Bordentown City

Environmental Resource Inventory

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Note: GIS Maps were created using data layers available from the NJ Department of Environmental Protection (except the Existing Land Use and Open Space maps, the data for which was supplied by Burlington County Office of Economic Development and Regional Planning). Information contained in these maps reflects the best available data as of October 2005.

What is an Environmental Resource Inventory?

According to the Association of New Jersey Environmental Commissions, an Environmental Resources Inventory (or ERI), is "a compilation of text and visual information about the natural resource characteristics and environmental features of an area." The ERI is a report based upon factual information, and provides a municipality with a baseline documentation for assessing environmental issues. It is an important planning tool for environmental commissions and planning boards. It is recommended that the ERI be adopted as part of the municipal master plan, specifically as part of the conservation element (this is envisioned to be the case in Bordentown City). The ERI is a living document, which should be updated periodically as new information becomes available and assessment techniques become more refined.

Two New Jersey state laws, the Environmental Commission Enabling Legislation (NJSA 40:56A) and the Municipal Land Use Law (NJSA 40:55D-1), give environmental commissions the authority and responsibility for conducting and maintaining ERIs.

An ERI includes text, maps, tables, photos and figures that describe and quantify the local environment. Basic ERI information, including such topics as location, topography, climate, soils, geology, hydrology, vegetation, wildlife and land use, serves as the foundation of the document. The inclusion of additional information such as air quality, transportation, historic resources, noise and regional relationships serves to create the most comprehensive report possible. Finally, sections such as a glossary, references and appendices ensure that the information presented in the ERI is accurately and completely documented.

An ERI can be used in a variety of ways. In Bordentown City, the ERI will be used as a guide in the site plan review process; help prioritize open space acquisition; save tax dollars by helping to prevent costly environmental problems; assist in the municipal land use planning process; serve as a reference for municipal ordinances and best management practices; and provide an educational resource for residents.

Hardcopies of the ERI will be available at City Hall and the Bordentown Public Library. Additionally, a limited number of PDF files on CD-ROM will be made available to the public.

The Bordentown City Environmental Commission has been working on the ERI since its inception in 2002. It was completed without the customary assistance of private consultants, at minimal cost to the City. Environmental Commission members brought their expertise, passion and knowledge of the local environment to the project, and in the process gained a greater understanding of the local environment.

The very features that drew early settlers to this confluence of waterways in the 17th century continue to define Bordentown City as a special and unique place for its 21st century residents. It is hoped that the Bordentown City Environmental Resource Inventory will serve current and future residents well as the City approaches its 325th year as a place of settlement on the bluffs of Crosswicks Creek.

THE NATURAL ENVIRONMENT

Location

Bordentown City is located on the western edge of central New Jersey, just southeast of Trenton, along a bend in the Delaware River, where the flow direction shifts from southeast to southwest. It is in the northernmost corner of Burlington County, and is bordered by:

- Mile Hollow Run(and Bordentown Township) to the northeast;
- Bordentown Township to the east and south;
- Blacks Creek (and Bordentown Township) to the southwest;
- The Delaware River (and Pennsylvania) to the west;
- Crosswicks Creek (and Hamilton Township, Mercer County) to the northwest.

Physiography

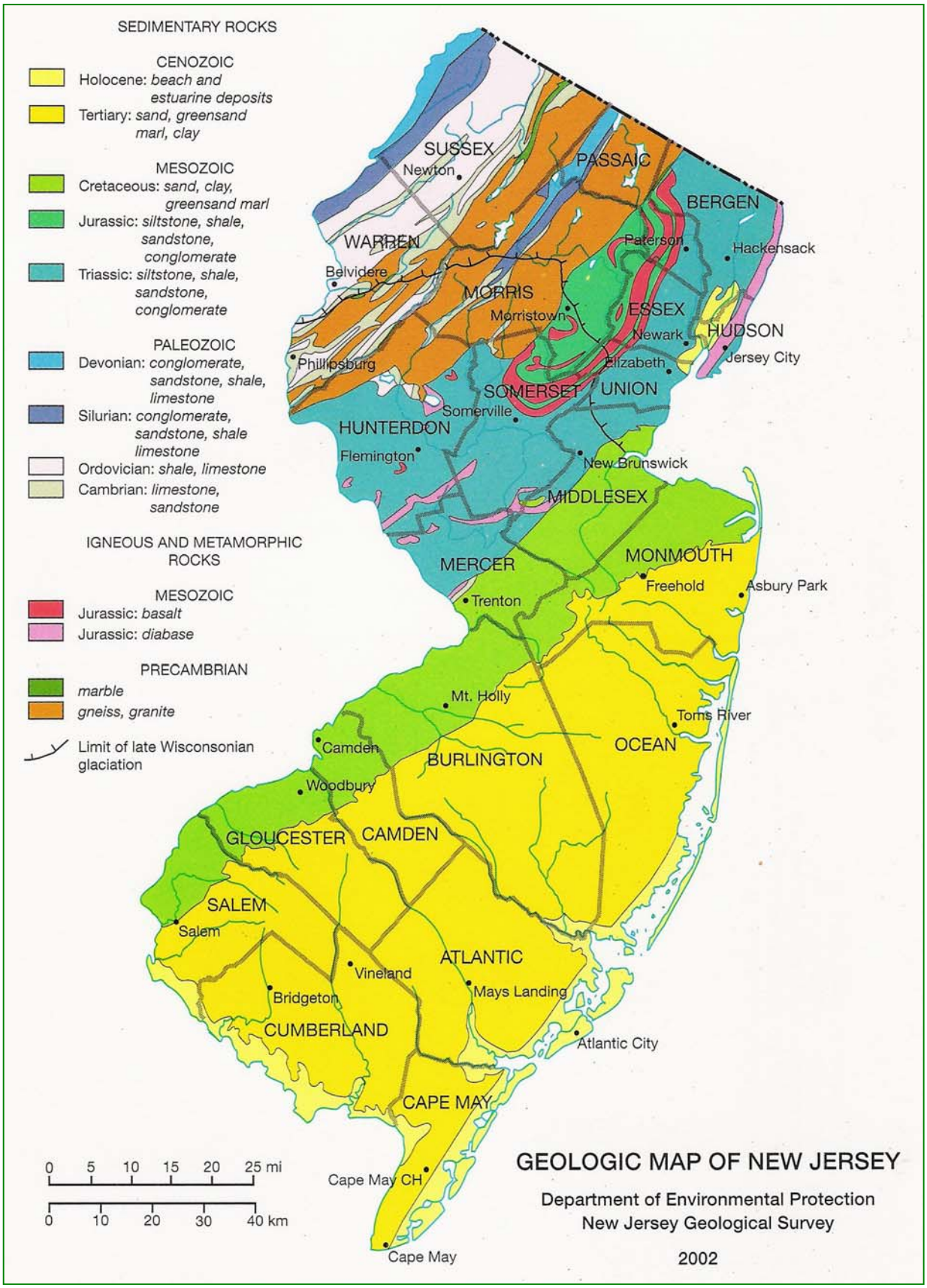
New Jersey can be divided into four major geomorphic or physiographic provinces, each characterized by rocks (or sediments) of similar type, origin, and age, similar landscapes, and a general northeast/southwest trend. (See the Geologic Map of New Jersey on page 3.) Bordentown City is part of the Coastal Plain, which covers 3/5 of the area of the state, southeast of a line from Trenton to Carteret. It is a broad, flat to gently undulating, low-lying area, composed of a wedge of unconsolidated sediments gently dipping southeastward. This wedge also thickens to the southeast, from 50 to 150 feet along the Delaware River, to 4,500 feet at Atlantic City, to 40,000 feet thick 50 miles offshore. Coastal plain sediments include deltaic and marine deposits of Cretaceous to Tertiary age (145 to 1.75 million years ago), resulting from fluctuating sea level; a thin veneer of fluvial sands and gravels of Pliocene and Miocene age (23 to 1.75 million years ago); and alluvial, beach, swamp, eolian, and tidal marsh deposits from the Quaternary Period (the last 1.75 million years).

Bordentown City is located in the Inner Coastal Plain subprovince, characterized by higher elevations, more local topographic relief, and generally finer textured deposits than found in the Outer Coastal Plain.

Topography

Most of Bordentown City is nearly level to gently sloping, with elevations between 50 and 100 feet above sea level. Steep slopes are found along stream channels cut by Thorntown Creek, Mile Hollow Run, Love Bridge Run, and Blacks Creek, and on 50 foot bluffs above Crosswicks Creek. Tidal marsh deposits along the Crosswicks and Blacks Creeks are less than 10 feet above sea level.

Regional Map



Geologic Map of New Jersey

Climate

The global weather patterns that take place based upon the Earth's rotation, tilt and land/water distribution are the factors responsible for our climates. Climates are the common weather conditions usually found in a particular location. While the weather fluctuates daily at any particular place, over time, the same kind of weather will reoccur. This recurring weather pattern for each area is known as the climate for that locale.

German climatologist, Wladimir Köppen, separated the world's climates into several major groupings. The Eastern United States falls under the classification Moist Subtropical Mid-Latitude Climate, a general temperature profile based on latitude. This climate generally has warm and humid summers with mild winters. It extends from 30° to 50° latitude mainly on the eastern and western borders of most continents. During the winter, the chief weather element is the mid-latitude cyclone. Convective thunderstorms are prevalent during the summer months.

The Climate of New Jersey

The Garden State is located about halfway between the Equator and the North Pole, on the eastern coast of the United States. This geographic placement results in the state being influenced by hot, dry, wet, and cold airstreams, leading to daily weather that is highly variable.

New Jersey is 166 miles long from north to south, and 65 miles at its greatest width. While this may not seem very large, there is a marked difference in climate between Cape May in the south and the Kittatinny Mountains in the northwest.

The dominant feature of the atmospheric circulation over North America is the broad, undulating flow of air from west to east across the middle latitudes of the continent. These "prevailing westerlies" shift north and south and change in strength during the course of the year, exercising a major influence on the weather throughout New Jersey.

Some general observations about the temperature and precipitation in New Jersey include:

- Average yearly precipitation ranges from 40 inches along the southeast coast to 51 inches in north-central parts of the state. Many areas average between 43 and 47 inches.
- Most areas receive 25 to 30 thunderstorms annually, with fewer storms near the coast than farther inland. Approximately five tornadoes occur across the state each year.
- Measurable precipitation falls on approximately 120 days. Fall months are usually the driest, with an average of eight days with measurable precipitation. Other seasons average between 9 and 12 days per month of precipitation.
- Average number of freeze-free days varies from 163 in the northern Highlands, 179 in the central and southern interior, and 217 along the seacoast.
- Snow may fall from about mid-October to the end of April in the Highlands and from about mid November to mid-April in southern counties.
- All New Jersey weather stations have registered temperature readings of 100 degrees F or higher and have records of 0 degrees F or below.

Although New Jersey is one of the smallest states in the Union, with a land area of 7,836 square miles, it has five distinct climate regions. The geology, distance from the Atlantic Ocean, and prevailing atmospheric flow patterns create distinct variations in the daily weather between each of the regions.

Bordentown City falls within what is known as the Central Zone, closely bordered by the Pine Barrens region.

Central Zone

The Central Zone has a northeast to southwest orientation, running from New York Harbor and the Lower Hudson River to the great bend of the Delaware River in the vicinity of Trenton. This region has many urban locations, and the concentration of buildings and paved surfaces serve to retain more heat, thus affecting local temperatures. Due to the concrete, brick and asphalt, the observed nighttime temperatures in heavily developed parts of the zone are often warmer than nearby suburban and rural areas. This phenomenon is commonly referred to as a "heat island" effect.

The northern edge of the Central Zone is often the boundary between freezing and non-freezing precipitation during the winter. Areas to the south of the Central Zone tend to have nearly twice as many days with temperatures above 90 degrees F than the 15-20 commonly observed in the central portion of the state.

Pine Barrens Zone

Scrub pine and oak forests pervade the interior southern portion of New Jersey, hence the name, Pine Barrens. Sandy soils, which are porous and not very fertile, have a major impact on this region's climate. On clear nights, solar radiation absorbed during the day is rapidly radiated back into space, resulting in surprisingly low minimum temperatures.

The porous soil allows any precipitation to quickly infiltrate and leave surfaces rather dry. Drier conditions allow for a wider range between the daily maximum and minimum temperatures, and make the area vulnerable to forest fires.

Local Statistical Information

Statistical analysis of climatic data generates descriptive information, which reflects the average atmospheric conditions at a location, as well as generating probabilities that extreme events will occur.

The Office of the New Jersey State Climatologist of Rutgers University, as well as the National Weather Service, collects information on climate data in New Jersey through the operation of individual weather stations located throughout the state.

Measurements of temperature, precipitation, frost points and snowfall are some of statistical climatic data relevant to our locale. While there are no weather stations located in Bordentown City, pertinent data is collected from the nearest weather stations operating in Hightstown, Trenton and Pemberton, New Jersey.

Temperature readings are collected daily and monthly. The average, or mean temperature, reflects the average of a series of temperatures taken over a period of time. Maximum temperature indicates the highest temperature during a specified time period, while the average maximum temperature reflects the average of the maximum readings over the specified time period. Similarly, minimum temperatures indicate the lowest temperature during a specified time period, and the average minimum temperature reflects the average of the minimum readings.

Precipitation is measured on a daily and monthly basis in New Jersey. Precipitation refers to all forms of water - liquid or solid - that fall from the atmosphere and reach the ground. Precipitation includes, but is not limited to, rain, drizzle, snow, hail, sleet, and ice crystals. Precipitation does not include dew. The average precipitation refers to the average number of inches for a given time period.

YEAR(S)	Average Daily Maximum Temp. (Deg F)	Average Daily Minimum Temp. (Deg F)	Average Daily Mean Temp. (Deg F)	Average Monthly Precipitation (Inches)	Average Monthly Snowfall (Inches)
1971-2000 (Normals)	62.5	42.0	52.3	4.0	1.9
2001	63.9	44.2	54.1	3.0	
2002	64.5	45.0	54.8	3.3	
2003 (incomplete)	52.5	34.7	43.6	3.6	

Air Quality

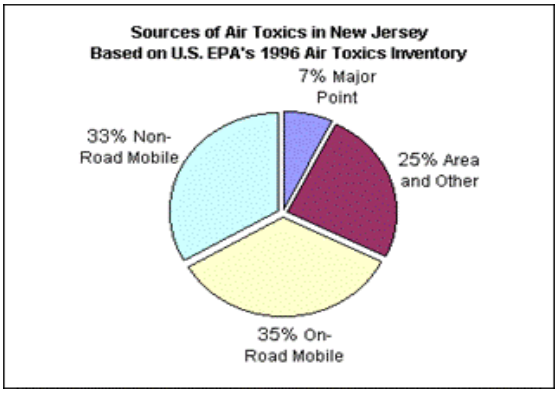
The air quality of Bordentown City is greatly impacted by its location in the urban expanse of the Northeastern corridor of the United States. Exposure to air toxics is a widespread problem that occurs throughout the entire state of New Jersey. These pollutants come from a wide variety of sources, including traditional industrial and utility sources, smaller manufacturing and commercial sources, mobile sources, residential activities and construction equipment. As part of Burlington County, Bordentown City is affected by all three types of air pollution: mobile, point and area.

Mobile sources include both on-road vehicles (such as cars, trucks, buses and motorcycles) and non-road equipment (such as ships, airplanes, agricultural and construction equipment) and contribute significantly to air pollution. Nationwide, mobile sources are responsible for about 75% of carbon monoxide pollution.

Point sources include major industrial facilities like chemical plants, steel mills, oil refineries, power plants, and hazardous waste incinerators. Point sources are defined as those that emit 10 tons per year of any of the criteria pollutants (see page 8) or hazardous air pollutants (see page 9) or 25 tons per year of a mixture of air toxics.

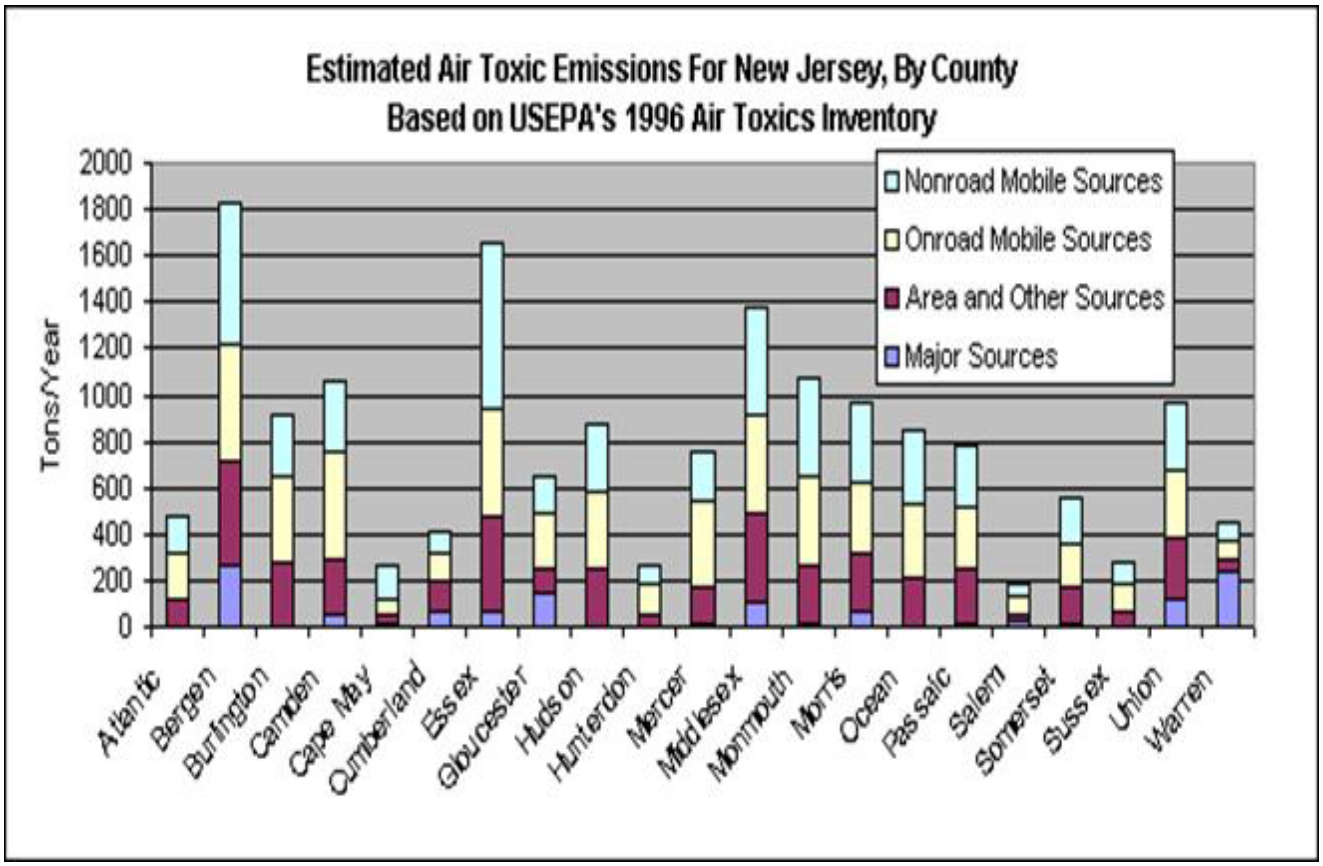
Area sources include small pollution sources like dry cleaners, gas stations, and auto body paint shops. Area sources are defined as sources that emit less than 10 tons per year of a criteria or hazardous air pollutant or less than 25 tons per year of a combination of pollutants. Though emissions from individual area sources are relatively small, collectively their emissions can be of concern - particularly where large numbers of sources are located in heavily populated areas.

Mobile sources are the largest contributors to air toxics emissions in New Jersey, with on-road mobile sources accounting for 35%, and non-road mobile sources contributing 33%. **Area sources** represent 25% of the inventory. **Major point sources** account for the remaining 7% of the inventory.



Comparison of Emissions by County

When the emissions estimates are broken down by county, it is evident that the areas with the largest air toxic emissions are generally those with the largest population in the smallest space. This is directly related to high levels of vehicle use, solvent use, and other population-related types of activities in those counties. In the chart below, Burlington County ranks 8th highest for total estimated air toxic emissions among the 21 counties in New Jersey.



Criteria Pollutants

The United States Environmental Protection Agency (USEPA) has set National Ambient Air Quality Standards (NAAQS) which define the maximum legally allowable concentration for the following six pollutants: ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, particulate matter (PM), and lead. These six chemicals, known as criteria pollutants, occur frequently in ambient air and can injure human health and harm the environment. If the NAAQS for a pollutant is exceeded, adverse effects on human

health may occur. Areas of the country where air pollution levels persistently exceed the standards may be designated by the USEPA as **non-attainment areas.**

Bordentown City is located in Burlington County, which is situated in the Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD non-attainment area for failing to meet the national ambient air quality standard for the air pollutant Ozone.

