New Jersey (see **Figure 7e**). The purpose is to provide information for NJ Forest Fire Service personnel, government agencies, and others interested in assessing WFH throughout New Jersey. Modified Anderson Land Use/Land Cover Classifications from the 2002 Land Use/Land Cover dataset were assigned Wildfire Fuel Hazard Rankings (0 = Water, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High, 5 = Extreme, 6 = Urban, 7 = Agriculture, 8 = Barren Land). Areas with 30% or greater slope and Wildfire Fuel Hazard 1 to 4 were increased by 1 (e.g. Low became Moderate, etc.) (NJDEP, 2009).

The majority of North Brunswick is in the categories not rated for Wildfire Fuel Hazard (water, urban, agriculture and barren). Less than 1% is rated extreme or very high wildfire fuel hazard, while only 7.6% is rated high or moderate (see **Table 7.2** and **Figure 7e**).

Table 7.2: Wildfire Fuel Hazard

Wildfire Fuel Hazard	Acres	Percent
Extreme	27.4	0.3%
Very High	45.2	0.5%
High	152.2	1.9%
Moderate	449.7	5.7%
Low	1,798.7	22.8%
Water, Urban, Agriculture and Barren	5397.372	68.6%
Source: NJDEP, 2009		

C. Wildlife

Great blue heron

New Jersey hosts 323 bird species, 89 mammal species, 44 reptile, 35 amphibian, 85 freshwater fish and over 300 marine finfish species. This high diversity in such a small state is partly due to New Jersey's geographic position where northern ecosystems reach their southern limit and where southern ecosystems reach their northern limit. In addition, the state provides a wide variety of habitats including mountains, valleys, rolling hills, wetlands, pinelands, beaches, estuaries and rivers (NJDEP Division of Fish and Wildlife, January 19, 2012).

The NJDEP website offers checklists for the birds, mammals, reptiles and amphibians of New Jersey, with notes on the status of each (e.g. common or rare) (see **Internet Resources**). A variety of plant and animal species enjoy North Brunswick's diversity of habitat types. Catalogues of mammals, herptiles and fish are not available specifically for either Middlesex County or the township.

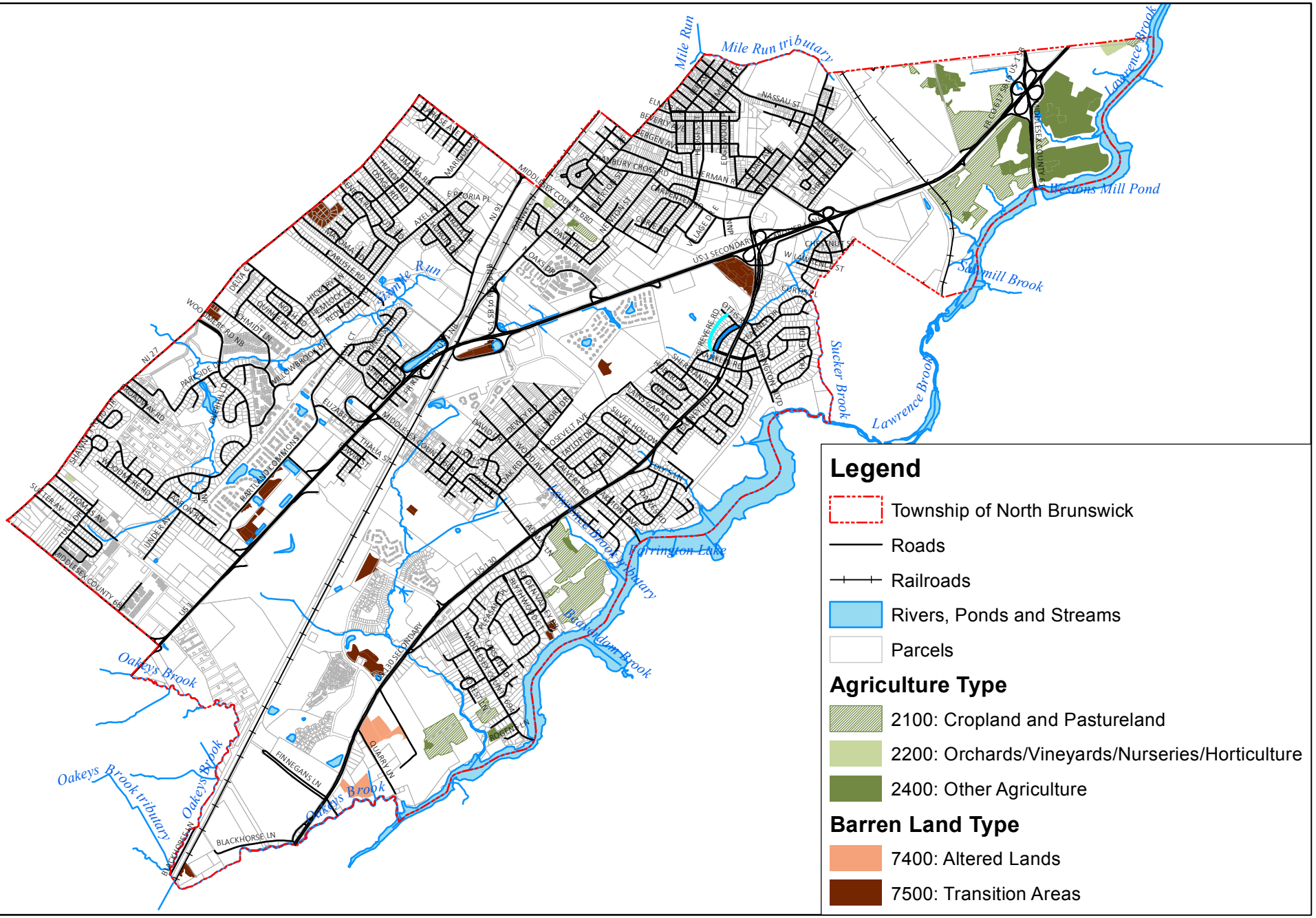


Figure 7a: 2007 Land Use / Land Cover Agriculture and Barren Types

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

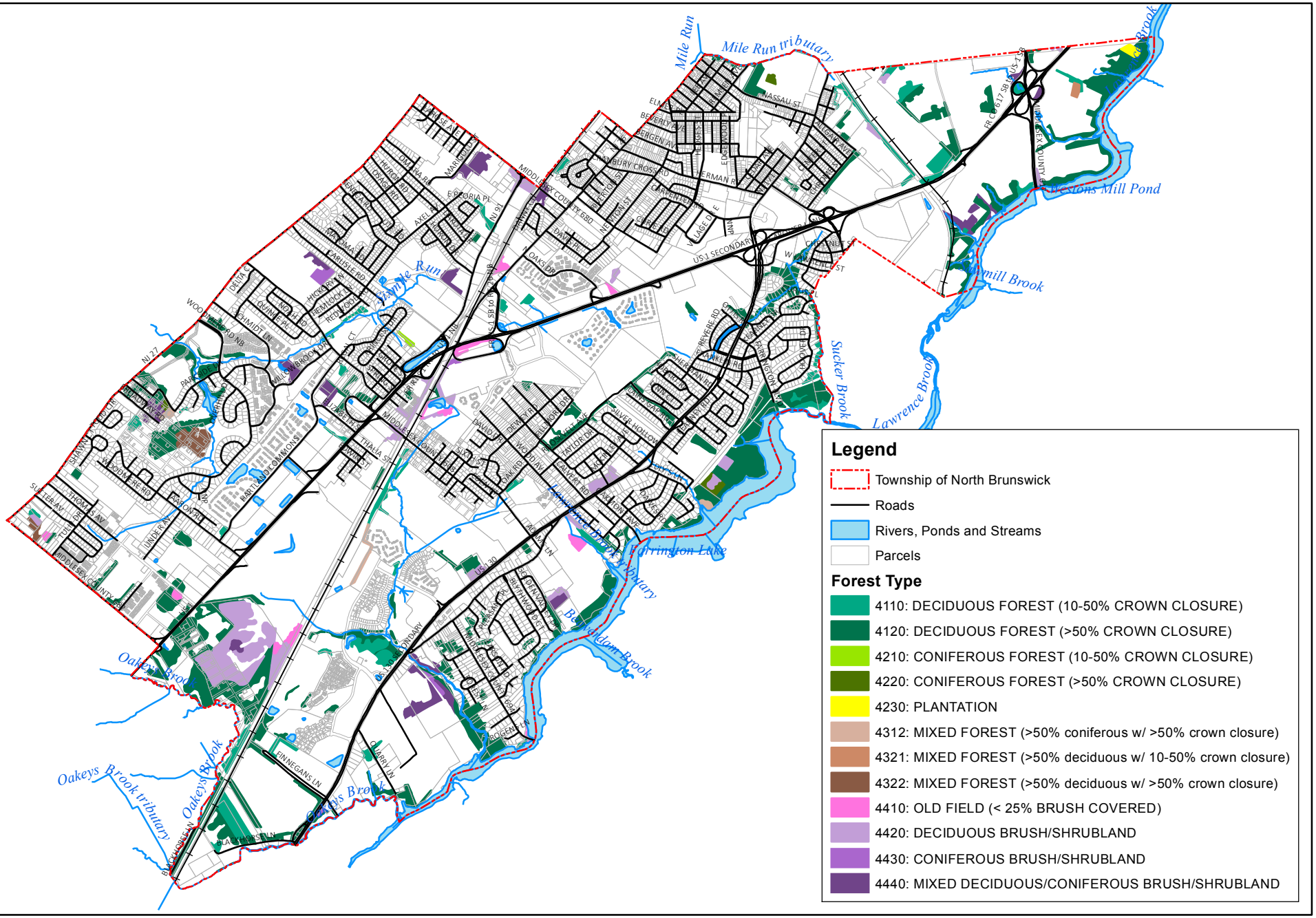


Figure 7b: 2007 Land Use / Land Cover Forest Types

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

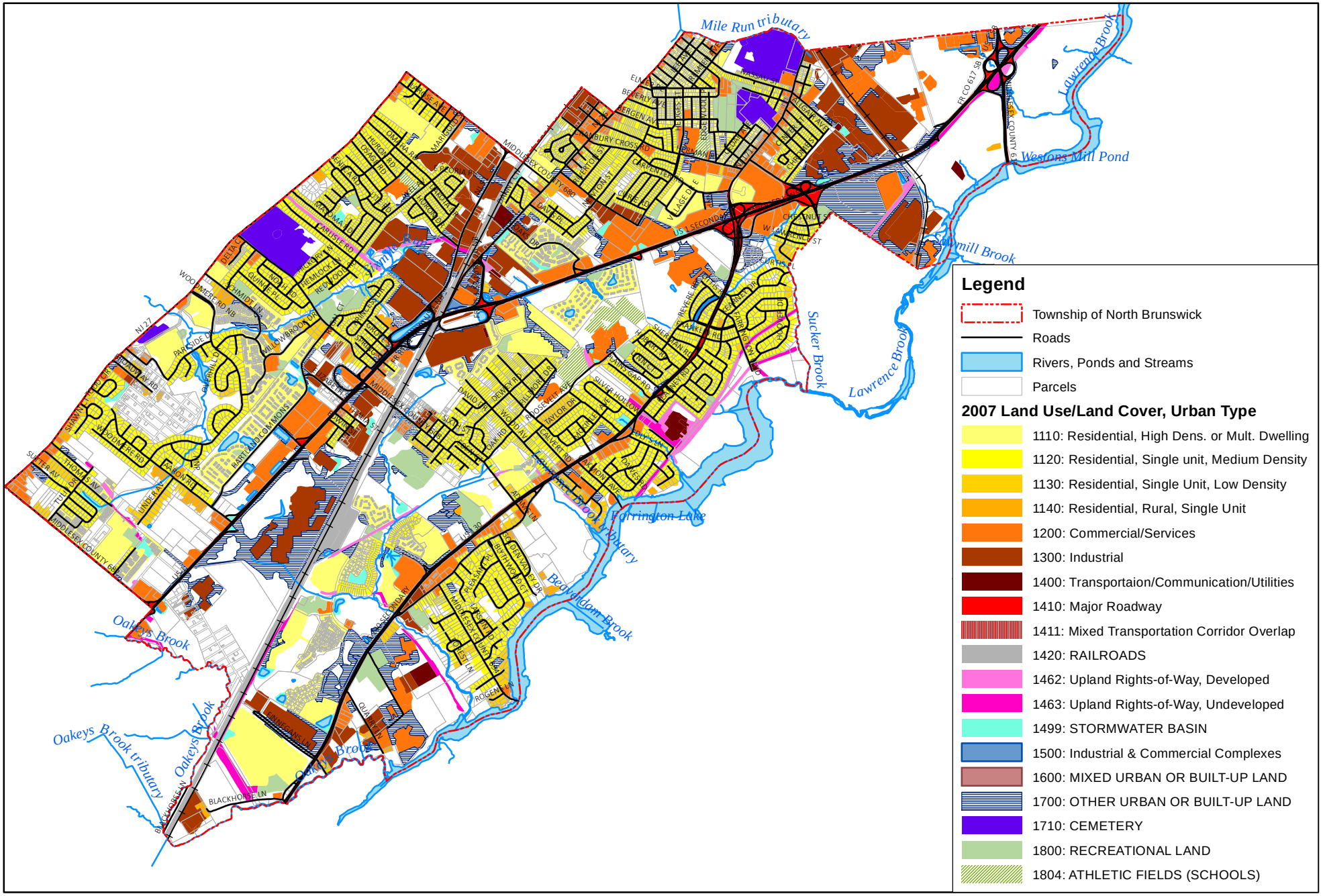


Figure 7c: 2007 Land Use / Land Cover Urban Types

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

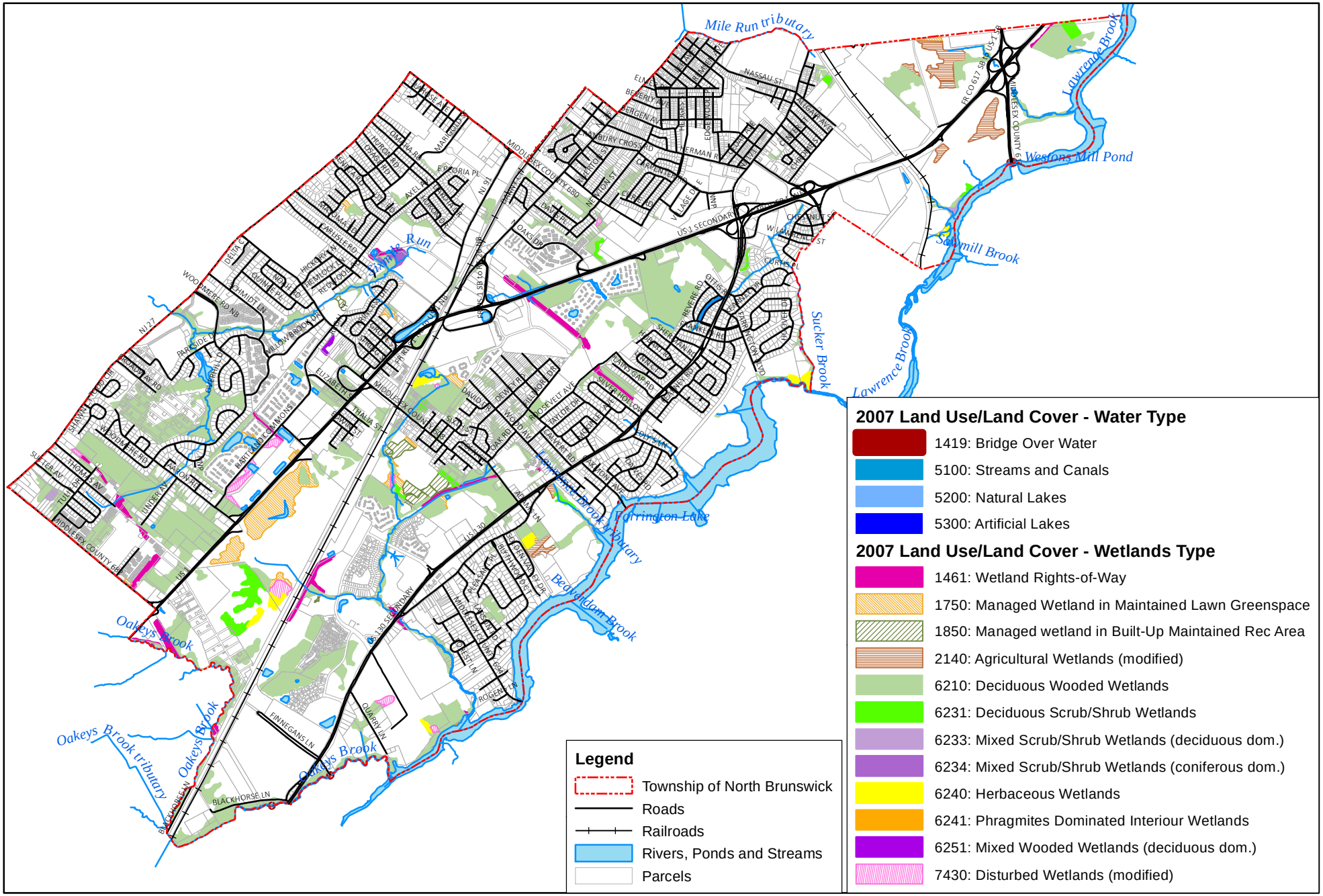


Figure 7d: 2007 Land Use / Land Cover Water and Wetland Types

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

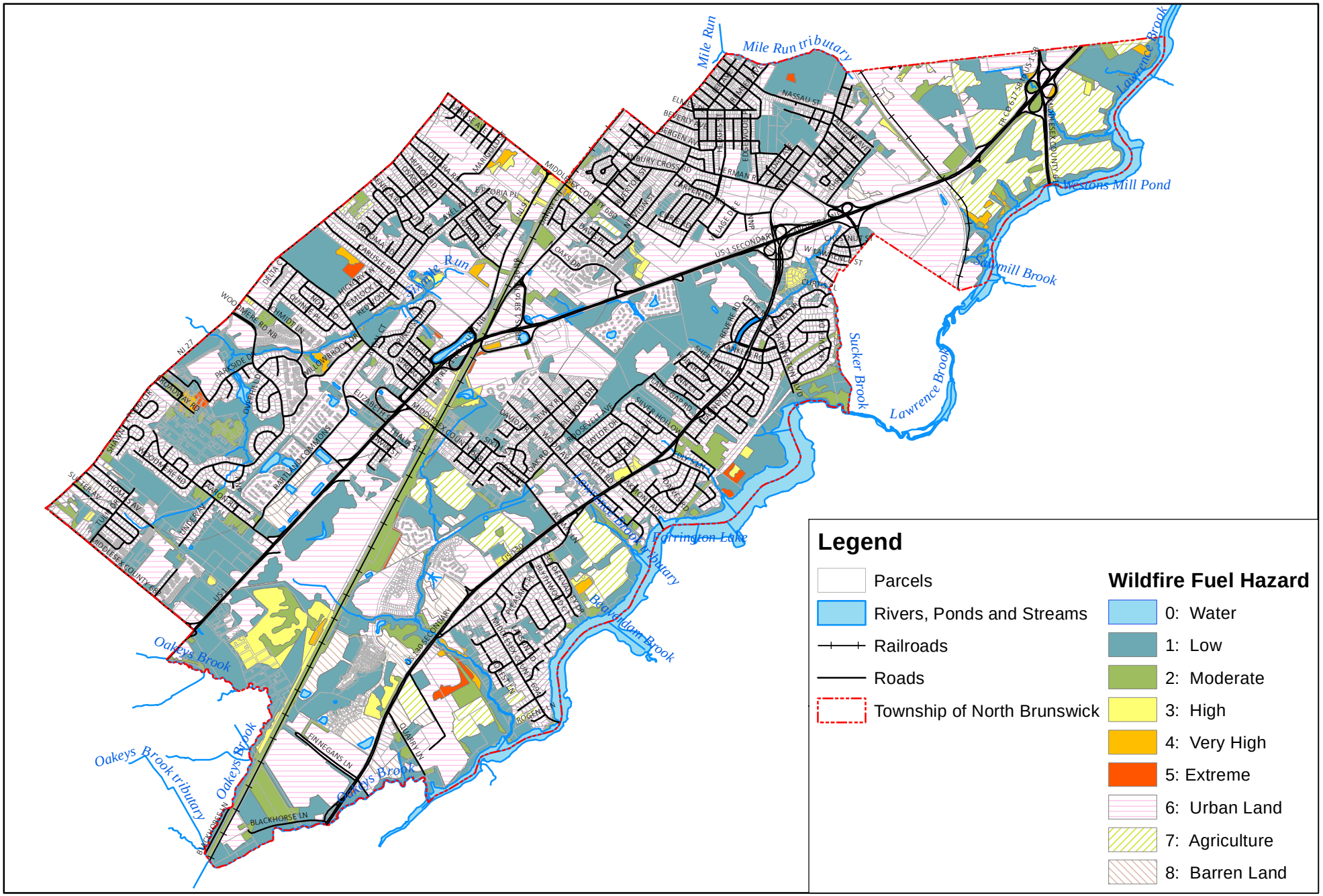


Figure 7e: Wildfire Fuel Hazard

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Black Bear

Black bears (*Ursus americanus*), the largest land mammals in the state, have been seen in North Brunswick (North Brunswick Environmental Commission, 2013). After indiscriminate hunting and habitat loss for centuries, the bear population has rebounded in the last 30 years. The NJ bear population in 2010 was estimated to be approximately 3,278 in the area open to hunting (north of I-78 and west of I-287). Bears are most frequently seen during the breeding season of June and July, when the males travel extensively in search of females. Black bears are omnivorous in food preferences, consuming a range of foods from skunk cabbage, berries, nuts, insects, small mammals, road-kill and human garbage. They are sometimes responsible for damage to bird feeders, beehives, sweet corn, livestock, garbage, etc. Black bears that are fed, unintentionally or intentionally, can become dangerous and may have to be destroyed (NJ Division of Fish and Wildlife, August 12, 2013).

The Division of Fish and Wildlife offers information and techniques for damage and nuisance prevention (see **Internet Resources**).

White-tailed Deer

The white-tailed deer (*Odocoileus virginianus*), the largest herbivore living wild in New Jersey, is seen frequently in North Brunswick. Although the deer is a large animal, individuals tend to stay in a one square mile or less home range, one of the smallest ranges among wild ruminants (Burnett, 2004).

Biologists have estimated that before the arrival of European settlers, there were about 8-11 white-tailed deer per square mile. By the early 1900's, New Jersey's deer herd was reduced to a handful by unregulated hunting. However, efforts to protect the deer herd were so successful that deer were considered over-populous by the 1920's (Latham et al, 2005). In addition, deer have been able to adapt to human-altered habitats. Studies have shown that deer densities of over 10-15 per square mile have negative impacts on the diversity of understory vegetation and on the native songbird and wildflower populations that depend on a diverse understory, while deer populations in excess of 20 per square mile prevent tree regeneration (Latham et al, 2005).

Where deer are overabundant, this results in excessive damage to agricultural crops, gardens and residential landscaping; an increased incidence of deer/vehicle collisions; prevention of forest regeneration (which impacts plants and animals dependent on the forest); and the potential for reduced deer health due to inadequate nutrition and the spread of disease (Honachefsky, 2000; Latham et al, 2005; Sauer, 1998). Despite these impacts, deer remain a natural part of the ecosystem, and are not solely responsible for diversity loss and habitat degradation.

Documentation of deer population numbers is not available for Middlesex County or North Brunswick, therefore it is unknown whether the population exceeds either the number that can be sustained over an extended period (*ecological carrying capacity*) or the number that can coexist compatibly with local human populations (*cultural carrying capacity*) (NJDEP, 1999).

Hunting statistics give an indication of the deer population. The state is divided into 70 Deer Management Zones (DMZs), with differing deer hunting regulations applied to different DMZs. North Brunswick is located in DMZ 14. There are no public areas open to hunting in North Brunswick; however, deer hunting is permitted in Six Mile Run State Park, which is adjacent to the township. From the 1997/1998 season to the 2012/2013 season, an average of 2,241 deer (7 per square mile) was harvested in DMZ 14 (NJDEP Division of Fish and Wildlife, October 1, 2013).

Coyotes

The population of eastern coyotes (*Canis latrans*) was reduced to 100 in the state in 1975, but has rebounded to the current population of 3,000 spread throughout 96% of the state. This wild canid was first noted in North Brunswick Township between 1970 and 1979, the first coyote sighting within Middlesex County. The coyote is the largest wild canine found in NJ, primarily nocturnal, and extremely wary of humans. The coyote closely resembles a small German shepherd, except that its snout is longer, and its tail is bushier, black-tipped, and held horizontally or lower. They are not pack animals, although the young may remain with the parents for 1½ years. Coyotes are opportunistic predators, feeding on small animals, carrion, insects, fruit and other vegetable matter. They occasionally kill and eat small livestock (e.g. chickens, sheep) and pets, and raid garbage. Sightings alone should not cause alarm but are a signal to take measures to make a property less hospitable to the coyotes and to safeguard children, pets and livestock (McBride, 2006). NJDEP receives reports of approximately 0 to 30 coyote sightings annually in North Brunswick; fewest in the northeast corner and most in the southwest corner of the township (NJ Division of Fish and Wildlife, July 1, 2012).

Birds

Of New Jersey's 323 species of birds, 308 have been sighted within Middlesex County. In the report, Birds of Middlesex County, Wheeler states, "The last 25 years have brought an ecological recovery that would have once seemed impossible, thanks largely to stronger environmental laws, a local corporate shift away from heavy industry, and an active citizenry befitting one of the oldest settled areas in the United States. While Middlesex County will never be mistaken for a pristine Eden, we are setting a model for post-industrial ecological recovery, as we transform former industrial brownfields into vibrant greenfields of wildlife habitat and hiking trails." (Wheeler, 2007). Farrington Lake, Rutgers Display Gardens and the Lawrence Brook waterway, within North Brunswick, are among the best birding locations in the county (Wheeler, 2007).

Canada Goose

The Canada goose (*Branta canadensis*) is one of New Jersey's most easily recognized birds, with its black head and neck, white check patch and undersides, brown back and large size (2'-3' tall, 10-12 lbs.). There are two distinct populations in NJ, migratory geese that visit the state in the winter and non-migratory geese that nest in the state. Sources estimate the NJ population of resident Canada geese at approximately 83,000 to 96,800 (USDA, January 2003; NJDEP, March 2001).

While many people enjoy the sight of a few geese, according to the USDA and NJDEP, this high population of non-migrating geese can cause the following problems:

- overgrazing of lawns and athletic fields, which impacts aesthetics and causes erosion
- damage to cropland, increasing erosion hazard and crop losses
- accumulations of feces on land, creating a health risk from disease-causing organisms
- degradation of water quality, from fecal bacteria, nitrogen and phosphorous
- hazards to aircraft at airports
- aggression and attacks on humans
- noise (USDA, January 2003; NJDEP, March 2001).

As migratory game species, Canada geese are afforded federal and state protection. Therefore, any management techniques involving handling nests, eggs or birds require a permit (USDA Animal and Plant Health Inspection Service, January 2003).

The ponds and lakes in North Brunswick support populations of Canada geese and have the potential for human/goose conflicts. In 2003, the township adopted an ordinance prohibiting feeding of wild waterfowl (Township of North Brunswick, December 1, 2003).

Wildlife of Vernal Pools

Vernal pools are defined as confined depressions, either natural or man-made, that maintain ponded water for part of the year, have no permanent outflow, and are devoid of breeding fish populations. These temporary wetlands provide habitat to many species of amphibians, several of which breed exclusively in vernal pools, as well as a multitude of insects, reptiles, plants, and other wildlife. Certification of a vernal pool may be achieved by documenting breeding activity of obligate[34] vernal pool species (such as wood frogs or spotted salamanders; see **Table 7.3**) or by documenting both the presence of facultative species and photographic evidence that the pool goes dry or demonstrating the absence of fish (Tesauro, no date).

Deborah J. Kratzer

The bullfrog is a facultative vernal pool species

There are 4 potential vernal pools within North Brunswick (see **Figure 7f**). Site 2006 is near Linder Avenue, Site 2002 is near Renaissance Park, Site 2022 is near Revere Road and Site 2034 is located on Cook Campus. These sites are designated "potential vernal pools" because they appear to be vernal pools based on a Rutgers University study of aerial photos, but have not yet received NJDEP certification, which would require field verification of its characteristics (NJDEP ONLM, March 21, 2013).

Table 7.3: Obligate And Facultative Fauna Species Found In Vernal Habitats

Obligate Vernal Pool Breeding Species	Facultative Vernal Pool Breeding Amphibians	Reptiles that Inhabit Vernal Pools on a Seasonal Basis
Eastern tiger salamander *ENDANGERED* Marbled salamander *Special Concern* Spotted salamander Jefferson salamander *Special Concern* Blue-spotted salamander *ENDANGERED* Jefferson x Blue-spotted salamander *ENDANGERED* Wood frog Eastern spadefoot toad Fairy shrimp (order Anostraca)	Green frog Bullfrog Pickerel frog Southern leopard frog Carpenter frog *Special Concern* Northern spring peeper Northern cricket frog New Jersey chorus frog Upland chorus frog Northern gray treefrog Southern gray treefrog *ENDANGERED* Pine barrens treefrog *ENDANGERED* Four-toed salamander Long-tailed salamander *THREATENED*	Wood turtle *THREATENED* Spotted turtle *Special Concern* Mud turtle Eastern painted turtle Common snapping turtle (These reptiles visit vernal pools primarily to eat the eggs and larvae of amphibians.)
Note: Species in black are either known to occur in North Brunswick or their ranges include Middlesex County; species in gray have ranges that do not include Middlesex County, therefore it would be unlikely to find them in North Brunswick.		
Sources: Kenney et al, no date; Gessner and Stiles, February 2001; N.J.A.C 7:7A, Appendix 1.		

[34] Obligate species are dependent on vernal pool habitats for reproduction. Facultative species sometimes use vernal pools, but can use other habitats as well.

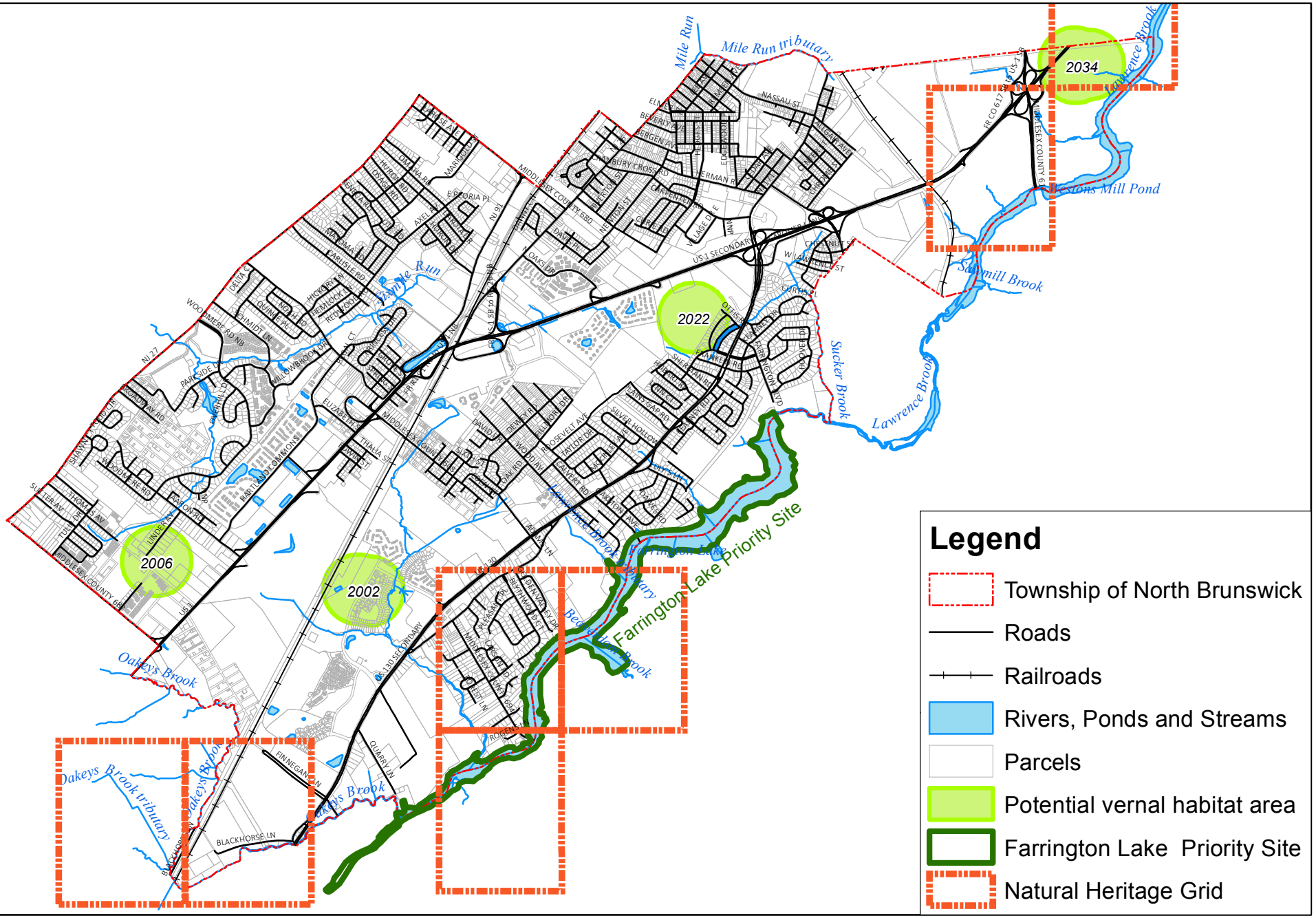


Figure 7f: Potential Vernal Habitats & Natural Heritage Priority and Grid

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Fish

Recreational fishing is popular in the 290-acre Farrington Lake and in the 92-acre Westons Mill Pond (NJDEP Division of Fish and Wildlife, August 19, 2013). There are not, however, any systematic surveys of fish species within the township. See **Section 6I** for Fish Consumption Advisories.

D. Endangered, Threatened and Special Concern Species

The health of an area's animal and plant populations can be an indicator of the health and sustainability of the environment for people. The decline or disappearance of one (or more) species may signal the deterioration of the habitat. Other species, and human health and welfare, may soon follow. Preserving the future of endangered and threatened species helps preserve our own species, benefiting human health and quality of life by protecting watersheds, preserving land in its natural state, and restoring wildlife habitat. Many people also place an intrinsic value on all species (Conserve Wildlife Foundation, March 18, 2002).

Many species are naturally rare in parts of their range, especially at the periphery. New Jersey often lies at the southern periphery of the range for many "northern" species and at the northern edge of the range of many "southern" species. Therefore, a species considered rare or imperiled within the state of New Jersey is not necessarily in danger of extinction worldwide. In addition, many rare species depend on large tracts of continuous undisturbed habitat to survive. If these habitats are interrupted by developed areas, the patches may become too small to support certain species.

The NJ Endangered Species Conservation Act was signed into law on December 14, 1973 (N.J.S.A. 23:2A-1 - 15), preceding the federal Endangered Species Act by two weeks. This milestone legislation established laws to protect and restore the state's endangered and threatened wildlife whose survival in New Jersey is imperiled by loss of habitat, overexploitation, pollution, or other impacts (NJDEP, October 6, 2004). In February 2012, NJDEP updated the Endangered and Nongame Species rules (N.J.A.C. 7:25), revising the species list based on science, upgrading the status of some recovering species and adding some declining species to the list (NJDEP Division of Fish and Wildlife, April 2 2012 and January 18, 2011).

Table 7.4 presents the definitions used by NJDEP in describing the status of species. In order to better document the status or change in status of species, NJDEP solicits information from the general public concerning sightings of endangered, threatened and special concern species. People should use the appropriate reporting forms (see **Internet Resources** and **Appendix C.1 and C.2)**.

Table 7.4: Definitions of Species Status

STATE STATUS	STATE STATUS DEFINITIONS
Animals: Two animal lists provide state status codes after the Endangered and Nongame Species Conservation Act of 1973 (N.J.S.A. 23:2A-13 et. seq.): the list of endangered species (N.J.A.C. 7:25-4.13) and the list defining status of indigenous, nongame wildlife species of New Jersey (N.J.A.C. 7:25-4.17(a)). The status of animal species is determined by the Endangered and Nongame Species Program (ENSP), with the review and approval of the Endangered and Nongame Species Advisory Committee. Status for animals separated by a slash (/) indicate a dual status. First status refers to the state breeding population, and the second status refers to the migratory or winter population.	
E	An **endangered species** is one whose prospects for survival within the state are in immediate danger due to one or many factors - a loss of habitat, overexploitation, predation, competition, disease. An

	endangered species requires immediate assistance or extinction will probably follow.
T	A **threatened species** is a species that may become endangered if conditions surrounding the species begin to or continue to deteriorate.
SC	The term **Special Concern** applies to animal species that warrant special attention because of some evidence of decline, inherent vulnerability to environmental deterioration, or habitat modification that would result in their becoming a Threatened species. This category would also be applied to species that meet the foregoing criteria and for which there is little understanding of their current population status in the state.
S	A **stable species** is one whose population is not undergoing any long-term increase/decrease within its natural cycle.
U	An **undetermined species** is one about which there is not enough information available to determine the status.
Plants: Plant taxa listed as endangered are from New Jersey's official Endangered Plant Species List (N.J.A.C. 7:5C – 5.1).	
E	Native New Jersey plant species whose survival in the State or nation is in jeopardy.
FEDERAL STATUS	**FEDERAL STATUS DEFINITIONS**
LE	Taxa formally listed as **endangered.**
LT	Taxa formally listed as **threatened.**
REGIONAL STATUS	**REGIONAL STATUS CODES FOR PLANTS AND ECOLOGICAL COMMUNITIES**
LP	Indicates taxa listed by the **Pinelands Commission** as endangered or threatened within their legal jurisdiction. Not all species currently tracked by the Pinelands Commission are tracked by the Natural Heritage Program. A complete list of endangered and threatened Pineland species is included in the NJ Pinelands Comprehensive Management Plan.
HL	Indicates taxa or ecological communities protected by the **Highlands Water Protection and Planning Act** within the jurisdiction of the Highlands Preservation Area.
GLOBAL & STATE CODE	The Nature Conservancy developed a ranking system for use in identifying elements (rare species and ecological communities) of natural diversity most endangered with extinction. Each element is ranked according to its global, national, and state (or subnational in other countries) rarity. These ranks are used to prioritize conservation work so that the most endangered elements receive attention first. Definitions for element ranks are after The Nature Conservancy (1982: Chapter 4, 4.1-1 through 4.4.1.3-3).
GLOBAL CODE	**GLOBAL ELEMENT RANK DEFINITIONS**
G1	**Critically imperiled globally** because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2	**Imperiled globally** because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3	Either **very rare and local throughout its range or found locally** (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; with the number of occurrences in the range of 21 to 100.
G4	**Apparently secure globally**; although it may be quite rare in parts of its range, especially at the periphery.
G5	**Demonstrably secure globally**; although it may be quite rare in parts of its range, especially at the periphery.
GH	Of **historical occurrence** throughout its range i.e., formerly part of the established biota, with the expectation that it may be rediscovered.
STATE CODE	**STATE ELEMENT RANK DEFINITIONS**
S1	**Critically imperiled in New Jersey** because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres). Elements so ranked are often restricted to very specialized conditions or habitats and/or restricted to an extremely small geographical area of the state. Also included are elements which were formerly more abundant, but because of habitat destruction or some other critical factor of its biology, they have been demonstrably reduced in abundance. In essence, these are elements for which, even with intensive searching, sizable additional occurrences

	are unlikely to be discovered.
S2	**Imperiled in New Jersey** because of rarity (6 to 20 occurrences). Historically many of these elements may have been more frequent but are now known from very few extant occurrences, primarily because of habitat destruction. Diligent searching may yield additional occurrences.
S3	**Rare in state** with 21 to 100 occurrences (plant species and ecological communities in this category have only 21 to 50 occurrences). Includes elements which are widely distributed in the state but with small populations/acreage or elements with restricted distribution, but locally abundant. Not yet imperiled in state but may soon be if current trends continue. Searching often yields additional occurrences.
S4	**Apparently secure** in the state, with many occurrences.
S5	**Demonstrably secure** in state and essentially ineradicable under present conditions.
SH	Elements of **historical occurrence** in New Jersey. Despite some searching of historical occurrences and/or potential habitat, no extant occurrences are known. Since not all of the historical occurrences have been field surveyed, and unsearched potential habitat remains, historically ranked taxa are considered possibly extant, and remain a conservation priority for continued field work with the expectation they may be rediscovered.
B	Refers to the **breeding** population of the element in the state.
N	Refers to the **non-breeding** population of the element in the state.
Note: To express *uncertainty*, the most likely rank is assigned and a question mark added (e.g., G2?). A range is indicated by combining two ranks (e.g., G1G2, S1S3).	
Source: NJDEP Division of Fish and Wildlife, March 22, 2010	

Endangered, Threatened & Special Concern Animals

The NJDEP Division of Fish and Wildlife, Endangered and Nongame Species Program's (ENSP) mission is: "To actively conserve New Jersey's biological diversity by maintaining and enhancing endangered and nongame wildlife populations within healthy functioning ecosystems." The program is responsible for the protection and management of New Jersey's wildlife, including 50 endangered, 36 threatened and 100 species currently listed as special concern (NJDEP Division of Fish and Wildlife, April 2, 2012 and February 21, 2012). For state-wide species lists, see **Internet Resources**.

A search of NJDEP Division of Parks and Forestry *Natural Heritage Database* in March 2013 revealed the documented presence of 1 state endangered (bald eagle), 1 state threatened species (wood turtle) and 4 special concern animals in North Brunswick (see **Tables 7.4** for code definitions and **Table 7.5** for list**).** Special concern animal species, which warrant concern due to evidence of decline or vulnerability, include 4 birds, the brown thrasher, great blue heron (nesting and foraging), northern parula and wood thrush.

Endangered, Threatened & Special Concern Plants

The Endangered Plant Species List Act (N.J.S.A. 13:1B-15.151) was enacted in 1989, defining endangered plants as "any native plant species whose survival in the State or the nation is in jeopardy... and any species having five or fewer extant populations within the State." The Division of Parks and Forestry has the responsibility of creating the list of NJ endangered plant species (N.J.A.C. 7:5C–1.1). While the rule does not provide any protection for officially listed species, several regulatory agencies within NJDEP responsible for protecting plant habitat have incorporated the Endangered Plant Species List into their criteria for review of permits (NJDEP, January 4, 2007).

Information on the special plants of NJ is tracked in the *Natural Heritage Database* by the NJDEP Office of Natural Lands Management (ONLM). A search of the Natural Heritage Database in March 2013 revealed the documented presence of 4 special concern plants in North Brunswick (see **Table 7.4** for code definitions and **Table 7.6** for the species list and descriptions**).** These include 1 critically imperiled plant (5 or fewer occurrences in the state); 1

Table 7.5: Natural Heritage Database Animal Species in North Brunswick

Common Name	Scientific Name	Feature Type	Rank*	Federal Status	State Status	Global Rank	State Rank	Habitat
Vertebrates, birds:								
Bald Eagle+	*Haliaeetus leucocephalus*	Foraging	4	NA	State Endangered	G5	S1B,S2N	Near lakes and rivers
Brown Thrasher	*Toxostoma rufum*	Breeding Sighting	2	NA	Special Concern	G5	S3B,S4N	Scrubby fields, forest edges
Great Blue Heron	*Ardea Herodias*	Foraging	2	NA	Special Concern	G5	S3B,S4N	Wetlands, shores
Great Blue Heron	*Ardea Herodias*	Nesting Colony	2	NA	Special Concern	G5	S3B,S4N	Wetlands, shores
Northern Parula	*Parula Americana*	Breeding Sighting	2	NA	Special Concern	G5	S3B	Mature forests along streams and wetlands
Wood Thrush	*Hylocichla mustelina*	Breeding Sighting	2	NA	Special Concern	G5	S3B	Deciduous and mixed forests with abundant leaf litter
Vertebrates, reptiles:								
Wood Turtle+	*Glyptemys insculpta*	Occupied Habitat	3	NA	State Threatened	G4	S2	uses a mosaic of wetland and upland habitats

Note: For status and rank definitions, refer to **Table 7.4**.
***Rank** refers to Landscape Project v. 3.1 Habitat Rank (see **Section 8f**).
+Species reports for these species are included in **Appendix C.5 and C.6**.
Sources: NJDEP ONLM, March 21, 2013; Schwartz, 200; Cornell Lab of Ornithology, October 10, 2013

imperiled plant (6 to 20 occurrences), 1 rare plant (21 to 100 occurrences) and 1 historical occurrence (not found recently) (NJDEP ONLM, March 21, 2013).

Appendix C.3 includes a list of Middlesex County rare species and natural communities. The species found in nearby locations within the county could be present in North Brunswick if suitable habitat is present within the township.

E. Projecting Endangered, Threatened and Special Concern Species

Wildlife Action Plan

NJDEP Division Fish and Wildlife prepared a Wildlife Action Plan (WAP) in 2008, required by the US Fish and Wildlife Service in order to qualify for future federal funds through the State Wildlife Grants program. This program provides federal funds to states for the conservation of species that are endangered, threatened, or have special conservation needs. A 25% match, provided by citizen contributions, is required. NJ has received approximately $1.2 million dollars of State Wildlife Grants funding each year (NJDEP, January 23, 2008).

The report states,

> "The greatest threats to NJ's natural resources include habitat loss, destruction, alteration, and fragmentation. This has been a recurring theme within NJ for years as it is the most densely populated state in our nation with an annually increasing population requiring additional homes, roads, commercial buildings, schools, etc. Additional threats include, but are not limited to, invasive species (flora and fauna, aquatic and terrestrial), pollution, and unsustainable land management practices." (NJDEP, January 23, 2008)

Table 7.6: Natural Heritage Database Plant Species in North Brunswick

Scientific Name	Common Name	Federal Status	State Status
Agastache nepetoides	Yellow Giant-hyssop	-	-
Regional Status	**Global Rank**	**State Rank**	**Last Observed**
HL	G5	S2	07-31-1941

Description:
4-7' tall with a few branches; central stem square in cross section
leaves are opposite, lance to oval shaped, 6" x 3", serrated margins
blooms mid-summer to early fall; individual flowers are short-lived
pale yellow flowers are densely crowded on each 4-16" long x ¾ - 1" wide spike

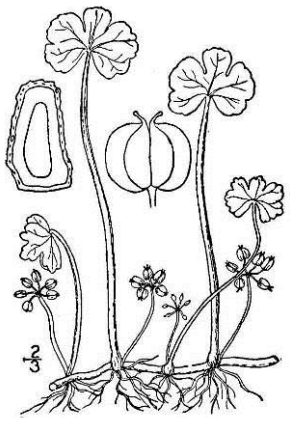
Habitat:
deciduous woodlands, woodland borders and openings


USDA-NRCS PLANTS Database / Britton and Brown

Scientific Name	Common Name	Federal Status	State Status
Hydrocotyle ranunculoides	Floating Marsh-pennywort	-	E
Regional Status	**Global Rank**	**State Rank**	**Last Observed**
LP, HL	G5	S1	07-30-2012

Description:
leaf stems grow from horizontal stems and are 4-12" tall
Stems and leaves are thick, fleshy and can float on water
leaves are up to 3" , rounded with lobes
1-4" flowering stalks grow from the horizontal stems.
Small star-like flowers are greenish white or greenish on ½" umbels
blooms summer or early fall

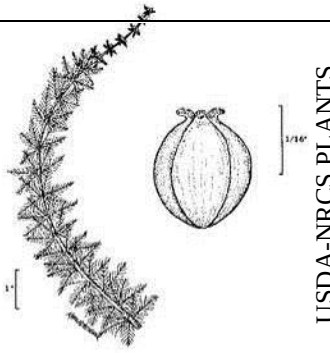
Habitat:
marshes, swamps, and ponds; often forms large dense colonies of plants in muddy soil or shallow water


USDA-NRCS PLANTS Database / Britton and Brown

Scientific Name	Common Name	Federal Status	State Status
Myriophyllum verticillatum	Whorled Water-milfoil	-	E
Regional Status	**Global Rank**	**State Rank**	**Last Observed**
LP, HL	G5	SH	03-28-1935

Description:
Submerged perennial with thick stem up to 3 m long, rarely branching
Leaves whorled, linear and 20-35 mm long
Flowers sessile, in whorls of 4-5, in the axils of bracts

Habitat:
Stagnant waters, lakes, ditches, slow streams


USDA-NRCS PLANTS Database / USDA NRCS.

Scientific Name	Common Name	Federal Status	State Status
Phoradendron leucarpum	American Mistletoe	-	-
Regional Status	**Global Rank**	**State Rank**	**Last Observed**
LP, HL	G5	S3	04-27-1932

Description:
Evergreen parasitic subshrub
Leaves are opposite, thick, leathery, evergreen, oval
White berries are eaten by birds; remain sticky when excreted onto branches, sprouting where they land

Habitat:
Grows on high branches of hardwood trees


oldwikisource, December 2004

Note: For status and rank definitions, refer to **Table 7.4.**

Sources: NJDEP ONLM, March 21, 2013; illustrations from USDA-NRCS PLANTS Database / Britton and Brown, 1913 and oldwikisource, December 2004; descriptions from Encyclopedia of Life, October 10, 2013 and Carolina Nature, October 10, 2013.

A WAP specific to each region identifies habitats, wildlife of greatest conservation need, and threats. Conservation goals and actions are identified and prioritized, and potential partnerships are outlined with landowners, the public and conservation organizations, wildlife professionals and local, state and federal agencies. North Brunswick is in the Central portion of the Piedmont Region. This zone is distinctive because it represents a transition area between the hardwood forests of northern New Jersey and the deciduous-coniferous forests of the Pinelands. The Landscape Project, discussed below, is an integral part of the plan (NJDEP, January 23, 2008).

The Landscape Project

The *Landscape Project* is a pro-active, ecosystem-level approach to the long-term protection of rare species and their important habitats in New Jersey. Its goal is to protect New Jersey's biological diversity by maintaining and enhancing rare wildlife populations within healthy, functioning ecosystems. It provides users with peer reviewed, scientifically sound wildlife data that is easily accessible and can be used by state, county, and local governments, as well as nongovernmental conservation organizations and private land owners for planning, open space acquisition, and land-use regulation (NJDEP Division of Fish and Wildlife, 2012).

The NJDEP, Division of Fish and Wildlife, Endangered and Nongame Species Program is responsible for the Landscape Project. Version 3.1 was released in 2012. The dataset was created by intersecting endangered, threatened and priority species data with the 2007 Land Use/Land Cover GIS layer, which was derived from aerial photography. The resulting data layer identifies, delineates and ranks (based on the conservation status of species present) critical habitat statewide. **Table 7.7** lists rank definitions. Each habitat patch is coded for the number of special concern, state threatened, state endangered and federally listed species present.

Table 7.7: Landscape Project Habitat Rank Definitions

Rank	Definition
1	**Suitable Habitat** – Rank 1 is assigned to patches that meet habitat-specific suitability requirements such as minimum size criteria for endangered, threatened or priority wildlife species, but that do not intersect with any confirmed occurrences of such species.
2	**Special Concern** – Rank 2 is assigned to patches containing one or more occurrences of species considered to be species of special concern
3	**State Threatened** – Rank 3 is assigned to patches containing one or more occurrences of State threatened species.
4	**State Endangered** – Rank 4 is assigned to patches with one or more occurrences of State endangered species.
5	**Federally Listed** – Rank 5 is assigned to patches containing one or more occurrences of wildlife listed as endangered and threatened pursuant to the Federal Endangered Species Act of 1973.
Sources: NJDEP Division of Fish and Wildlife, 2012	

Figure 7g illustrates the Landscape Project Version 3.1. While most (72%) of North Brunswick is not suitable wildlife habitat, the township does contain 3% of Rank 4 habitat for the presence of state endangered species; >1% Rank 3 for state threatened species; 9% Rank 2 for special concern species; and 16% is Rank 1 for suitable habitat (see **Table 7.8** and **Figure 7g)**.

Table 7.8: Landscape Project v.3.1

Land Use Type	Acres	Percent
Rank 1	1284.73	16.32
Rank 2	694.93	8.83
Rank 3	9.18	0.12
Rank 4	246.99	3.14
No rank	5636.75	71.60
Total Acres	7872.58	100.00
Source: NJDEP, February 21, 2012		

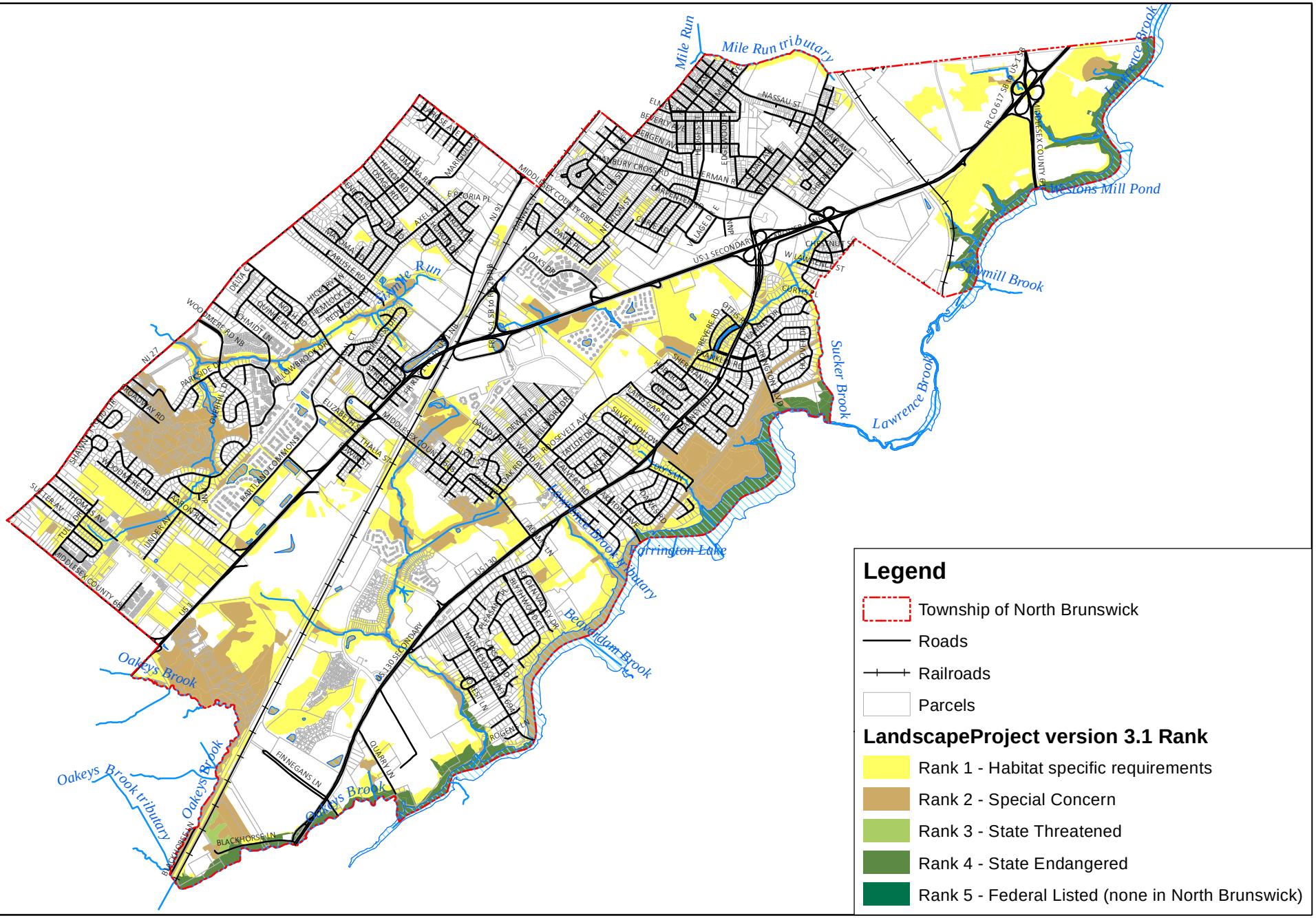


Figure 7g: Landscape Project Version 3.1

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
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N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Natural Heritage Grid and Priority Sites

Natural Heritage Priority Sites have been identified by the NJDEP Office of Natural Lands Management (ONLM) as areas critically important for preservation of New Jersey's biological diversity. These are considered some of the best and most viable occurrences of endangered and threatened plant species and natural communities, but other occurrences of endangered and threatened plant species may exist. There is one Natural Heritage Priority Site in North Brunswick (NJDEP ONLM, March 21, 2013 and 2007).