Ozone can be formed when a mixture of oxygen and nitrogen dioxide is exposed to bright light. Such mixtures occur in the polluted air of large cities. On sunny days where nitrogen dioxide pollution from traffic is high, the concentration of ozone in the air can reach levels that are dangerous for plants, animals, and people.

Burlington County: Exposure to Criteria Air Pollutants

1999 Emissions Summary of Criteria Air Pollutants for Burlington County
(expressed in tons of pollutant emitted)

Source	Carbon monoxide	Nitrogen oxides	PM-2.5	PM-10	Sulfur dioxide	Volatile org. compounds
Mobile	77,874	13,999	1,708	5,231	1,294	7,672
Area	8,385	3,735	1,422	3,407	1,388	7,408
Point	3,725	27,836	47	61	388	2,682
All Sources	**89,984**	**45,570**	**3,177**	**8,699**	**3,070**	**17,763**

2002 Summary of Pollutant Concentrations

Pollutant	NAAQS Standard	Highest Recorded Concentration	2nd Highest Recorded Concentration	Number of NAAQS Exceedances
Carbon monoxide				
1-hour average	35 ppm	7.6 ppm	7.6 ppm	0
8-hour average	9 ppm	3.6 ppm	2.5 ppm	0
Sulfur dioxide				
24-hour average	0.14 ppm	.019 ppm	.01 ppm	0
Annual mean	0.03 ppm	.004 ppm	0 ppm	0

Hazardous Air Pollutants (HAPs)
Another larger group of pollutants, called air toxics, are likely to be emitted into the air in quantities that are large enough to cause adverse health effects. In 1990 the U.S. Congress amended the federal Clean Air Act to address a list of 188 of these air toxics by developing control technology standards. This particular group of air toxics is known as Hazardous Air Pollutants (HAPs). The USEPA recently completed an analysis which provides estimates of what the exposure to more than 30 hazardous air pollutants might have been throughout the country in 1996. This analysis is part of the National-Scale Air Toxics Assessment (NATA).

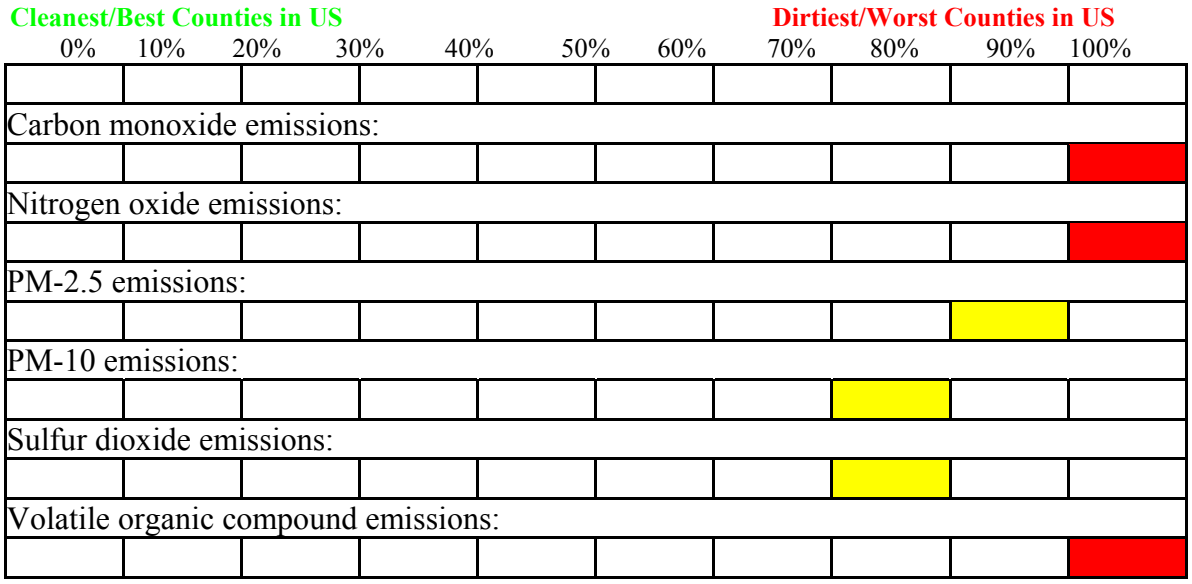
The 1996 Emission Inventory

As part of the NATA, USEPA prepared a comprehensive list of air toxics emissions for the entire country in 1996. Although there are bound to be some errors in the details of a massive undertaking such as this, a summary of the emissions inventory can give some indication of what may be the most important sources of air toxic emissions in New Jersey and Burlington County. Health risk assessment from hazardous air pollutants also involves uncertainties. Risk estimates are calculations based on models; they are useful for ranking purposes but are not necessarily predictive of any actual individual's risk of getting cancer or other diseases.

Based on the EPA's 1996 Emissions Inventory, Burlington County ranked among the dirtiest/worst 10% of all counties in the U.S. in terms of non-cancer hazards from hazardous air pollutants. Burlington County ranked 12th of the 21 counties in New Jersey. The approximately 420,000 people living in Burlington County face a cancer risk more than 100 times the goal set by the Clean Air Act. Mobile sources contribute to 81% of the air cancer risk. Point sources contribute to 11% of the air cancer risk. Area sources contribute to 8.4% of the air cancer risk.

In addition to cancer, hazardous and criteria air pollutants have recognized links to respiratory illness, and reproductive as well as developmental (relating to children) toxicity. Other suspected health links include cardiovascular, gastrointestinal and musculoskeletal problems.

Air Quality Rankings: Health Risks, Exposure, Emissions for Burlington County



Air Quality Index

The USEPA monitors air quality through the use of the Air Quality Index (AQI). The AQI is an index for reporting daily air quality. It reports how clean or polluted the air is, and what associated health concerns people should be aware of. The EPA uses the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, the EPA has established national air quality standards to protect against harmful health effects.

An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. So, AQI values below 100 are generally thought of as

satisfactory. When AQI values are above 100, air quality is considered to be unhealthy—at first for certain sensitive groups of people, then for everyone as AQI values get higher.

The EPA has divided the AQI scale into six categories, shown below:

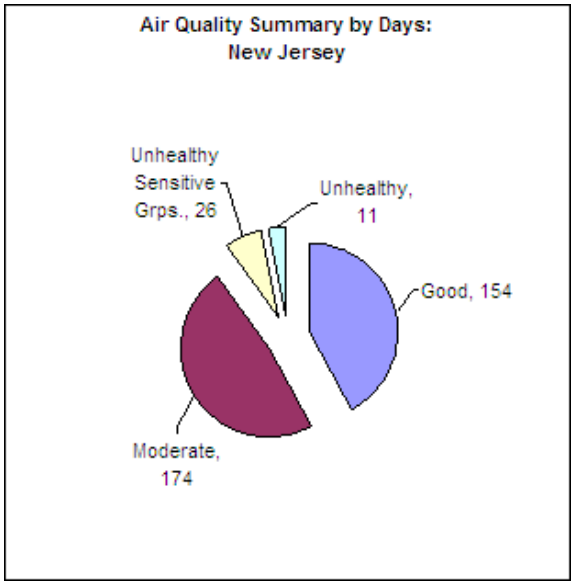
Air Quality Index (AQI) Values	Levels of Health Concern
When the AQI is in this range:	*...air quality conditions are:*
0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for Sensitive Groups
151 to 200	Unhealthy
201 to 300	Very Unhealthy
301 to 500	Hazardous

In many U.S. communities, AQI values are mostly below 100, with values greater than 100 occurring several times a year. Several metropolitan areas in the United States have more severe air pollution problems, and the AQI in these areas may often exceed 100. AQI values higher than 200 are very infrequent, and AQI values above 300 are extremely rare.

AQI values can vary significantly from one season to another. In winter, for example, carbon monoxide is likely to be the pollutant with the highest AQI values in some areas, because cold weather makes it difficult for car emission control systems to operate effectively. In summer, ozone is the most significant air pollutant in many communities, since it forms in the presence of heat and sunlight. AQI values also can vary depending on the time of day. For example, ozone levels often peak in the afternoon, while carbon monoxide is usually a problem during morning or evening rush hours.

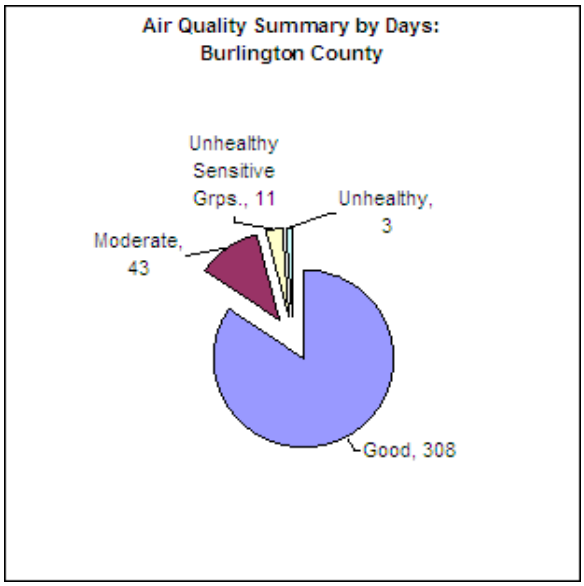
2001 AQI Summary: State of New Jersey

A summary of the AQI ratings for New Jersey in 2001 is presented in the pie chart on page 11. In 2001 there were 154 “Good” days, 174 were “Moderate”, 26 were rated “Unhealthy for Sensitive Groups”, 11 were considered “Unhealthy”, and none were rated “Very Unhealthy”. This indicates that air quality in New Jersey is considered good or moderate most of the time, but that pollution is still bad enough to adversely affect some people on about one day in ten.



2001 AQI Summary: Burlington County

A summary of the AQI ratings for Burlington County in 2001 is presented in the pie chart below. In 2001 there were 308 "Good" days, 43 were "Moderate", 11 were rated "Unhealthy for Sensitive Groups", 3 were considered "Unhealthy", and none were rated "Very Unhealthy". This indicates that air quality in Burlington County is considered good to moderate most of the time. When compared to the figures for the entire state, Burlington County has more "Good" days and less "Unhealthy" days.



The 19 Air Toxics of Greatest Concern in New Jersey

In order to determine whether the New Jersey air concentrations predicted for the 33 air toxics in USEPA's 1996 NATA presented a potential problem for human health, New Jersey Department of Environmental Protection (NJDEP) compared them to their chemical-specific health benchmarks. To do this, they divided the modeled air concentration by the health benchmark concentration to get a number called a risk ratio. If the risk ratio for a specific chemical is less than one, the air concentration does not pose a health risk. If it is greater than one, it may be of concern. The risk ratio also shows just *how much* higher or lower the estimated air concentration is than the health benchmark.

The preliminary analysis of the state and county average air toxics concentrations generated by NATA indicates that 19 of the chemicals were predicted to exceed their health benchmarks in one or more counties in 1996. 18 of these are cancer-causing chemicals. Predicted concentrations of these 19 pollutants vary around the state, depending on the type of sources that emit them. This is summarized in the table below.

Pollutant of Concern	Extent	Primary Source of Emissions
Benzene	Statewide	Mobile; Background Concentration
1,3-Butadiene	Statewide	Onroad Mobile
Carbon tetrachloride	Statewide	Background Concentration
Chloroform	Statewide	Background Concentration; Point
Diesel particulate matter	Statewide	Nonroad Mobile
Ethylene dibromide	Statewide	Background Concentration
Ethylene dichloride	Statewide	Background Concentration
Formaldehyde	Statewide	Mobile
Acrolein	20 Counties	Mobile
Polycylic organic matter	20 Counties	Area
Chromium compounds	17 Counties	Area
Acetaldehyde	13 Counties	Mobile
Perchloroethylene	11 Counties	Area; Background Concentration
7-PAH	5 Counties	Area
Arsenic compounds	4 Counties	Area; Point
Cadmium compounds	4 Counties	Area
Nickel compounds	4 Counties	Area
Beryllium compounds	1 County	Area
Hydrazine	1 County	Area

Note: Of the 19 chemicals listed in the chart above, only the last 5 chemicals do not exceed their health benchmarks in Burlington County.

For a more detailed summary of statewide and Burlington County averages of air toxics concentrations, their risk ratios, and their sources, see the table in Appendix A (1996 NATA Modeled Air Concentrations Compared to Health Benchmarks).

For a more detailed description of point source emissions by facility in Burlington County, see Appendix B (1999 Emissions of Criteria Pollutants by Facility in Burlington County).

Summary

Bordentown City is located in the bend of the Delaware River, nestled between Mercer County to the north, Bucks County to the west and Burlington County to the south and east. These counties are home to power plants, steel mills, army and air force bases, and a wide array of industry which are point sources of air pollution. Furthermore, emissions from the hundreds of thousands of cars and trucks that pass by Bordentown City are a primary cause of mobile source pollution for our community. The vicinity of our community to the New Jersey and Pennsylvania Turnpikes, Interstates 295 and 195, and Routes 130 and 206, has a detrimental impact on the local air quality. Additional factors, such as local businesses like dry cleaners and gas stations, poorly affect the air. When all of these sources are taken in to consideration, the quality of the air that residents breathe can be considered in jeopardy and already a health risk for some.

Geology

The New Jersey Coastal Plain is composed of a wedge of sediments that can be divided into units or formations. The geologic formations comprising the older basal beds beneath Bordentown City were deposited 70 to 100 million years ago, during the Upper Cretaceous Period. In general, these formations are exposed at the surface according to age (older to younger) from west to east as shown in GIS Map 1.

The *Potomac Formation*, also referred to as the *Raritan Formation*, comprising the substratum of the alluvial/tidal marsh deposits in the Delaware River channel at the mouths of Blacks and Thorntown Creeks, and Mile Hollow Run. Near Bordentown this unit consists largely of thick beds of light-colored sands and massive to thick-bedded variegated (red, white, yellow) silty clays, although exposures are rare because of the widespread cover of surficial sediments. It is the basal unit of the Coastal Plain, in this area overlying basement rocks of Early Paleozoic age (439-570 million years ago). Both the Potomac and the Raritan represent a wide variety of depositional environments, from continental to marine, although in the Bordentown area this unit is generally lacking in fossils. The Potomac/Raritan formation serves as the water source for Bordentown City and Township, representing the middle aquifer of the Potomac-Raritan-Magothy (PRM) aquifer system.

The *Magothy Formation* forms the substratum along the western edge of the City, and along Blacks Creek. Throughout most of New Jersey, the Magothy consists of several variable units, also representing part continental and part marine depositional environments. In the Bordentown area it is about 30 to 50 feet thick, consisting of rapidly lensing dark clays and light colored cross-bedded sands that are well exposed in the striking bluffs along the Delaware River and Crosswicks Creek, and along Mile Hollow Run. The Magothy serves as the upper aquifer in the PRM system.

The *Merchantville Formation* forms the heavy substratum for most of Bordentown City. It consists of a black, glauconitic micaceous clay and silty clay, with a massive structure and greasy appearance, that "weathers to a coherent brown earth" (Wolfe, 1977). In the Bordentown area it is thicker bedded and more glauconitic than further east. The best exposures of the Merchantville are in the tributaries on the west side of Blacks Creek (Owens and Minard, 1964). It is a marine shelf deposit, about 50 feet thick, formed during the first advance of the sea onto the coastal plain during the Cretaceous, and is the oldest glauconitic unit to outcrop in New Jersey. A diverse assemblage of casts and molds of marine fossils such as ammonites and mollusks are common.

Merchantville Formation, Blacks Creek

A small area of the *Woodbury Clay* underlies the eastern edge of town, south of Thorntown Creek. It is a thick, massive, dark gray, micaceous clayey silt, with more clay and less greensand than the underlying Merchantville. Small particles of pyrite, an iron sulfide mineral, are locally abundant, and upon oxidation can create extremely acid conditions. The Woodbury is approximately 50 feet thick near Bordentown, and is interpreted as a marine inner shelf deposit. The fine textured material is commonly used as landfill liner due to its slow permeability, and the formation is famous for producing (in Haddonfield in the 1860's) the bones of *Hadrosaurus foulkii*, the first dinosaur skeleton to be mounted and displayed publicly.

Outcrops of these older formations may be seen in cutbanks along streams, or material can be exposed during excavations. In many areas, these deposits are covered by younger, surficial materials.

Greensand

South Jersey's claim to mineralogic fame might be its "greensand marl" deposits, stretching across the inner coastal plain from Monmouth to Salem Counties. Greensand deposits contain the mineral glauconite, a dioctahedral iron-rich layer silicate similar to illite, commonly found as a green to black pellet of micaceous clay. Glauconite was formed in an offshore marine environment during the Tertiary and Cretaceous periods, 45 to 85 million years ago. Greensand deposits often contain phosphorus and calcium carbonate, high amounts of some trace elements, and in some cases pyrite, which can create extremely acid, or "poison marl," conditions. The greensand belt includes the Merchantville formation, which makes up much of the substratum of Bordentown City.

Glauconite-bearing soils are among the best agricultural soils in the state, and greensand has been used as a soil amendment in NJ since the 1760's. Although once considered a valuable potash source, its real benefit is to soil physical properties, through increased water and nutrient holding capacity. Greensand use peaked in the late 1800's, when up to 1 million tons were dug per year, with application rates of 20 to 50 tons per acre. As late as 1923 there were still about 80 active greensand pits in New Jersey, but with the advent of chemical fertilizers, the industry faded. Glauconite has found other uses through the years as a binding additive for brick making, in the production of green glass, and as a water softener.

Glauconite is still used in water treatment, and the only remaining commercial greensand producer in the US is the Inversand Corporation in Sewell, Gloucester County. Manganese-coated greensand is used by the Bordentown water treatment plant to remove iron, manganese, and hydrogen sulfides from groundwater. Inversand also supplies a Pennsylvania company, Fertrell, which markets a greensand soil conditioner. The Sewell pit, like most greensand deposits, has also been an extremely valuable site for Cretaceous and Tertiary fossils.

Surficial deposits in the Bordentown City area include:

The *Arkose 1* of Owens and Minard (1975), also known as the *Pensauken Formation*, which covers the western edge of the City, south of Thorntown Creek. It is an orange to reddish brown gravelly sand, with minor silt and clay, which can be locally glauconitic. It is believed to have been deposited between 2 and 10 million years ago (Pliocene to Upper Miocene) by the stream system that was an extension of the Hudson River (Owens and Sohl, 1969).

Greensand 2 (Owens and Minard, 1975), mapped in pockets in central and north central Bordentown City, is described as a yellow-green to light olive brown glauconitic sand with basal beds of yellow brown gravel, of Pleistocene age (1.75 million to 10,000 years ago).

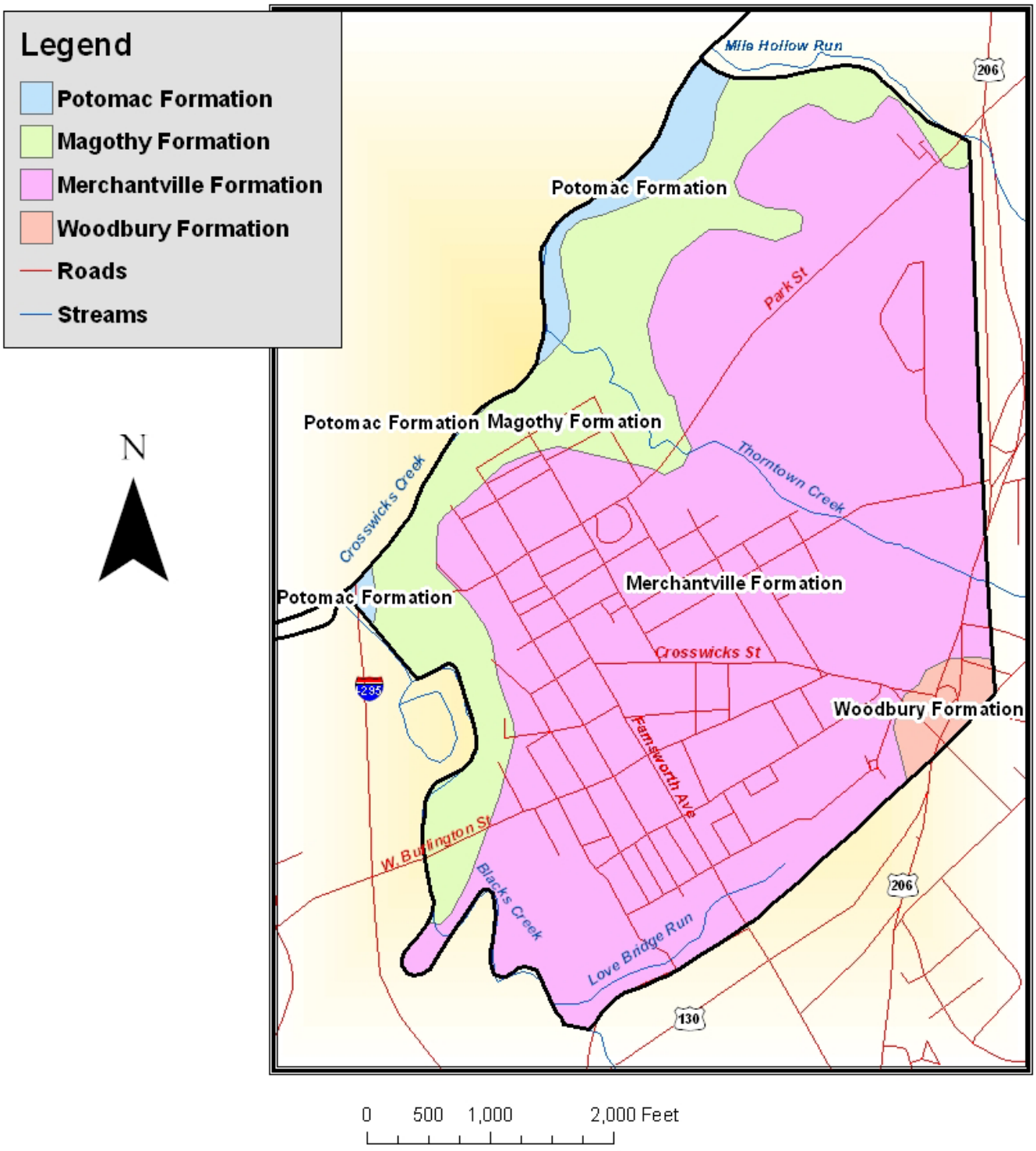
Fluvial deposits at Spring Lake, mapped by Newell et al. (2000) as covering a large portion of residential Bordentown City. These are part of the Trenton Gravel, and are described by Owens and Minard (1979) as gray to pale reddish brown interstratified sands and gravelly sands, lacking the iron staining and cementation found in the Pensauken and Bridgeton formations, and generally less weathered. They are estimated also of Pleistocene age, reworked glacial debris from the Illinoian stage, or older.