Farrington Lake (Site number S.USNJHP1*2333A) is a large, lake-like portion of a dammed stream channel (see **Figure 7f**). This site contains an excellent population of a state listed endangered plant species and also contains a population of a special concern plant. The boundary includes all documented populations of a rare aquatic plant (which is restricted to shallow water at several points along the shore) and contiguous suitable habitat. There are two adjacent Priority Sites in neighboring East Brunswick Township: Beaverdam Branch, which is a red maple swamp containing a federally listed plant, and Riva Avenue, which is a sandy mowed field adjoining a wooded thicket, containing a special concern plant (NJDEP ONLM, March 2007).

The NJDEP Office of Natural Lands Management (ONLM) has developed the *Natural Heritage Grid Map* (see **Figure 7f**), which provides a general representation of the locations of rare plant species and natural communities, including both historically and recently documented habitat. The purpose of the Grid Map is to document rare plant species and natural community habitats to inform decision-makers who need to address the conservation of natural resources. The species found (or historically found) in the grids are listed in **Table 7.6**. The map identifies potentially sensitive areas, and indicates where custom database searches are needed for land use decision-making. The Grid Map does not include habitat for animal species, and not all areas have been surveyed (NJDEP ONLM, March 21, 2013).

F. Invasive Nonindigenous Species

Nonindigenous species (also called non-native, alien, exotic or introduced species) are those species that have been introduced outside their natural geographic range as a result of human actions, whether intentionally (e.g. as sources of food, for landscaping purposes or the release of unwanted pets) or unintentionally (e.g. in the ballast of a ship or in a load of lumber). *Invasive nonindigenous species* are those non-native species that rapidly and aggressively invade natural plant communities. The most problematic of these displace native species, contribute to local elimination of species or even extinctions, alter the community structure, and may eventually disrupt ecosystem processes (Snyder et al, 2004). Preliminary research in NJ has documented over 1,200 species of nonindigenous plant species, or as much as 62% of the state's total vascular flora (Snyder et al, 2004).

Native plants can be susceptible to introduced diseases, to which they have not evolved resistance. The chestnut blight fungus was an accidental introduction that destroyed all mature chestnut trees, once one of the dominant trees in the New Jersey landscape. Another introduced fungus, Dutch elm disease, destroyed the American elm.

In addition, native plants may have little resistance to certain introduced insects, and/or these insects may have no natural enemies in their new surroundings, allowing them to rapidly reach pest proportions. Introduced insects, which may be impacting North Brunswick's trees, include the hemlock wooly adelgid and gypsy moth (NJ Forest Service, 2010). They weaken their host trees, which often succumb to successive years of infestation, to diseases carried by the insect pests, such as bacterial leaf scorch, or other environmental stresses.

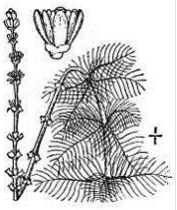
For these reasons, the Final Report of the New Jersey Comparative Risk Project, which evaluated the relative risks of environmental problems to the people and ecosystems of New Jersey identified invasive species (including plants, insects, and other organisms) as one of the state's top environmental problems (Steering Committee of the New Jersey Comparative Risk Project, 2003).

Some of the most problematic invasive exotic species in North Brunswick include phragmites, mugwort, barberry, stiltgrass, autumn olive and multiflora rose. While there is no official invasive species list for North Brunswick, An Overview of Nonidigenous Plant Species in New Jersey (Snyder et al, 2004) profiles 27 nonindigenous plant species that aggressively invade natural plant communities in New Jersey, which are summarized in **Table 7.9**.

Table 7.9: Invasive Nonindigenous Plants

Scientific Name	Common Name	Problems Caused	Illustration	Illus. Source
Acer platanoides	Norway maple	Dispersed seeds easily sprout in shade, crowding out native plants. Canopy produces deep shade and roots produce a toxic substance preventing growth of wildflowers and other trees under its canopy.		Jan Samanek, State Phytosanitary Administration, Bugwood.org
Ailanthus altissima	tree of heaven	Aggressive in disturbed areas, crowding out native plants.		Britton and Brown, 1913, Vol. 2: 446.
Alliaria petiolata	garlic mustard	Aggressive in shady habitats, crowding out native plants.		Deborah J. Kratzer
Artemisia vulgaris	Mugwort or common wormwood	Crowds out native plants.		Deborah J. Kratzer

Berberis thunbergii	Japanese barberry	Can grow so thick in the understory of open forests that it shades out indigenous understory plants. Affects soil properties, particularly pH, which can affect plant establishment. Can form nearly impenetrable thorny thickets that impact the recreational value of natural lands.		Deborah J. Kratzer
Celastrus orbiculatus	Oriental bittersweet	The vine twines around surrounding plants, impeding sap flow. Also makes host plants too heavy, increasing wind, snow & ice damage.		Deborah J. Kratzer
Cirsium arvense	Canada thistle	Competes with crops and degrades pastures (inedible to livestock).		Deborah J. Kratzer
Dipsacus fullonum	wild teasel	Highway mowing equipment and discarded dried teasel heads from flower arrangements can lead to the establishment of new colonies, often forming a monoculture that displaces native communities.		Steve Dewey, Utah State University, Bugwood.org
Elaeagnus umbellate	autumn olive	Sprouts vigorously in disturbed areas, produces shade, preventing sprouting of native trees.		Deborah J. Kratzer
Euonymus alatus	burning bush	Grows well in many sites, especially upland forests and pastures, crowding out native plants.		James H. Miller, USDA Forest Service, Bugwood.org

Hedera helix	English ivy	Grows vigorously in deep shade, inhibiting growth of native woodland plants. Vines up tree trunks, adding to weight, and increasing likelihood of wind damage.		Deborah J. Kratzer
Ligustrum vulgare	common privet	Crowds out more desirable native plants.		USDA PLANTS Database, Bugwood.org
Lonicera japonica Thunberg	Japanese honey-suckle	Spreads aggressively in disturbed habitats, crowding out native plants. Aggressive roots can decrease the growth of native trees and vines. Vines engulf small trees and shrubs, causing them to collapse. Leafs out very early in spring, which could inhibit flowering by spring ephemerals.		Deborah J. Kratzer
Lythrum salicaria	purple loosestrife	Spreads aggressively in wetlands, eliminating open water habitats and crowding out native plants. Contributes to the loss of wildlife that depend on native wetland plants.		John D. Byrd, Mississippi State University, Bugwood.org
Microstegium vimenium	Japanese stiltgrass	Spreads aggressively in disturbed, moist, shady areas, crowding out native plants. May raise pH and reduce organic soil horizon.		Deborah J. Kratzer
Myriophyllum spicatum L.	Eurasian water-milfoil	An aquatic plant that begins growing earlier in spring than most indigenous aquatic plants, it quickly overtops, outshades, and outcompetes surrounding vegetation.		Britton and Brown, 1913, Vol. 2: 614.

Miscanthus sinensis	Chinese silver grass	Escapes from ornamental plantings and can form large clumps along disturbed areas, crowding out native vegetation. It is also extremely flammable and increases fire risks where it grows.		James H. Miller, USDA Forest Service, Bugwood.org
Phyllostachys aurea	Golden bamboo	Forms dense monocultural thickets that crowd out other plants. Difficult to eradicate once established.		Chuck Bargeron, Univ. of Georgia, Bugwood.org
Polygonum cuspidatum	Japanese knotweed	Spreads aggressively in disturbed, sunny areas, especially river banks and wetlands, crowding out native plants.		Tom Heutte, USDA Forest Service, Bugwood.org
Potamogeton crispus L.	curly leaf pondweed	An aquatic plant that begins growing earlier in spring than most indigenous aquatic plants, it quickly overtops, outshades, and outcompetes surrounding vegetation. Can form dense mats that disrupt boating, swimming, and fishing.		Mohlenbrock , 1995
Rosa multiflora	multiflora rose	Spreads everywhere, except standing water, crowding out native plants and degrading pastures.		James H. Miller, USDA Forest Service, Bugwood.org
Rubus phoenicolasius	wineberry	Forms an extensive, nearly impenetrable understory layer in favorable locations such as moist soils in forests over dolomite, marble, shale, diabase, and traprock, crowding out native plants.		Jil M. Swearingen, USDI National Park Service, Bugwood.org

Viburnum plicatum	Japanese viburnum	Shade tolerant shrub considered highly threatening to native plant communities.		Richard Webb, Self-employed horticulturist, Bugwood.org
Vinca minor	periwinkle	Spreads in shady forests, crowding out native plants.		Jill M. Swearingen, USDI National Park Service, Bugwood.org
Wisteria floribunda and W. sinensis	Japanese and Chinese Wisteria	Aggressive climbing vines that girdle tree trunks and branches. Dense canopies weigh down branches and shade underlying areas.		Ted Bodner at USDA-NRCS PLANTS Database
Sources: Snyder & Sylvan, 2004; Swearingen et al., 2002; Center for Invasive Species and Ecosystem Health (bugwood.org), 2010; Britton and Brown, 1913; Mohlenbrock, 1995; Ted Bodner at USDA-NRCS PLANTS Database				

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- Gardening for Butterflies: http://www.state.nj.us/dep/fgw/ensp/pdf/literature/butterfly_gardening.pdf
- National Audubon Society: http://www.audubon.org/bird/at_home/
- New Jersey Audubon Society: http://www.njaudubon.org/SectionBackyardHabitat/Welcome.aspx
- NJDEP Outdoor Classroom links: http://www.state.nj.us/dep/seeds/syhart/outclass.htm
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- Species of Special Concern of NJ: http://www.njfishandwildlife.com/ensp/pdf/spclspp.pdf

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Rare Plant Report Form: http://www.state.nj.us/dep/parksandforests/natural/heritage/natherrareplantspeciesreportform1_2008.doc

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Forest Health: http://www.state.nj.us/dep/parksandforests/forest/njfs_forest_health.html

8: OPEN SPACE & RECREATION

A. Purposes & Funding


Deborah J. Kratzer

North Brunswick Community Park (NBCP)

The purposes of open space preservation include:

- provide adequate active and passive recreation;
- provide recreational and open space opportunities on an equal and accessible basis for all citizens;
- maintain water quality and groundwater recharge areas;
- protect sensitive environmental features;
- protect historic areas;
- maintain biodiversity;
- minimize erosion or damage from flooding; and
- maintain rural character (ANJEC, no date).

Funding for open space comes from a variety of sources, including municipal, county, state and federal sources and private land trusts. Private land trusts are non-profit organizations that "can often act faster and be more creative in their real estate transactions than established government agencies" according to Howe (1989). Landowners are able to reap tax benefits through charitable donations to a land trust. Many successful open space purchases combine a number of funding sources and strategies.

The Garden State Preservation Trust Act provides state funds for land acquisition and park development through the Green Acres program.

Private land trusts working to preserve land in northern New Jersey include the Trust for Public Land, New Jersey Conservation Foundation, New Jersey Natural Lands Trust and New Jersey Agricultural Land Trust. These organizations and the Association of New Jersey Environmental Commissions (ANJEC) are sources for in-depth information concerning open space preservation through various funding, planning, and zoning techniques (see **Internet Resources**).

B. Greenway Establishment & Maintenance

A *greenway* is a corridor of undeveloped land or open space, which often protects environmental features, such as a stream corridor, floodplain, forested ridgeline, or animal migration route, but which can also preserve a scenic view and provide recreational opportunities, such as parks or biking/hiking trails. Greenway corridors also have the potential for positive economic impacts, by creating jobs, enhancing property values, expanding local businesses, attracting new businesses, increasing local tax revenues, decreasing local government expenditures, and promoting a local community. The publication Economic Impacts of Protecting Rivers, Trails and Greenway Corridors outlines procedures for analyzing economic impacts of a greenway project, and provides examples. Decision-makers can benefit from

recognition of potential economic impacts as well as intrinsic values of greenways in support of decisions that enhance the well-being of the community (National Park Service, 1995).

Garden State Greenways is an online planning tool designed for all those involved in conserving open space, farmland, and historic areas in New Jersey. It uses GIS to identify *hubs* **(**larger areas of undeveloped land with important natural resource values) and linear *connectors* between these hubs. The goal of the program is to help coordinate efforts of both private groups and government agencies (NJ Conservation Foundation, 2005).

Local governments often use a variety of planning and zoning techniques for establishing greenways, including creating a greenway map and adopting it as part of the Master Plan, creating a Greenway Overlay District, cluster zoning and Transfer of Development Rights. These strategies can be combined with land preservation, private land trusts, and conservation easements to meet the Borough's open space and recreation goals (Howe, 1989).

Before a greenway is established, issues of maintenance, public access and monitoring of easements must be addressed to ensure long-term success of the project (Howe, 1989).

One of the Township of North Brunswick's goals is to "Promote the development of a comprehensive, Township-wide system of greenways, bikeways, and other pedestrian connections" (Heyer, Gruel & Associates, May 2006). The *Land Use Element* and *Recreation and Open Space Element* of the Master Plan list some specific properties with potential to contribute to greenway connections. The "Conceptual Greenway Opportunities Map" and the "Acquisition Opportunities Map" in the Master Plan illustrate some potential greenways. In addition, the *Circulation Element* presents goals and objectives related to improving pedestrian and bicycle systems.

C. Open Space & Recreation

North Brunswick's Recreation and Open Space Element of the Master Plan identifies the various county and municipal parks and recreation facilities located within the township (Heyer, Gruel & Associates, May 2006). In addition, it outlines the township's conservation, open space and recreation strategies, recommended actions, and recommendations for acquisition of parks and recreational facilities.

An updated inventory of the preserved open space and recreation properties within the township is presented in **Table 8.1** and **Figure 8a**. Approximately 214.71 acres have been preserved by Middlesex County within North Brunswick, while the township has preserved 799.53 acres (222.69 acres of parks and 362.13 acres of undeveloped municipally-owned property). Using the acreage figures in the GIS data files (which may differ somewhat from deed acreage), a total of 799.53 acres have been preserved in North Brunswick, which is approximately 10.16% of the township.

Glenn Sandor

The Pulda Farm

The North Brunswick website includes a photo tour of the township's open space (see **Internet Resources**). A variety of active and passive open space and recreation opportunities are available within the township. The parks that have natural areas include Farrington Lake Conservation Area, Hidden Lake Open Space and Conservation Area, Luke Open Space and Conservation Area and North Brunswick

Community Park. A summary of the facilities found at each park is shown in **Table 8.1**. Some of these are described in the paragraphs below. An inventory of the blocks, lots and locations of the open space is provided in **Table 8.2** and illustrated in **Figure 8a**.

Table 8.1: North Brunswick Municipal Park Facilities

Park	Acres	Baseball/ Softball	Basketball	Fishing	Flagpole	Football Field	Lights	Natural Area	Pavilion/ Picnic Area	Playground Equipment	Restrooms	Soccer Fields	Tennis Courts	Trails
Applegate	0.9		*							*				
Babbage Park	16.72	*	*		*	*	*		*	*	*	*		*
Boyds Pond / Tot Lot	2.4			*						*				
Brunswick Knolls	1.85		*							*			*	
Colonial Gardens	0.5		*							*				
Columbus Park	0.25													
Donald J. Caruso Field	6.29	*												
Eisenhower Park	1.19		*							*				
Farrington Oaks	1.31		*							*				
Farrington Lake Conservation Area	146.2			*				*						*
Frisch Park	1.3	*	*							*				
Hermann Park	2.42		*							*			*	
Hidden Lake Open Space and Conservation Area	50.94			*				*	*					
Hoover Tract	3.42			*				*	*					
JFK Park	5.16											*		
Luke Open Space and Conservation Area	22.60		*					*		*				
Martin Luther King Jr. Park	0.27		*							*				
North Brunswick Community Park	105.21				*		*	*		*	*			*
North Brunswick Open Space and Conservation Area	42.13							*						
The Ramble	7.57							*						
Renaissance Park	14.13	*			*		*		*	*	*	*		
Sabella Park	28.97	*	*		*	*	*		*	*	*	*		
September 11th Memorial Park	1.33				*									
Vanderbilt Park	0.33									*				
Veterans Park	16.87	*			*				*	*	*	*	*	

Source: North Brunswick, November 11, 2013

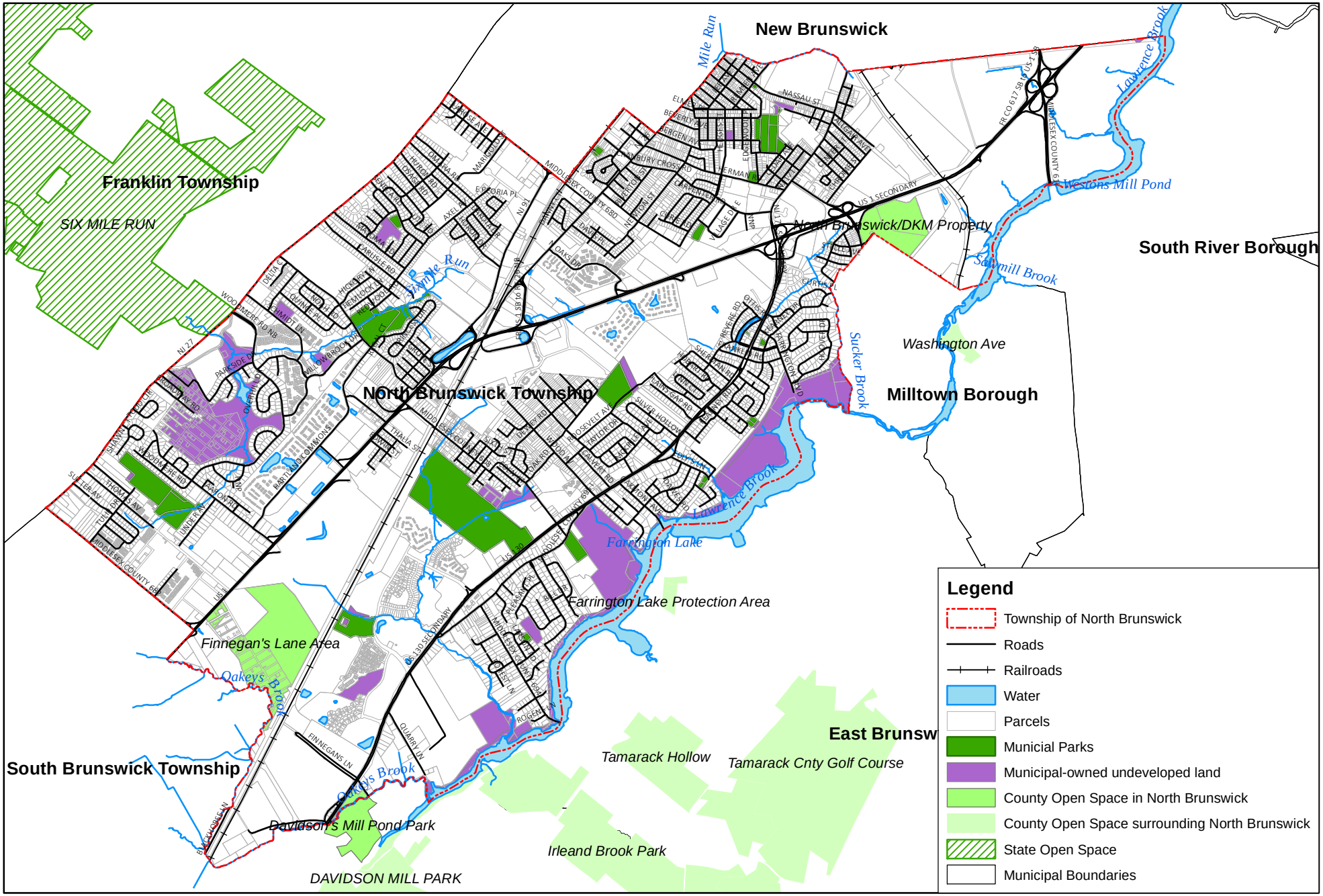

Figure 8a: Open Space and Recreation

0 0.25 0.5 1 Miles

N

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Municipal Parks

North Brunswick Community Park (NBCP)

Centrally located in the township, the former 105-acre Otken Farm was purchased by the Township for development of an active recreational facility. It is accessed from Route 130. The park includes lighted fields for soccer, baseball and softball, playground equipment, a 2.17 mile walking / jogging trail, rest rooms, concession stands, a dog park and a butterfly garden (North Brunswick, 2013). **Figure 8b** shows 2012 aerial photography of NBCP.

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The butterfly garden at NBCP displays many native plants favored by butterflies and birds,

Luke Park

Luke Park is located near the western corner of North Brunswick off Tulip Drive. The entire park is deciduous wooded wetlands, which limits development while providing a refuge for wildlife and native plants. There is a basketball court and playground area (Heyer, Gruel & Associates, May 2006). **Figure 8c** shows 2012 aerial photography of Luke Park and the surrounding area.

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Forested wetlands cover Luke Park (left). Native understory shrubs at Luke Parks include spicebush (Lindera benzoin) and winterberry (Ilex verticillata) (right).

Hidden Lake (North Brunswick Conservation Area)

The North Brunswick Conservation Area surrounds Hidden Lake just north of Luke Park on the township's border with Franklin Township (Somerset County). Hidden Lake is on Six Mile Run and covers approximately 4 acres. The area is constrained by wetlands. The township has acquired additional parcels in the Hidden Lake area and will continue to analyze the property for its most appropriate public use. Possibilities include an addition to the Hidden Lake Conservation Area, a future school site and an auxiliary site for the Department of Public Works (Heyer, Gruel & Associates, May 2006). **Figure 8c** shows 2012 aerial photography of Hidden Lake and the surrounding area.

Farrington Lake Open Space

Creation or maintenance of vegetated buffers and open space along water margins can help prevent or reduce erosion and water pollution by slowing and filtering polluted runoff. North Brunswick has approximately 3.8 miles of Lawrence Brook waterfront (excluding the portion on the Cook Campus of Rutgers University), almost all of which is preserved open space

or recreation land. **Figures 8d, 8e and 8f** show 2012 aerial photography of the southern, central and northern portions of Farrington Lake Open Space.

"The Cascades," formerly known as the Pulda Farm, is located on Farrington Lake in the vicinity of Wood Avenue. It was preserved as part of the Township Planning Board's approval of a development application. Access to land adjacent to Farrington Lake was required, in addition to an American with Disabilities Act (ADA) accessible pedestrian walkway and pier on Farrington Lake (Heyer, Gruel & Associates, May 2006).

Table 8.2: Municipal Preserved Open Space & Recreation Areas

Name	Block	Lot	Location	Acres*
Applegate Playground	227	71	Edwards Place	0.17
	227	72	Edwards Place	0.82
adjacent to Applegate Playground	227.03	27	20 Tall Oaks Drive	5.70
Babbage Park	179	9	Glenridge Avenue	1.93
	183	1	Edison Avenue	5.96
	183	29.01	Edison Avenue	0.22
	184	1	Edison Avenue	4.46
	185	1	Willow Avenue	1.55
	187	1.01	Edison Avenue	1.71
Boyds Pond / Tot Lot	243	1	South Boyd Parkway	2.00
	244	5	South Boyd Parkway	0.14
Brunswick Knolls	18.03	8	Ohio Avenue	7.58
	18.03	12	Seneca Road	1.76
Colonial Gardens	266	8	Kearney Drive	0.57
Columbus Park	183	6	Nassau St & Remsen Avenue	0.24
Donald J. Caruso Field	227	19	Old Georges Road	6.28
Eisenhower Park	262	161	Clinton Road & Madison Drive	0.55
	262	178	Stockton Drive	0.68
Farrington Lake Conservation Area	224	78.01	Farrington Lake	0.50
	224	78.02	Farrington Lake	1.74
	224	77.01	Farrington Lake	4.16
	224	74.01	Farrington Lake	0.94
	224	72.01	Farrington Lake	0.77
	224	73.01	Farrington Lake	3.78
	224	71.01	Farrington Lake	0.21
	224	58	Farrington Lake	1.19
	224	70	60 Church Lane	0.09
	224	75.01	Farrington Lake	21.96
	224	71.02	Farrington Lake	0.04
	224	57.05	Lake Farrington Drive	1.52
	227	48.01	Farrington Lake	0.61
	227	42.01	Farrington Lake	0.67
	227	37.01	Farrington Lake	1.52
	227	33.02	Farrington Lake	6.30
	227	46.01	Farrington Lake	0.91
	227	43.01	Farrington Lake	0.58
	227	33.01	Farrington Lake	0.19
	227	33.03	Farrington Lake	2.09
	227	47.01	Farrington Lake	0.36
	227	20.01	300 Old Georges Road	67.44
	262	104.01	Farrington Lake	3.58
	262	102.01	Farrington Lake	47.10
	262	64	Hoover Drive	6.64
	262	65.01	Sucker Brook	26.89
	262	110.01	Farrington Lake	0.98

Name	Block	Lot	Location	Acres*
	262	75	Farrington Boulevard	0.93
	262	103.01	Farrington Lake	7.89
Farrington Lake Conservation Area/Hoover Tract	262	63	Hoover Drive	3.41
Farrington Oak Playground	262	131	Morton Road	0.39
	262	135	Edly's Lane	0.58
Frisch Park	91	59	Mcauliffe Drive	0.28
	91	60	Mcauliffe Drive	0.95
Hermann Park	140	54	Schirra Road	2.32
Hidden Lake Open Space and Conservation Area	4	10.01	Harold Street	0.03
	4	13.01	Harold Street	0.08
	4.01	2	Paul Avenue	0.55
	4.01	1	Lincoln Place	0.13
	4.02	1	Ruth Road	0.78
	4.02	4	Ruth Road	0.44
	4.04	2.01	Parkside Drive	13.65
	4.14	12	Harrison Avenue	0.32
	4.15	85	Hidden Lake	4.19
	4.15	64	Hidden Lake Drive	34.11
	4.19	4	Leonard Street	0.07
	4.19	5	Sherwood Boulevard	0.03
	4.19	6	Sherwood Boulevard	1.20
	4.19	1	Sherwood Boulevard	0.81
	4.20	1	Ruth Road	0.22
	4.21	1	Ruth Road	1.96
	4.22	1	Ruth Road	0.00
	4.23	1	Shirley Street	0.21
	4.24	1	Shirley Street	0.54
	4.25	1	Shirley Street	0.29
	4.26	3	Mark Road	1.56
	4.27	1	Caroline Street	1.67
	4.28	1	Cleveland Avenue	1.00
	4.28	2	Caroline Street	0.09
	4.29	1	Harrison Avenue	0.28
	4.30	6	Harrison Avenue	0.77
	4.30	5	Harrison Avenue	0.08
	4.30	4	Harrison Avenue	0.21
	4.30	3	Harrison Avenue	0.04
	4.30	2	Harrison Avenue	0.26
	5	9	Sherwood Boulevard	0.09
	5	10	Sherwood Boulevard	0.09
	5	16	Harold Street	0.09
	6	8	Ruth Road	0.37
	6	14	Harold Street	0.09
	8	10	Cleveland Avenue	0.37
	8	7	Cleveland Avenue	1.84
	8	9	Harrison Avenue	0.09
	9	7	Matthew Road	0.09
	9	8	Matthew Road	0.14
	9	5	Harold Street	0.09
	9	2	Harold Street	0.09
	9	9	Cleveland Avenue	2.34
	10	3	Leonard Street	0.18
	10	2	Mark Road	2.57
	10	6	Matthew Road	0.09

Name	Block	Lot	Location	Acres*
Hidden Lake Open Space and Conservation Area	10	4	Leonard Street	0.18
	10	5	Matthew Road	0.09
	11	7	Broadway Road	0.09
	11	16	Mark Road	0.64
	11	20	Mark Road	0.05
	11	19	Mark Road	0.18
	11	3	Mark Road & Harold Street	0.18
	11	18	Mark Road	0.14
	12	18	Broadway Road	0.09
	12	6	Sherwood Boulevard	0.09
	12	16	Broadway Road	0.09
	12	8	Sherwood Boulevard	0.09
	12	17	Broadway Road	0.09
	12	15	Broadway Road	0.09
	12	7	Sherwood Boulevard	0.09
	12	2	Harold Street	0.09
	12	14	Broadway Road	0.09
	12	13	Broadway Road	1.06
	13	9	Leonard Street	0.41
	13	2	Harold Street	0.09
	13	7	Ruth Road	0.51
	13	5	Ruth Road	0.64
	13	3	Ruth Road	0.46
	13	8	Ruth Road	0.09
	49	3	Leonard Street	0.09
	49	8	Sherwood Boulevard	2.39
	50	3	Ruth Road	2.02
	51	6	Sherwood Boulevard	1.47
	51	1	Broadway Road	0.28
	52	4	Broadway Road	0.14
	52	3	Broadway Road	0.09
	52	6	Shirley Street	1.84
	53	4	Caroline Street	2.94
	54	1	Leonard Street	0.09
	54	2	Leonard Street	0.09
	54	4	Caroline Street	2.80
	55	4	Matthew Road	0.09
	55	6	Caroline Street	2.48
	55	1	Leonard Street	0.09
	55	3	Matthew Road	0.18
	56	3	Cleveland Avenue	0.18
	56	1	Leonard Street	0.18
	56	4	Caroline Street	2.66
JFK Park	4.39	9.01	Schmidt Lane	5.14
Luke Park	4	14	Tulip Drive	21.60
	4	22.01	Thomas Avenue	8.87
	4	22.02	Violet Drive	6.64
	4	22.03	Tulip Drive	1.13
	4	33.02	Linder Avenue	0.19
	4	34.02	Linder Avenue	0.37
Martin Luther King Jr. Park	6	17	Sherwood Boulevard	0.28
no name	4.34	125.02	1280 Schmidt Lane	4.18
no name	229	19	Route 130	0.13
North Brunswick Community Park	148	103	2051 Route 130	104.91
adjacent to North Brunswick Community Park	148	101.02	Adams Lane	6.89

Name	Block	Lot	Location	Acres*
	148	87	Ninth Street	1.21
	148	88	Tenth Street	1.49
	148	89	Eighth Street	0.96
	148	90	Darmody Avenue	0.13
	148	92	Darmody Avenue	1.40
	148	101.03	Adams Lane	0.55
Renaissance Park	148.06	4	Renaissance Boulevard	11.84
	148.06	4	Renaissance Boulevard	11.84
Sabella Park	17	156.01	Cozzens Lane	7.54
	17	158.01	1453 Cozzens Lane	0.29
	17.02	160.34	Cozzens Lane	0.72
	17.02	160.36	12 Redwood Road	0.80
September 11th Memorial Park	175	29	Hermann Road	1.72
Vanderbilt Park	259	30.01	Prospect Avenue	0.17
Veteran's Park	143	162	Roosevelt Avenue	16.92
*Acres from GIS may differ from deed acres.				
Source: North Brunswick, October 20, 2011				

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Farrington Lake Dam (left) and path (right)

County Parks

Davidson's Mill Pond Park

Located mainly in South Brunswick, approximately 37 acres of this county park is found near the southern tip of North Brunswick, southeast of Route 130. Davidson's Mill Pond Park's 482 acres contain a mix of forests and open fields, in addition to Davidson's Mill Pond (an impoundment on the Lawrence Brook). Features include a small boat launching ramp and approximately 2.5 miles of trails (Middlesex County, 2013).

Finnegan's Lane Area

The majority of this 135 acre site is in the floodplain, and much of it is also wetlands. It is undeveloped.

North Brunswick / DKM Property

This 49-acre county-owned property is currently undeveloped. It is located adjacent to Milltown Borough, south of US Route 1 and east of County Route 606. According to North Brunswick's Master Plan, the plans for the property include using half for development and expansion of the New Jersey Economic Development Authority (NJEDA) Technology Center,

while the other half will be added to the Middlesex County Parks system and developed into active recreation fields including soccer and baseball (Heyer, Gruel & Associates, May 2006).

D. Walking Routes

As mentioned in **Section 8B**, one of North Brunswick's Master Plan goals is to "Promote the development of a comprehensive, Township-wide system of greenways, bikeways, and other pedestrian connections" (Heyer, Gruel & Associates, May 2006). Part of this effort is the creation of the walking routes illustrated in **Figure 8g**. **Table 8.3** lists the lengths of these walking routes/trails. Because portions of routes 1 through 5 overlap, **Figure 8h** shows these trails at a larger scale in order to more clearly see them.

Table 8.3: Walking Routes/Trails

Name	Length (miles)
Governor's Point Loop	3.88
Farrington Loop #2	2.14
Farrington Loop #1	3.01
Farrington Loop #2 Proposed	0.98
1	2.06
2	2.26
3	2.58
4	3.31
5	2.10
Source: North Brunswick GIS, January 25, 2013	

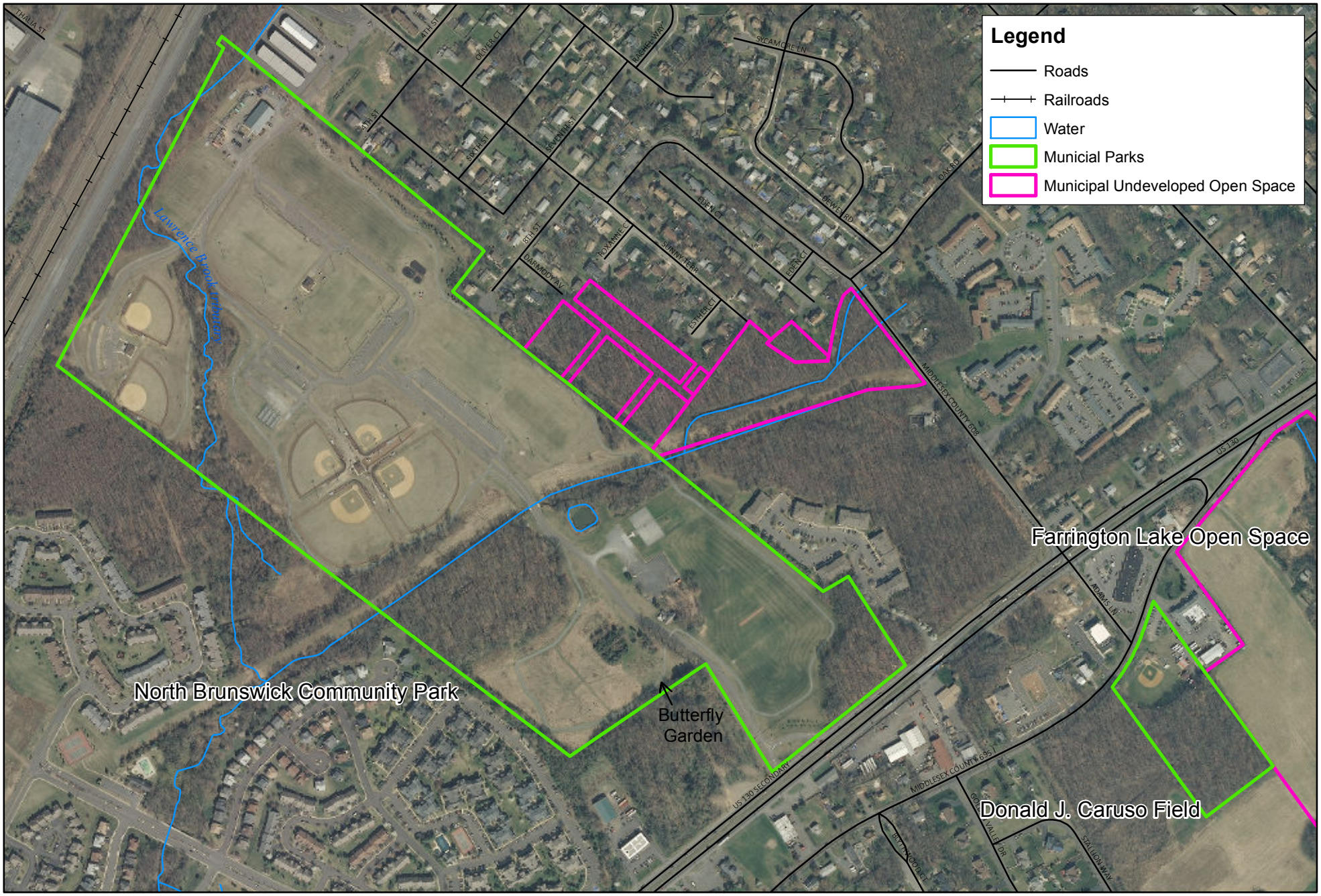

Figure 8b: 2012 Aerial Photography of North Brunswick Community Park

0 0.05 0.1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

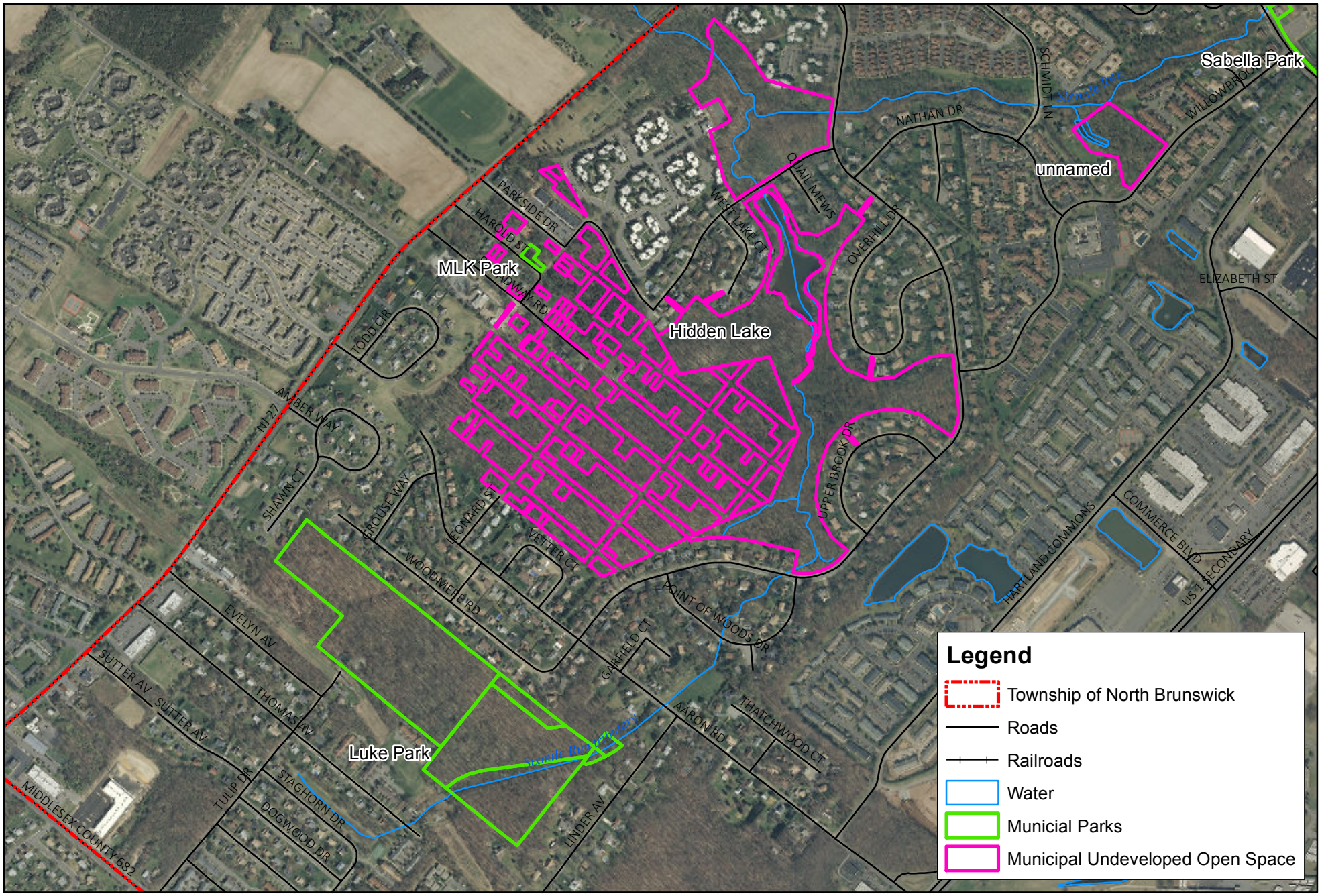

Figure 8c: 2012 Aerial Photography of Luke Park & Hidden Lake Conservation Area

0 0.05 0.1 0.2 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
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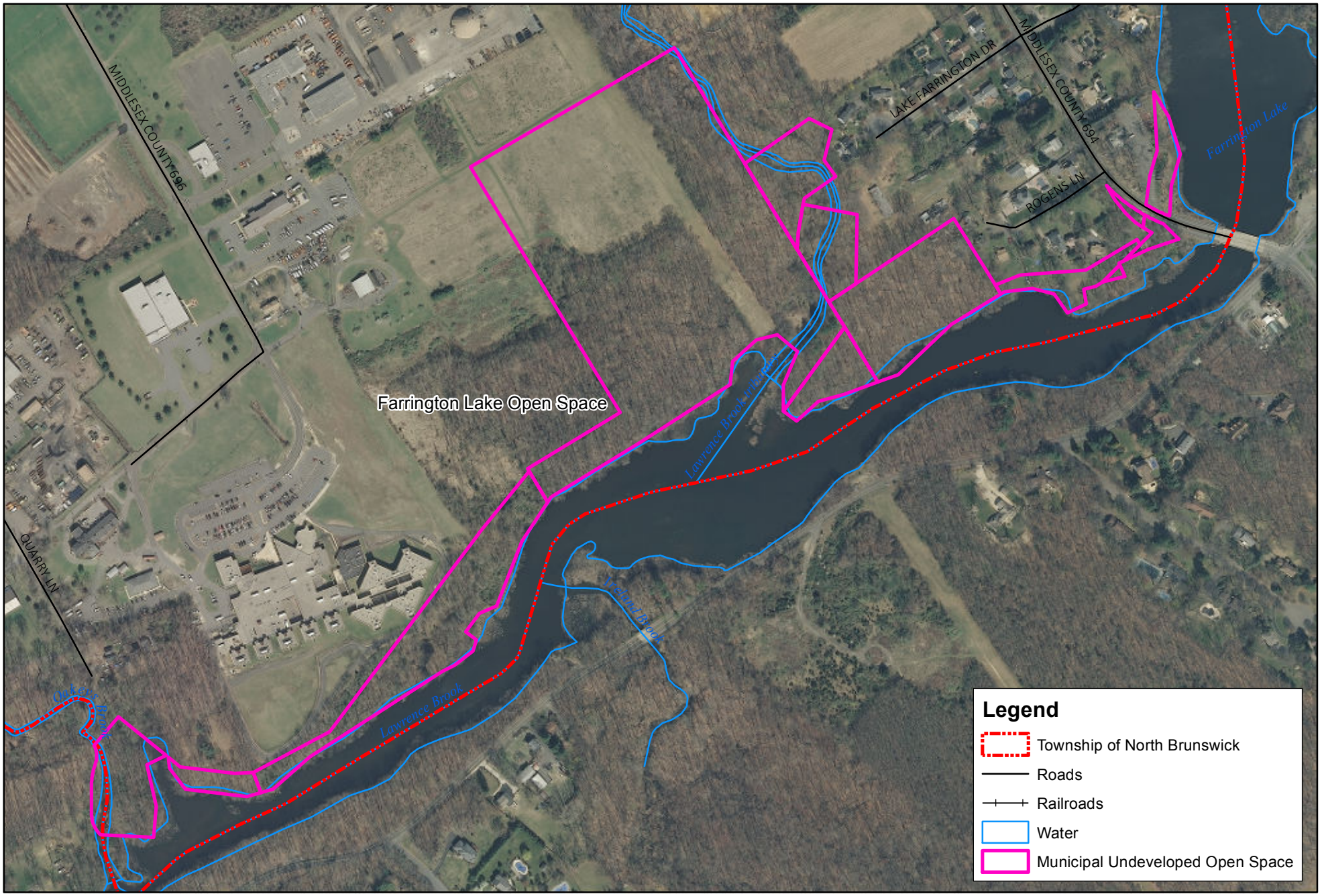

Figure 8d: 2012 Aerial Photography of Southern Section of Farrington Lake Open Space

0 0.05 0.1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
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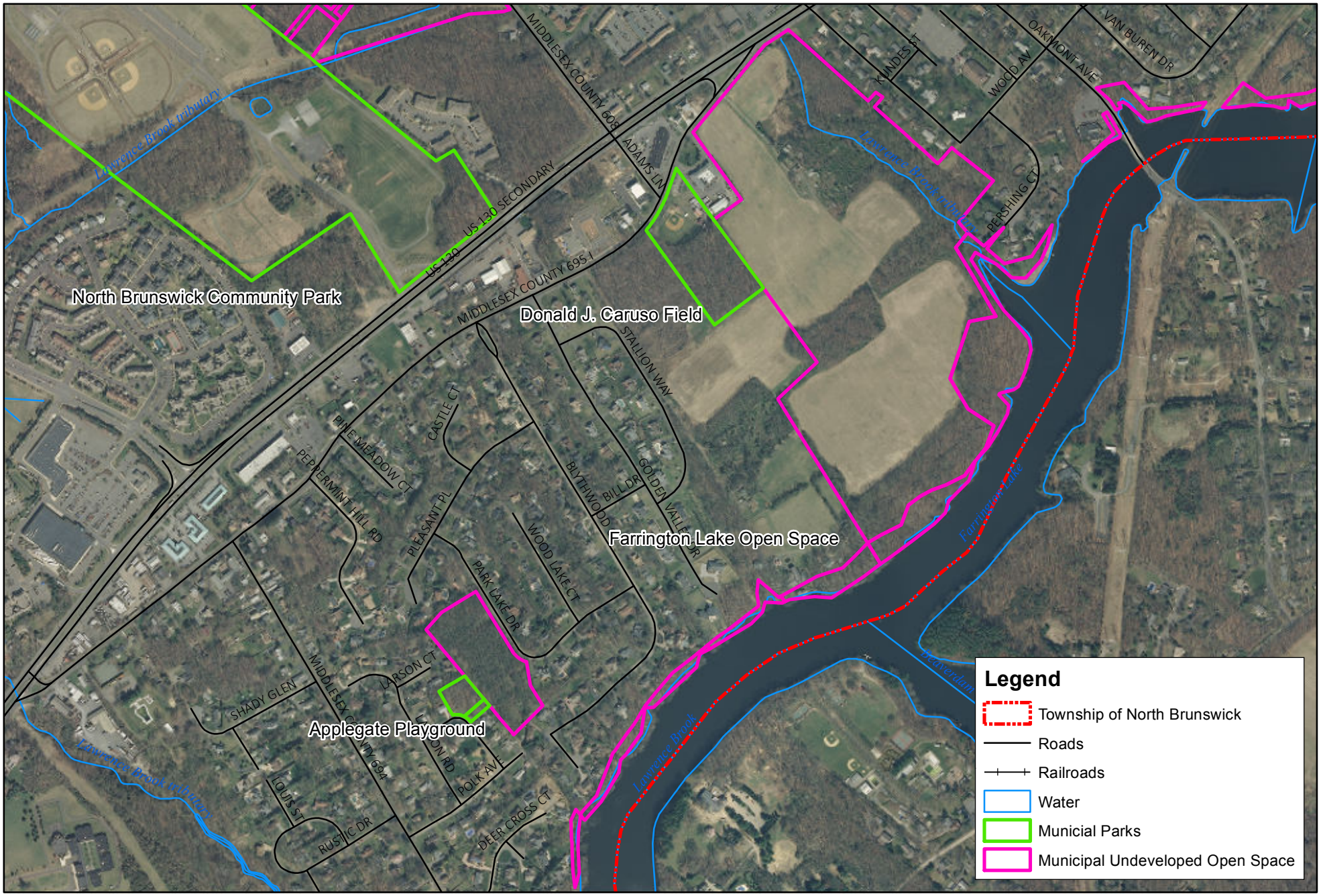

Figure 8e: 2012 Aerial Photography of Central Section of Farrington Lake Open Space

0 0.05 0.1 0.2 Miles

N

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

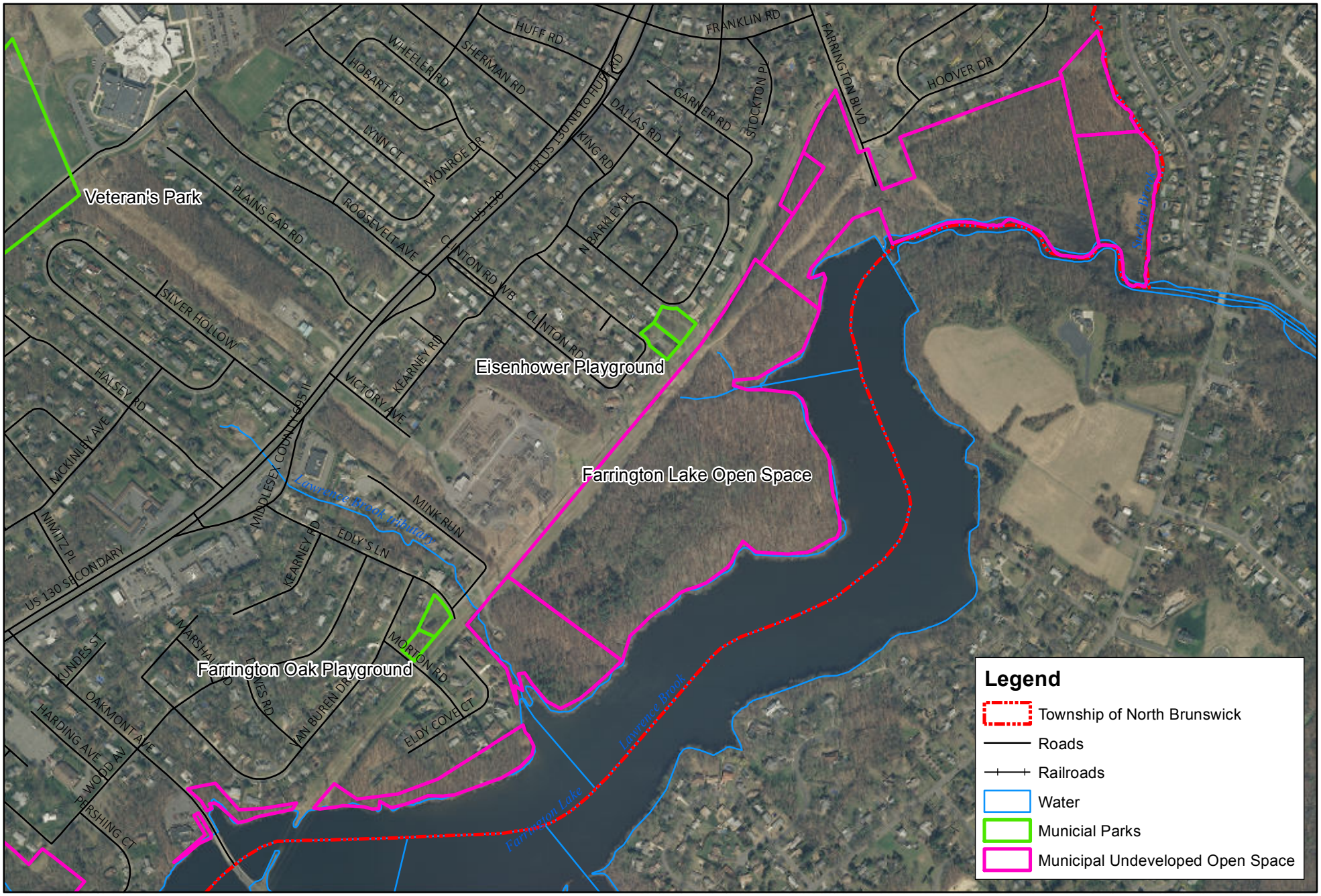

Figure 8f: 2012 Aerial Photography of North Section of Farrington Lake Open Space