More recent deposits include:

Alluvial/flood plain deposits of sand, silt, clay and gravel in stream channels.

Freshwater tidal marsh deposits composed of organic matter, tidal deposited silts and clays, and fluvial sands.

Human Deposited dredge spoils along the Delaware River, commonly placed over tidal marsh areas.



GIS Map 1. Bedrock Geology

Soils

Soils perform essential functions in maintaining environmental health and quality, including:

- Sustaining biological activity, diversity, and productivity;
- Regulating and partitioning water and solute flow;
- Filtering, buffering, degrading, immobilizing and detoxifying organic & inorganic materials;
- Storing and cycling nutrients and other elements;
- Providing support for socioeconomic structures.

As soils vary in their physical, chemical, and mineralogical properties, their capability to perform these important functions also varies. Soils can also be degraded, e.g., through erosion, contamination, and compaction, which can affect their ability to function. Knowledge of soil distribution patterns and soil properties can help to put our soils to their best use and keep them functioning optimally.

In general, soils of the coastal plain are formed in unconsolidated deposits of sand, silt, clay, and gravel, predominantly of fluvial and marine origin. A soil survey for Burlington County was issued by the USDA Soil Conservation Service in 1971, and updated slightly upon digitization in 2003 (see GIS Map 2). Five soil series and seven miscellaneous areas were originally mapped in Bordentown City. Soils in a series generally have the same sequence of horizons, have the same drainage class, are formed from the same type of parent material, and have similar physical and chemical properties. Soil series are further separated by surface texture, substratum, and slope into phases which serve as mapping units. Soil series and their substratum phases mapped in Bordentown can be differentiated as follows:

Texture & Mineralogy	**Drainage Class**	
	Well-drained	Moderately well-drained
moderately coarse, low glauconite	***Freehold***	***Holmdel***
moderately coarse, low glauconite, heavy substratum	***Freehold clayey substratum***	
thick sandy surface, moderately coarse subsoil, low glauconite	***Tinton***	
heavy subsoil, low glauconite		***Keyport***
moderately coarse, no glauconite,	***Sassafras***	
moderately coarse, no glauconite, heavy substratum	***Sassafras clayey substratum***	

Table 1: Soils in Bordentown City

Two soil series (and two map units) make up most of the area of residential Bordentown City: Sassafras fine sandy loam, clayey substratum, 0 to 2 percent slopes (SaekA); and Freehold fine sandy loam, clayey substratum, 2 to 5 percent slopes (FrmkB). The approximate acreage and proportional extent of the soils and miscellaneous areas mapped in Bordentown City are listed in Table 2. The limitations for these soils for some community development and recreational uses are given in Table 3.

Sassafras soils are moderately coarse-textured with little or no glauconite. Permeability and available water capacity are moderate. Soil reaction is extremely acid to strongly acid, unless limed. These soils have formed in old stream deposits, and are generally associated with the Pensauken formation. The subsoil has distinctly more clay than the surface layer, and these soils are well drained, i.e., the water table is below 40 inches during most or all of the growing season. Nearly all of the Sassafras soil in the inner Coastal Plain was once farmland, but now much of it has been developed for residential and commercial use. Hydrologic Soil Group is B.

Sassafras Soil, Railroad Avenue

Sassafras fine sandy loam, clayey substratum, 0 to 2 percent slopes (SaekA) is the predominant soil mapped in the residential portion of Bordentown City. In this area, the clayey substratum is generally part of the Merchantville formation and often contains glauconite, with textures ranging from heavy silty clay loam to silty clay to clay. This layer has slow permeability, and water perches on it, or moves laterally, after heavy rains. This zone is normally found at a depth of 40 to 60 inches, but in some areas in Bordentown City it is only 30 inches or so from the surface. Because of the substratum, this soil has severe limitations for septic systems.

There is a small section of Sassafras soil without the clayey substratum. *Sassafras fine sandy loam, 2 to 5 percent slopes* (SaeB) is found along the eastern edge of the City, in a residential section just east of Route 130 and north of Route 528. It is essentially the same soil as above, except the substratum in this phase has moderate permeability.

Freehold soils are similar to Sassafras, but contain 2 to 10 percent (by volume) of glauconite in the solum. This increases water and nutrient holding capacity; as a result Freehold soils rank among the best agricultural soils in the state. They are well drained, with moderate or moderately slow permeability, and a moderately high or high available water capacity. Soil reaction is extremely acid to strongly acid, unless limed. Hydrologic Soil Group is B.

Freehold fine sandy loam, clayey substratum, 2 to 5 percent slopes (FrmkB) is mapped in the northeastern portion of residential Bordentown City. These soils have the slowly permeable substratum similar to the above Sassafras: a thick, dark gray deposit that is part of the Merchantville formation. Freehold soils without the clayey substratum are found in the northwestern part of the City. Most of the area mapped as *Freehold fine sandy loam, 0 to 2 percent slopes* (FrmA) is occupied by the Park Street Apartments, with *Freehold fine sandy loam, 2 to 5 percent slopes* (FrmB) covering much of the landscaped open space (lawn area) of the Divine Word property.

Freehold fine sandy loam, 5 to 10 percent slopes (FrmC) comprises a wooded area along Mile Hollow Run.

Keyport soils have a moderately fine or fine-textured subsoil, with varying amounts of glauconite. They have a high available water content and slow permeability. These soils are moderately well drained, i.e., they have a water table between 18 and 40 inches for a significant period of time during the growing season. Soil reaction is extremely acid to strongly acid, unless limed. Hydrologic Soil Group is C. In Bordentown City, Keyport soils are found on steep slopes where streams have exposed the marine clay beds of the Merchantville and Magothy formations.

Keyport loam, 5 to 10 percent slopes (KeoC), is found along Blacks and Thorntown Creeks.
Keyport loam, 10 to 15 percent slopes (KeoD) is also found along Blacks and Thorntown Creeks.
Keyport loam, 15 to 25 percent slopes (KeoE) is found on the exposed bluffs of the Magothy Formation along Crosswicks Creek.

Holmdel soils are moderately well drained, moderately coarse-textured, with 2-10% glauconite in the solum. They have a moderately high or high available water capacity, and a moderate or moderately slow permeability. Soil reaction is extremely acid to strongly acid, unless limed. Hydrologic Soil Group is C. *Holmdel fine sandy loam, 0 to 2 percent slopes* (HodA) is mapped on the northern edge of city, a wooded area along Mile Hollow Run.

Tinton soils are well drained with a thick sandy surface layer over a moderately coarse-textured subsoil containing 2-10% glauconite. They have a low or very low available water content, and a moderately rapid permeability. Soil reaction is extremely acid to strongly acid, unless limed. Hydrologic Soil Group is A. *Tinton sand, 5 to 10 percent slopes* (ThfC) is also mapped on the northern edge of the City, in a woodland area along Mile Hollow Run.

Miscellaneous areas have little or no natural soil, are difficult to access for orderly examination, or for other reasons, are difficult to classify. They can be characterized by disturbance, recent deposition, or highly variable composition. Four of the seven original miscellaneous areas mapped in Bordentown City have since been reclassified to higher level.

Miscellaneous areas found in Bordentown City include:

Fluvaquents, loamy, frequently flooded (Fmht), formerly *Alluvial land, loamy*, consist of stream deposits in areas adjacent to meandering perennial streams that are subject to frequent stream overflow. Drainage class can range from moderately well drained to very poorly drained, and soil textures can vary, but a sandy loam surface is common. Fluvaquents, or alluvial land, can be found in the Blacks and Thorntown Creek floodplains, generally adjacent to tidal marsh areas.

Udorthents, dredged fine material (Udmf), formerly *Made land, dredged fine materia*l, consist of those areas filled with fine material dredged from the Delaware River, mostly derived from the thick clay beds of the Magothy formation. The Bordentown Beach area is composed of dredged material.

Udorthents, refuse substratum (Udz), formerly *Made land, sanitary fill*, consist of small areas of rubbish disposal, covered with variable amounts of soil. A small delineation is found in the northern part of the City on the Divine Word Missionaries property.

Mannington-Nanticoke complex, very frequently flooded (Mamnv), formerly *Tidal marsh*, are those areas of freshwater tidal marsh wetlands along the Delaware River and its tributaries which are flooded twice daily. These are very productive, diverse ecosystems that serve as feeding and breeding areas for birds, mammals, and crustaceans, and are important in flood control and in filtering storm water and runoff before entering surface waters. The soils are generally high in organic matter and clay, which gives them an appreciable adsorptive capacity, and are anaerobic, except for a thin surface layer. Soil reaction is generally close to neutral. More recent Soil Surveys use the Mannington and Nanticoke series for these marshes. Areas of Tidal marsh in Bordentown City are found along Blacks and Crosswicks Creeks.

Tidal Marsh, Blacks Creek, west of Oliver St.

Pits, sand and gravel (PHG) are excavation sites for sand or gravel, ranging from 4 to 20 feet deep. A small delineation is found in the northern part of the City on the Divine Word Missionaries property.

Urban land, sandy (USD) consists of cut and fill areas developed for commercial, residential, or industrial use, now covered with a high proportion of impervious surface. This area is occupied by Ocean Spray facilities.

Urban land, clayey substratum (USF) consists of cut areas where the heavy clay sediments of the Merchantville formation had been exposed, and are now covered with a high proportion of impervious surface. In Bordentown City, this area is along Routes 206/130 near the intersection with Route 528.

Bordentown Beach/Boat Ramp area (Udorthents, dredged fine material)

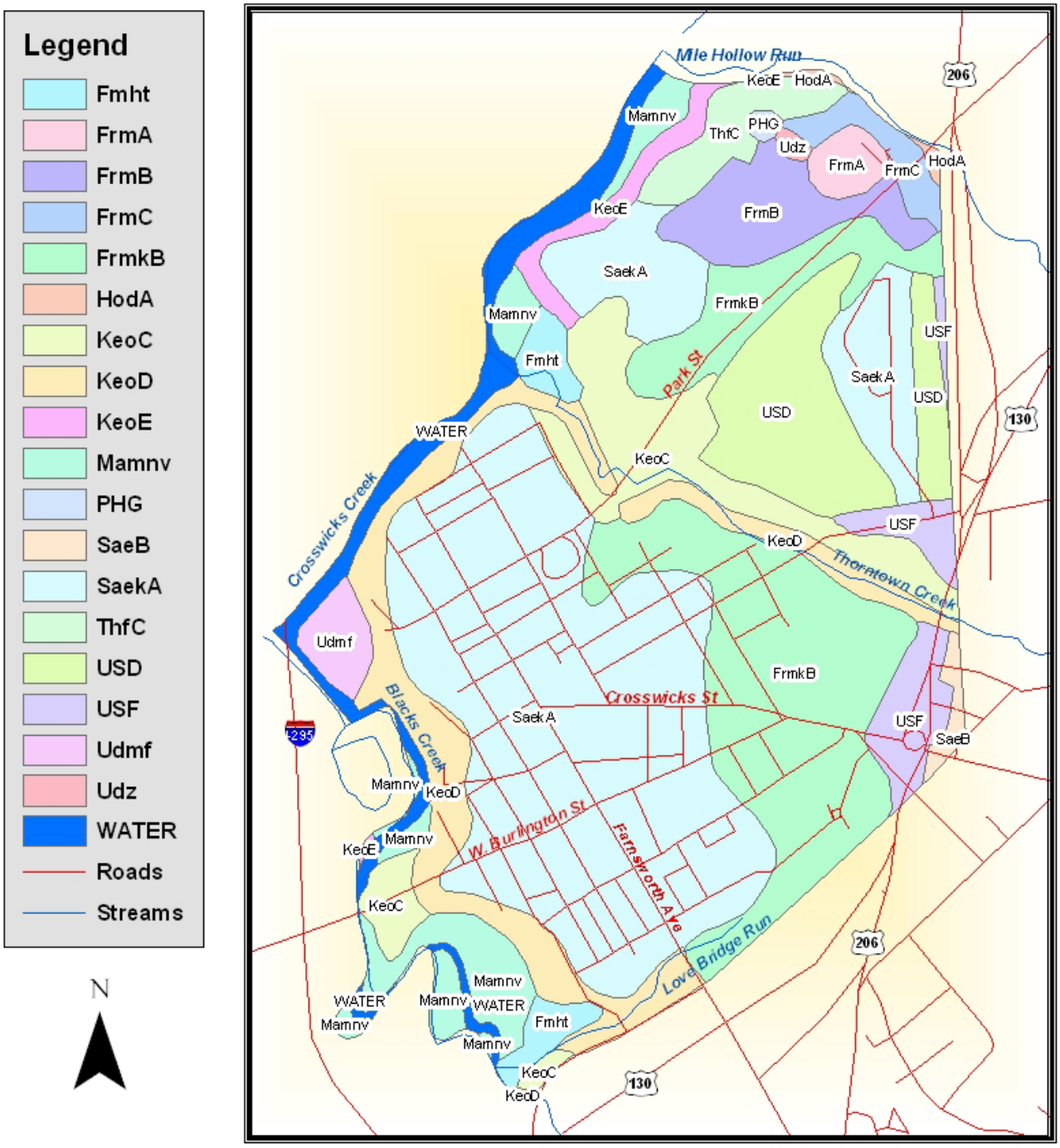
Tidal marsh, mouth of Thorntown Creek (Mannington-Nanticoke complex, frequently flooded)

Symbol	Map unit	Acres	Percent
Fmht	*Alluvial land. loamy*	13.7	2.4
FrmA	*Freehold fine sandy loam, 0 to 2 percent slopes*	5.7	1.0
FrmB	*Freehold fine sandy loam, 2 to 5 percent slopes*	22.5	3.9
FrmC	*Freehold fine sandy loam, 5 to 10 percent slopes*	43.7	7.6
FrmkB	*Freehold fine sandy loam, clayey substratum, 2 to 5 percent slopes*	106.8	18.5
HodA	*Holmdel fine sandy loam, 0 to 2 percent slopes*	4.5	0.8
KeoC	*Keyport loam, 5 to 10 percent slopes*	7.0	1.2
KeoD	*Keyport loam, 10 to 15 percent slopes*	44.0	7.6
KeoE	*Keyport loam, 15 to 25 percent slopes*	12.8	2.2
Udmf	*Made land, dredged fine material*	7.5	1.3
Udz	*Made land, sanitary fill*	1.1	0.2
Mamnv	*Tidal marsh*	25.6	4.6
PHG	*Pits, sand and gravel*	1.1	0.2
SaekA	*Sassafras fine sandy loam, clayey substratum, 0 to 2 percent slopes*	211.1	36.6
SaeB	*Sassafras fine sandy loam, 2 to 5 percent slopes*	4.0	0.7
ThfC	*Tinton sand, 5 to 10 percent slopes*	13.2	2.3
USD	*Urban land, sandy*	44.3	7.9
USF	*Urban land, clayey*	7.7	1.3

Table 2. Approximate acreage and proportional extent of the soils and miscellaneous areas in Bordentown City

Map unit	Dwellings with basements	Local roads & streets	Playgrounds	Paths & trails
FrmA	slight	moderate (frost action)	slight	slight
FrmB	slight	moderate (frost action)	moderate (slope)	slight
FrmC	slight	moderate (frost action, slope)	severe (slope)	slight
FrmkB	moderate (wetness)	moderate (frost action)	moderate (slope)	slight
HodA	severe (wetness)	severe (frost action)	moderate (wetness)	moderate (wetness)
KeoC	severe (wetness)	severe (frost action)	severe (slope)	moderate (wetness)
KeoD	severe (wetness)	severe (frost action)	severe (slope)	moderate (wetness)
KeoE	severe (wetness, slope)	severe (frost action)	severe (slope)	moderate (wetness, slope)
SaeB	slight	moderate (frost action)	slight	slight
SaekA	moderate (wetness)	(moderate (frost action)	slight	slight
ThfC	moderate (slope)	moderate (slope)	severe (slope, sandy surface)	severe (sandy surface)

Table 3. Soil limitations for some community development and recreational uses.



GIS Map 2. Soils

Steep Slopes

Slopes serve important natural, aesthetic and planning functions, such as abating noise, light or air pollution; buffering wind, rain and snow; providing a pleasing, distinctive setting; and acting as visual barriers between different development zones. Vegetated hillsides can serve as buffer areas that absorb the force of wind-driven rain and snow. They provide harmonious settings for human communities. And they can help offset some noxious effects of human activity--diminishing air, light and noise pollution.

The natural stability of slopes is determined by:

- steepness (described as a percentage based on the amount of rise over a certain distance-a 10 percent slope rises one foot over a 10 foot distance);
- length;
- subsurface geology;
- soil characteristics, such as erodibility, compactibility, percolation rate, water retention capacity, fertility;
- amount and type of vegetative cover;
- climate (precipitation, wind, freezing and thawing).

Slope can be a major constraint on land use. Areas with slopes as low as 5 percent are unsuitable for athletic fields and playgrounds; 10 to 15 percent can be restrictive for roads and streets, and those over 15 percent are problematic for dwellings. Removal of vegetation in areas with over 10% slope can result in severe erosion and mass movement of soil materials. In addition to the loss of valuable soil material, erosion also creates a water pollution problem. Local ordinances are common in New Jersey which limit development in areas with slopes greater than 15 or 25%.

The Results of Disturbing Slopes

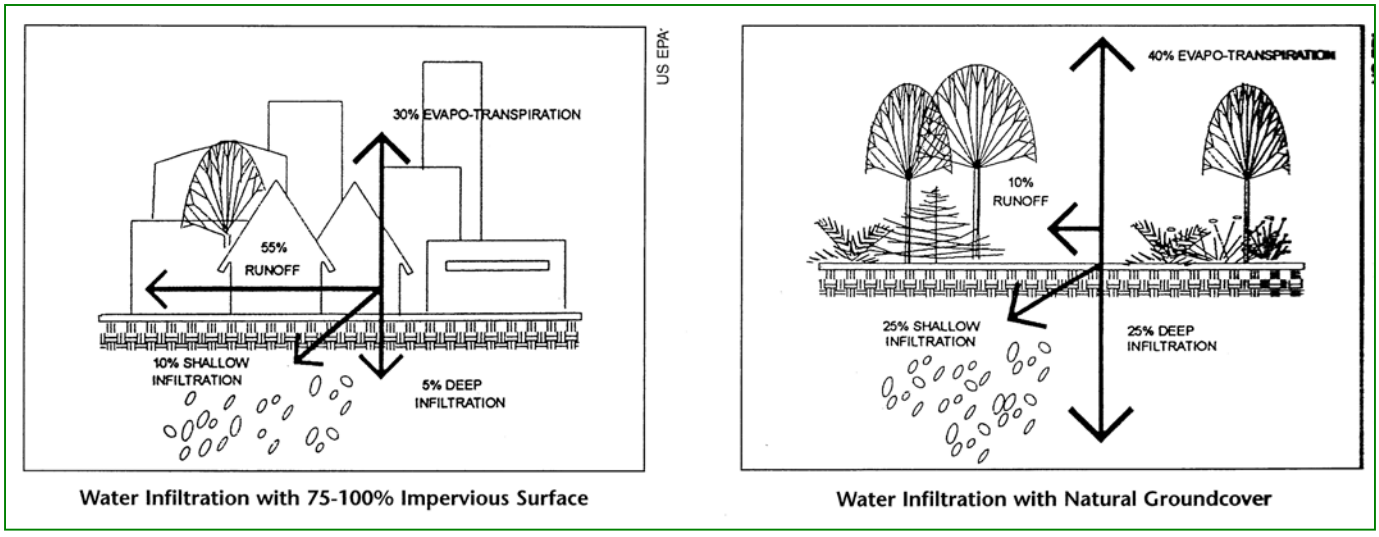
Disturbing the plant life, drainage patterns, topography or soils of slopes often increases the amount and speed of runoff and can cause erosion, soil creep, slumping (sections of soil shifting down and outward on the slope), and landslides. When a hillside is cleared, the usual result is more and faster runoff, especially when grading has smoothed a slope's natural roughness. Leaves and branches no longer shield the soil from wind and rain; roots no longer hold the soil in place; and the smoother slope allows the runoff to travel faster, thus increasing erosion and decreasing groundwater recharge. These problems become progressively worse on steeper slopes.