0 0.05 0.1 0.2 Miles

N

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
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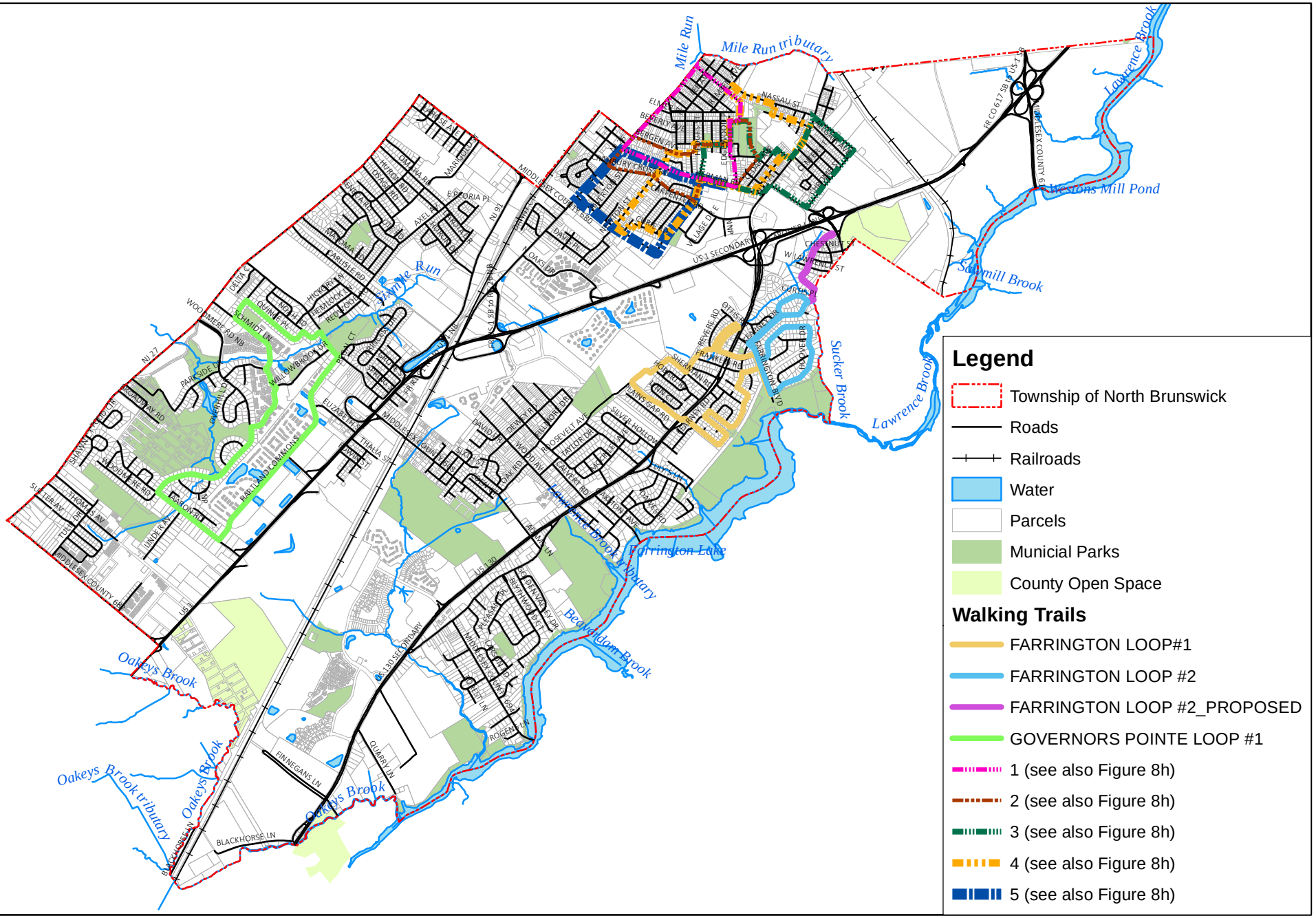

Figure 8g: Trails and Walking Routes

0 0.25 0.5 1 Miles

N

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
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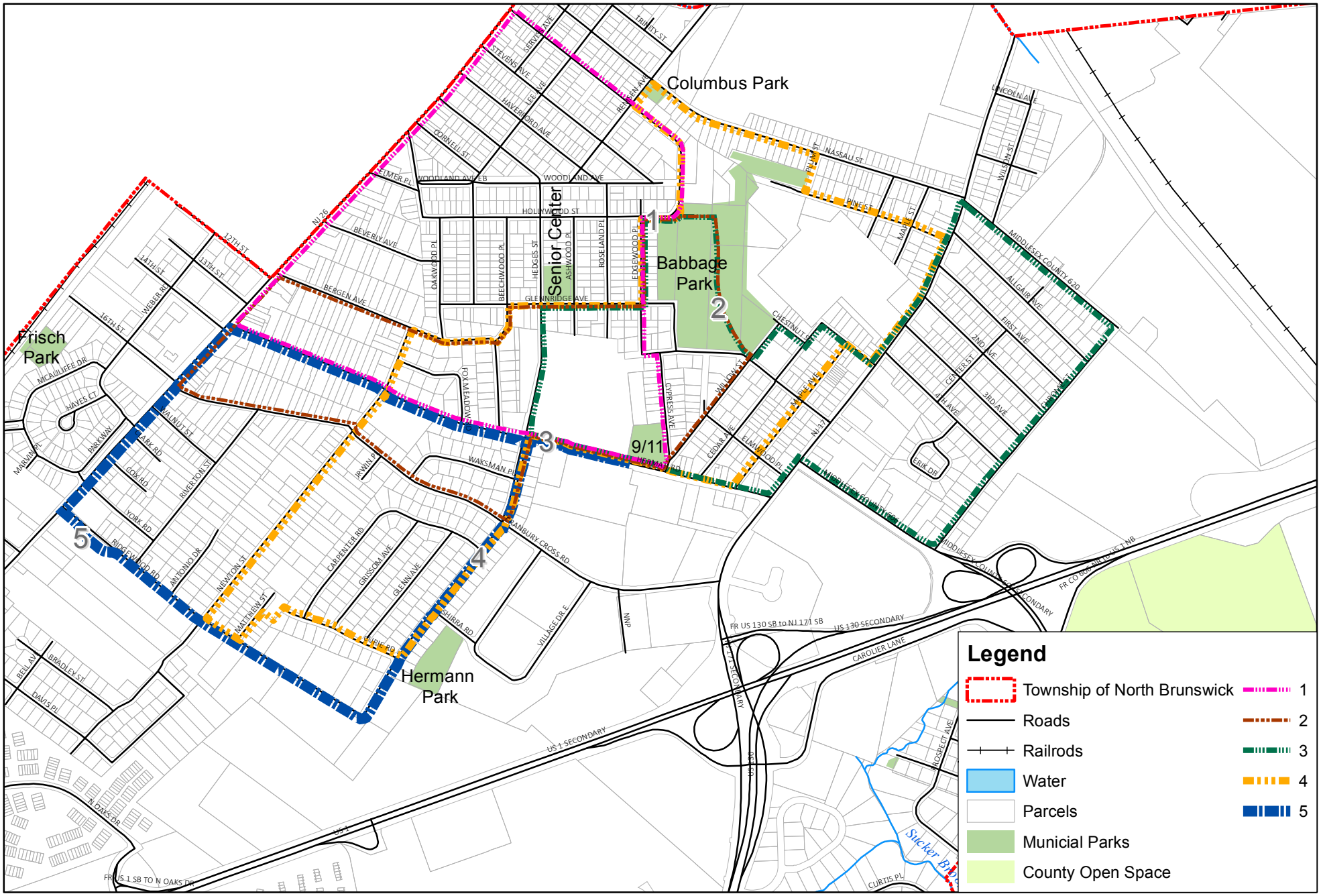

Figure 8h: Trails and Walking Routes 1 through 5

Data Sources: NJDEP, Mercer County, North Brunswick Twp.
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

References: Open Space

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North Brunswick GIS. January 25, 2013. North Brunswick Walking Trails. GIS data.

North Brunswick GIS. October 20, 2011. North Brunswick Parks and Undeveloped Properties. GIS data.

NJDEP, Green Acres Program. July 2011. NJDEP County Open Space and Recreation Areas in New Jersey (Version 201107). GIS data. http://www.state.nj.us/dep/gis/digidownload/zips/statewide/openspace_county.zip

Internet Resources: Open Space

ANJEC Handbook for Public Financing of Open Space in New Jersey: http://www.anjec.org/pdfs/PublicFinancingOpenSpace.pdf

Garden State Greenways http://www.gardenstategreenways.org

Native Plant Society of New Jersey: http://www.npsnj.org

NJ Natural Lands Trust: http://www.njnlt.org/

Parks:

North Brunswick Parks: http://www.northbrunswicknj.gov/DPRCS/DPR_Parks.html
Middlesex County, Davidson's Mill Pond Park: http://co.middlesex.nj.us/parksrecreation/davidson.asp

Rain Garden Manual: http://www.npsnj.org/pages/nativeplants_Rain_Gardens.html

Rutgers New Jersey Agricultural Experiment Station (NJAES) – information & links for farmers, gardeners, & consumers: http://njaes.rutgers.edu/

9: HISTORICAL RESOURCES

A. The History of the Township of North Brunswick

Pre-Colonial Period (12,000 years ago - 1600)

Humans arrived in New Jersey at least 12,000 to 13,000 years ago. This coincides with the end of the last ice age, therefore the climate was much colder, and the landscape consisted of spruce and pine forests. Very little is known about the people of the Paleo-Indian Period (12,000 to 10,000 years ago) and the later Archaic Period (10,000 to 3,000 years ago). The paucity of artifacts suggests a low population density.

The Woodland Period, from 3,000 years ago to the 1600s, is characterized by the appearance of ceramic vessels. Hunting, fishing and seasonal movement to take advantage of seasonally available resources were primary activities, while farming increased in importance. As the Indians became less nomadic, they cleared the forests for village sites and agriculture, and cut wood for fuel, shelters, canoes, tools and other implements. It was also common practice to deliberately set fires for the purpose of driving game and thinning and opening up forests.

In pre-colonial times, the Native Americans of New Jersey were the Lenape Indians, a branch of the Algonquins. At the time the first Europeans arrived in the area, there may have been as few as 2,000 or as many as 12,000 humans living in what is now New Jersey (1.4 persons/mi^2), compared to today's population of 40,742, or (3,320 persons/mi^2) now living in the Township of North Brunswick and 8,791,894 (1,008 persons/mi^2) in New Jersey (US Census, 2010).

1600 - 1700

By 1613, the Dutch had claimed the area reaching from Albany, New York to Lewes, Delaware, and called it New Netherland. The earliest records of the area that would become North Brunswick mention the Black Horse Tavern, a stagecoach stop built in 1670, and the Lion Tavern. Both were located on Georges Road, present day Route 130 and Route 695 (the latter is also known as Old Georges Road). The Dutch relinquished all of New Netherland to the English in 1674, at the conclusion of the Third Anglo-Dutch War (DeAngelo, June 2007).

1700 - 1800

Settlers purchased land from the Native Americans and built homes and farms. Fertile land, religious freedom, and the central location between New York and Philadelphia encouraged rapid growth in commerce and population. Some Dutch influence remained, but most of the residents were from England, Scotland, France, or the other colonies. Unfortunately, there were also slaves of African descent, up until the 1850 census.

While the ports of Perth Amboy and New Brunswick, on the Raritan River, became Royally Chartered Cities, surrounding areas were almost entirely agriculture. A gristmill was operational on Farrington Lake by 1750, near to location of the current dam. A snuff factory and a tannery were also built nearby around this time. Paths used by the Lenape were improved and became roads, enabling residents to transport the goods they produced to the ports, and to obtain the goods they needed (DeAngelo, June 2007; North Brunswick Historical Committee, 2011).

Dutch and French settlers founded North Brunswick in 1761. The township was first incorporated in 1779. North Brunswick was incorporated a second time in 1798, one of the state's original 104 townships. Later, portions of the township separated to become East

Brunswick and Milltown Borough (DeAngelo, June 2007; North Brunswick Historical Committee, 2011; Wikipedia, 2013).

During the American Revolution, both Washington's troops and the British traveled on what is now Route 27 on their way to and from important engagements (North Brunswick Historical Committee, 2011).

While most of the continent east of the Mississippi River was continuous woodlands in colonial times, "By the time New Jersey became a state in 1778, no extensive areas of land well suited to farming remained wooded in the central part of the state" (Robichaud and Anderson, 1994). The remaining forests were frequently and repeatedly cut for cordwood.

1800 - 1900

The township's first church was built in 1847. Located at the intersection of Old Georges Road and Church Road (Route 694), the Georges Road Baptist Church is still in use (North Brunswick Historical Committee, 2011).

The area became more industrialized, aided by advances in transportation. In 1830, the State of New Jersey Legislature granted a charter to the Camden and Amboy Railroad (C&A) for construction of a railroad connecting Camden and South Amboy. Innovations in track construction allowed the C&A Railroad to become the first successful, steam-powered railroad to operate in the United States. A branch line was completed in 1839 that connected New Brunswick with Bordentown. The Delaware & Raritan Canal (see **Figure 5c**) was built between 1830 and 1834 between Trenton and New Brunswick (DeAngelo, June 2007).

In 1864, Rutgers College (originally Queens College, established in 1766) purchased 98 acres for use as an experimental farm. The college was named after George H. Cook, state geologist and leader of the efforts to have Rutgers named the land-grant college in New Jersey. In 1912, the Cook family farm on Ryders Lane was added to the college (Cook History Project, November 10, 2003).

The Goetze Gasket and Packing Company was established in 1887. In 1898, The National Musical String Company opened, employing 120 people. The building, located on Georges Road, was listed on the National Register of Historic places in 1982 (North Brunswick Historical Committee, 2011).

The Williamson Wheelwright/Blacksmith Shop, originally on Route 27 in the southern part of North Brunswick, was preserved and moved to the East Jersey Olde Towne (a collection of original, reconstructed and replica 18th and 19th century buildings, located in Piscataway) (North Brunswick Historical Committee, 2011; Middlesex County Cultural and Heritage Commission, 2013).

Many of the locations mentioned here are shown on a circa 1876 map of North Brunswick (**Figure 9a)**. Approximate locations are also displayed on **Figure 9b**.

1900 - present

By 1900, Middlesex County was more industrial than agricultural (DeAngelo, June 2007). However, aerial photographs taken in 1930 (see **Figure 1b**) show that North Brunswick continued to be dominated by agriculture. Comparing aerial photographs taken over the years

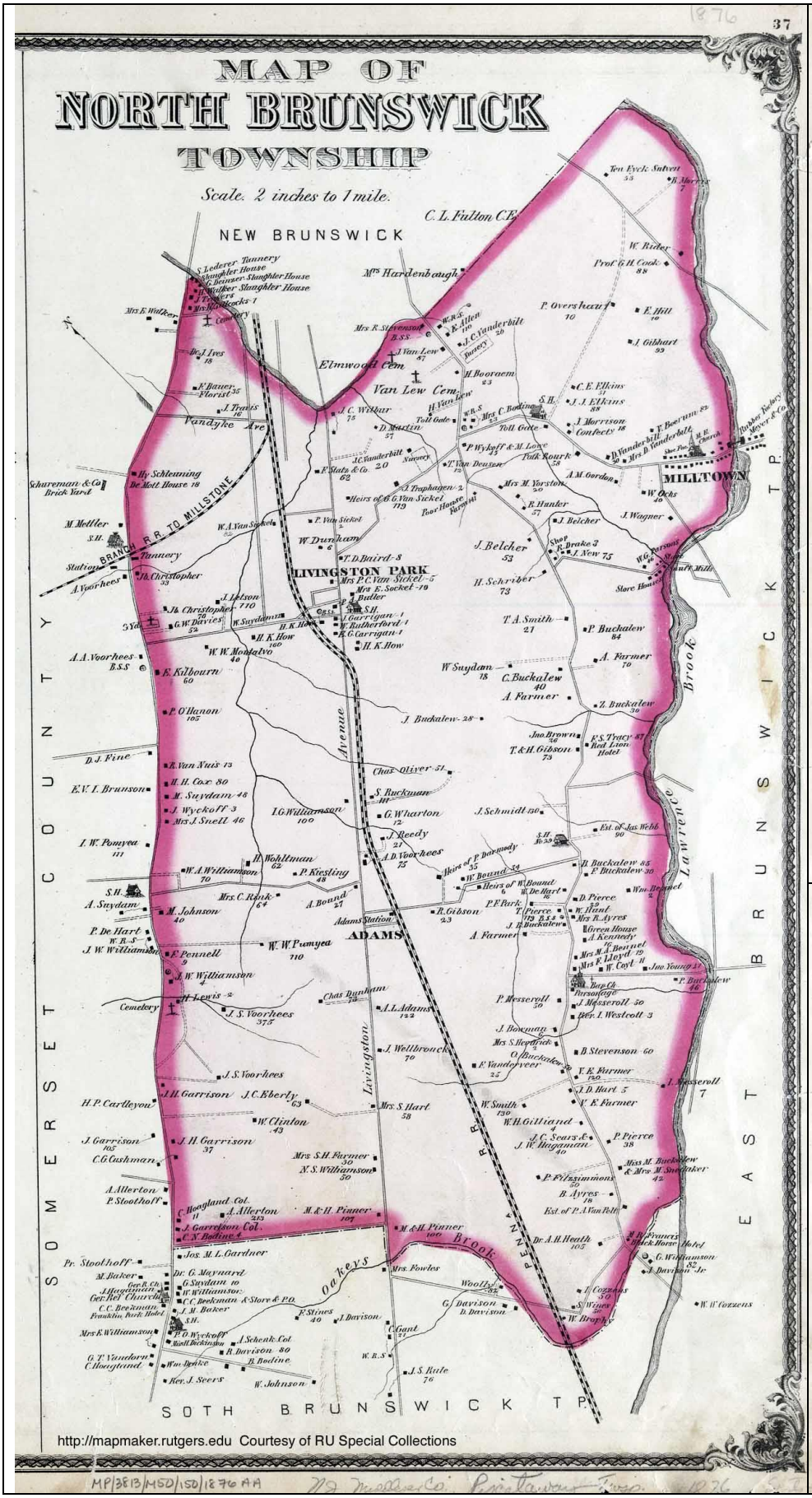

Figure 9a: Historical Map (ca.1876)

Source: Rutgers Special Collections, 1876. Historical Map of North Brunswick Township.

reveals that rapid urbanization occurred in the township from the late 1950s to the early 1970s (Historic Aerials, 1931-2007).

The North Brunswick Environmental Committee was formed in the 1970s and encouraged carpooling and recycling (North Brunswick Historical Committee, 2011).

B. Historic Preservation

A *Historic site* means any real property, man-made structure, natural object or configuration or any portion or group of the foregoing of historical, archaeological, cultural, scenic or architectural significance. A *Historic District* is one or more historic sites and intervening or surrounding property significantly affecting or affected by the quality and character of the historic site or sites (MLUL, 2002).

Historic preservation is the planned effort to help protect structures, objects and properties of historic importance.

National and State

In 1966, the National Historic Preservation Act created the National Register of Historic Places, which offered the protection of privately owned historic buildings and properties from federal government actions. It established criteria (see **Table 9.1**) for inclusion on the National Register and created a review process for public projects that threatened encroachment or razing of registered properties. It also enabled states to set up similar processes to protect registered properties from municipal, county and state encroachments. New Jersey created its State Register of Historic Places in 1970.

Table 9.1: Criteria for Evaluation for Inclusion in the National Register of Historic Places

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and: A. That are associated with events that have made a significant contribution to the broad patterns of our history; or B. That are associated with the lives of persons significant in our past; or C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or D. That have yielded or may be likely to yield, information important in prehistory or history. Note: Properties are usually at least 50 years old to be considered eligible.
Source: National Register of Historic Places, 2013

In addition, the New Jersey Municipal Land Use Law (MLUL) gives municipalities the express authority to zone for the protection of historic resources and to regulate private encroachments on designated historic properties. The MLUL outlines a specific planning process regarding the creation of local historic districts and the review of development activity within the districts (MLUL, 2002).

County

The mission of Middlesex County Cultural and Heritage Commission is to develop county-wide programs and promote public interest in local and county history, in the arts, and in the cultural values, goals, traditions of the community, the State and the Nation. The Commission undertakes the restoration, operation, maintenance and preservation of real property acquired by the County. The Commission is authorized to establish museum and cultural programs, exhibits and displays including the fine and performing arts, engage in archaeological,

genealogical and historic research, publish reports and engage in such related activities to promote and develop public interest and understanding of historic and cultural matters (Middlesex County Cultural and Heritage Commission, 2013).

Municipal

North Brunswick's Department of Parks, Recreation, and Community Services applies each year for a History Grant through the Middlesex County Cultural and Heritage Commission to fund local history programs. Past projects include "In our Voices" and "Changing Landscape of North Brunswick" (Township of North Brunswick, 2013).

C. Historical Inventory

As discussed above in **Section 9A**, the area of Middlesex County now defined as North Brunswick has a documented history (with European settlers) going back to the 1600s, as well as earlier history with the Lenape Indians in pre-colonial times.

One of the first steps of historical preservation is enumeration of an area's history, mapping its sites with archeological or historical potential, and generating a detailed inventory of historical buildings.

Archeological Grid

The NJDEP Historic Preservation Office (HPO) has developed a GIS layer consisting of $^1/_2$ mile grid cells indicating the presence of archaeological sites. It should be noted that other archeological sites may exist that have not yet been identified or documented. Because archaeological sites are particularly sensitive to destruction and vandalism, the grid format protects precise site locations while alerting users of this data to the possible presence of archaeological resources (NJDEP HPO, 2011).

Six grid squares lie within North Brunswick. One of the grid squares is near the Route 1/Route 617 interchange, while the other five are contiguous and found surrounding the intersections of Routes 1, 26 and 91 and the railroad (shown in **Figure 9b**).

New Jersey and National Register of Historic Places

Historic properties in the Township of North Brunswick that have met all the New Jersey or National Register criteria for significance in American history, archaeology, architecture, engineering or culture, and possess integrity of location, design, setting, materials, workmanship, feeling and association are listed in **Table 9.2**. The list provides details and reference numbers for these buildings, structures, sites, objects, and districts listed on the New Jersey Register of Historic Places (SR) and the National Register of Historic Places (NR) (National Register of Historic Places, 2013).

The National Musical String Company is the only North Brunswick site on the National Register. As shown in **Figure 9c**, the structure is partially within New Brunswick. There are 10 sites on the New Jersey Register of Historic Places, including the National Musical String Company, the Georges Road Baptist Church, the Route 27 Bridge over Six Mile Run, the Pliny Park House, the Carter Wallace Laboratory (demolished in 2007), the railroads, and three prehistoric sites. There are no Historic Districts within North Brunswick.

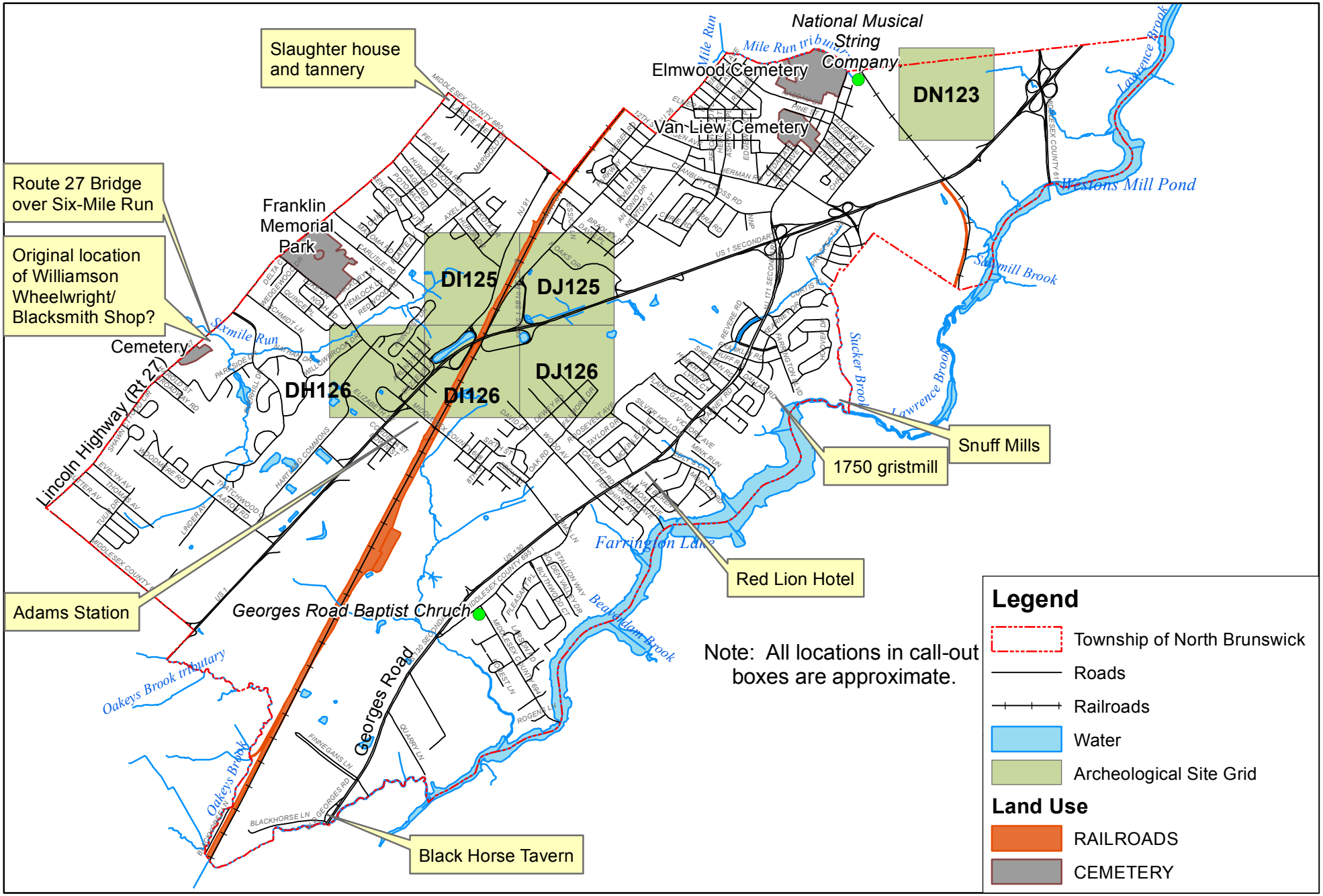

Figure 9b: Historical and Archeological Resources

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

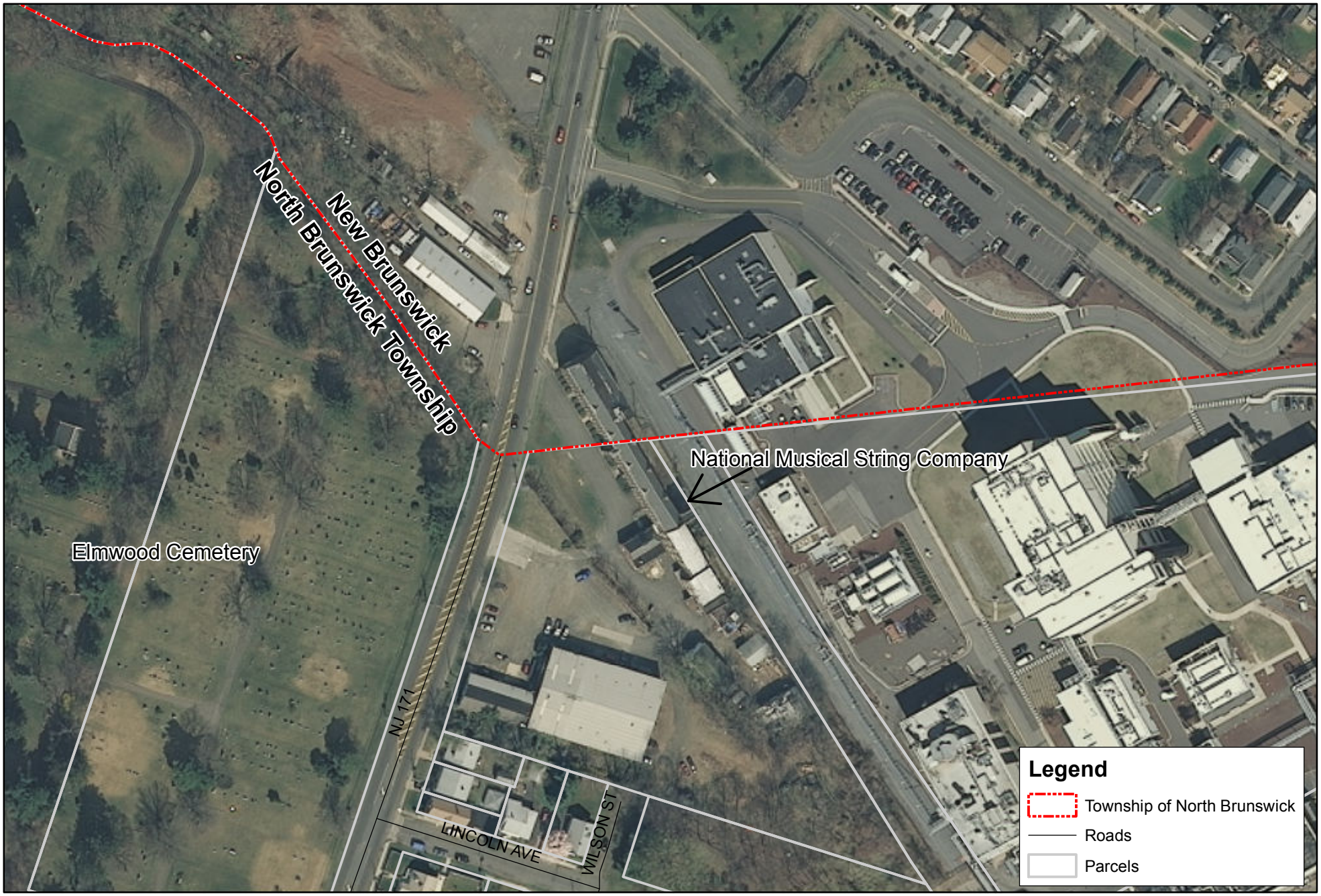

Figure 9c: 2012 Aerial Photography
National Musical String Company

0 0.01 0.02 0.04 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Table 9.2: New Jersey and National Register of Historic Places

National Register of Historic Places	
National Musical String Company (added 1982 - - #82003283) - 120 Georges Rd. , New Brunswick	
Historic Significance:	Event, Architecture/Engineering
Architect, builder, or engineer:	Ben C. DeKamp
Architectural Style:	No Style Listed
Area of Significance:	Architecture, Industry, Performing Arts
Period of Significance:	1875-1899
Owner:	Private
Historic Function:	Industry/Processing/Extraction
Historic Sub-function:	Manufacturing Facility
Current Function:	Commerce/Trade
Current Sub-function:	Business
State Register of Historic Places	
Camden and Amboy Railroad Branch Line Historic District (ID#2969) - Camden and Amboy branch line right of way from Bordentown City to Adams Lane, North Brunswick, Middlesex County and Burlington County, Bordentown City SHPO: Opinion 5/21/1991 (Previous opinions 7/21/87 and 9/21/90)	
Carter Wallace Laboratory (ID#1884) - US Route 1 (Demolished c.2007) DOE 6/5/1989 SHPO Opinion 6/23/1988	
College Farm Prehistoric Site (28-Mi-75) (ID#3305) - New Brunswick City & North Brunswick SHPO Opinion 6/5/1980	
Georges Road Baptist Church (ID#1831) - 430-440 Church Lane Old Georges Road SHPO Opinion 3/22/1994 (Previous SHPO Opinion 12/30/1993)	
National Musical String Company (ID#1872) - 120 Georges Road, North Brunswick NR: 4/20/1982 (NR Reference #82003283 SR: 3/27/1981	
NJ Route 27 (3E) Bridge (SI&A#1216158)(ID#1889) - NJ Route 27 over Six Mile Run (also located in Somerset County Franklin Township) DOE: 5/1/1995 (Not individually available and non-contributing to Six Mile Run HD; SHPO Opinion of 2/22/1993 overturned by DOE)	
Pennsylvania Railroad New York to Philadelphia Historic District (ID#4568) SHPO Opinion 10/2/2002 Also Hudson County Weehawken Township	
Pliny F. Park House (ID#1833) - 2051 US Route 130 SHPO Opinion 3/22/1994 Previous SHPO Opinion 12/30/1993 Surrounding property now developed as athletic fields	
Prehistoric Site (28-Mi-128) (ID#3312) SHPO Opinion 3/17/1988 Previous SHPO Opinion 12/4/1987	
Raritan River Railroad Historic District (ID#4 954) - Right of Way between South Amboy and New Brunswick, Includes Kearny Branch and Gillespie Branch (South Amboy City, East Brunswick Township, Milltown Borough, New Brunswick City, North Brunswick Township, Sayreville Borough and South River Borough, Middlesex County) SHPO Opinion 3/31/2004	
Sources: National Register of Historic Places, November 10, 2013; NJDEP Historic Preservation Office (HPO), April 5, 2013	

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Municipal Land Use Law Chapter 291 Laws of N.J. 1975. NJ Statutes Annotated compiled as 40:55D-1 et. seq. with amendments through the 209th State Legislature, January 2002. http://njpo.org

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http://www.nationalregisterofhistoricplaces.com
http://www.nationalregisterofhistoricplaces.com/nj/Middlesex/districts.html [none in North Brunswick]
http://www.nationalregisterofhistoricplaces.com/nj/Middlesex/state.html

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http://en.wikipedia.org/wiki/North_Brunswick,_NJ

Internet Resources: Historical Resources

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Middlesex County Cultural and Heritage Commission: http://www.co.middlesex.nj.us/culturalheritage/index.asp

National Register of Historic Places Home Page: http://www.nationalregisterofhistoricplaces.com

New Jersey Historic Preservation Office: http://www.state.nj.us/dep/hpo/

10: REGIONAL RELATIONSHIPS

A. Raritan Basin Watershed Alliance

The Raritan Basin Watershed Management Project began in 1999 when the NJDEP funded a partnership of government agencies, nonprofit groups and academia to coordinate watershed activities and to develop a watershed management plan for the Raritan Basin. The project, led by the New Jersey Water Supply Authority, completed 7 characterization and assessment reports and 2 background reports, which determined a baseline condition for the Raritan Basin against which future degradation or improvement could be compared. Some of the issues examined by the technical reports included population growth, land use, riparian areas, aquatic habitat, water supply, ground water, surface water quality and pollutant loadings. Based on this foundation, the Raritan Basin Watershed Management Plan was completed in 2003. This plan identified six key issues that must be addressed in order to restore and protect the region's water resources:

- surface water pollution,
- stormwater management,
- ground water recharge losses,
- riparian area (stream corridor) losses,
- biological impairment of streams, and
- water supply limitations (Shallcross and Stanuikynas, August 2002).

The *Raritan Basin Watershed Alliance* was formed in 2003 in order to:

- Create public and official support for Plan implementation
- Create coalitions/partnerships for Plan implementation and assist with acquisition of financial and other resources where requested
- Encourage and support implementation efforts and assist with project planning
- Keep the Raritan Plan current and continually improving
- Maintain and enhance technical knowledge and capabilities of the Basin and ensure dissemination to those who need it (New Jersey Water Supply Authority, 2009).

B. Sustainable Raritan River

The *Sustainable Raritan River* is an initiative formed by the Raritan River Collaborative in 2009, which is made up of over 100 organizations, including environmental, historical and cultural organizations, Federal, State and County government, Rutgers University, and businesses. The purpose is to balance social, economic and environmental objectives towards the common goal of restoring the Raritan River, its tributaries and its estuary for current and future generations. The project uses a regional approach, supported by state and federal organizations and implemented at the local and county level. Goals include the following:

- Greenways, Recreation and Public Access
- Habitat Preservation and Resource Stewardship
- Remediation and Prevention of Future Pollution
- Water Quality, Stormwater and Infrastructure

- Balancing Redevelopment and Restoration (Ferrer et al, 2010; Grim et al, 2011).

C. Water Supply Planning

The goal of statewide water supply planning, mandated by the Water Supply Management Act (N.J.S.A. 58:1A-1), is to make recommendations on the management of the State's surface and ground water supplies to ensure that the State's water supplies could withstand foreseeable drought and that aquifers are not depleted.

One result of the first Statewide Water Supply Plan, developed in 1982, was the rehabilitation of the Delaware & Raritan Canal. The 1996 Statewide Water Supply Plan, a revision of the 1982 plan, recommended improved water resources protection, water supply and water delivery management, and water conservation. To accomplish these goals, NJDEP's Water Quality Planning Rules were developed to ensure that water supply withdrawals do not interfere with the assimilative capacity of our streams, rivers and estuaries. In addition, water purveyors are required to develop water conservation plans that are implemented during periods of drought (NJDEP Division of Watershed Management, 2011).

D. Water Quality Management Planning

Watershed management is the process of managing all of the water resources within the area of a watershed, rather than on a site-specific basis. A watershed management approach is based on three key components: 1) a geographic focus; 2) continuous improvement based on sound science; and 3) partnerships/stakeholder involvement. All of North Brunswick is within the Lower Raritan/Middlesex County water quality management area (see **Figure 10a**) (NJDEP Office of Environmental Planning, 1997).

Revisions to the Water Quality Management Planning Rules (N.J.A.C. 7:15) were adopted July 7, 2008. These rules establish:

- procedures for preparation, adoption, amendment, revision, and certification *Water Quality Management (WQM) Plans*;
- procedures for NJDEP's review of projects and activities for consistency with WQM plans;
- adoption of other NJDEP rules, priority systems and project priority lists, sludge management plans, regional stormwater management plans, effluent limitations, wastewater management plans, 201 Facilities Plans, and other documents in WQM Plans;
- coordination of WQM planning with the Highlands RMP, other programs and municipal zoning;
- mechanisms to resolve conflicts;
- procedures for submission, adoption, and updating *wastewater management plans (WMPs)* (wastewater planning responsibility is assigned to counties and requires them to update the WMPs);
- the process for identifying waterbodies on the List of Water Quality Limited Segments and establishing total maximum daily loads (TMDLs) (see **Section 6E** for more about TMDLs) (NJDEP, August 7, 2013).

The NJDEP administers the Statewide *Water Quality Management (WQM)* Planning rules found in N.J.A.C. 7:15. The rules establish a mechanism for determining whether proposed

projects or activities are consistent with the statewide WQM Plan (see **Internet Resources**). This process includes development and adoption of a *Wastewater Management Plan (WMP)*, a document that provides 20-year planning for wastewater and certain other water quality concerns. Middlesex County, the responsible agency for the WMP within the county, must notify, seek comments from, and offer to confer with all government units that have regulatory or planning jurisdiction over wastewater or land use in the county, and all government units and public utilities that own, operate, or have contracts or NJDEP permits for sewerage facilities identified in the WMP. A WMP is valid only after submission to NJDEP and adoption by the Governor or his designee as a WQM plan amendment (NJDEP Division of Water Quality Management Planning, August 7, 2013).

The WMP includes mapping the planned method of wastewater disposal for specific areas. On these maps, the public *Sewer Service Areas* (SSAs) are areas served by sewers. Areas not designated as SSAs are planned for service by individual subsurface disposal system (septic systems) discharging less than 2,000 gallons per day (gpd) (where the site conditions and existing regulations allow).

Statewide, counties are updating their WMPs at the time of this writing. On October 7, 2013, a proposed amendment to the Lower Raritan/Middlesex County WQM Plan was published in the NJ Register, beginning a 30-day comment period. This amendment provides for a Middlesex County *Future Wastewater Service Area* (FWSA) (a FWSA was previously proposed in May 2013 but not adopted). A link to notices of public hearings for any proposed changes can be found in the **Internet Resources**.

North Brunswick is within the Sewer Service Area (SSA) of the Middlesex County Utility Authority, which discharges to surface water (after treatment). The current SSA is shown in **Figure 10a,** which illustrates the entire extent of the Middlesex County Utility Authority, including much of Middlesex County (NJDEP BWR, May 16, 2013). In Section 2 of this report, **Figure 2f** shows the same SSA, but focused only North Brunswick Township.

E. State Development & Redevelopment Plan

The NJ Department of State's Business Action Center Office for Planning Advocacy[35] "coordinates statewide planning to protect the environment and guide future growth into compact, mixed-use development and redevelopment. The office implements the goals of the State Development and Redevelopment Plan to achieve comprehensive, long-term planning; and integrates that planning with programmatic and regulatory land-use decisions at all levels of government and the private sector." (NJ Department of State, 2011).

The *State Development and Redevelopment Plan* is a dynamic vision of New Jersey's development and conservation patterns, incorporating new data from state agencies, counties and municipalities on a continuing basis. It should be noted that the following information and map are current as of August 2013, but may change.

The purpose of the 2001 State Plan is to:

> "Coordinate planning activities and establish Statewide planning objectives in the following areas: land use, housing, economic development, transportation, natural resource conservation, agriculture and farmland retention, recreation, urban and suburban redevelopment, historic preservation, public facilities and services, and intergovernmental coordination" (N.J.S.A. 52:18A-200(f)) (NJ Department of State, December 2011).

[35] The State Plan was formerly under the NJ Department of Community Affairs Office of Smart Growth (OSG).

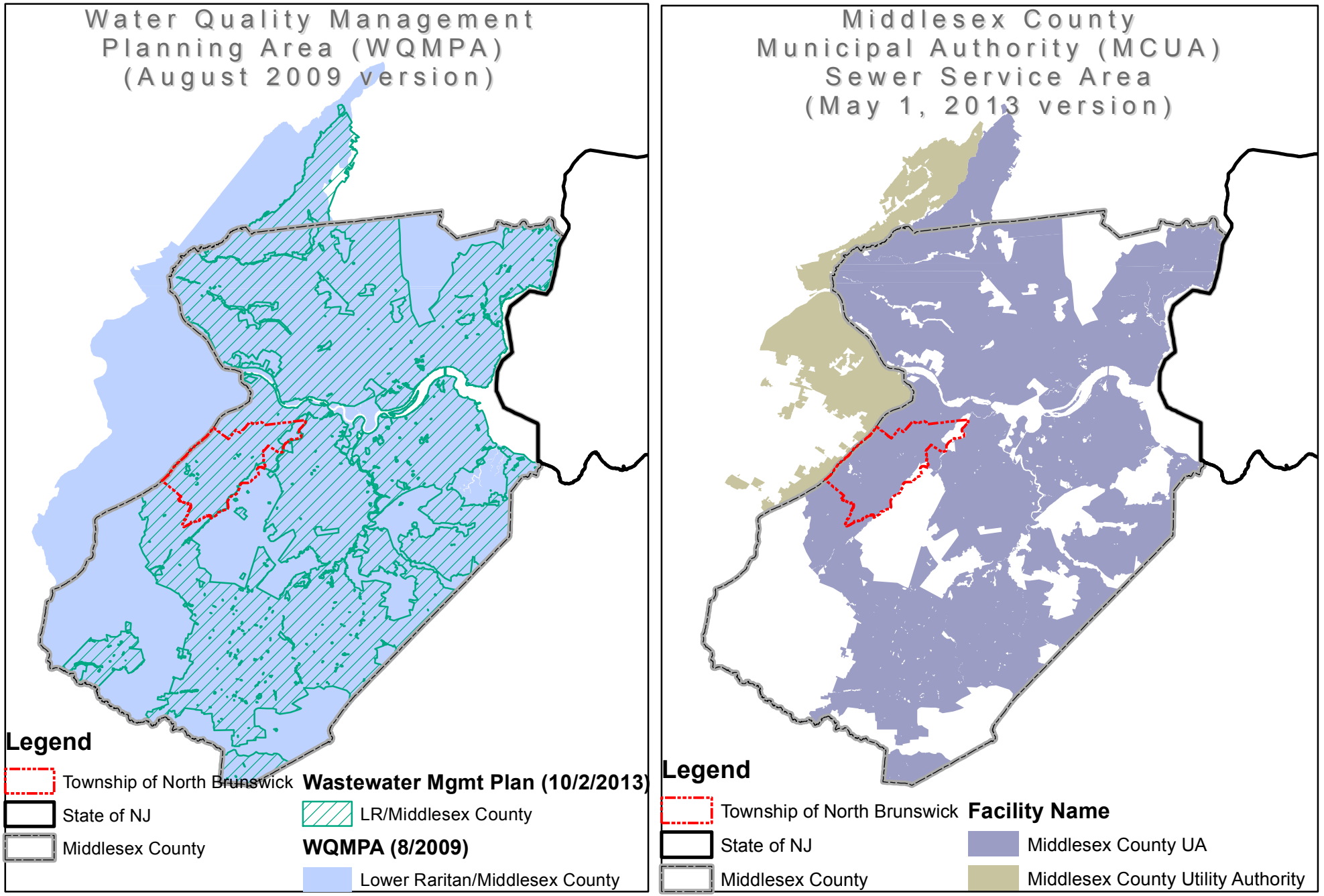

Figure 10a: Wastewater Management & Sewer Service Area

0 2 4 8 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

The State Plan Policy Map has two major components: Planning Areas, which identify the current natural and built characteristics in each area, and Centers, where most growth will be accommodated. There are 5 main Planning Areas in the state: Metropolitan, Suburban, Fringe, Rural and Environmentally Sensitive (shown in **Figure 10b**).

All of North Brunswick is within the *PA-1 Metropolitan Planning Area*. The State Plan's goals for the Metropolitan Planning Area are to "Provide for much of the state's future redevelopment; revitalize cities and towns; promote growth in compact forms; stabilize older suburbs; redesign areas of sprawl; and protect the character of existing stable communities" (NJ State Planning Commission, 2001).

The entire township is further designated as part of the *Smart Growth Area.* Smart Growth is the term used to describe well-planned, well-managed growth that adds new homes and creates new jobs, while preserving open space, farmland, and environmental resources. In New Jersey, Smart Growth supports development and redevelopment in recognized Centers, with existing infrastructure that serves the economy, the community and the environment. There are two Centers within North Brunswick, *Route 1-N Brunswick* and *Route 130 Corridor*.

While the Environmentally Sensitive Planning Area is used to protect and manage large areas of natural and environmental resources, there are significant cultural and environmental resources found throughout the other Planning Areas, as well. The Plan refers to these sites as *Historic and Cultural Sites* and *Critical Environmental Sites* (see **Figure 10b**). The Plan treats these designated areas with the relevant provisions of historic, cultural and scenic and environmental Statewide Policies and the Environmentally Sensitive Planning Area. Within North Brunswick, the area including and surrounding Weston's Mill Pond is the one area designated as a Critical Environmental Site (NJ State Planning Commission, March 1, 2001).

Another aspect of the state planning process is the denotation of *brownfields*, defined as any former or current commercial or industrial site, currently vacant or underutilized, on which there has been, or there is suspected to have been, a discharge of a contaminant. Brownfields are discussed in **Section 5I**.

References: Regional Relationships

Raritan Basin Watershed Alliance

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Water Supply Planning

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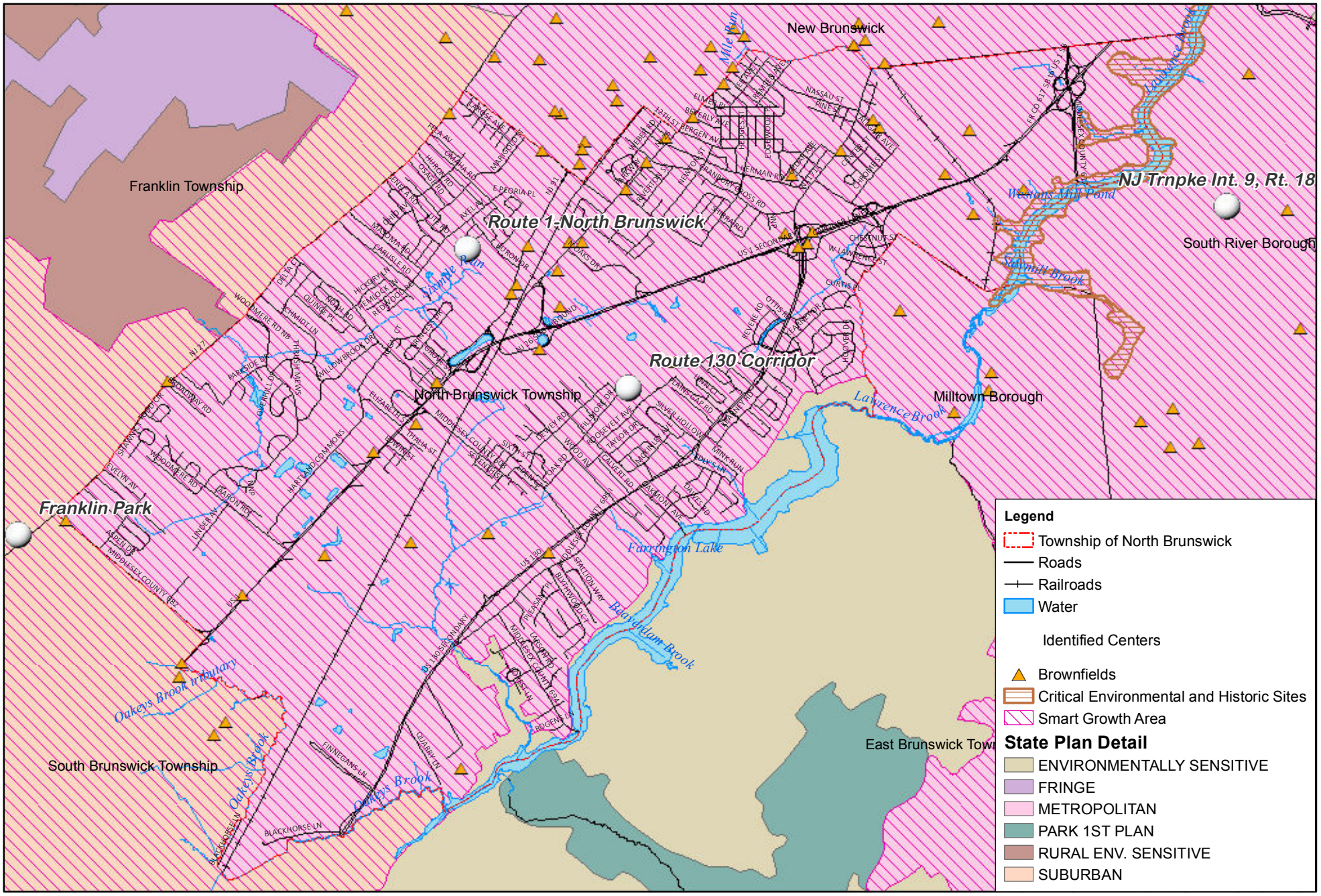

Figure 10b: State Development and Redevelopment Plan

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

N

Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data, but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

Water Quality Management Planning
NJDEP. July 7, 2008 (latest amendment). N.J.A.C. 7:15: Water Quality Management Planning. 97 pages. http://www.nj.gov/dep/rules/rules/njac7_15.pdf

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Middlesex County. October 7, 2013. Proposed Amendment to the Lower Raritan/Middlsex County Water Quality Management Plan. 6 pages and map. Public Notice: http://www.nj.gov/dep/wqmp/docs/20131007-lower-raritan-middlesex-county.pdf. Map: http://www.nj.gov/dep/wqmp/docs/20131007-lower-raritan-middlesex-county-map.pdf

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NJ Department of State Business Action Center. August 21, 2013. The 2001 State Plan Policy Map and Other Maps. GIS data. http://www.nj.gov/state/planning/resources-gis.html
Brownfields SiteMart, 01/14/2013 bfsitemart.zip (also shown on **Figure 2g**)
Critical Environmental and Historic Sites, 10/17/2012 cehs2.zip
Identified Centers, 01/18/2013 cenpt2.zip (2 in North Brunwick)
Planning Areas, 01/18/2013 splan2.zip
Smart Growth Areas, 05/20/2013 sgareas.zip
Center boundaries (05/20/2013); Cores (09/12/2012); Endorsed Plans (05/20/2013); Historic and Cultural Sites (10/11/2001); Nodes (08/21/2013); Urban Complex (03/01/2001) – **none in North Brunswick**

NJ State Planning Commission. March 1, 2001. New Jersey State Development and Redevelopment Plan Executive Summary. 58 pages. http://www.state.nj.us/state/planning/docs/execsumm030101.pdf

Internet Resources: Regional Relationships

Middlesex County
Planning Board Home Page: http://www.co.middlesex.nj.us/planningboard/index.asp
Environmental Resource Directory: http://www.co.middlesex.nj.us/planningboard/resource-directory.asp
Most recent public notice for WMP revision and information about public hearing and public comment:
http://www.nj.gov/dep/wqmp/docs/20131007-lower-raritan-middlesex-county.pdf.
Most recent proposed SSA map revision:
http://www.nj.gov/dep/wqmp/docs/20131007-lower-raritan-middlesex-county-map.pdf

NJDEP Division of Water Quality Management Planning: http://www.nj.gov/dep/wqmp/
Lower Raritan/Middlesex: http://www.nj.gov/dep/wqmp/wmpadopted.html#lowerraritan
Wastewater Management Plan Public Notices: http://www.nj.gov/dep/wqmp/wmpnotices.html

Raritan Basin Watershed Alliance: http://www.raritanbasin.org/alliance.html

State Development and Redevelopment Plan: http://www.nj.gov/state/planning/

Sustainable Raritan River: http://raritan.rutgers.edu/

11: COMPOSITE MAP OF ENVIRONMENTALLY CRITICAL AREAS

Throughout this document, many environmental and natural features of the Township of North Brunswick Park have been documented, described and mapped. One of the greatest values of mapping with a Geographic Information System (GIS) is to easily combine features in new ways. To accomplish this, **Figure 11** combines some of the mapped layers from previous sections, displaying features that make an area environmentally critical together on one map.

A useful definition of an "environmentally critical area" is provided in the Stormwater Management regulations (N.J.A.C. 7:8):

> " 'Environmentally critical area' means an area or feature which is of significant environmental value, including, but not limited to: stream corridors; natural heritage priority sites; habitats of endangered or threatened species; large areas of contiguous open space or upland forest; steep slopes; and well head protection and groundwater recharge areas. Habitats of endangered or threatened species are identified using the Department's Landscape Project as approved by the Department's Endangered and Nongame Species Program (NJDEP, April 19, 2010)."