Runoff carries eroded sediments to lowland areas, to wetlands, ponds and streams, where the resulting turbidity and siltation can damage or destroy aquatic life and disrupt the ability of wetlands to filter and purify water. This combination of increased runoff and stream siltation affects the ability of streams and wetlands to retain water, changing the pattern and rate of the water's rise and fall and causing increased flooding.

Changing topography by excavating or grading the foot of a slope or cutting into the face of a hillside often promotes instability and erosion. Erosion, slippage or excessive runoff may also result when existing soils are replaced with soils more suited for septics or lawns. Soils on ridgelines and steep slopes often are thin and susceptible to wind and water erosion. Only specialized vegetation thrives in these conditions; conventional landscaping usually does not and may require excessive upkeep.

Steep, eroding slope, Mile Hollow Run

Steep, eroding slope, Thorntown Creek



Water Infiltration with 75-100% Impervious Surface

Water Infiltration with Natural Groundcover

In any case, even a brief denuding of ridgelines and steep slopes can cause soil losses that will discourage any regrowth of plant life and habitat.

Dramatic runoff problems often result when slopes are covered with impervious surfaces, such as buildings, roads, driveways and parking lots. Since water can't percolate into the soil, it runs off the site, picking up speed as it travels across these smoother surfaces. Eroding surrounding soils, this high velocity runoff carries increased amounts of silt into nearby surface waters. Excessive runoff sometimes also results in flooded or icy conditions in parking lots and roads.

In addition to the obvious problems of runoff, erosion and landslides, altering the soils or vegetation on slopes may also reduce the percolation of water into the soil and disrupt the recharge of groundwater and aquifers. Aquifers in areas of steep bedrock, like parts of northern New Jersey, do not contain much water. Poorly designed or excessive development that disrupts aquifer recharge while increasing the demand for water for human consumption can result in periodic or permanent water shortages.

Aquifers can also be damaged by the heavy road salting typical in hilly areas and from septic installation on slopes, where soils are thin or otherwise unsuitable for leach fields. In such areas, septic effluent may seep out on the face of the hillside.

Grading hillsides and ridgelines sometimes alters drainage divides, sending more runoff in one direction and less in another. Clearing and grading may even alter the local climate, changing the path and severity of wind, precipitation, noise and pollution.

Local regulations can address some of these problems, but designing, building and maintaining development on steep slopes will inevitably mean higher costs for the developer and for the municipality. Problems often come to light after construction is finished and the developer is gone. Then the municipality may be stuck with burdensome costs for stormwater management, septic failures, sewering, winter storm maintenance, construction of public water systems, or fire and emergency services.

Steep Slopes in Bordentown City

In general, landscapes of the Coastal Plain exhibit less relief than those in North Jersey. Unlike areas of exposed bedrock, the highly erosive nature of unconsolidated sandy sediments precludes the formation of steep slopes.

According to the Soil Survey (GIS Map 2), slopes in most of residential Bordentown City are characterized by nearly level A (0 to 2%) and gently sloping B (2 to 5%) classes, where Sassafras and Freehold soils are underlain by the clayey substratum of the Merchantville formation. Strongly sloping (5 to 10%) Tinton and Freehold soils are found in wooded areas along Mile Hollow Run, above the Magothy formation. The steepest slopes in the City are along streams where the clayey substratum has been exposed, and, due to the cohesive forces of the clay, can hold the banks together to resist erosion. Strongly sloping (5 to 10%) and very strongly sloping (10 to 15%) Keyport soils are found along Thorntown Creek in both the Magothy and Merchantville formations, and along Blacks Creek and Love Bridge Run in the Magothy. Keyport soils along Crosswicks Creek are even steeper (15 to 25%), with slope in some areas reaching 50% or more, highlighting the cross-bedded strata of the Magothy.

Steep slope, Crosswicks Creek

Hydrology

The continuous movement of water between the atmosphere and the earth's surface, and beneath the surface, is called the hydrologic cycle. Water from the earth's surface is evaporated into the atmosphere, where it condenses and falls back as precipitation. A small part of this precipitation is intercepted by vegetative cover and lost through evaporation. The water that reaches the soil can be wholly or partly absorbed in the process of infiltration. The rate of infiltration is affected by rainfall intensity, soil conditions, vegetative cover, and the slope of the land. Water that infiltrates is available for plant growth, evaporation, or further movement down through the soil profile. Some of the water taken up by plants is released back into the atmosphere as transpiration. When water is delivered to the surface faster than it can be absorbed, it will move over the surface as runoff. Runoff can erode soil, and can carry this material, along with other dissolved and suspended constituents it accumulates from the soil surface, as non-point source pollution into surface water. Increases in the amount of impervious surface from development result in an increase in the volume of stormwater runoff. Unless control measures are in place, this can bring about downstream flooding, streambank erosion, and severe alteration of drainage patterns.

In a water budget for the Pinelands area of the New Jersey Coastal Plain with an annual precipitation of 45 inches, Rhodehamel (1970) estimated 22.5 inches of evapotranspiration, 20 inches of infiltration, and only 2.5 inches of runoff. The low amount of surface runoff for this area is a result of the high infiltration rate of the sandy soil.

Groundwater

Water beneath the surface can be divided into two main zones, an unsaturated zone and a saturated zone. In the unsaturated zone, pore space is filled with both air and water. The saturated zone, where pore space is filled completely with water, is considered *groundwater*. The upper surface of groundwater is referred to as the *water table*. Groundwater usually excludes the *vadose water*, the water traveling between the surface and the water table. The depth to the water table can range from zero, when it is at the soil surface, to hundreds or even thousands of feet deep. As precipitation is the main source of groundwater, the depth to water table varies seasonally and from year to year. It is generally highest during winter and early spring, and begins to decline with the growing season. The water table is usually near the surface around permanent bodies of surface water such as streams and wetlands. Ground water can interact with each of these types of surface waters in several ways. Streams can gain water from inflow of groundwater through the streambed (ground-water runoff), or lose water to groundwater by outflow through the streambed. A single stream can gain in some places and lose in others. Wetlands can also receive groundwater inflow, have outflow to groundwater, or have both inflow and outflow in different areas.

Rocks and unconsolidated sediments vary widely in their ability to store and transmit water. The water storing capacity is related to the total amount of pore space, or porosity, whereas the transmitting ability is dependent on the interconnection and size of the pores, or permeability. An *aquifer* is a body of permeable rock or sediment capable of storing significant quantities of water, through which groundwater moves. An *aquitard* is a body of rock or sediment with low values of hydraulic conductivity, allowing some movement of water through it, but at rates of flow lower than those of adjacent aquifer. An *aquiclude* is a rock or sediment with very low values of hydraulic conductivity, which, although it may be saturated with groundwater, is almost impermeable with respect to

groundwater flow. In general, sand and gravel beds transmit and store water better than silts and clays. Sands and gravels make the best aquifers, or water-producing bodies, while silts and clays make better confining beds. Aquifers can be *confined*, or surrounded both above and below by slowly permeable or impermeable layers, or *unconfined*, without a slowly permeable or impermeable layer above and more directly.

Within an aquifer, groundwater flows somewhat differently than surface waters. While the latter flow downhill under the influence of gravity, groundwater flows toward areas having lower hydraulic pressure, or "head". Areas having higher hydraulic head, at relatively high elevations in the landscape, are the areas where groundwater is recharged, especially if the soil is sandy or gravelly. Areas with lower head, at lower landscape elevations such as concave areas, valleys or estuaries, are often discharge zones. Groundwater commonly flows upward in these discharge zones, being forced against the pull of gravity by water higher in the aquifer that has greater hydraulic head. Groundwater moves relatively slowly, traveling at a rate between a fraction of an inch and a few tens of feet per year, depending on the permeability of the aquifer. As a result of this extended period of time in which the water is in contact with aquifer materials, groundwater can dissolve many soluble materials.

The Coastal Plain deposits of New Jersey can be classified into a sequence of aquifers and confining units based on the porosity and permeability of the sediments. The Coastal Plain is one of seven aquifers in New Jersey given Sole Source designation, i.e., it is an aquifer which contributes more than 50 percent of the drinking water to a specific area, and the water would be impossible to replace if contaminated. Currently about 75 percent of withdrawals by public-supply water systems in the Coastal Plain are obtained from groundwater.

The Potomac-Raritan-Magothy (PRM) aquifer system is one of the most productive and heavily pumped water bearing units of the Coastal Plain. This system contains three aquifers, the lower, middle, and upper, separated by two confining units. The middle Potomac-Raritan-Magothy aquifer serves as the water source for Bordentown City. On some geologic maps this is referred to as the Raritan formation.

Before the removal of significant amounts of groundwater from the PRM aquifer, higher elevations along the north central edge of the Coastal Plain served as recharge areas, and the outcrop areas of PRM formations along the Delaware River served as discharge areas. Since pumping began, however, groundwater flow has been altered, i.e., the normal flow of groundwater in the aquifer toward the Delaware River has been reversed. Water levels have been lowered in areas of groundwater withdrawal to create “cones of depression” in the water table, and this has eventually induced recharge from the Delaware River. This can potentially affect water quality in the PRM aquifer.

Groundwater recharge can be estimated according to a method by Charles et al. (1993) using climate, soil, and land-use land-cover factors. This does not estimate aquifer recharge, as it includes recharge to both aquifers and non-aquifers. Groundwater recharge by this method is illustrated in GIS Map 3. Areas with the highest recharge potential, in blue, include those wooded areas in the northern part of the City, underlain by soils without the clayey substratum. Infiltration is minimal in urban and industrial areas, and wetland areas (high water table), shown in red.

Groundwater quality

Groundwater in the PRM aquifer is generally of good chemical quality, low in dissolved solids, except for local hardness and high concentrations of iron and manganese. All chloride concentrations in

Burlington County are less than 20 parts per million, as the saltwater front in the Delaware River does not extend beyond Camden. However, a potential source of contamination is the infiltration of pollutants with river water. In general, outcrop areas are susceptible to contamination, especially when the water table is high, and the soil is sandy and low in organic matter. Formations of the Coastal Plain are hydrologically interconnected such that they respond collectively as an interrelated aquifer system.

The NJDEP has performed source water assessment of each source of public drinking water and determined the susceptibility to contamination for each source for eight contaminants. The factors affecting water quality were separated into two categories: *sensitivity factors*, including well type and depth, soil organic matter and clay content, which assess how sensitive the water source is to contamination; and *intensity factors* such as land use, non-point and point sources, which assesses how frequently contaminants are used near the source. The susceptibility rating does not determine if a water source is actually contaminated.

Bordentown City's water supply is drawn from four unconfined wells along the north bank of Crosswicks Creek just east of Route 206 in Hamilton Township, Mercer County. Most of the source, or recharge, area for these wells is located northeast of the wells in Mercer County, a predominantly residential area. The aquifer lies beneath the Magothy formation in much of the recharge area, and in some sections the Merchantville as well.

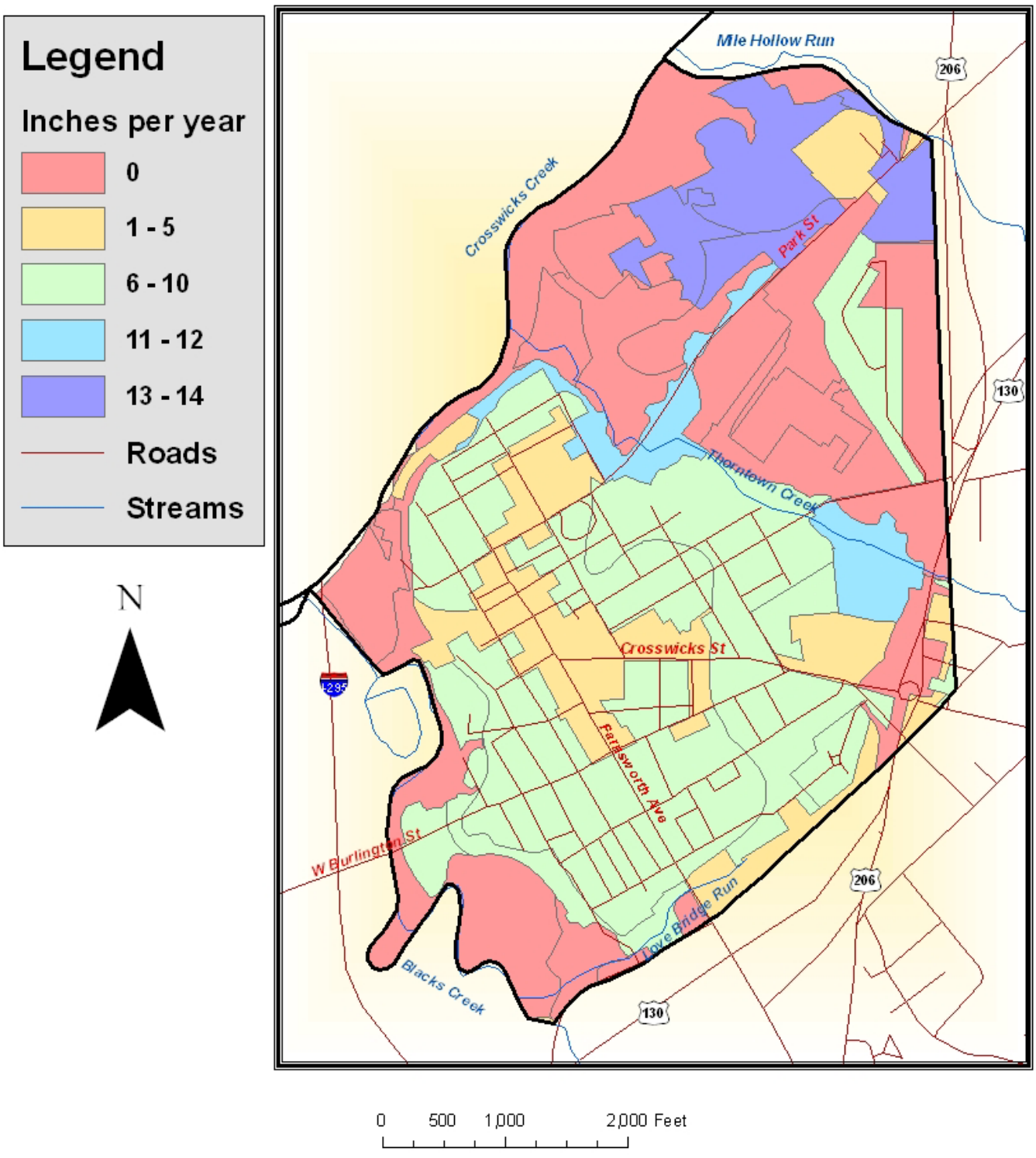
The NJDEP Source Water Assessment Program rating for each of the four wells is shown in the following table:

Pathogens	Nutrients	Pesticides	VOCs*	Inorganics	Radionuclides	Radon	DBP**
4 M	4H	4L	4H	1H; 3M	2H; 2M	4M	3H; 1M

Ratings: L=low; M=medium; H=high

*Volatile Organic Compounds: solvents, degreasers, and gasoline components.
**Disinfection Byproduct Precursors: byproducts of the reaction between disinfectants (e.g., chlorine) and dissolved organic materials.

Many of the ratings reflect the dominant land use (urban) of the recharge area. All four wells are rated as highly susceptible to contamination by nutrients and volatile organic compounds, and low to pesticides.



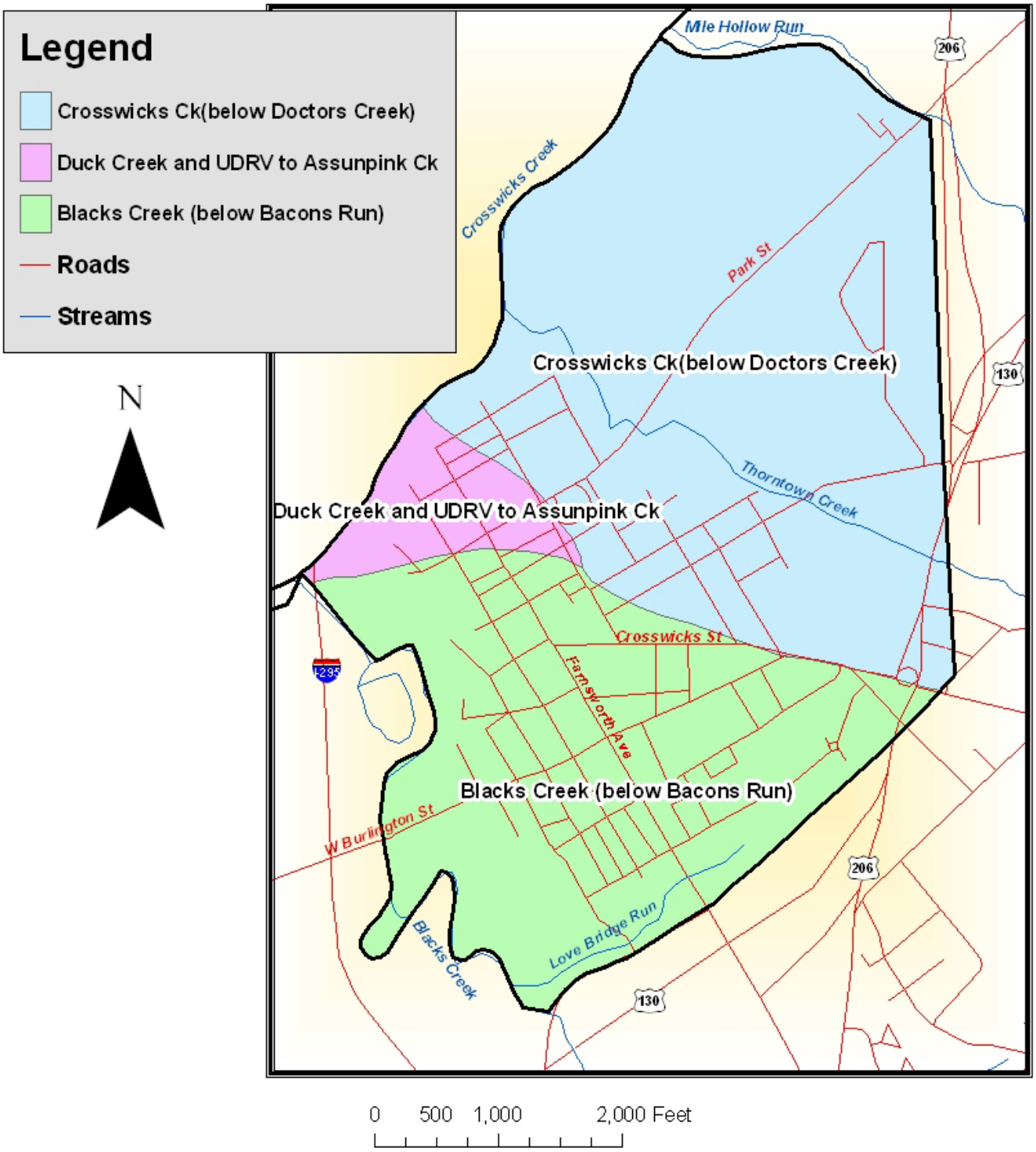
GIS Map 3. Groundwater Recharge

Surface Water

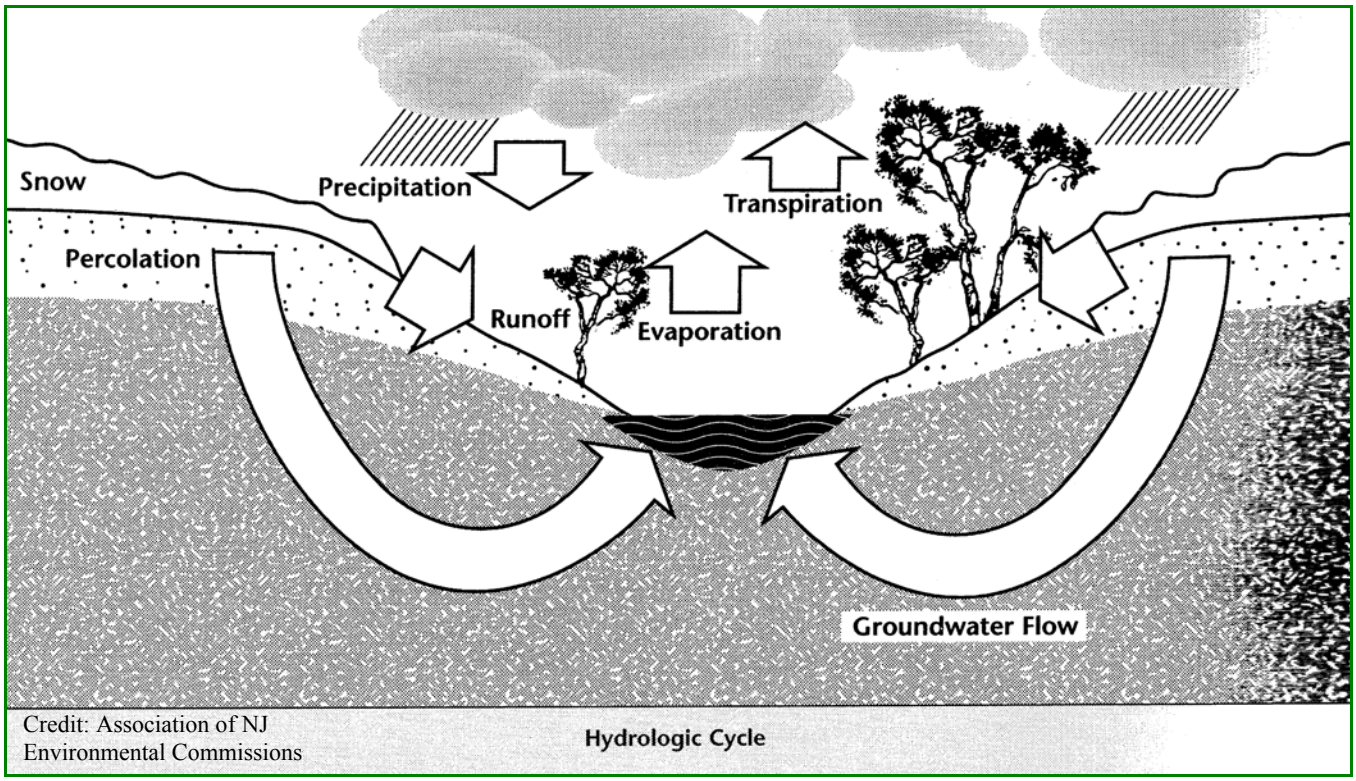
Surface water includes water visible on land including lakes, ponds, rivers, streams, bogs, wetlands, bays and oceans. Although a predominately urbanized municipality, Bordentown City contains a variety of surface water, the majority of which is freshwater wetlands (including tidal areas), wetlands and marshy areas, as well as waterways ranging from seasonal streams to major rivers. The major water bodies include Crosswicks Creek, forming the northwestern boundary of the City; Blacks Creek, which forms the southwestern boundary of the City; Mile Hollow Run, a stream that forms the northeastern boundary; Thorntown Creek, which intersects the City at a roughly east to west direction; and Love Bridge Run, a seasonal stream that loosely follows a portion of the southern boundary of the City. A small portion of the Delaware River channel, where it meets the mouth of Crosswicks Creek, lies adjacent to the City boundary. Wetlands include large areas associated with the Blacks Creek channel and the mouth of Thorntown Creek (partially due to a vestigial dike built by Joseph Bonaparte to create an artificial lake on the adjacent Point Breeze estate in the 1820s), as well as other smaller areas.

Bordentown City is within *Watershed Management Area (WMA) #20 (Assiscunk, Crosswicks, and Doctors Creeks)*, one of 20 watersheds designated by the NJ Department of Environmental Protection (NJDEP) in the state. A watershed, or drainage basin, is an area that includes all the land over which water flows to reach a body of water. Within WMA 20, Bordentown City lies within three watersheds: A-Duck Creek, B-Crosswicks Creek, and F-Blacks Creek. Within these watersheds, the City is split into three sub-watersheds (see GIS Map 4): *A-1 (Duck Creek and Upper Delaware River Valley (UDRV) to Assunpink Creek),* a small area at the mouth of Crosswicks Creek, corresponding roughly to the "Bordentown Beach" area; *B-2 (Crosswicks Creek below Doctors Creek)*, extending from an east-west line just south of Thorntown Creek all the way to the northern border; and *F-3 (Blacks Creek below Bacons Run)*, extending roughly from Farnsworth Avenue to the southern border.

Mouth of Thorntown Creek, emptying into Crosswicks Creek (B-2 watershed), low tide



GIS Map 4. Watersheds



Credit: Association of NJ Environmental Commissions

Hydrologic Cycle

Surface Waters in Bordentown City

All surface water within Bordentown City ultimately drains to the **Delaware River**, which flows in a southeasterly direction just north of the City. According to the Delaware Riverkeeper, "The Delaware River is the last major free flowing river on the East Coast. Originating in the Catskill Mountains of New York, the East and West branches of the Delaware River meet in Hancock, New York and form the main stem of the river. The River flows a total of 375 miles from the Catskills to the sea. Its watershed includes 12,765 square miles in portions of four states -- New York, New Jersey, Pennsylvania, and Delaware -- and is home to nearly 6 million people." Although technically not within Bordentown City's borders, the Delaware River meets the mouth of Crosswicks Creek at the northwestern border of the City.

Delaware River, looking south from I-295 bridge

Delaware River, looking north from I-295 bridge

Crosswicks Creek is 25 miles long and drains an area of 146 square miles to the Delaware River at Bordentown City. It drains sections of Ocean, Burlington, Monmouth and Mercer counties. The creek forms the northwestern boundary of Bordentown City, from Mile Hollow Run at the northernmost edge, running south to the intersection with Blacks Creek and the Delaware River. It is tidal for the entire portion within Bordentown City (and as far as Crosswicks Mill Dam), exhibiting water level changes of as much as eight (8) feet.

Crosswicks Creek, low tide, looking upstream (north) from mouth of Thorntown Creek

Looking south towards RiverLINE bridge

Looking south from Mile Hollow Run

Blacks Creek, forming the western boundary of the City (with minor exceptions due to manmade redirection of the channel during I-295 construction), originates in Mansfield and North Hanover Townships, and enters Bordentown City via channelized construction below Route 130 a quarter mile south of Farnsworth Avenue. It is a tidal freshwater stream up to approximately Route 206, where the tidal influence ceases. Blacks Creek is generally navigable by watercraft to Route 130. Stormwater from the area of Bordentown City south of Crosswicks Street drains into storm drains leading to Blacks Creek, which empties into the Delaware River. Steep slopes characterize the southwestern portion of Blacks Creek, on the Township side, just below the Route 130 bridge. Further downstream, there is an artificial oxbow lake that was created just above the railroad bridge on Blacks Creek by I-295.

Blacks Creek, looking north from Burlington Street bridge, low tide

Looking south from end of Lime Kiln Alley

Looking north from Route 130 bridge

Thorntown Creek begins in Mansfield Township, traverses Bordentown Township, and enters the City beneath Route 206 behind Gilder Field. It continues in a roughly east/west direction and is characterized by a broad flood plain. A manmade pond was constructed in the early part of the 20th century just north of Elizabeth Street, and was used for recreational purposes (skating in the winter, swimming in the summer) by City residents. The dam has since deteriorated. As it approaches Crosswicks Creek, the area around the mouth of Thorntown Creek exhibits progressively steep bluffs, exceedingly rare for the portion of the Delaware River Estuary between Trenton and the Delaware Bay. Thorntown Creek exhibits tidal influence for approximately a quarter mile upstream from its mouth at Crosswicks Creek. Stormwater from the area generally north of Crosswicks Street empties into Thorntown Creek, which drains to Crosswicks Creek, and then into the Delaware River.

Thorntown Creek, high tide, near Crosswicks Creek

Mouth of Thorntown Creek, looking towards Crosswicks creek

Mouth of Thorntown Creek, low tide

Mile Hollow Run, a shallow stream that forms the northeastern boundary between the City and Township, enters the City at the intersection of Route 206 and Park Street. It exhibits a tidal influence where it enters Crosswicks Creek. The mouth of Mile Hollow Run is characterized by extremely steep slopes comprised of eroded soils. This area is known locally as "Jumbo" and was used in the past as a recreational bathing beach.

Mile Hollow Run, west of Route 206

Mouth of Mile Hollow Run

Mile Hollow Run emptying into Crosswicks

Love Bridge Run is an intermittent stream (prone to drying up during the summer months or during periods of long drought) that drains the south-southeastern portion of the City. It springs from a wooded area between West Chestnut Street and Route 130, flows underneath Farnsworth Avenue, and parallels Mill Street down into the flood plain of Blacks Creek, a marshy tidal area at the southwest corner of Bordentown City. Love Bridge Run is characterized by increasingly steep slopes as it progresses towards Blacks Creek. Residential development occurs immediately adjacent to both banks along most of the stream corridor. Love Bridge Run is subject to tidal activity at the marshy mouth where it empties into Blacks Creek.

Love Bridge Run, east of Farnsworth Avenue

Ridgeway Brook is an intermittent stream that drains the area between the freight railroad tracks along Park Street and the self-storage facility on Rt. 206. The stream rises behind the Landon Drive neighborhood, flows in a north-northeasterly direction paralleling the railroad tracks, and enters Mile Hollow Run in a channelized culvert under Rt. 206/Park Street intersection. *(Ridgeway Brook does not appear on maps for Bordentown City. The existence of this stream was (re) discovered in 2004, and since it was unnamed, the name "Ridgeway Brook" was chosen for the local topography where it is found.)*

Ridgeway Brook, between Park Street and Route 206 (Route 206 in the background)

Wetlands

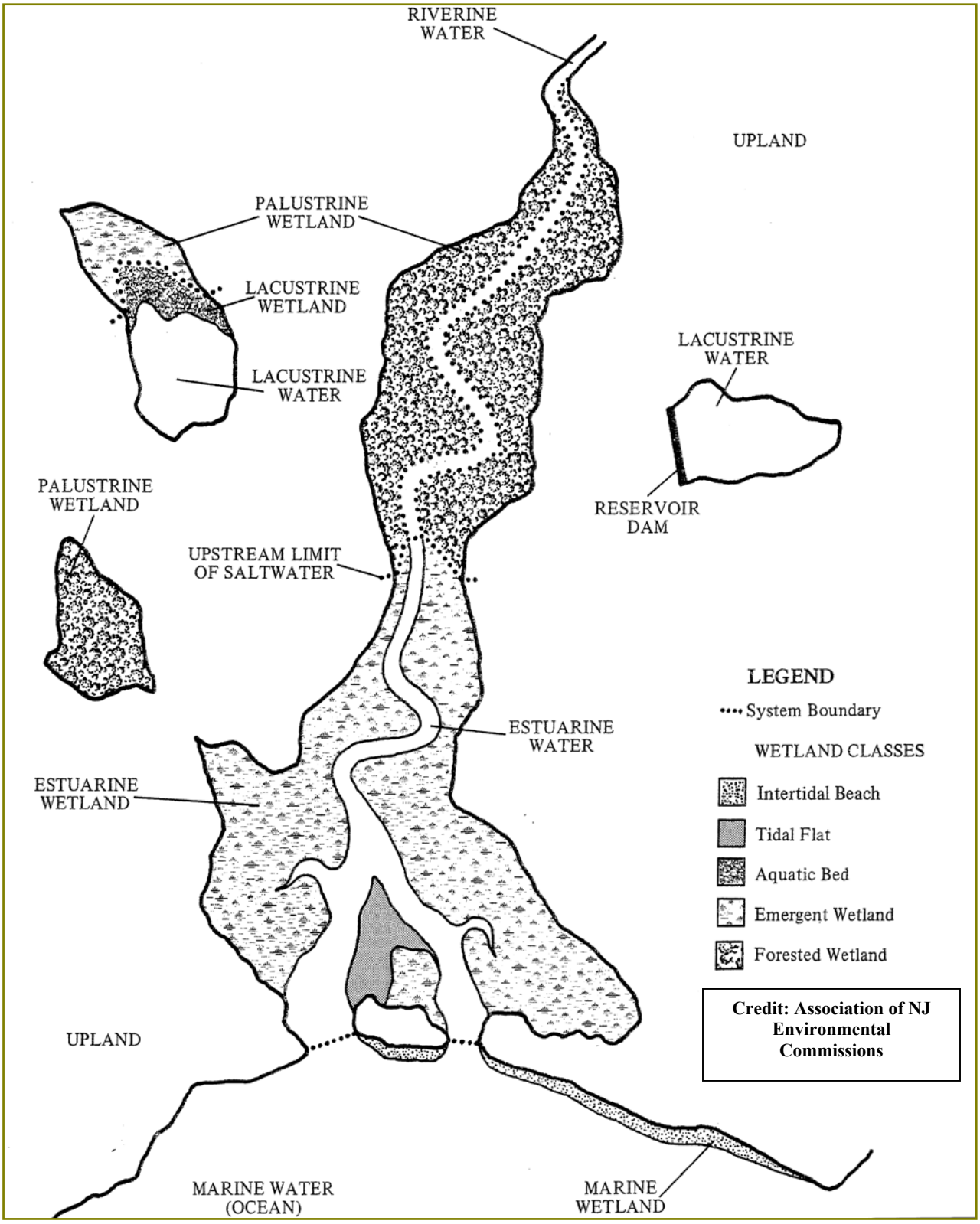
Traditionally, bogs and swamps were considered unnecessary by-products of oceans, rivers and streams--at worst, symbols of death and decay, sources of methane, breeding grounds for noxious odors and mosquitoes; at best, they were considered a nuisance. If unusable by humans, wetlands were commonly assumed to be worthless to nature. In New Jersey and throughout the United States, laws and regulations often encouraged developers to fill in wetlands and make them "useful."

Now we have learned how important wetlands are:

- By filtering sediment and pollutants from the water flowing through them, wetlands protect water quality.
- During periods of heavy rainfall, wetlands act as a natural flood-control device.
- Wetlands provide habitat for many species of birds, mammals, reptiles, amphibians and fish and a rich diversity of plant life. Nearly half New Jersey's threatened or endangered species live in freshwater or coastal area wetlands.
- Wetlands help regulate the water level in streams and rivers by retaining water during wet periods and releasing it during dry periods. They help stabilize the water table by holding surface water and letting it seep into the groundwater supply.
- Wetlands along a shoreline or stream bank help stabilize the land, buffering it from erosion.
- Draining wetlands for urban development results in greater runoff and probability of flooding as well as the destruction of wildlife habitat.

Wetlands are not wastelands. They are useful, both to nature and to people. Especially since we have destroyed about half our natural wetlands, we must preserve what remains if we want to maintain a healthy environment.

Freshwater wetlands adjacent to Crosswicks Creek (note skunk cabbage, a wetlands indicator species)



Wetland Classes

Defining Wetlands

Wetlands are neither dry land nor water bodies, but rather the transition from one to the other. Wetlands are saturated with water or covered by shallow water at least part of each year, or part of most years. Wetlands tend to evolve through natural or human activity, emerging as dry land or submerging under rising water levels.

The 1987 New Jersey Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 et seq.) officially defines a wetland: "An area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation..."

A general definition of wetlands, presented by the U.S. Fish and Wildlife Service and in use since 1956, says: “The term...wetlands refers to lowlands covered with shallow and sometimes temporary or intermittent waters. They are referred to by such names as marshes, swamps, bogs, wet meadows...Shallow lakes and ponds, usually with emergent vegetation as a conspicuous feature, are included in the definition, but the permanent waters of streams, reservoirs and deep lakes are not included.”

Wetlands ecosystems are important for a variety of reasons. They are often described as “the kidneys of the landscape.” Wetlands may benefit the local environment in many ways. They can filter pollutants from water, prevent floods, recharge aquifers and protect shorelines from erosion. They also provide habitat for a wide variety of flora and fauna.

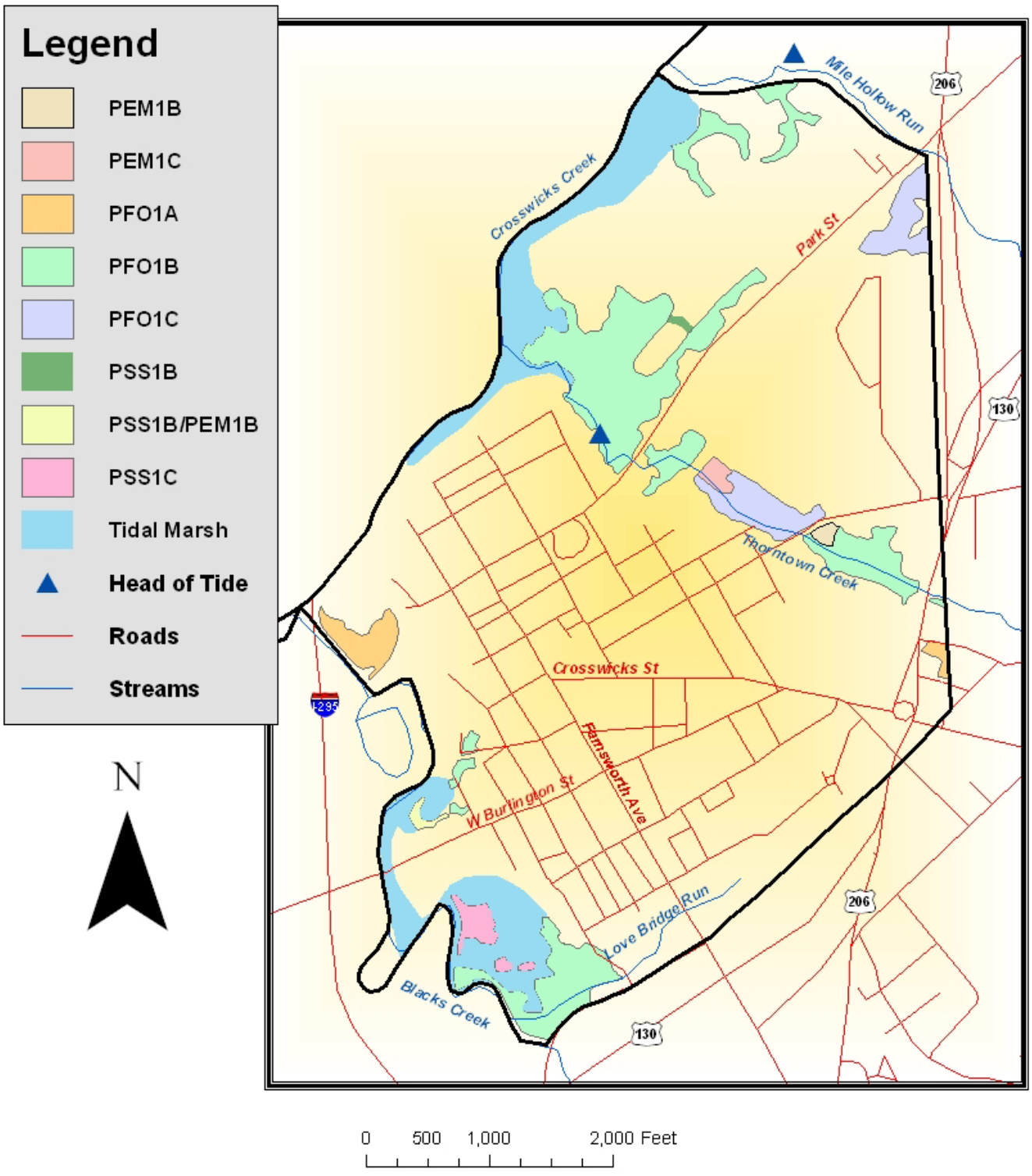
Wetlands may include three main features: the presence of water; unique soils differing from adjacent upland soils; and supportive of vegetation that is adapted to wet conditions. In addition, wetlands often occur at the boundary between deep water and uplands; they may vary in both size and location; and while water may be present for extended periods of time, the depth of water and length of time a wetland is covered by water may very according to season and region.

Wetlands Classification

Wetlands can be classified with the U.S. Fish and Wildlife Service hierarchical classification, or Cowardin system, based on plants, soils, and frequency of flooding. The highest level of classification is a *system*, a broad category sharing similar hydrology, geomorphology, chemistry, and biology. Most of the wetlands in Bordentown City are classified as *palustrine*, which includes all non-tidal wetlands dominated by trees, shrubs, persistent emergents, and all such wetlands in freshwater tidal areas. The *class* of a particular wetland describes the general appearance of the ecosystem, generally in terms of the dominant vegetation.

Three wetland classes are identified in Bordentown City, as follows:

Emergent Wetland, characterized by erect, rooted, herbaceous aquatic plants;
Scrub-Shrub Wetland, dominated by woody vegetation less than 20 feet tall;
Forested Wetland, predominantly woody vegetation 20 feet or taller in height.



GIS Map 5. Wetlands

Finer differences in vegetation are recognized at the *subclass* level. The *persistent* subclass is used with Emergent Wetlands, indicating a predominance of those species that normally remain standing until the beginning of the next growing season. Both Scrub-Shrub and Forested Wetlands in the City are characterized by the *broad-leaved deciduous* subclass.