Figure 11 combines the following:

- Steep slopes greater than 15%
- Flood Zones
- Wetlands (from 2007 Land Use data; an LOI is necessary to determine actual boundary of wetlands)
- 50 foot wetlands buffers (from 2007 Land Use data; an LOI is necessary to determine actual buffer for wetlands – not all wetlands are given a 50 foot buffer)
- Forested areas (from 2007 Land Use data)
- Potential Vernal Habitat
- Natural Heritage Grid Map (for generalized locations of rare plants)
- Natural Heritage Priority Site (Farrington Lake)
- Landscape Project Rank 3 & 4 (threatened and endangered species)
- State Development and Redevelopment Plan Critical Areas

References: Environmentally Critical Areas

NJDEP. April 19, 2010. N.J.A.C. 7:8 Stormwater Management Rule. Date last amended: April 19, 2010. 39 pages. http://www.nj.gov/dep/rules/rules/njac7_8.pdf

Steep slopes: See Section 3B; Figure 3d
Floodplains: See Section 6B; Figure 6d
Wetlands & wetlands buffers: See Section 6C; Figure 6e
Forested areas: See Section 7A; Figure 7b
Potential Vernal Habitat: See Section 7C; Figure 7g
Natural Heritage Grid Map: See Section 7F; Figure 7g
Natural Heritage Priority Site: See Section 7F; Figure 7g
Landscape Project Rank 3 & 4: See Section 7F; Figure 7f
State Development and Redevelopment Plan Critical Areas: See Section 10E; Figure 10b

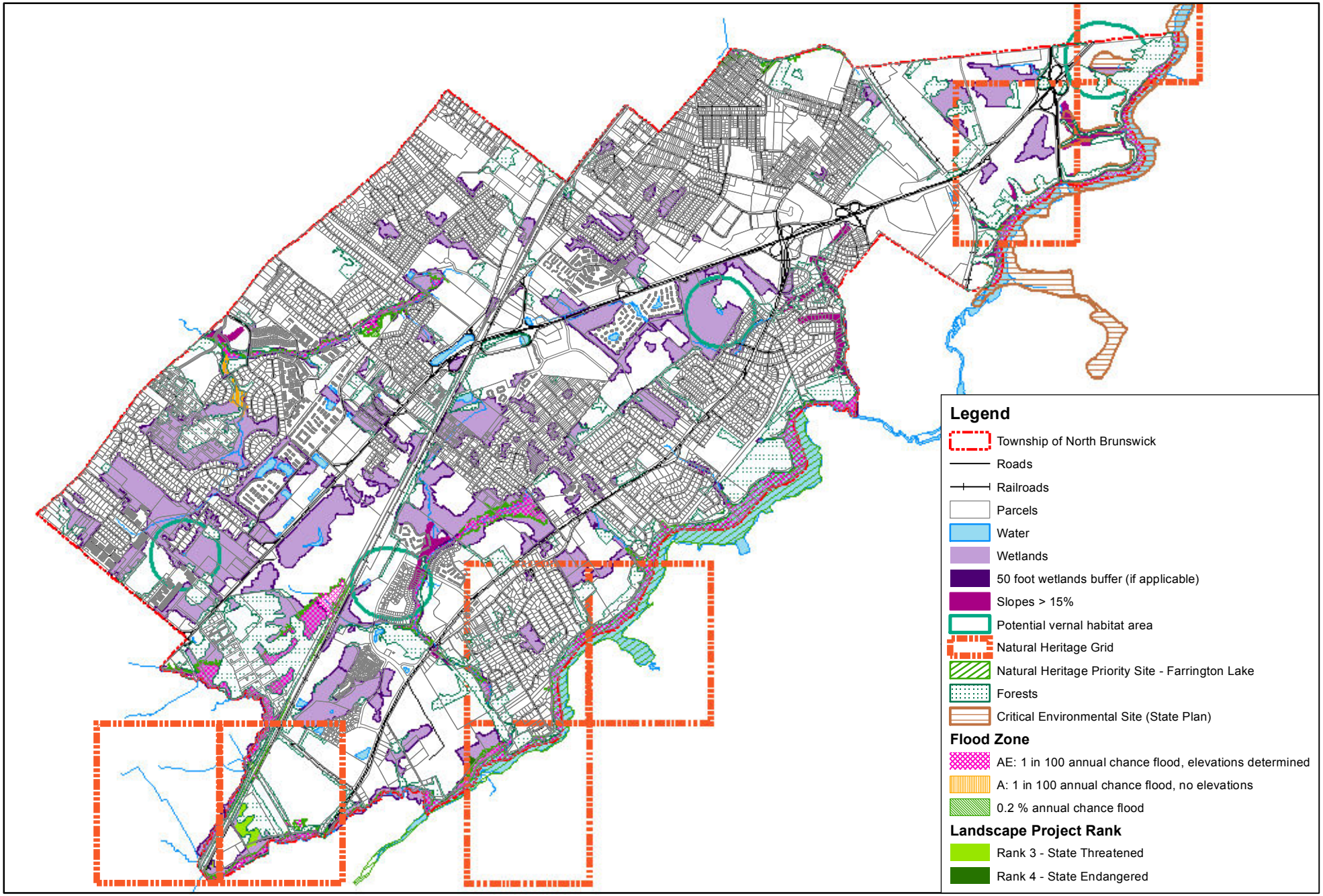

Figure 11: Environmentally Critical Areas

0 0.25 0.5 1 Miles

North Brunswick Environmental Resource Inventory
Prepared by Kratzer Environmental Services

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Data Sources: NJDEP
Note: Map accuracy is limited to the accuracy and scale of the original data sets.
Disclaimer: This map was developed using NJDEP digital data,
but this secondary product has not been verified by NJDEP and is not NJDEP authorized.

APPENDIX A: DATA USE AGREEMENTS

Contents

A.1 Terms of Agreement for use of NJDEP GIS data

(Required by NJDEP Office of Information Management, Bureau of Geographic Information and Analysis.)

1. Digital data received from the NJDEP are to be used solely for internal purposes in the conduct of daily affairs.

2. The data are provided, as is, without warranty of any kind and the user is responsible for understanding the accuracy limitations of all digital data layers provided herein, as documented in the accompanying Data Dictionary and Readme files. Any reproduction or manipulation of the above data must ensure that the coordinate reference system remains intact.

3. Digital data received from the NJDEP may not be reproduced or redistributed for use by anyone without first obtaining written permission from the NJDEP. This clause is not intended to restrict distribution of printed mapped information produced from the digital data.

4. Any maps, publications, reports, or other documents produced as a result of this project that utilize NJDEP digital data will credit the NJDEP Geographic Information System (GIS) as the source of the data with the following credit/disclaimer:

> This (map/publication/report) was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been verified by NJDEP and is not state-authorized.

5. Users shall require any independent contractor, hired to undertake work that will utilize digital data obtained from the NJDEP, to agree not to use, reproduce, or redistribute NJDEP GIS data for any purpose other than the specified contractual work. All copies of NJDEP GIS data utilized by an independent contractor will be required to be returned to the original user at the close of such contractual work. Users hereby agree to abide by the use and reproduction conditions specified above and agree to hold any independent contractor to the same terms. By using data provided herein, the user acknowledges that terms and conditions have been read and that the user is bound by these criteria.

A.2 Cautions and Restrictions on Use of Natural Heritage Data

(Required by NJDEP Division of Parks and Forestry, Natural Lands Management.)

CAUTIONS AND RESTRICTIONS ON NATURAL HERITAGE DATA

The quantity and quality of data collected by the Natural Heritage Program is dependent on the research and observations of many individuals and organizations. Not all of this information is the result of comprehensive or site-specific field surveys. Some natural areas in New Jersey have never been thoroughly surveyed. As a result, new locations for plant and animal species are continuously added to the database. Since data acquisition is a dynamic, ongoing process, the Natural Heritage Program cannot provide a definitive statement on the presence, absence, or condition of biological elements in any part of New Jersey. Information supplied by the Natural Heritage Program summarizes existing data known to the program at the time of the request regarding the biological elements or locations in question. They should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments. The attached data is provided as one source of information to assist others in the preservation of natural diversity.

This office cannot provide a letter of interpretation or a statement addressing the classification of wetlands as defined by the Freshwater Wetlands Act. Requests for such determination should be sent to the DEP Division of Land Use Regulation, P.O. Box 439, Trenton, NJ 08625-0439.

The Landscape Project was developed by the Division of Fish & Wildlife, Endangered and Nongame Species Program in order to map critical habitat for rare animal species. Natural Heritage Database response letters will also list all species (if any) found during a search of the Landscape Project. However, this office cannot answer any inquiries about the Landscape Project. All questions should be directed to the DEP Division of Fish and Wildlife, Endangered and Nongame Species Program, P.O. Box 400, Trenton, NJ 08625-0400.

This cautions and restrictions notice must be included whenever information provided by the Natural Heritage Database is published.

NJ Department of Environmental Protection
Division of Parks and Forestry
Natural Lands Management

APPENDIX B: METADATA FOR GIS DATA LAYERS USED FOR THIS REPORT

Data Disclaimers in **Appendix A** apply to the use of these data layers and the maps created from them. The user is responsible for understanding the accuracy limitations of the digital data layers, as documented in the accompanying report and metadata summaries, and the metadata files which accompany the data.

Appendix B: GIS Data Layers Used for this Report

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
All	NJDEP BGIS	Municipalities of New Jersey (Clipped to Coast), Version 20090116	1/16/2009	1:2,400	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/muncoast.zip
Most Maps Display these Base Layers	Middlesex Co	Railroad Centerlines of Middlesex County	n/a	n/a	n/a
	NJDEP BGIS	National Hydrography Dataset (NHD) Streams 2002	11/1/2010	1:2,400	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/nhdstreams2002shp.zip
	NJDEP BGIS	NJDEP 2002 Waters of New Jersey (Lakes and Ponds), Version 20080501	5/1/2008	1:2,400	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/njwaterbody.zip
	NJDEP BGIS	State of New Jersey Composite of Parcels Data, New Jersey State Plane NAD83 and MOD-IV Tax List Search Database	07/29/2011	n/a	https://njgin.state.nj.us/NJ_NJGINExplorer/IW.jsp?DLayer=Parcels by County/Muni
	NJDOT	New Jersey Roadway Network	5/31/2005	1:2,400	http://www.state.nj.us/transportation/gis/data.shtm
Figure 1a: Location of Township (also 2a, 3a, 3f, 5c, 6a, 10a)	NJDEP BGIS	NJDEP County Boundaries for the State of New Jersey	1/23/2003	1:24,000	<http://www.state.nj.us/dep/gis/digidownload/zips/statewide/stco.zip>
	NJDEP BGIS	NJDEP State Boundary of New Jersey	11/1/1998	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/state.zip
Figure 1b: 1930 Aerial Photography	NJOIT OGIS	1930s Aerial Photography of New Jersey Web Map Service (WMS)	10/1/2009	1:24,000	https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp
Figure 1c: 1995 Aerial Photography	USGS	USGS 1997 Digital Orthophoto Quadrangles for New Jersey, MRSID format (NJSPC, NAD83)	11/23/97	1:40,000	https://njgin.state.nj.us/NJ_NJGINExplorer/IW.jsp
Figure 1d: 2002 Aerial Photography	NJOIT OGIS	New Jersey 2002 High Resolution Orthophotography	7/31/2003	1:19,200	https://njgin.state.nj.us/NJ_NJGINExplorer/IW.jsp
Figure 1e: 2007 Aerial Photography	NJOIT OGIS	New Jersey 2007 - 2008 High Resolution Orthophotography, JPEG2000 5K Tiles (2009 revision)	11/1/2009	1:2,400	https://njgin.state.nj.us/NJ_NJGINExplorer/IW.jsp

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
Figure 1f: 2012 Aerial Photography	NJOIT OGIS	New Jersey 2012 - 2013 High Resolution Orthophotography, NAD83 NJ State Plane Feet, MrSID Tiles	3/1/2013	1:2,400	https://njgin.state.nj.us/NJ_NJGINExplorer/IW.jsp
Figure 1g: Land Use Type (2007)	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
Figure 1h: Change to Urban Land Use	NJDEP BGIS	NJDEP 1995/97 Land use/Land cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	12/1/2000	1:12,000	http://www.state.nj.us/dep/gis/lulc95shp.html
	NJDEP BGIS	NJDEP 2002 Land use/Land cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	3/4/2008	1:2,400	http://www.state.nj.us/dep/gis/lulc02shp.html
	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
Figure 2a: Drought Regions, Weather & Air Quality	NADP	National Atmospheric Deposition Network	1/10/2004	n/a	n/a
	NJDEP BAM	NJDEP Ambient Air Quality Monitors	3/1/2006	1:1,600	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/airqm.zip
	NJGS	DGS00-1 NJDEP Drought Regions of New Jersey	5/1/2004	1:24,000	http://www.state.nj.us/dep/njgs/geodata/dgs00-1.htm
	ONJSC	Weather Stations	3/8/2013	n/a	spreadsheet created from online data
Figure 2e: Sanitary Sewers	NJDEP BWR	Statewide Sewer Service Area for New Jersey (Util_wastewater_servicearea)	10/2/2013	n/a	http://www.nj.gov/dep/gis/listall.html
	North Brunswick	North Brunswick Sanitary Force Mains	1/25/2013	n/a	n/a

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
(continued) Figure 2e: Sanitary Sewers	North Brunswick	North Brunswick Sanitary Mains	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Sanitary Manholes	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Sanitary Pumpstations	1/25/2013	n/a	n/a
Figure 2f: Stormwater	North Brunswick	North Brunswick Stormwater Basins	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Stormwater Chambers	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Stormwater Headwalls	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Stormwater Inlets	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Stormwater Manholes	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Stormwater Outlet Structures	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Stormwater Pipes	1/25/2013	n/a	n/a
	North Brunswick	North Brunswick Stormwater Unequal Pipes	1/25/2013	n/a	n/a

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
Figure 2g: Brownfields	NJDS OPA	Brownfields SiteMart Locations	1/12/2013	n/a	http://www.nj.gov/state/planning/bfsitemart.zip
Figure 3a: Physiographic Provinces	NJGS	Physiographic Provinces of New Jersey	6/30/2002	1:100,000	http://www.state.nj.us/dep/njgs/geodata/dgs02-7.htm
Figure 3b: Elevation Contours	NJGS	DGS00-3 Topographic Elevation Contours for New Jersey (1:100,000 Scale): Flemington	12/29/1999	1:100,000	http://www.state.nj.us/dep/njgs/geodata/dgs00-3.htm
	NJGS	DGS00-3 Topographic Elevation Contours for New Jersey (1:100,000 Scale): Newark	12/29/1999	1:100,000	http://www.state.nj.us/dep/njgs/geodata/dgs00-3.htm
Figure 3c: Shaded Elevation (Hillshade)	USDA	National Elevation Data 3 meter or better	1/1/2000	3m	http://ned.usgs.gov/downloads.asp
Figure 3d: Steep Slopes	NJDEP NJFFS	2002 NJFFS Wildfire Fuel Hazard for Middlesex County, New Jersey	4/17/2009	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/njfh/midfh02.zip
	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 3e: Bedrock Geology	NJGS	Bedrock Geology for New Jersey - Faults	6/30/1999	1:100,000	http://www.state.nj.us/dep/njgs/geodata/bedgeol/faults.zip
	NJGS	Bedrock Geology for New Jersey 1:100,000 Scale	6/30/1999	1:100,000	http://www.state.nj.us/dep/njgs/geodata/dgs04-6.htm
	NJGS	DGS03-2 Abandoned Mines of New Jersey (1:24,000 scale)	6/21/2006	1:24,000	http://www.state.nj.us/dep/njgs/geodata/dgs03-2.htm
Figure 3f: Earthquakes and Faults	NJGS	Earthquakes Epicentered In New Jersey	6/24/2013	n/a	http://www.state.nj.us/dep/njgs/geodata/dgs04-1.htm
Figure 3g: Surficial Geology	NJGS	Surficial Geology of New Jersey	1/1/2006	1:100,000	http://www.state.nj.us/dep/njgs/geodata/dgs07-2.htm
Figure 4a: Soil Map Units	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
Figure 4b: Soils - Depth to Restrictive Layer	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 4c: Soils - Depth to High Water Table	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 4d: Soils - Hydrologic Group	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 4e: Soils - Septic Limitations	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 4f: Potentially Acid Soils	NJGS	Coastal Plain Sediments with Potential to Form Acid (Sulfate) Soils	5/24/2010	1:100,000	http://www.state.nj.us/dep/njgs/geodata/dgs09-2.htm
Figure 4g: Soils - Drainage Class	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 4h: Agricultural Soils	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 4i: Soils - Frost Action	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov
Figure 5b: Aquifers & NJGS/USGS GW Monitoring wells	NJGS	DGS96-3 Ambient Ground-Water Quality of the New Jersey Part of the Newark Basin	11/5/1995	1:24,000	http://www.state.nj.us/dep/njgs/geodata/dgs96-3.htm
	NJGS	DGS98-5 Aquifers of New Jersey	4/22/1999	1:100,000	http://www.state.nj.us/dep/njgs/geodata/dgs98-5.htm
Figure 5c: D&R Canal & USGS monitoring wells	NJGS	DGS08-1: Canals and Water Raceways of New Jersey	12/1/2010	1:24,000	http://www.njgeology.org/geodata/dgs08-1.htm

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
	USGS	Active Groundwater Level Network	8/15/2013	n/a	http://groundwaterwatch.usgs.gov/default.asp
Figure 5d: Ground Water Recharge (NJGS)	NJGS	DGS02-3: Ground-Water Recharge for WMA 9 (Lower Raritan River, South River and Lawrence Brook), NJ & WMA 10, (Millstone River), NJ	10/21/2004	1:24,000	http://www.njgeology.org/geodata/dgs02-3/dgs02-3.htm
Figure 5e: Aquifer Potential (NJGS)	NJGS	DGS07-1: Aquifer Recharge Potential for Middlesex County, NJ	1/4/2005	1:24,000	http://www.njgeology.org/geodata/
Figure 5f: Contaminated Sites	NJDEP SRP	NJDEP Classification Exception Areas/Well Restriction Areas Polygon Maps for New Jersey (Edition 20120130)	1/30/2012	1:1,000	http://www.nj.gov/dep/gis/stateshp.html#CEA
	NJDEP SRP	NJDEP Deed Notice Extent Polygons in New Jersey, (Edition 20120130)	1/30/2012	1:24,000	http://www.nj.gov/dep/gis/stateshp.html#DEEDPOLY
	NJDEP SRP	NJDEP Known Contaminated Site List for New Jersey (Non-Homeowner), Edition 201202	2/1/2012	1:1,000	http://www.nj.gov/dep/gis/stateshp.html#KCSL
Figure 6a: Watersheds & Watershed Management Areas	NJDEP DWM	NJDEP Watershed Management Areas in New Jersey (Version 200901)	1/1/2009	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/depwmas.zip
	NJDEP OEA	NJDEP Head of Tide Points for Watercourses of New Jersey	1/1/1986	n/a	http://www.nj.gov/dep/gis/stateshp.html#HOT
	NJGS	14 Digit Hydrologic Unit Code Delineations for New Jersey (Version 20110225)	2/25/2011	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip
Figure 6b: Sub-watersheds	NJGS	14 Digit Hydrologic Unit Code Delineations for New Jersey (Version 20110225)	2/25/2011	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip
Figure 6c: Streams & Culverted Sections of Streams	NJDEP BGIS	National Hydrography Dataset (NHD) Streams 2002	11/1/2010	1:2,400	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/nhdstreams2002shp.zip
	North Brunswick	North Brunswick Stormwater Culverts	1/25/2013	n/a	n/a

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
Figure 6d: Floodplains	FEMA	Digital Flood Insurance Rate Map Database, Middlesex County, New Jersey	7/6/2010	1:12,000	http://msc.fema.gov/
Figure 6e: Wetlands	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
Figure 6f: Surface Water Quality Standards	NJDEP WMS BFBM	NJDEP Surface Water Quality Standards of New Jersey (Version 201012)	12/1/2010	1:2,400	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/swqs.zip
Figure 6g: Integrated List	NJDEP WMS BWQSA	2010 New Jersey Integrated List of Waters (Integrated List) (Edition 201205)	5/1/2012	1:24,000	http://www.nj.gov/dep/gis/stateshp.html#IR
Figure 6h: Surface Water Discharges	NJDEP BPO	NJDEP Aquatic Pesticides	10/1/2009	n/a	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/aquapest.zip
	NJDEP DWQ	NJPDES Surface Water Discharges in New Jersey, (1:12,000) Version 20111116	11/16/2011	1:12,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/njpdesswd.zip
Figure 6i: Percent Impervious Surface	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
Figure 6j: Surface Water & Stream Flow Monitoring Sites	NJDEP BFBM	Ambient Stream Quality Monitoring Sites (1998 - 2010)	11/20/2008	1:12,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/swpts.zip
	NJDEP BFBM	NJDEP Ambient Biomonitoring Network (AMNET) Edition 201205	5/1/2012	1:1,200	http://www.nj.gov/dep/gis/stateshp.html#AMNET
	NJDEP BFBM	NJDEP Existing Water Quality Stations in New Jersey	10/19/2007	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/ewqpoi.zip
	NJDEP BFBM	NJDEP Fish Index of Biotic Integrity Monitoring Network (2000-2009)	12/15/2010	n/a	http://www.nj.gov/dep/gis/stateshp.html#FISHIND

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
(continued) Figure 6j: Surface Water & Stream Flow Monitoring Sites	NJDEP BFBM	NJDEP Supplemental Ambient Surfacewater Monitoring Network (SASMN)	12/21/2010	1:24,000	http://www.nj.gov/dep/gis/stateshp.html#SASMN
	NJDEP BFBM	STORET Water Quality Monitoring Stations	8/1/2005	n/a	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/storet.zip
	NJGS	14 Digit Hydrologic Unit Code Delineations for New Jersey (Version 20110225)	2/25/2011	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip
	USGS	USGS continuous-streamflow gaging locations in New Jersey	4/17/2002	n/a	http://www.njgeology.org/geodata/dgs02-5/streamgage.zip
	USGS	USGS stream crest gaging locations in New Jersey	4/17/2002	n/a	http://www.njgeology.org/geodata/dgs02-5/creststage.zip
	USGS	USGS stream lowflow gaging locations in New Jersey	4/17/2002	n/a	http://www.njgeology.org/geodata/dgs02-5/lowflow.zip>
	USGS	USGS surface-water quality gaging stations in New Jersey	4/17/2002	n/a	http://www.njgeology.org/geodata/dgs02-5/wqgages.zip
Figure 7a: Land Cover - Agriculture and Barren Land	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
Figure 7b: Land Cover - Forest	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
Figure 7c: Land Cover - Urban	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
Figure 7d: Land Cover - Water & Wetlands	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
Figure 7e: Wildfire Fuel Hazard	NJDEP NJFFS	2002 NJFFS Wildfire Fuel Hazard for Middlesex County, New Jersey	4/17/2009	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/njfh/midfh02.zip
Figure 7f: Landscape Project version 3.1	NJDEP ENSP	NJDEP Species-Based Habitat, Piedmont Plains Region (Version 3.1, 20120221)	2/21/2012	1:12,000	http://www.njfishandwildlife.com/ensp/landscape/
Figure 7g: Vernal Pool Habitats & Priority Site	NJDEP ENSP	NJDEP Species-Based Habitat, Vernal Habitat (Version 3.1, 20120221)	2/21/2012	1:12,000	http://www.njfishandwildlife.com/ensp/landscape/
	NJDEP ONLM	NJDEP Natural Heritage Grid Map, Version 200911	11/1/2009	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/nhpgrid.zip
	NJDEP ONLM	NJDEP Natural Heritage Priority Sites	3/1/2007	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/prisites.zip
Figure 8a: Preserved Open Space, Recreation and Agriculture	Middlesex Co	Middlesex County Municipal Open Space	9/28/2010	n/a	n/a
	Middlesex Co	Middlesex County Open Space	9/28/2010	n/a	n/a
	NJDEP GA	NJDEP County Open Space and Recreation Areas in New Jersey (Version 201107)	7/1/2011	n/a	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/openspace_county.zip
	NJDEP GA	NJDEP State Owned, Protected Open Space and Recreation Areas in New Jersey (Version 200812)	12/10/2008	1:24,000	https://njgin.state.nj.us/NJ_NJGINExplorer/jviewer.jsp?pg=DataDownloads
	North Brunswick	North Brunswick Parks	10/20/2011	n/a	n/a
	North Brunswick	North Brunswick Undeveloped Open Spaces	10/20/2011	n/a	n/a
Figure 8b: Walking Routes	North Brunswick	North Brunswick Walking Trails	1/25/2013	n/a	n/a

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
Figure 8c: Walking Routes - detail	North Brunswick	North Brunswick Walking Trails	1/25/2013	n/a	n/a
Figure 9: Archeological Grid	NJDEP NHR HPO	NJDEP Archaeological Site Grid of New Jersey (Edition 2011)	5/31/2011	n/a	http://www.nj.gov/dep/gis/stateshp.html#HISTSITEG
Figure 10a: WQMP areas; Wastewater Management Areas	NJDEP DWM BWR	Statewide Sewer Service Area for New Jersey, Edition 20131002 (Util_wastewater_servicearea)	10/2/2013	n/a	http://www.nj.gov/dep/gis/stateshp.html#SSA
	NJDEP DWM BWR	Water Quality Management Planning Areas (Version 200908)	8/1/2009	1:24,000	http://www.nj.gov/dep/gis/stateshp.html#WATMAN
Figure 10b: State Development and Redevelopment Plan	NJDS OPA	Brownfields SiteMart Locations	1/12/2013	n/a	http://nj.gov/state/planning/resources-gis.html
	NJDS OPA	Critical Environmental and Historic Sites (polygons) of the NJ State Development and Redevelopment Plan, adopted March 1, 2001	10/17/2012	1:24,000	http://nj.gov/state/planning/resources-gis.html
	NJDS OPA	Identified Centers of the State Development and Redevelopment Plan	1/17/2013	1:24,000	http://nj.gov/state/planning/resources-gis.html
	NJDS OPA	Planning Areas of the NJ State Development and Redevelopment Plan, adopted March 1, 2001	1/17/2013	1:24,000	http://nj.gov/state/planning/resources-gis.html
	NJDS OPA	Smart Growth Areas	5/15/2013	1:24,000	http://nj.gov/state/planning/resources-gis.html
Figure 11: Composite Map of Environmentally Sensitive Features (continued) Figure 11: Composite Map of Environmentally Sensitive	FEMA	Digital Flood Insurance Rate Map Database, Middlesex County, New Jersey	7/6/2010	1:12,000	http://msc.fema.gov/
	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html

Map	Source of Data*	Data Title	Date	Scale	Online Linkage
Features	NJDEP BGIS	NJDEP 2007 Land use/Land Cover Update, Lower Raritan, South River and Lawrence, WMA09 & Millstone, WMA10	7/12/2010	1:2,400	http://www.state.nj.us/dep/gis/lulc07shp.html
	NJDEP ENSP	NJDEP Species-Based Habitat, Piedmont Plains Region (Version 3.1, 20120221)	2/21/2012	1:12,000	http://www.njfishandwildlife.com/ensp/landscape/
	NJDEP ENSP	NJDEP Species-Based Habitat, Vernal Habitat (Version 3.1, 20120221)	2/21/2012	1:12,000	http://www.njfishandwildlife.com/ensp/landscape/
	NJDEP NJFFS	2002 NJFFS Wildfire Fuel Hazard for Middlesex County, New Jersey	4/17/2009	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/njfh/midfh02.zip
	NJDEP ONLM	NJDEP Natural Heritage Grid Map, Version 200911	11/1/2009	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/nhpgrid.zip
	NJDEP ONLM	NJDEP Natural Heritage Priority Sites	3/1/2007	1:24,000	http://www.state.nj.us/dep/gis/digidownload/zips/statewide/prisites.zip
	NJDS OPA	Critical Environmental and Historic Sites (polygons) of the NJ State Development and Redevelopment Plan, adopted March 1, 2001	10/17/2012	1:24,000	http://nj.gov/state/planning/resources-gis.html
	USDA	Soil Survey Geographic (SSURGO) database for Middlesex County, New Jersey	11/21/2012	1:24,000	http://datagateway.nrcs.usda.gov

***Source of GIS Data:**

Abbreviation	Data Source
FEMA	Federal Emergency Management Agency
Middlesex County	Middlesex County
NADP	National Atmospheric Deposition Network
NJDEP BAM	New Jersey Department of Environmental Protection (NJDEP), Department of Environmental Regulation (DER), Bureau of Air Monitoring (BAM)

Abbreviation	Data Source
NJDEP BFBM	New Jersey Department of Environmental Protection (NJDEP) Bureau of Freshwater Biological Monitoring (BFBM)
NJDEP BGIS	New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS)
NJDEP BPO	New Jersey Department of Environmental Protection (NJDEP), Division of Compliance and Enforcement (C&E), Bureau of Pesticide Operations (BPO)
NJDEP BWR	New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management (DWM), Bureau of Watershed Regulation (BWR)
NJDEP DWM	New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management (DWM)
NJDEP DWM BWR	New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management (DWM), Bureau of Watershed Regulation (BWR)
NJDEP DWQ	New Jersey Department of Environmental Protection (NJDEP), Division of Water Quality, Bureau of Surface Water Permitting
NJDEP ENSP	New Jersey Department of Environmental Protection (NJDEP), Division of Fish Wildlife (DFW), Endangered Nongame Species Program (ENSP)
NJDEP GA	New Jersey Department of Environmental Protection (NJDEP), Green Acres Program
NJDEP NHR HPO	New Jersey Department of Environmental Protection (NJDEP), Natural and Historic Resources (NHR), Historic Preservation Office (HPO)
NJDEP NJFFS	New Jersey Department of Environmental Protection (NJDEP), New Jersey Forest Fire Service (NJFFS)
NJDEP OEA	Department of Environmental Protection (DEP), Office of Environmental Analysis (OEA), Coast Survey Ltd. (CTD),
NJDEP ONLM	NJ Department of Environmental Protection (NJDEP), Office of Natural Lands Management (ONLM)
NJDEP SRP	New Jersey Department of Environmental Protection (NJDEP), Site Remediation Program (SRP)
NJDEP WMS BFBM	NJ Department of Environmental Protection (NJDEP), Water Monitoring & Standards (WMS), Bureau of Freshwater and Biological Monitoring (BFBM)
NJDEP WMS BWQSA	New Jersey Department of Environmental Protection (NJDEP), Water Monitoring & Standards (WMS), Bureau of Water Quality Standards and Assessment (BWQSA)
NJDOT	New Jersey Department of Transportation
NJDS OPA	NJ Department of State, Office for Planning Advocacy (formerly the Office of State Planning)
NJGS	New Jersey Department of Environmental Protection (NJDEP), New Jersey Geological Survey (NJGS)
NJOIT OGIS	NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS)
North Brunswick	North Brunswick GIS
USDA	U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS)
USGS	U.S. Geological Survey (USGS), Water Resources Division
ONJSC	Office of the New Jersey State Climatologist (coordinates entered into spreadsheet)

APPENDIX C: THREATENED AND ENDANGERED SPECIES

Contents:

C.1 List of Rare Plant Species of Middlesex County

Source: http://www.nj.gov/dep/parksandforests/natural/heritage/textfiles/middlesex.pdf

C.2 Rare Plant Reporting Form

Source:
http://www.nj.gov/dep/parksandforests/natural/heritage/textfiles/NHRPSR_Form_March2014.docx

C.3 Rare Wildlife Reporting Form

Source: http://www.state.nj.us/dep/fgw/ensp/rprtform.htm

The following fact sheets are authored by the NJDEP Endangered and Nongame Species Program. These threatened and endangered species have been reported within North Brunswick. Fact sheets were not available for all species.