Water regime modifiers are also applied. *Temporary* indicates the presence of surface water for brief periods during the growing season, but otherwise the water table is well below the surface. In *saturated* wetlands, the substrate is saturated for extended periods during the growing season, but surface water is seldom present. *Seasonal* denotes surface water is present for extended periods, especially early in the growing season, but is absent by the end of the season.

GIS Map 5 shows the wetland classification of Bordentown City:

PEM1B: Palustrine, Emergent, Persistent, Saturated
These wetlands make up a small area along Thorntown Creek south of Elizabeth Street.

PEM1C: Palustrine, Emergent, Persistent, Seasonal
These wetlands occupy a small area along Thorntown Creek southeast of Park Street.

PFO1A: Palustrine, Forested, Broad-leaved Deciduous, Temporary
These wetlands occur at the mouth of Blacks Creek, the area commonly known as "Bordentown Beach." This area was created from dredge spoils from the Delaware River.

PFO1B: Palustrine, Forested, Broad-leaved Deciduous, Saturated
These are the most extensive type of wetlands in the City. They are found primarily along Thorntown Creek, including the portion below Park Street, and between Park Street and the freight railroad line by Ocean Spray, as well as a portion behind Gilder Field (between Elizabeth Street and Routes 206/130). Another area is found along Crosswicks Creek just south of the mouth of Mile Hollow Run. Finally, wetlands of this type occur at the mouth of Love Bridge Run and north along Blacks Creek

PFO1C: Palustrine, Forested, Broad-leaved Deciduous, Seasonal
This type of wetlands occurs in two areas: along Thorntown Creek between the freight railroad line and Elizabeth Street, and along Ridgeway Brook southeast of Park Street.

PSS1B: Palustrine, Scrub-Shrub, Broad-leaved Deciduous, Saturated
A small section of these wetlands is found adjacent to the forested wetlands north of Thorntown Creek and northwest of Park Street.

PSS1B/PEM1B: Palustrine, Scrub-Shrub, Broad-leaved Deciduous, Saturated/ Palustrine, Emergent, Persistent, Saturated
A small area of this compound type of wetlands is found along Blacks Creek just north of West Burlington Street.

PSS1C: Palustrine, Scrub-Shrub, Broad-leaved Deciduous, Seasonal
Several small areas of these wetlands are found along Blacks Creek between West Burlington Street and Route 130.

Tidal Marsh

These are also very extensive, found in both Crosswicks and Blacks Creeks. They are very productive and diverse tidal emergent wetlands, found predominantly in the middle and south Atlantic coast of the United States.

Blacks Creek, freshwater tidal marsh, looking northwest towards main channel

Blacks Creek tidal marsh

Thorntown Creek tidal marsh

Impacts of Development

Important land uses within WMA 20 include agricultural, forested, residential/commercial development and military installations. Development and agricultural runoff in Bordentown Township and Chesterfield Township contributes significantly to the degradation of water quality in the waterways within Bordentown City limits. Runoff from agriculture, lawn care chemicals, pet waste, and automotive fluids all find their way to the waterways that flow through Bordentown City.

How Does Urbanization Change a Watershed?

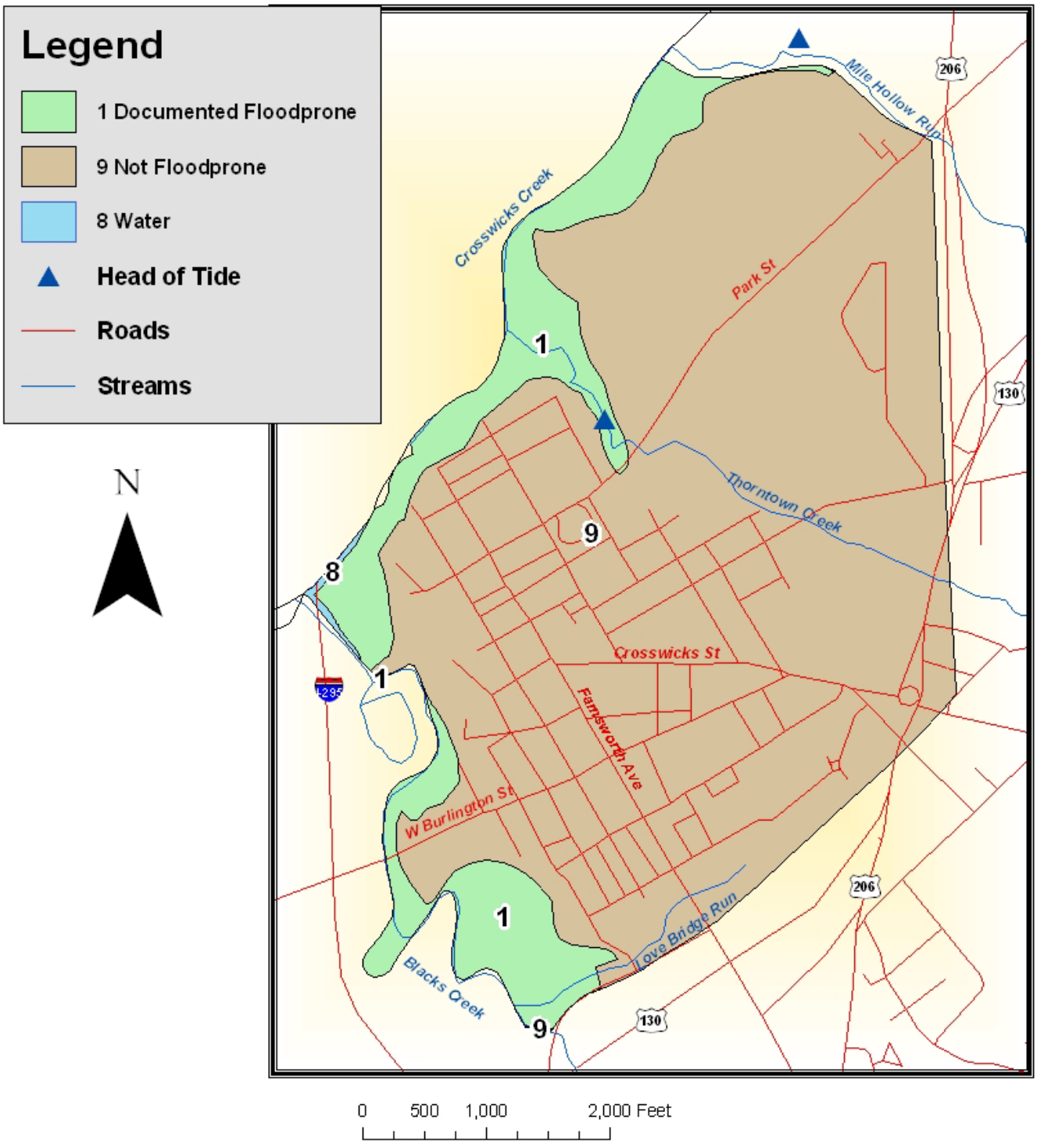
Urbanization (or development) has a great effect on local water resources. It changes how water flows in the watershed and what flows in the water. Both surface and ground water are changed. As a watershed becomes developed, trees, shrubs and other plants are replaced with impervious surfaces (roads, rooftops, parking lots and other hard surfaces that do not allow stormwater to soak into the ground). Without the plants to store and slow the flow of stormwater, the rate of stormwater runoff is increased. Less stormwater is able to soak into the ground because sidewalks, roads, parking lots and rooftops block this infiltration. This means a greater volume of water reaches the waterway faster and less of that water is able to infiltrate to ground water. This, in turn, leads to more flooding after storms, but reduced flow in streams and rivers during dry periods. The reduced amount of infiltrating water can lower ground water levels, which in turn can stress local waterways that depend on steadier flows of water.

In the stream, more erosion of stream banks and scouring of channels will occur due to volume increase. This degrades habitat for plant and animal life that depend on clear water. Sediment from eroded stream banks clogs the gills of fish and blocks light needed for plants. The sediment settles to fill in stream channels, lakes and reservoirs. This also increases flooding as well as the need for dredging to clear streams or lakes for boating and habitat**.**

GIS Map 6 indicates the potential flood hazard areas of Bordentown City.

Blacks Creek, looking south from Burlington Street bridge, March 2005 Flood

Bordentown Beach/Boat Ramp area, March 2005 Flood



GIS Map 6. Flood Hazard Areas

In addition to the high flows caused by urbanization, the increased runoff also contains increased contaminants. These include litter, cigarette butts and other debris from sidewalks and streets, motor oil poured into storm sewers, heavy metals from brake linings, settled air pollutants from car exhaust and pesticides and fertilizers from lawn care. These contaminants reach local waterways quickly after a storm.

Water Quality

Importance of Water Quality

According to the US Environmental Protection Agency:

"Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and groundwater environments, across coastal and inland areas. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health. Water quality in a body of water influences the way in which communities use the water for activities such as drinking, swimming or commercial purposes. More specifically, the water may be used by the community for: supplying drinking water, recreation (swimming, boating), irrigating crops and watering stock, industrial processes, navigation and shipping, production of edible fish, shellfish and crustaceans, protection of aquatic ecosystems, wildlife habitats and scientific study and education."

Documented water quality reports exist for Blacks Creek and Crosswicks Creek:

Blacks Creek

According to *NJDEP Water Quality Status* report, Blacks Creek is classified as a Freshwater Non-Trout (FW2-NT) waterbody. The Biological Impairment rating is "Moderately Impaired", according to samples from 1993 taken at Route 130.

The Delaware Riverkeeper Network has gathered water quality reports for Blacks Creek in Bordentown Township. It is expected that extrapolating the results for the Bordentown City portion of the Creek would yield figures indicating similar or increased degradation of water quality. See results below:

Delaware Riverkeeper Network Data Summary
Monitoring Station: Bridge on unnamed road off Route 206 North, Bordentown Township.

pH	6.5 - 8.5
Nitrates	0.44 - 4.40 ppm
Phosphate	0.1 - 2.0 ppm
Dissolved Oxygen	6.5 - 13.0 ppm
Dissolved Oxygen Saturation	70.6 – 115.0%

Crosswicks Creek

According to *NJDEP Water Quality Status* report, Crosswicks Creek is classified as a Freshwater Non-Trout (FW2-NT) waterbody. The Biological Impairment Rating is "Moderately Impaired", according to samples from 1993 taken at Point Breeze (Divine Word Missionaries property).

The Delaware Riverkeeper Network has also gathered water quality reports for Crosswicks Creek in Groveville (Hamilton Township). It is expected that extrapolating the results for the Bordentown City portion of the creek would yield figures indicating similar or increased degradation of water quality. See results below:

Delaware Riverkeeper Network Data Summary
Monitoring Station: Groveville Bridge in Groveville (Hamilton Township)

pH	6.0 - 7.5
Nitrates	0.44 - 4.40 ppm
Phosphate	0.2 - 1.0 ppm
Dissolved Oxygen	6.5 - 14.0 ppm
Dissolved Oxygen Saturation	68.9 - 111.7%

According to the Delaware Riverkeeper Network web site, for both Crosswicks Creek and Blacks Creek, "[T]he results of the monitoring to date indicate that pH, dissolved oxygen (DO), and DO saturation are in the range generally considered acceptable to support wildlife and are similar to neighboring tributaries. *The nitrates and phosphate, however, are the highest observed in the region*. Nitrate is the principal form of nitrogen in most surface waters, but high concentrations of nitrate may be related to heavy fertilizer applications to lawns and crops and reflect unsanitary conditions because human and animal wastes are major sources of nitrate. Nitrate concentrations are correlated with phosphate concentrations, indicating similar sources for both nutrients."

Regarding Blacks Creek, the Riverkeeper reports that "[T]he volunteers have confirmed what you already know - Blacks Creek has its problems, but is still a viable ecosystem worth protecting and restoring. It supports wildlife and offers tranquility and recreation. Blacks Creek needs continued monitoring so that field-tested stream conditions can be used as input to devise strategies for improving water quality and streamside habitat. Continued monitoring is also important to ensure the problems are identified early and corrected before significant degradation occurs."

Delaware River

Only a small portion of the Delaware River is contiguous with Bordentown City. The water quality in the Delaware varies dramatically depending on location, and specific data regarding the point where it intersects with Bordentown City is limited. However, data regarding bacterial content is available from a sampling site in Trenton.

Sampling Site	Sample date	River miles	Enterococcus	Enterococcus Standard	Fecal Coliform	Fecal Coliform Standard
Trenton	8/23/04	131.04	160	33	480	200

According to the Delaware River Basin Commission, fecal coliform and *Enterococcus* bacteria levels are monitored as indicators of sewage pollution or non-point sources of human and animal waste in waterways. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. *Enterococcus* bacteria are a non-pathogenic subgroup of fecal *Streptococcus* and are measured as an indicator of the presence of human fecal material. Epidemiological studies have determined a correlation between *Enterococcus* concentrations in water and increased probabilities of illness in swimmers. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water.

***Note**:* The Delaware River Basin Commission's recreational use standards for fecal coliform and enterococcus bacteria are based upon the average of several samples over a period of time. While individual samples taken on a single day such as those reported here may exceed the number listed under the standard column, the standard is not violated until the average of several samples exceeds this value. Individual sample exceedances commonly occur following rainfall events due to non-point source runoff and discharges from combined sewer overflows. The unit of measurement is cfu/100mL. *(Source:* Delaware River Basin Commission*)*

Sources of Pollution

Sources of pollution of surface waterways include “point” source and “nonpoint” source pollution. *Point source*, or piped, pollution, refers to industrial and municipal wastewater discharges of pollutants into surface water. Within the City, industrial point source pollution originates from Ocean Spray (Thorntown Creek). Immediately adjacent to the City, municipal point source pollution originates from the Bordentown Sewerage Authority (Blacks Creek, just upstream from Route 130). Further, there are other industrial and municipal point sources of pollution upstream along the Delaware River, Crosswicks Creek, Blacks Creek, and Thorntown Creek. Point source pollution is generally regulated by NJDEP, which issues permits for known point sources and sets standards for pollution levels. *Nonpoint source* pollution refers to the diverse, widespread and unregulated sources, including erosion and chemical runoff from lawns and farms; automotive fluids and road salts from parking lots and roads; leaking chemicals from septic tanks, underground tanks, and airborne pollutants; and fecal pathogens from pet waste, farm animals, and wildlife. Due to its amorphous origins, standards or regulations for nonpoint source pollution are difficult to implement. However, a variety of protective ordinances and public education programs may help reduce the impact of nonpoint source pollution.

Point sources of pollution within Bordentown City (or in Bordentown Township) that effect waterways within the municipality include the following facilities:

NJDEP Permitted Discharges: Permit #, Receiving Waters (*Source*: NJDEP)

NJPDES Permit #	Facility Name	Effective Start Date	Expiration Date	Discharge Category Description	Street Address	Receiving Waterway
NJ0103829	Ocean Spray Cranberries	7/1/00	6/30/05	Significant Indirect User	104 E. Park St.	Thorntown Creek
NJG0104272	Ocean Spray Cranberries	2/1/04	1/31/09	Land Appl/Food processing	104 E. Park St.	Thorntown Creek
NJG0110019	Ocean Spray Cranberries	6/1/02	5/31/07	Basic Industrial Stormwater	104 E. Park St.	Thorntown Creek
NJG0149438	Bordentown City	4/1/04	2/28/09	Tier A Municipal Stormwater general permit	324 Farnsworth Ave.	Various

Several other facilities upstream are point sources of pollution of waterways that flow through Bordentown City, including the Bordentown Sewerage Authority (Blacks Creek) and the Bordentown Water Department (Crosswicks Creek).

A number of hazardous waste sites in the upper reaches of WMA 20 may contribute to contamination of surface waters, including McGuire Air Force Base, Hopkins Farm site (volatile organics), Wilson Farm site (volatile organics), and Goose Farm site (volatile organics).

Nonpoint sources of pollution include agricultural runoff, suburban/urban surface runoff, and roadways and housing construction. The lower reaches of Crosswicks Creek receive herbicides, pesticides, fertilizer and silt from agricultural runoff. Stream bank erosion from pasture land also contributes to silt loads. Runoff from suburban developments, storm sewers and road maintenance, as well as local septic systems, have also resulted in nonpoint source pollution of waterways in WMA 20.

Some common nonpoint source pollutants include:

- Nutrients (nitrates and phosphates)
- Sediments
- Pesticides and herbicides
- Pathogens (viruses and bacterias)
- Heavy Metals
- Automotive Fluids
- Road Salts

According to NJDEP, the waterways in WMA 20 (in general) either partially support or fail to support the “aquatic life” designated use. In addition, Crosswicks Creek specifically fails to support primary contact recreation (swimming) based upon the fecal coliform bacteria levels recorded at the monitoring stations.

Specifically, NJDEP reports that"[P]ortions of Crosswicks Creek and tributaries will meet the fish propagation/maintenance goal, but swimmable status can not be assigned to the watershed. The

macroinvertebrate survey of 1984 indicates that fish life may be stressed in the upper watershed, as such this section is considered to be partially meeting the fish propagation maintenance use. In the Lower Crosswicks Creek this use is met. Fecal coliform counts in streams frequently exceed the standard for swimming."

Best Management Practices for Improving Water Quality

A variety of best management practices (BMP) should be employed to control pollution of local waterways. According to the U.S. Environmental Protection Agency, recommended BMPs include:

- Keep litter, pet wastes, leaves, and debris out of street gutters and storm drains--these outlets drain directly to lakes, streams, rivers, and wetlands.
- Apply lawn and garden chemicals sparingly and according to directions.
- Dispose of used oil, antifreeze, paints, and other household chemicals properly, not in storm sewers or drains.
- Clean up spilled brake fluid, oil, grease, and antifreeze. Do not hose them into the street where they can eventually reach local streams and lakes.
- Control soil erosion by planting ground cover and stabilizing erosion-prone areas.
- Encourage local government officials to develop construction erosion/sediment control ordinances.
- Have septic systems inspected and pumped, at a minimum, every 3-5 years so that they operate properly.
- Purchase household detergents and cleaners that are low in phosphorous to reduce the amount of nutrients discharged into lakes, streams and coastal waters.
- Manage animal waste to minimize contamination of surface water and ground water.
- Protect drinking water by using less pesticides and fertilizers.
- Reduce soil erosion by using conservation practices and other applicable best management practices.
- Dispose of pesticides, containers, and tank rinsate in an approved manner.

Pet waste bag station, Hilltop Park

Storm Drain Inlet, East Burlington St. Note stencil, trash rack, and bicycle safe grate.

Vegetation

Native Communities

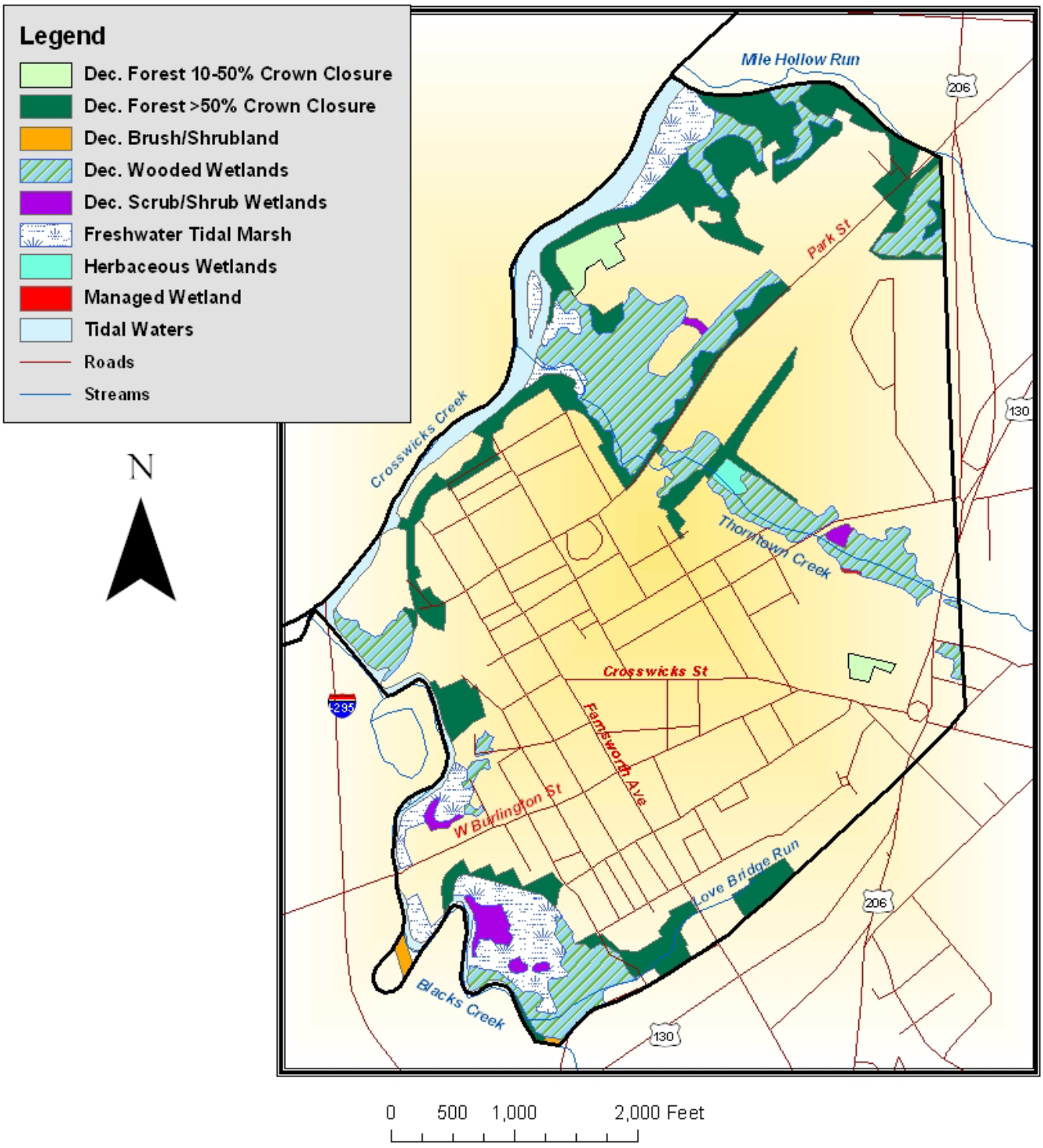
The Inner Coastal Plain is often characterized by botanists as a transition area between the Mixed Oak forest to the north and the Pine-Oak forest of the Outer Coastal Plain. Many species of northern affinity reach their southern limit here, and southern species their northern limit.

The natural vegetation of Bordentown City is depicted with Anderson Land Use-Land Cover Classification System map units in GIS Map 7. The remaining tracts of *deciduous wooded uplands* in Bordentown City generally fit the Beech-Oak Forest type of Robichaud and Buell (1973). Once covered by chestnut and beech trees, these areas have been cut repeatedly since European settlement. American beech, white and red oak are common, along with tulip tree and American holly. Understory trees include dogwood, ironwood, and sassafras; shrubs include maple-leaved viburnum, witch hazel, spicebush, and arrowwood. Rhododendron, more generally associated with cool, moist sites in North Jersey, reach considerable size on north-facing slopes along Thorntown and Blacks Creeks. According to Markley (1971), the Keyport soils on these slopes support the only native stands of rhododendron in the coastal plain. Vines include Virginia creeper and poison ivy; may apple, jack in the pulpit, and fake solomon's seal are the common herbaceous plants.

The ***deciduous brush/shrubland*** is an area along Route I-295, formerly cleared, which has re-vegetated with sweet gum, tulip tree, black locust, and poison ivy. Invasives are common, including multiflora rose, Japanese honeysuckle, and winged euonymous (Quigley, 2005).

The ***deciduous wooded wetlands*** are found along stream channels, primarily on alluvial deposits in the floodplain. Dominant trees include box elder, silver maple, white ash, and sycamore; shrubs include spicebush, elderberry, and the invasive privet, multiflora rose, and Japanese barberry. Jewelweed and the invasive garlic mustard and Japanese stiltgrass are found in the herbaceous layer (Quigley, 2005). The ***deciduous scrub-shrub wetlands*** includes those areas with vegetation less than 20 feet in height, and is characterized by a similar suite of trees and shrubs, and the ***herbaceous wetlands*** contain many of the same herbaceous plants as above. Both of these areas are also found in the floodplains of the City's streams.

Freshwater tidal marsh wetlands are found along Blacks and Crosswicks Creeks. Submerged vegetation such as spatterdock, waterweed, and water milfoil grow in the streams and permanent ponds. High marsh is the most widespread habitat, dominated by a mixture of annuals and perennials, including arrow arum, tearthumb, cattail, reed canary grass, pickerelweed, arrowhead, giant ragweed, and wild rice. Primary production peaks late in the growing season. As of 2003, botanist Mary Leck of Rider University had identified 850 species of plants, including 28 endangered, threatened, or rare for New Jersey, in the Hamilton-Trenton-Bordentown tidal marsh.



GIS Map 7. Natural Vegetation

State Endangered and Rare Plant Species

Endangered

Pale Indian Plantain (*Cacalia atriplicifolia*)
Low Flatsedge (*Cyperus tenuifolia*)
Wafer Ash (*Ptelea trifoliata*)
Star Chickweed (*Stellaria pubera*)

Rare

Purple Giant Hyssop (*Agastache scrophularifolia*)
Frank's Sedge (*Carex frankii*)
Smartweed Dodder (*Cuscata polygonorum*)
Toothed Tick-trefoil (*Desmodium cuspidatum*)
American Starwort (*Elantine americanum*)
Tall Thoroughwort (*Eupatorium altissimum*)
Mud Plantain (*Heterantera multiflora*)
River-bank Quillwort (*Isoetes riparia*)
Narrow-panicled Rush (*Juncus brevicaudatus*)
Torrey's Rush (*Juncus torreyi*)
Winged Monkey Flower (*Mimulus alatus*)
Eastern White Water Crowfoot (*Ranunculus longirostris*)
Subulate Arrow Head (*Sagittaria subulata*)
Smith's Bulrush (*Schoenoplectus smithii*)
Black Woolgrass (*Scirpis atrocinctus*)
Wild Pink (*Silene caroliniana*)
Smooth Hedge-nettle (*Stachys tenuifolia*)
Humped Bladderwort (*Utricularia gibba*)
Flat-leaved Bladderwort (*Utricularia intermedia*)

Wild Rice, Crosswicks Creek

Pickerelweed, Crosswicks Creek

All Endangered and Rare plant species were identified in the Hamilton-Trenton-Bordentown Marsh, with the exception of Star Chickweed, which was found in the woodlands along the lower reach of Thorntown Creek.

Beech-Oak upland forest near Thorntown Creek

Tidal marsh and wooded wetlands, Blacks Creek

Hamilton-Trenton-Bordentown Marsh

A freshwater tidal marsh is an area that experiences significant tidal fluctuations, but is beyond the reach of saltwater movement. Freshwater tidal marshes are highly diverse, extremely productive areas which can actually rival the tropical rainforests in the amount of plant material produced each year.

The tidal marshes in Bordentown City are part of the Hamilton-Trenton Marsh system, a 1,250 acre wetland-upland complex which includes the northernmost section of freshwater tidal marsh on the Delaware River. As of March 2003, species inventories in the complex have identified 850 species of plants, including 28 endangered/threatened/rare for New Jersey; 28 species of butterflies, including 1 rare for the region; 60 species of fish, including 1 endangered; 23 amphibians and reptiles; 237 species of birds, 100 nesting species; and 19 species of mammals (Leck, 2004).

In addition to its ecological value for primary production and habitat diversity, the marsh functions as a buffer between the suburban and freshwater environments, helping to prevent flooding and filtering and absorbing nonpoint source pollutants to protect water quality. It provides both recreational opportunities (hiking, canoeing, birding, fishing, and hunting) as well as educational opportunities; it's a great field trip site for students of all ages; and the over 50 research papers on the Hamilton-Trenton Marshes have substantially increased worldwide understanding of freshwater tidal marsh ecology. The area is also historically significant as the stomping ground of noted naturalists Charles Conrad Abbott and Charles Lucien Bonaparte, and archeologically important as a Woodland Indian site.

Skunk Cabbage, Thorntown Creek

Rhododendrons, Thorntown Creek (abandoned stormwater manhole in foreground)

Wildlife

From estuarine wetlands to grassy back yards, Bordentown City provides a small but diverse cross-section of wildlife habitats typical of much larger municipalities. Because it is an urbanized area, the built-up area provides a different wildlife habitat than surrounding suburban and rural townships. Shade trees along streets and in backyards provide roosting spots for birds and small mammals. Back yard feeders provide winter food for birds and squirrels.

Geography contributes to an abundant number of wildlife species that can be found in and around Bordentown. On a global scale, the City is part of the Atlantic Flyway, with birds and monarch butterflies passing through Bordentown from points as far north as the Arctic Circle to tropical regions of the southern United States, Central America, or South America. Relative to the State of New Jersey, Bordentown is not far from the Atlantic Ocean, with its abundance of seabirds and other marine life. Regionally, the City is near the upper estuary of the Delaware River, which also fosters an abundance of habitat types. Finally, the City is bordered by forests and freshwater tidal wetlands, further contributing habitat and food.

Surprising to many, there are natural habitats within the city boundaries. The Landscape Project, a critical area mapping initiative of the New Jersey Division of Fish and Wildlife's Endangered and Nongame Species Program, seeks to protect biological diversity by maintaining imperiled wildlife populations and their habitats. In addition to preserving the critical habitats of threatened and endangered species, this initiative will help reduce the threat of flooding; allow for the biodegradation of environmental contaminants; enhance the recharging of groundwater reserves; and protect valuable open space. The mapping of critical habitat will help prioritize conservation acquisitions, serve as a guide for municipal planning efforts, and provide citizens with a conservation tool.

Using the landscape classification established by the New Jersey DEP's Endangered Species Program, Bordentown falls within the Piedmont Plains Landscape. Stretching from Bergen County next to the Hudson River, it proceeds southwest along the Delaware River, with another branch hugging Raritan Bay and coastal Monmouth County. The region's open space is characterized by farm and grasslands, fragmented woodlands and tidal freshwater marshes. Within this landscape category are habitat types ranging from upland forests to estuarine wetlands. Specifically in Bordentown City, natural communities mapped include emergent wetlands, forested wetlands, and forest. Most of these habitats lie within, or adjacent, to stream corridors of Blacks Creek, Crosswicks Creek, Mile Hollow Run, and Thorntown Creek. Because of the proximity of Bordentown to the Hamilton-Trenton-Bordentown Marsh, many wildlife species associated with that wetland system may also find refuge in Bordentown's other natural areas. At the same time, many species may spend part of their lives within these marshes, and occasionally venture into the City's built up landscape in search of food or shelter. Many residents have seen fox, wild turkeys, raccoons, rabbits, and groundhogs in their yards. It is not unusual to find hawks seeking prey of small mammals and birds.

Wildlife Habitats

Open Water

Although miles from the Delaware Bay, the tidal influence on the Delaware River influences the City's portions of Crosswicks Creek, Blacks Creek, Thorntown Creek and other smaller channels. The tidal waters support fish, including Killifish, Catfish, Shad and Yellow Perch. The fish populations, in turn, support fish-eating birds such as Mergansers, Cormorants, Osprey, Egrets, and Herons. Great-blue Herons, Green Herons, Ring-necked Ducks, and Wood Ducks are frequently observed in ponds and slow-moving stream areas. River Otter have recently reestablished the Hamilton/Trenton Marsh as home, and evidence of otter has been found along the banks of Crosswicks and Blacks creeks. Rivers and ponds also provide habitat for amphibians, such as Bullfrogs and Green Frogs, and turtles, including Eastern Painted, Red-bellied, and Snapping. There is evidence of Beaver and beaver dams along Crosswicks, Thorntown and Blacks Creeks.

Great Blue Heron, tidal marsh area

Mute Swan, tidal marsh area

Tidewater Mucket

Snapping Turtle, Thorntown Creek

Beaver activity, Blacks Creek

Marshes

These areas provide habitat for Muskrats, Marsh Wrens, Least Bitterns, Yellowthroats, and Red-winged Blackbirds. Waterfowl that could be found in the wetlands, as well as creeks, might include Canada Geese, Great Blue Heron, Herring Gull, and Mallard Ducks. Snapping Turtles and Muskrat lodges, especially in winter, have been sighted in the general area of the Trenton-Hamilton-Bordentown Marsh, as well as around the marshy areas of Blacks Creek.

Shrub Forest

Shrub forest wetlands are characterized by woody species and occur at the edges of marshes adjacent to upland areas. They also occur at the edges of marshes where they grade into swamps, with trees forming a distinct canopy, which in turn grade into wet forests and then to upland. Among the animals observed have been Baltimore Butterflies, Woodchuck, Red Fox, Willow Flycatchers (nesting), Eastern Kingbirds, Cardinals and Brown Snake.

Feral Cats

Feral cats are those that have become wild after living outside for a long period of time or are those born to ferals in the wild.

Feral cats survive in the same way as other wild animals do. With the capacity to find food and recuperate from serious injuries and major illnesses, their life expectancy is about 10 years. Feline leukemia, feline AIDS and distemper are the primary illnesses affecting feral cats. The feral population is made up of generations of cats living in the woods of Bordentown and among the City's population. The feral population is also enhanced by cats abandoned by irresponsible owners, and these "friendlies" are not accustomed to living in the wild; many are already pregnant, further increasing the unwanted population.

Although the feral cat population does thin out from illness, extensive cold stretches, and starvation, they will continue to propagate and if left unchecked, can multiply in astronomical numbers. In addition, unhealthy cats bring illness to the pet population.

According to Gordon Stull, DVM, there are approximately 500 to 1,000 in the Bordentown area. The current practice employed by the City, with the assistance of the non-profit Bordentown Cats, is to use a TNR program: *Trap, Neuter, Release*. This program has been documented in helping reduce the population while maintaining a healthy cat population. Bordentown Cats also seeks to have some cats adopted, thereby reducing the feral population and helping to assure more healthy lives for the population.

Another management effort sponsored by the Audubon Society is the *Cats Indoors Program*. Besides keeping cats indoors as much as possible, some of their practices parallel those of Bordentown Cats, including neutering, eliminating sources of food such as outdoor food dishes, and practices to require responsible pet ownership.

Upland Forests and the Built Environment

During the course of the year, a great variety of birds may be found in upland forests especially during spring and fall migrations. Brown Thrashers, Song Sparrows, and Carolina Chickadees are common. Tufted Titmice and White-breasted Nuthatch frequent winter bird feeders. Blue Jays, Cardinals, Grackles, House Sparrows, Morning Doves and Starlings are wide-ranging throughout the year. It is not unusual to hear the sound of woodpeckers pecking backyard trees searching for insects. Other birds commonly found in upland forests, transitional areas and the built environment include American Goldfinch (New Jersey's State Bird), White-throated Sparrows, and Indigo Bunting. Wintering birds frequenting bird feeders include Tufted Titmouse, Carolina Chickadees, Red-Wing Blackbird, and White Breasted Nuthatch. Some song birds that might be summer residents or spring-fall migrants could include Goldfinch, Common Flicker, American Robin, and various species of warblers. Mammals commonly found in Bordentown's natural and built environment include the ubiquitous Gray Squirrel, Raccoon, Opossum, Eastern Cottontail, Stripped Skunk, Groundhog, White-footed Mouse, and Microtus. Chipmunks, House Mice, Norwegian Rat, and Bats are frequently found in and around buildings. Relying on the upland and wetland forests for cover and food, White-tailed Deer can be found within the City, although they are not that numerous, due to limited habitats.

Incidental Species

Occasionally, species wander into the Bordentown area that are not typically found in this region. In recent years, Wild Turkeys have been observed within Bordentown City, far from the wooded areas of either northern New Jersey forests or the Pine Barrens. In April 2005, area residents were mesmerized by the appearance of a Beluga Whale in the Delaware River as it swam for over a week between Trenton and Burlington, subsisting on shad runs. Also recently found in Thorntown Creek is American Eel – not an exotic species, but unusual to find in streams in this area.

Federal and State Endangered and Threatened Species

Endangered species are those whose prospects for survival are in immediate danger. Threatened species are those that might become endangered if surrounding conditions begin to deteriorate. Both Federal and State-listed species and their habitats are offered levels of protection by various levels of government. The most notable protection measure is afforded listed species in terms of development controls. Any development infringing on wetlands that are part of a listed species habitat are subject to increased controls, which can range from wider vegetative buffers or construction prohibitions during nesting periods for a species, to outright prohibition of any development. Based on information from the New Jersey Natural Heritage Database and also the Landscape Classification System, the Bordentown area (generally corresponding to the Trenton West USGS Survey quadrangle) contains either habitat for, or observed listing for, nine listed species. Nearly all of the listed species are riverine or tidal marsh species associated with the Delaware River and its tributaries. GIS Map 8 indicates areas within the City that are considered critical habitat for threatened and endangered species by the Landscape Project. Areas of "Suitable Habitat" meet the suitability requirements for critical habitat. Areas of "Priority Concern" are those which have had sightings of priority species.

Bald Eagle ***(Haliaeetus leucocephalus)***
NJ status: endangered; federal status: threatened
The Hamilton-Trenton-Bordentown Marsh is a nesting and wintering habitat of the Bald Eagle. A nesting pair of eagles has been observed on Newbold's Island in Bordentown Township. Bald Eagles require a nesting location safe from human disturbance, typically a "supercanopy" tree with a high crown above the surrounding trees, enabling them to arrive and depart from the nest with ease. Bald Eagles are mostly fish eaters, although given the opportunity, will eat almost anything of a similar nature, including carrion. The Landscape Project has identified specific areas along Crosswicks Creek, Thorntown Creek, Blacks Creek, Mile Hollow Run and Love Bridge Run, consisting primarily of emergent wetlands, that serve as critical foraging habitat for Bald Eagles. GIS Map 9 outlines these areas of special concern.

Cooper's Hawk ***(Accipiter cooperii)***
NJ status: threatened; federal status: not listed
This hawk is generally found in woodlands and mixed riparian or wetland forests. About the size of a crow, they prey on smaller birds such as morning doves, sparrows, and starlings. They are commonly found to breed in remote wooded wetlands.

Pied-Billed Grebe ***(Podilymbus podiceps)***
NJ status: endangered; federal status: not listed
A small, brown diving bird, it nests in wetlands throughout New Jersey. It both breeds and winters in New Jersey. The diet consists of a variety of aquatic organisms, including fish, crustaceans, insects, and vegetation.

Bog Turtle ***(Clemmys muhlenbergii)***
NJ status: endangered; federal status: threatened
The Bog Turtle is the smallest native species of its type in the United States, measuring only 3-4 inches long as adults. Their habitats are well drained and shallow wetlands with soft, muddy bottoms.

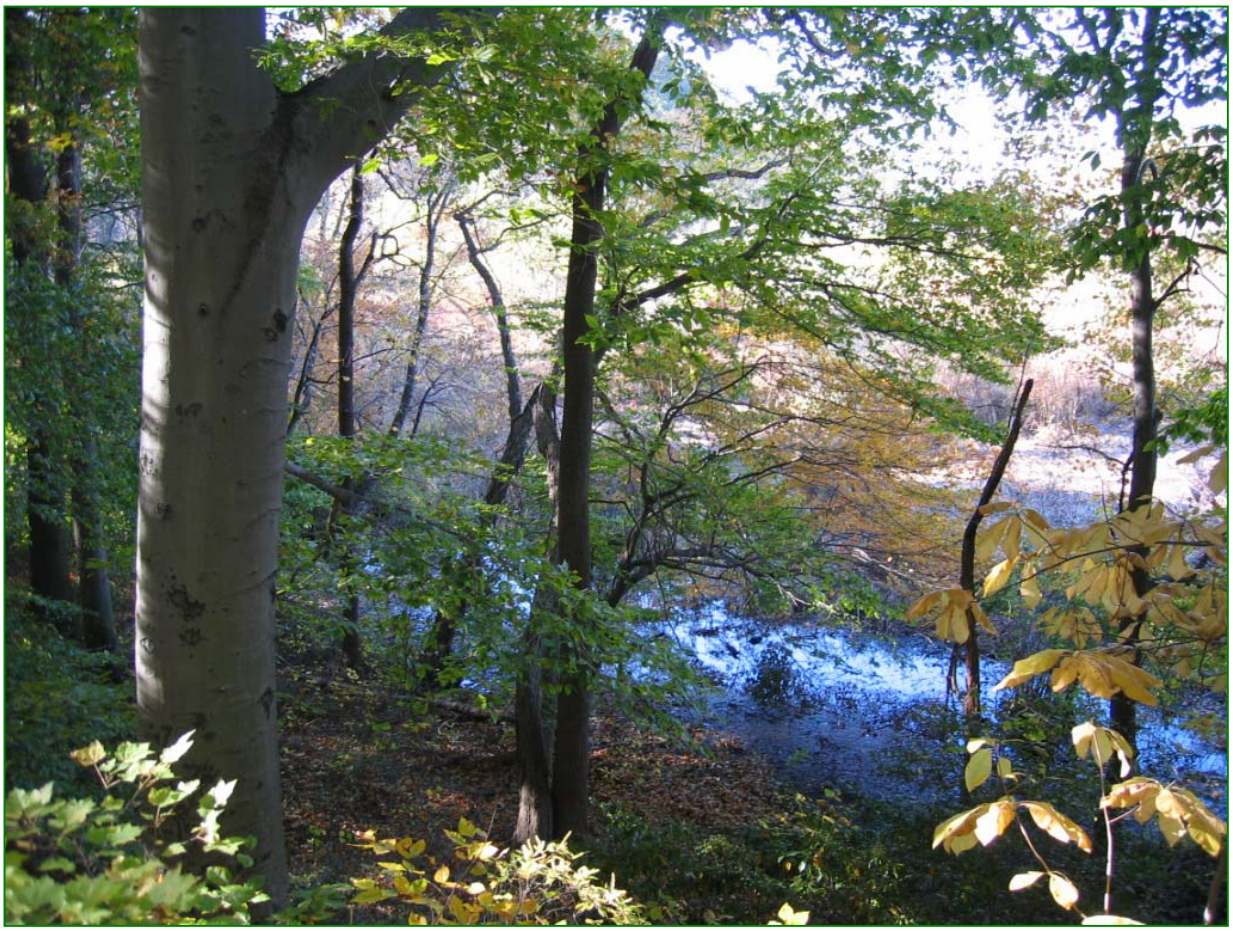
Wood Turtle ***(Clemmys insculpta)***
NJ status: threatened; Federal status: not listed
Noted for its sculpted shell, the Wood Turtle is found throughout eastern North America, south to Virginia, and mostly in northern New Jersey. Adults range from 5.5 to 8 inches in length. They reside in both aquatic and terrestrial environments.