C.4 Fact Sheet: Bald Eagle

Source: http://www.state.nj.us/dep/fgw/ensp/pdf/end-thrtened/baldeagle.pdf

C.5 Fact Sheet: Wood Turtle

Source: http://www.state.nj.us/dep/fgw/ensp/pdf/end-thrtened/woodtrtl.pdf

7/30/2008

Rare Plant Species and Ecological Communities Presently Recorded in the NJ Natural Heritage Database

Scientific Name	Common Name	Federal Status	State Status	Regional Status	G Rank	S Rank
County: **Middlesex**						
Terrestrial Community - Other Classification						
Leersia oryzoides - polygonum (caespitosum, hydropiper) herbaceous vegetation	Rice Cutgrass - (Oriental Ladysthumb, Marshpepper Knotweed) Coastal Plain Intermittent Pond Herbaceous Vegetation				G4	S2S3
Vascular Plant						
Agalinis auriculata	Ear-leaf False Foxglove			HL	G3	SX
Agastache nepetoides	Yellow Giant-hyssop			HL	G5	S2
Artemisia campestris ssp. caudata	Beach Wormwood			HL	G5T5	S2
Asclepias rubra	Red Milkweed			LP, HL	G4G5	S2
Asclepias variegata	White Milkweed			HL	G5	S2
Asclepias verticillata	Whorled Milkweed			HL	G5	S2
Aster concolor	Eastern Silvery Aster			LP, HL	G4?	S2
Aster radula	Low Rough Aster		E	LP, HL	G5	S1
Bidens bidentoides	Estuary Burr-marigold			HL	G3	S2
Bidens eatonii	Eaton's Beggar-ticks		E	LP, HL	G2	S1.1
Calamovilfa brevipilis	Pine Barren Reedgrass			LP	G4	S4
Carex barrattii	Barratt's Sedge			LP	G4	S4
Carex louisianica	Louisiana Sedge		E	LP, HL	G5	S1
Carex polymorpha	Variable Sedge		E	LP, HL	G3	S1
Carex retrorsa	Retrorse Sedge			HL	G5	S2
Carex utriculata	Bottle-shaped Sedge			HL	G5	S2
Carex willdenowii var. willdenowii	Willdenow's Sedge			HL	G5T5	S2
Castilleja coccinea	Scarlet Indian-paintbrush			HL	G5	S2

County: **Middlesex**

Ceratophyllum echinatum	Spiny Coontail		E	LP, HL	G4?	S1
Clematis occidentalis var. occidentalis	Purple Clematis			HL	G5T5	S2
Crataegus calpodendron	Pear Hawthorn		E	LP, HL	G5	S1
Cuphea viscosissima	Blue Waxweed			HL	G5?	S3
Cyperus lancastriensis	Lancaster Flat Sedge		E	LP, HL	G5	S1
Desmodium humifusum	Trailing Tick-trefoil		E	LP, HL	G1G2Q	S1
Draba reptans	Carolina Whitlow-grass		E	LP, HL	G5	SH
Elatine americana	American Waterwort			HL	G4	S2
Epilobium angustifolium ssp. circumvagum	Narrow-leaf Fireweed			HL	G5T5	S1
Eupatorium altissimum	Tall Boneset			HL	G5	S2
Gentiana saponaria var. saponaria	Soapwort Gentian			HL	G5TNR	S3
Helonias bullata	Swamp-pink	LT	E	LP, HL	G3	S3
Hottonia inflata	Featherfoil		E	LP, HL	G4	S1
Hydrocotyle ranunculoides	Floating Marsh-pennywort		E	LP, HL	G5	S1
Isoetes riparia var. riparia	Shore Quillwort			HL	G5?T5?Q	S3
Lathyrus ochroleucus	Cream Vetchling		E	LP, HL	G4G5	SH
Liatris scariosa var. novae-angliae	Northern Blazing-star		E	LP, HL	G5?T3	SH
Listera australis	Southern Twayblade			LP, HL	G4	S2
Lygodium palmatum	Climbing Fern			LP, HL	G4	S2
Lysimachia hybrida	Lowland Loosestrife			HL	G5	S3
Malaxis unifolia	Green Adder's-mouth			HL	G5	S2
Melanthium virginicum	Virginia Bunchflower		E	LP, HL	G5	S1
Micranthemum micranthemoides	Nuttall's Mudwort		E	LP, HL	GH	SH
Mimulus alatus	Winged Monkey-flower			HL	G5	S3
Myriophyllum tenellum	Slender Water-milfoil		E	LP, HL	G5	S1
Myriophyllum verticillatum	Whorled Water-milfoil		E	LP, HL	G5	SH

County: **Middlesex**

Phoradendron leucarpum	American Mistletoe		LP, HL	G5	S2
Plantago maritima var. juncoides	Seaside Plantain		HL	G5T5	S2
Platanthera ciliaris	Yellow Fringed Orchid		LP, HL	G5	S2
Platanthera flava var. flava	Southern Rein Orchid	E	LP, HL	G4T4?Q	S1
Platanthera flava var. herbiola	Tubercled Rein Orchid		HL	G4T4Q	S2
Platanthera peramoena	Purple Fringeless Orchid	E	LP, HL	G5	S1
Polygala polygama	Racemed Milkwort		HL	G5	S2
Polygonum glaucum	Sea-beach Knotweed	E	LP, HL	G3	S1
Puccinellia fasciculata	Saltmarsh Alkali Grass		HL	G3G5	S2
Pycnanthemum torrei	Torrey's Mountain-mint	E	LP, HL	G2	S1
Ranunculus pusillus var. pusillus	Low Spearwort		HL	G5T4?	S2
Rhododendron canadense	Rhodora	E	LP, HL	G5	S1
Ribes cynosbati	Prickly Gooseberry		HL	G5	SH
Sabatia dodecandra var. dodecandra	Large Marsh-pink		HL	G5?T4T5	S2
Sagittaria australis	Southern Arrowhead	E	LP, HL	G5	S1
Sagittaria calycina var. spongiosa	Tidal Arrowhead		HL	G5T4	S3
Scirpus maritimus	Saltmarsh Bulrush	E	LP, HL	G5	SH
Scutellaria leonardii	Small Skullcap	E	LP, HL	G4T4	S1
Solidago elliottii	Elliott's Goldenrod		HL	G5	S3
Solidago rigida	Prairie Goldenrod	E	LP, HL	G5T5	S1
Stachys hyssopifolia	Hyssop Hedge-nettle		HL	G5	S2
Triglochin maritima	Seaside Arrow-grass	E	LP, HL	G5	S1
Utricularia gibba	Humped Bladderwort		LP, HL	G5	S3
Utricularia purpurea	Purple Bladderwort		LP, HL	G5	S3
Verbena simplex	Narrow-leaf Vervain	E	LP, HL	G5	S1

County: **Middlesex**

Viburnum opulus var. americanum	Highbush-cranberry		HL	G5T5	S3
Vicia americana var. americana	American Purple Vetch		HL	G5T5	S1
Viola brittoniana var. brittoniana	Britton's Coast Violet		HL	G4G5T4T5	S3
Zigadenus leimanthoides	Death-camus	E	LP, HL	G4Q	S1

Natural Heritage Rare Plant Species Reporting Form

This form is used to report a personal field sighting of a rare plant species (element occurrence) tracked by the Natural Heritage Database. It may also be used to summarize locational information from a published or unpublished report. Plant species tracked include those appearing on the List of Endangered Plant Species and Plant Species of Concern (http://www.nj.gov/dep/parksandforests/natural/heritage/spplant.html). The Office of Natural Lands Management can provide copies of the list upon request. In order for this form to be processed, the sections preceded by an asterisk (*) must be completed.

Send completed form to: DEP, Division of Parks and Forestry, Office of Natural Lands Management, Natural Heritage Program, Mail Code 501-04, P.O. Box 420, Trenton, NJ 08625-0420 or email to Natlands@dep.state.nj.us

Form Completion Date: _____ *** Date(s) of the Observation(s):** _____

Common Name: _____ *Scientific Name:* _____

***Location Map:** *A mapped location of the occurrence must accompany this form*. The ideal format is to locate the site on a photocopied section of a U.S. Geological Survey 7.5 minute topographical map, and to also sketch a second map showing finer details. Be sure to provide the name of the USGS map.

GPS Coordinates (If available please provide the following)**:**

Datum Used:	☐ NAD 1983	☐ NAD 1927	☐ WGS84	☐ Other _____
Lat/Long (if applicable):	_____ N (Latitude)		_____ W (Longitude)	
UTM (if applicable)	18 N/S: _____ Northing		_____ Easting	
Accuracy Level:	+/-_____ ☐feet or ☐meters			

***Directions to Site:** Directions to the element occurrence using a readily locatable and relatively permanent landmark on or near the site (such as a road intersection, a prominent hill or cliff) as the starting point. Use clear, complete sentences so that someone who is unfamiliar with the area will be able to relocate the element occurrence using your written directions (e.g., "About 50 ft. N. of small stream draining Brindel Lake, 0.5 mi. SE of Brindeltown and 0.2 mi. WSW of jct. of Range Rd. and Rt. 539, Fort Dix").

Identification: How was the species identification made? Name the identification manuals used or the experts consulted. Were there identification problems?

***Number of Individuals Observed:**

☐ 1-10 ☐ 11-50 ☐ 51-100 ☐ 101-1,000 ☐ 1,001-10,000 ☐ >10,000

If possible, provide the exact number of individuals and an estimated percentage of flowering/fruiting individuals. For rhizomatous plants such as grasses and sedges, what was counted as individual – separate culms or entire clumps or patches?

Life Stages Present: Check life stages observed and provide an estimate of the numbers of individuals for each life stage.

☐ vegetative ___ ☐ in bud ___ ☐ flower ___ ☐ seed dispersing ___ ☐ seedling ___ ☐ dormant ___

Associated Species/Additional Biological Data: List any associated species and/or additional rare species observed at this site. What else was observed? Provide information on the general condition or vigor of the individuals and viability of the population(s). A separate Rare Plant Species Reporting Form is recommended for each element occurrence observed.

Habitat Data: Describe the specific area where the occurrence is located. List natural community types, dominant vegetation and information on the physical environment such as substrate type, hydrology, moisture regime, slope and aspect. Also, describe the surrounding landscape.

Threats: Describe any current or potential threats to this occurrence. If invasive species are present, please list.

Ownership: If known, please provide landowner(s) name, address, phone #, block, lot.

Information Source:

***Name, Address and Phone #** (of person filing report):

Name:	
Address:	
Phone Number:	

*Does this information come directly from ☐ a field visit or ☐ a published or unpublished report?

Citation: For information taken from a published or unpublished report, please provide a copy of the cover page and the pertinent portions of the report. If a copy can not be provided, list below the author, date, title, publisher, and page numbers.

Voucher: Was the observation vouchered with ☐ a photograph? ☐ a video/digital format? ☐ a specimen?
If possible, attach a copy of the photograph, etc. If specimen voucher, please provide the name of the repository:

Confirmation: Would you accompany a biologist to the site if needed? ☐ yes ☐ no

Additional Comments: (use extra sheets if needed)

***Attachment: Include a mapped location of the occurrence and a sketched map with finer details and landmarks.**

Last Revised 2/27/2014

RARE WILDLIFE SIGHTING REPORT FORM

REPORT FORM MUST BE ACCOMPANIED BY AN AERIAL PHOTOGRAPH, SATELLITE IMAGE, OR TOPOGRAPHIC MAP WITH THE LOCATION PRECISELY MARKED. PLEASE PRINT LEGIBLY.
*The inclusion of a map is mandatory, please see other side for further information on obtaining a map.

General Information

Today's Date _____
Common Name _____ Scientific Name (If known) _____

Where did the sighting take place?

Municipality/ Township _____ County _____

Topographic quad (if known) _____ Coordinates in state plane feet (if known) _____ _____

Directions to location with landmarks, which will enable the future relocation of the site where the species was sighted:

_____

_____

_____

Land Owner (name, address and phone number, if known) _____
Describe habitat at the point of sighting and habitat in the general area of the sighting location.

_____

_____

Would you accompany a biologist to the site if needed? ☐ Yes ☐ No
Can you describe any immediate or future plans to develop or disturb the site? ☐ Yes ☐ No
If so, please describe. _____

_____

Locational Accuracy

1. Is your depiction of the sighting location on the topographic map or aerial photo within 6m (20ft) of the animals actual location on the ground? ☐ Yes ☐ No (if no, answer question 2 below)

2. Your mapping is accurate to within ___ meters ___ feet ___ miles of the actual location.

What was observed?

How was the species identification made? (ex. Sighting, Call, Road Kill, etc.) _____

Date and time of this sighting (ex. August 20, 2004, 10:30am) _____

How frequently has this species been sighted at this location and over how long a period of time? _____

_____

Number of individuals sighted: Adult ____ Immature ____ Larva ____ Unknown/Other ____

Describe sighting and activity observed (ex. Nesting, Perched, Flying, Sunning, etc.) _____

Describe physical features that identify the sighted animal as the species you are reporting. _____

_____

_____

Were photos taken? ☐ Yes ☐ No Was video recorded? ☐ Yes ☐ No Was audio recorded? ☐ Yes ☐ No
(PHOTOS/VIDEO/AUDIO ARE STRONGLY ENCOURAGED IN ORDER TO VERIFY THE ACCURACY OF A SIGHTING. Items should be identified with the date taken, location, and observer signature. Items will not be returned.)

List manuals used or experts consulted to verify identification. _____

Provide a brief background on wildlife knowledge and/or experience, or additional information that would add to the validity of the sighting. _____

_____

Can this be verified by someone else or can anyone vouch for your identification skills? ☐ Yes ☐ No _____

Describe any additional information that may be useful in regards to the condition of the animal or location.

_____

_____

Your Contact information

Name _____
Street _____
City _____ State _____ ZIP _____
Daytime Phone ( ) - E-mail _____

Preferred method of contact _____

Signature _____

☐ I'm 18 or over and all information contained on this form and in the supporting documentation is true and accurate to the best of my knowledge.

Conserve Wildlife
N.J. Division of Fish, Game & Wildlife
Endangered & Nongame Species Program

Return to:
Endangered and Nongame Species Program
NJ Division of Fish and Wildlife
P.O. Box 420
Mail Code 501-03
Trenton, NJ 08625-0420
609-292-9400

NEW JERSEY DIVISION OF
Fish and Wildlife

Instructions

1. Complete this form for first-hand field observations only.
2. DO NOT COMPLETE THIS FORM if the source of your information is a report, letter, conversation, or other document. Send us the documentation instead.
3. Attach a copy of a map.(*see below*)
4. Only report one species at each location per form and map.

***Mapping**

A map is necessary to help our biologists determine if suitable habitat is present at the location. Once the suitability of the area is determined the map provided aids in the delineation of land to be protected. Ideally the most accurate form of map is an aerial photo, which can be obtained from http://www.state.nj.us/dep/gis/imapnj/imapnj.htm, if you are comfortable with your ability to identify the location of the sighting accurately on them. In addition, satellite-derived images are available at http://www.maps.google.com. These images can be printed and clearly marked with a pen. An alternative to an aerial photo or satellite image is a topographic map. You may also print copies of topographic maps from the internet at http://www.topozone.com. Please use 1:24,000 scale topographic maps only. Please provide either an image or a topographic map, but NOT both. Thank you.

Refer to the DFW website for further information: http://www.njfishandwildlife.com/ensp/rprtform.htm

Wildlife Notes

NJ Division of Fish and Wildlife
Endangered and Nongame Species Program

Bald Eagle

(Haliaeetus leucocephalus)

THE BALD EAGLE IN NEW JERSEY

New Jersey was once home to more than 20 pairs of nesting bald eagles. As a result of the use of the pesticide DDT, the number of nesting pairs of bald eagles in the state declined to only one by 1970 and remained at one into the early 1980's. Use of DDT was banned in the United States in 1972. That ban combined with restoration efforts by biologists within the NJ Division of Fish and Wildlife's Endangered and Nongame Species Program (ENSP) acted to increase the number of New Jersey bald eagles to 119 active pairs in 2012.

The bald eagle is currently listed as endangered in New Jersey. Recently, the status of the bald eagle was changed from endangered to threatened on the federal endangered species list, and the species is being considered for removal from the federal list.

ENSP recovery efforts - implemented in the early 1980's - are now bearing fruit, as New Jersey's eagle population rebounds from the edge of extinction. In 1982, after Bear Swamp - New Jersey's only active bald eagle nest since 1970 - had failed to produce young for at least six consecutive years, ENSP biologists removed an egg for artificial incubation, and fostered the young back to the nest. The necessity of this fostering technique was due to eggshell thinning as a result of DDT contamination. The eggs, if left in the nest for the adult eagles to incubate, would crack under the birds' weight. Fostering continued successfully until 1989, when the previous female of the pair died and a new female was able to hatch her own eggs.

Increasing the production from a single nest, however, was not enough to boost the state's population in a reasonable amount of time. Mortality rates are high in young eagles (as high as 80%), and they do not reproduce until four or five years of age. ENSP instituted a hacking project in 1983 that resulted in the release of 60 young eagles in NJ over an eight-year period. These eagles have contributed to the increase in nesting pairs since 1990.

IDENTIFICATION

Adult bald eagles are distinguished by their full white heads and tails, but subadult and juvenile birds are brown overall with some white mottling. Both sexes have similar plumage, although the female is slightly larger than the male. With a wing span of six to seven feet, eagles are larger than most birds, but can be confused with vultures from a distance. While eagles eat mostly fish during the warmer months, they feed on waterfowl, muskrat, and carrion during winter and early spring.

BREEDING BIOLOGY

In New Jersey, nesting bald eagles reside year-round, usually remaining in the area of their nest. Eagles usually build their large stick nests close to water in trees taller than the forest canopy. They begin courtship and nest building in early January, adding to their existing nest. Pairs lay one to three eggs in mid-January to early March, and incubate for about 35 days. Upon hatching, the chicks are helpless and require close parental care. After about five weeks, the young birds begin to stand up and feed themselves when the adults deliver food. Young birds fledge the nest at 11 weeks of age in early July. Adults continue to feed young near the nest for several weeks while the young learn to fly and hunt. In late August many young eagles leave the area and may spend the following winter in the Chesapeake Bay area, where open water and abundant food provide favorable conditions.

MANAGEMENT

ENSP biologists continually work to manage and reduce disturbance in eagle habitats, especially around nest sites. Eagles are sensitive to human disturbance and will abandon their nest sites if people encroach on the area during the nesting season. Education and established viewing areas are important in minimizing disturbance, as are the efforts of eagle project volunteers. Biologists also work to protect habitat in a variety of ways, including working with landowners, land acquisition experts, and through the state's land use regulations.

Bald eagles are proven indicators of environmental health. As residents and consumers of fish, their health reflects the quality of resources shared by humans. ENSP is continuing to investigate the possible impacts of organochlorines and heavy metals in eagles and other raptors nesting in the Delaware Bay region. ENSP monitors these species during the nesting season to evaluate nest success and assess any problems that occur.

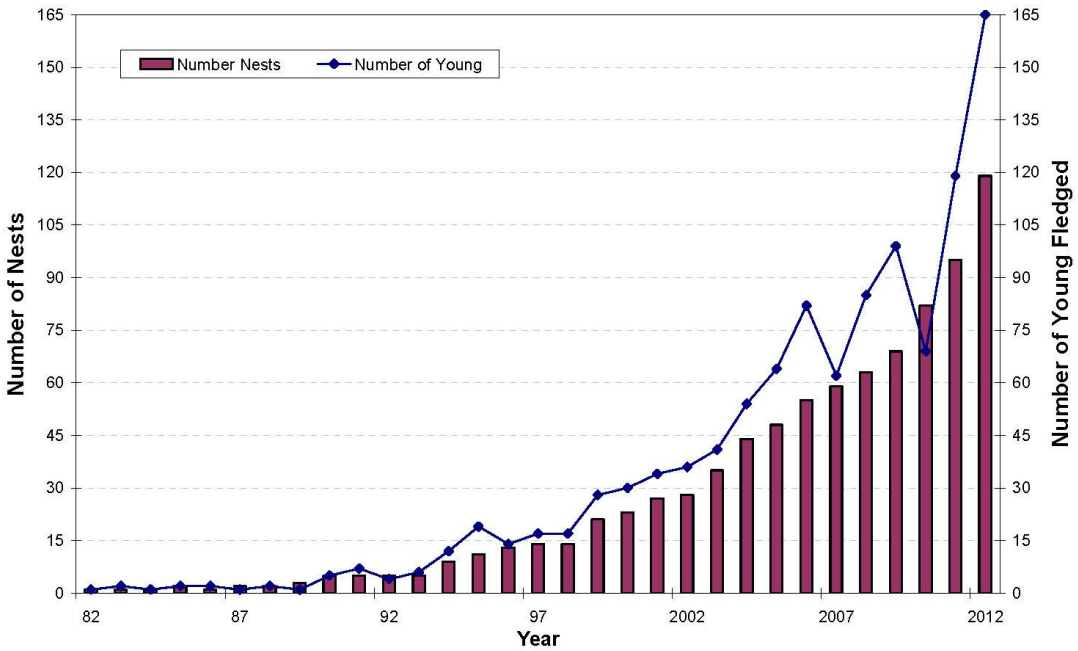
How You Can Help

The ENSP receives no funding from state tax dollars. You can help support New Jersey's bald eagles by:

- Checking-Off for Wildlife on the NJ State Income Tax Form
- Purchasing a *Conserve Wildlife* license plate
- Participating in the *Adopt an Eagle Nest Program*
- Making a donation to the Conserve Wildlife Foundation of NJ, a non-profit organization dedicated to supporting the eagle project
  www.conserverwildlifenj.org

For more information, please contact the ENSP at:
Endangered & Nongame Species Program
NJ Division of Fish and Wildlife
MC 501-03
P.O. Box 420
Trenton, NJ 08625-0420
(609) 292-9400
www.njfishandwildlife.com

VISIT THE NJ EAGLE CAM AT:
www.conservewildlifenj.org/education/eaglecam



To learn where you can view eagles in the state, purchase the NJ Wildlife Viewing Guide, available from the CWF

Wood Turtle, *Glyptemys insculpta*

Status: ***State:*** Threatened ***Federal:*** Not listed

Identification

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As the taxonomic name insculpta indicates, the wood turtle is distinguished by the sculpted or grooved appearance of its carapace, or upper shell. Each season a new annulus, or ridge, is formed, giving each scute (a scale-like horny layer) a distinctive pyramid-shaped appearance. As the turtle ages, natural wear smoothes the surface of the shell. While the scutes of the carapace are brown, the plastron, or underneath the shell, consists of yellow scutes with brown or black blotches on each outer edge. The legs and throat are reddish-orange. The male wood turtle has a concave plastron while that of the female is flat or convex. The male also has a thicker tail than the female. Adult wood turtles measure 14 to 20 cm (5.5 to 8.0 in.) in length (Conant and Collins 1991).

Habitat

Unlike other turtle species that favor either land or water, the wood turtle resides in both aquatic and terrestrial environments. Aquatic habitats are required for mating, feeding, and hibernation, while terrestrial habitats are used for egg laying and foraging. Freshwater streams, brooks, creeks, or rivers that are relatively remote provide the habitat needed by these turtles. Consequently, wood turtles are often found within streams containing native brook trout (Salvelinus fontinalis). These tributaries are characteristically clean, free of litter and pollutants, and occur within undisturbed uplands such as fields, meadows, or forests. Open fields and thickets of alder (Alnus spp.), greenbrier (Smilax spp.), or multiflora rose (Rosa multiflora) are favored basking habitats. Lowland, mid-successional forests dominated by oaks (Quercus spp.), black birch (Betula lenta), and red maple (Acer rubrum) may also be used. Wood turtles may also be found on abandoned railroad beds or agricultural fields and pastures. Nevertheless, wood turtle habitats typically contain few roads and are often over one-half of a mile away from developed or populated areas (Zappalorti et al. 1984). Individuals from relict or declining populations are also sighted in areas of formally good habitat that have been fragmented by roads and development.

Status and Conservation

Historically, the wood turtle was a fairly common species within suitable habitat in New Jersey. By the 1970s, however, declines were noted as wood turtles were absent from many historic sites due to habitat loss and stream degradation. Consequently, the wood turtle was listed as a threatened species in New Jersey in 1979. The New Jersey Natural Heritage Program considers the wood turtle to be "demonstrably secure globally," yet "rare in New Jersey" (Office of Natural Lands Management 1992).
Since the late 1970s, biologists have monitored and surveyed wood turtle sites in New Jersey, providing valuable data regarding the life history, reproduction, and habitat use of these turtles in the state. There is, however, a continuing need to examine the productivity and juvenile survival of wood turtles, which may be threatened by disturbance or predation.

In 1995, the wood turtle was proposed for inclusion on the federal endangered species list. Despite declines in several northeastern states, populations were considered stable enough throughout the species' entire range to deny listing. However, the wood turtle was considered by the U.S. Fish and Wildlife Service as a species that, "although not necessarily now threatened with extinction may become so unless trade in them is strictly controlled" (U.S. Fish and Wildlife Service 1995). As a result, international trade of these turtles is strictly monitored and regulated through the CITES Act (Convention on International Trade in Endangered Species of Wild Flora and Fauna Act). The New Jersey Endangered Species Act prohibits the collection or possession of wood turtles.