Short-Nose Sturgeon ***(Acipenser brevirostrum)***
NJ status: endangered; Federal status: endangered
Once found almost clogging the Delaware River and estuarine streams, sturgeon are now almost unheard of in our region. However, as an anadromous fish, they were prominent in the Delaware River and creeks in the Bordentown area.

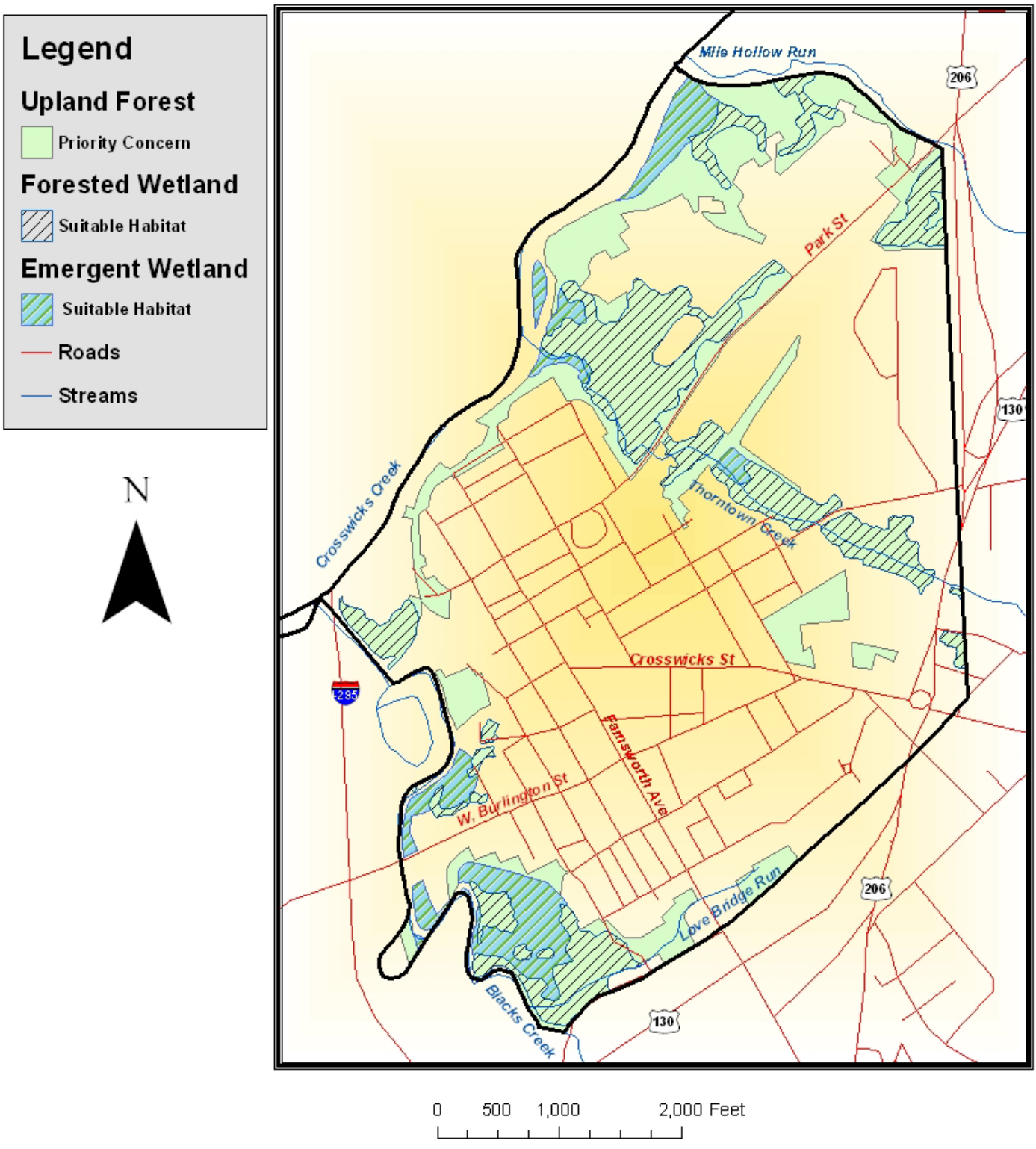
Eastern Pondmussel ***(Ligumia nastuta)***
NJ status: threatened; Federal status: not listed
In New Jersey, the Eastern Pondmussel can be found in the tidal Delaware River and several of its tributaries.

Tidewater Mucket *(Leptodea ochracea)*
NJ status: threatened; Federal status: not listed
Like the pondmussel, the Tidewater Mucket is found in the Delaware River, although it has been located in both tidal and freshwater portions of the river.

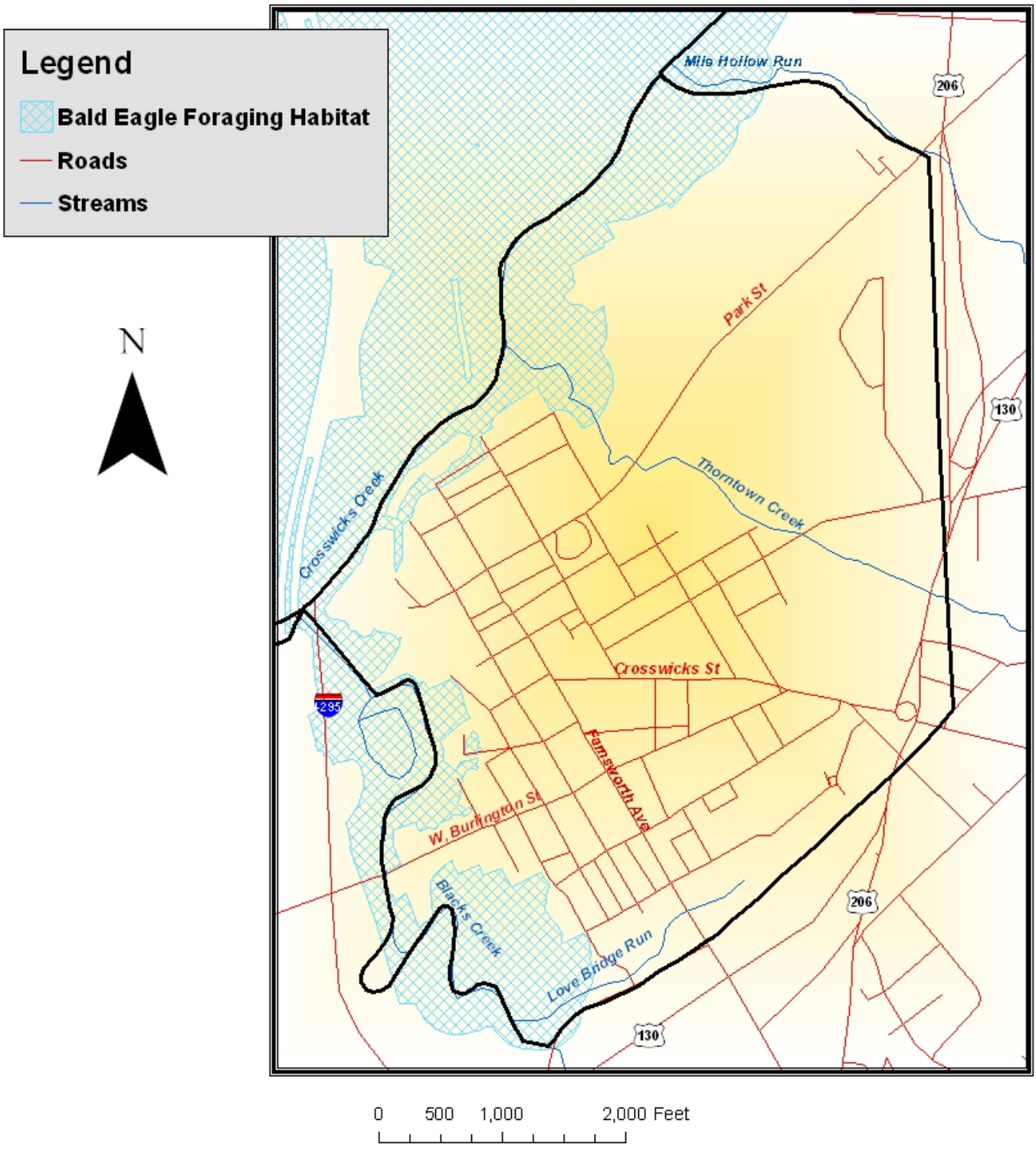
Yellow Lampmussel *(Lampsilis cariosa)*
NJ status: threatened; Federal status: not listed
The Yellow Lampmussel prefers large rivers, like the Delaware River where it has been found, and makes its home in sand/silt substrates.



Bald Eagle foraging habitat, confluence of Thorntown Creek and Crosswicks Creek
Note transition area, upland forest to tidal marsh, with old growth Beech tree and steep slopes



GIS Map 8. Landscape Project Habitat Priorities



GIS Map 9. Bald Eagle Foraging Habitat

Demographics

Population

The rise and fall of Bordentown City's population has been greatly influenced by its geography and history. According to the U.S. Census Bureau, the population of the City in 2000 was 3,969, and with a total square mileage of land area only .92 miles (one square mile total including water), Bordentown's density is 4,137 people per square mile, or four times the New Jersey average of 1,134.

A small geographic area and housing stock largely built up to the mid 20th century have influenced small changes in either population growth or decline in the city. In 1990 the population of the City was 4,341. The 2000 population represented an 8.6% decrease since 1990. Estimates for 2003 supplied by the New Jersey Department of Labor and Workforce Development indicate a 1% increase to 4,013.

Housing

With its founding in 1682, the City was the center for northern Burlington County's services and industry. It also was a transportation hub, being located at the most southerly point of the Delaware and Raritan Canal. This created a population center that led to its early residential and commercial development, and the older housing stock reflects growth in the 19th and early 20th century. Although not built-out, there is little suitable land remaining for residential development. These combined forces have influenced little population change in the City. The median year housing structures were built in Bordentown City is 1939, compared to 1960 for New Jersey. Within the City, of the total 1,884 housing units, only 52% are owner-occupied units, compared to the state average of 61%, which is close to the national average.

Race and Ethnicity

The demographic makeup of the City of Bordentown shows similarities and differences from the New Jersey norm. The racial composition of the City is largely white – 81.3%, compared to the New Jersey average of 72.6%. Blacks, or African Americans, make up 13.1% of the population, close to the New Jersey average of 13.6%. However, the City has few other race and ethnic groups, such as American Indians and Asians, comprising a combined 2% of population, compared to the state average of 5.9%. Year 2000 median household income of $47,279 was below the state average of $55,146.

High density of population, and in turn high density of residential units, in a small area can lead to certain environmental problems, such as increased amounts of run-off, non-point source pollution and increased demand on storm sewers. An aging housing and building stock means a higher proportion of service utilities that are also aged and subject to eventual leakage into ground and surface waters. Thus, it is crucial for City officials to monitor and maintain infrastructure.

With incomes that are below the New Jersey average, Bordentown City has limited financial resources for costly repairs to its utilities, and in the future will be greatly dependant on state and federal grants for their upkeep and replacement.

Transportation

Roads & Streets

Major Roads

Bordentown City is located close to a number of major roads. Exit 7 of the NJ Turnpike is within two miles of the City, providing North/South travel via a toll road. Interstate 295, a non-toll highway, has north and south exits within a mile of the City boundary. State Routes 130 and 206 also provide north/south travel options. Route 130 connects the Delaware River communities between Trenton and Camden. Route 206 connects Trenton and the Pinelands.

Municipal Streets

The streets in Bordentown City are aligned in a grid pattern that developed organically throughout the last 300 years. The main local streets connecting to major roads include Farnsworth Avenue, which serves as the main business district and bisects the City in a north/south axis between Rt. 130 and Crosswicks Creek; Park Street, which runs along a east/west axis between the RiverLINE light rail station and Rt. 206; and Burlington Street, which bisects the City along a east/west axis, and traverses the City between Route 206 in Bordentown Township and the City/Township border at Blacks Creek.

There is one traffic light in Bordentown City, located at the intersection of Crosswicks Street and Routes 206/130.

Principal arterial streets include Farnsworth Avenue, Prince Street, Park Street, Burlington Street and Union Street.

Farnsworth Avenue, looking south from Railroad Avenue

Farnsworth Avenue, looking south from Walnut Street

Local Traffic Counts

The data item Annual Average Daily Traffic (AADT) represents an estimate of all traffic counted for a 24-hour period at the location indicated:

Location	Street Name	Rt#	From	To	Date	AADT Count	Direction
Bord City	Prince St.	622	Just North of W. Burlington	Just North of W. Burlington St.	4/5/99	1,824	Both
Bord City	Park St.	622	West of Rt.206	West of Rt.206	6/2/98	4,206	Both
Bord Twp.	Bordentown Road	130	I-295	Rt.545 (Farnsworth Ave.)	12/4/97	13,684	South
Bord Twp.	Bordentown Road	130	I-295	Rt 545 (Farnsworth Ave.)	12/4/97	15,198	North
Bord Twp.	Bordentown Road	130	I-295	Rt 545 (Farnsworth Ave.)	12/4/97	28,882	Both
Bord Twp.	Rt 545	545	Rt. 206	Rt.130	6/2/98	7,538	Both
Bord Twp.	I-295	I-295	Rt. 130	I-195	10/18/00	31,628	North
Bord Twp.	E.Burlington St.		Rt. 622	2 Miles East of Union St.	4/5/99	2,200	Both
Bord Twp.	Rt. 206	206	Rt. 528	Rt. 130 Diverge	6/2/98	40,561	Both
Bord Twp.	Rt. 206	206	Rt. 545	Rt. 130 Merge	11/25/97	8,055	South
Bord Twp.	Rt. 206	206	Rt. 545	Rt.130 merge	11/25/97	9,241	North
Bord Twp.	Rt. 130	130	Rt. 545	Rt. 206 merge	6/2/98	27,900	Both

Source: Delaware Valley Regional Planning Commission

Mass Transit

Bordentown City is well-served by mass transit. Residents have a variety of options to travel to Trenton, New York and Philadelphia, and points in between and beyond, via means other than the automobile. The existence of these convenient transportation options within the downtown area qualify Bordentown City as a transit-friendly town center, providing a variety of options for young and old, disabled and car-free residents. Mass transit nodes are located within a 5-15 minute walk of the majority of residents..

Rail

Bordentown City is served by the RiverLINE light rail, which is owned and operated by NJ Transit. The system is comprised of diesel-powered light rail cars traveling on a rail line that is shared with Conrail. Opened in May 2004, the RiverLINE averages 6,100 weekday trips and has served over 3 million passengers as of September 2005. The 33-mile long line connects Trenton and Camden, with 20 stops in communities along the Delaware River, including: Trenton, Bordentown City, Roebling, Florence, Burlington City, Beverly, Edgewater Park, Delanco, Riverside, Cinnaminson, Riverton, Palmyra, Pennsauken and Camden. The track includes the right-of-way of the Camden and Amboy Line, which was opened between South Amboy and Bordentown in 1832.

RiverLINE light rail train, crossing Crosswicks Creek, headed north towards Trenton

The Trenton terminus is the Trenton Train Station, where riders may connect with multiple bus routes and Northeast Corridor Rail service, including destinations such as Newark Liberty International Airport and New York Penn Station. The Trenton station is also within walking distance of most government buildings in Trenton, and is served by the downtown Capital Connection bus service.

The Camden terminus is the Walter Rand Transportation Center, which provides bus and rail connections, including many NJ Transit bus routes and PATCO rail. Connecting destinations include Atlantic City, downtown Philadelphia, and SEPTA regional rail, which provides service to Philadelphia International Airport.

Regular fares are currently $1.25 one -way to any station, and are valid for two hours after purchase. Ticket must be validated at the station prior to travel. Monthly passes and 10-ride tickets are available. Discounted tickets for seniors, children and persons with disabilities are also available. Ticket vending machines are located on the platforms at all stations. The hours of operation are 6am-10pm weekdays, 6am-12 midnight Saturdays, and 6am-10pm Sundays and Holidays. The frequency of stops is every 30 minutes, with service every 15 minutes during morning and evening weekday rush hours. The travel time between Bordentown City and Trenton is 12 minutes. Travel to Camden is approximately 1 hour.

The Bordentown Station, accessible via Park Street, has a parking lot adjacent to the platform that contains approximately 200 spaces. Parking is free. Several handicapped spaces and a bicycle parking rack are located next to the station walkway. Bicycles are permitted on RiverLINE trains at all times. An informal weekday count (Source: Bicycle Coalition of Greater Philadelphia, Fall 2004 newsletter) yielded 20 bicycles on 13 select trains, the equivalent of 135 bicycles per day. Cyclists thus currently account for 2 to 3 percent of daily ridership. Connecting services at the Bordentown Station may be made with the Route #409 NJ Transit bus (see below). Schedule information is available at www.riverline.com. See the RiverLINE System Map in Appendix F.

The John Bull and the Camden & Amboy Line

The Camden & Amboy was the first railroad to operate in New Jersey. In 1815, John Stevens succeeded in getting the New Jersey Legislature to authorize the forming of a company "to erect a rail road from the River Delaware near Trenton to the River Raritan at or near New Brunswick." This legislation was the first railroad act of the United States. In 1830, the New Jersey Legislature granted a charter for the Camden & Amboy Railroad. Also delivered in 1831 was the engine *John Bull*, which Stevens purchased during his trip to England. The *John Bull*, shipped disassembled, was put together by Isaac Dripps, a young mechanic recently hired by Stevens, without benefit of blueprints or instructions.

The Trenton Branch was built, from Bordentown to Trenton, in 1837-1838 and Trenton to New Brunswick, connecting with the New Jersey Railroad, in 1837-1839. This branch was built alongside the Delaware and Raritan Canal from north of Bordentown through downtown Trenton to Kingston, where it left the canal and went northeast to New Brunswick.

For the first ride on the rails laid between White Hill and Bordentown, Isaac Dripps was the engineer, Benjamin Wiggins was the fireman and Col. Stevens was the conductor. Trenton's officials and notables came down for a free ride. Madame Murat, wife of Prince Murat of the Bonaparte household was the first woman to ride on the “iron horse” that day. The *John Bull* was retired from regular service in 1866.

A 1/16th replica of the *John Bull*, built by Ed Sholl, stands in the Smithsonian Institute in Washington, DC. In 1981, the original *John Bull* was operated on the 150th anniversary of its first use, becoming the oldest operable steam locomotive in the world.

The railroad bridge beneath Farnsworth Avenue, underneath which freight train service presently continues on a small portion of the original Camden & Amboy Line, is the oldest railroad bridge in continuous use in North America.

Sources: Downtown Business Association and the Camden & Amboy Railroad Historical Society, Inc.

Bus

The NJ Transit Route #409 Long Distance Suburban Bus provides service between Philadelphia and Trenton, with stops along the Route 130 corridor, including: Trenton Rail Station, Bordentown, Roebling, Florence, Burlington, Burlington Center, Mount Holly, Edgewater Park, Willingboro, Willingboro Shopping Center, Bridgeboro, Delran, Cinnaminson, Pennsauken, Moorestown, Camden, and Philadelphia.

Service is approximately every hour in both directions on weekdays, and approximately every two hours on weekends and holidays, from 6am-10pm.

Three bus stops are located in Bordentown City, including the corner of West Burlington Street and Farnsworth Avenue, the corner of Park Street and Second Street, and Park Street by the Park Street Apartment complex. Bus shelters are not provided at any bus stop.

Fares depend on distance of travel. Driver will make change. Discounted monthly passes and ten trip tickets are available. Discounted tickets for seniors, students, children and disabled persons are available, including transfers. Bicycles are permitted at all times in the underneath storage compartment, space permitting.

See www.njtransit.com for current schedule information.

Bicycle/Pedestrian

Due to its relatively dense land use pattern and interconnected street grid within one square mile, Bordentown City is a bicycle/pedestrian-friendly center. A wide variety of destinations are easily accessible via bicycle or foot, including grocery stores, restaurants, retail, schools, library, post office and municipal offices. Although the street pattern and density allows for these trips, there is much room for improvement, including rehabilitation and expansion of the sidewalk network; increased bicycle infrastructure (including signage, road striping and bicycle parking), and traffic calming measures along the main thoroughfares.

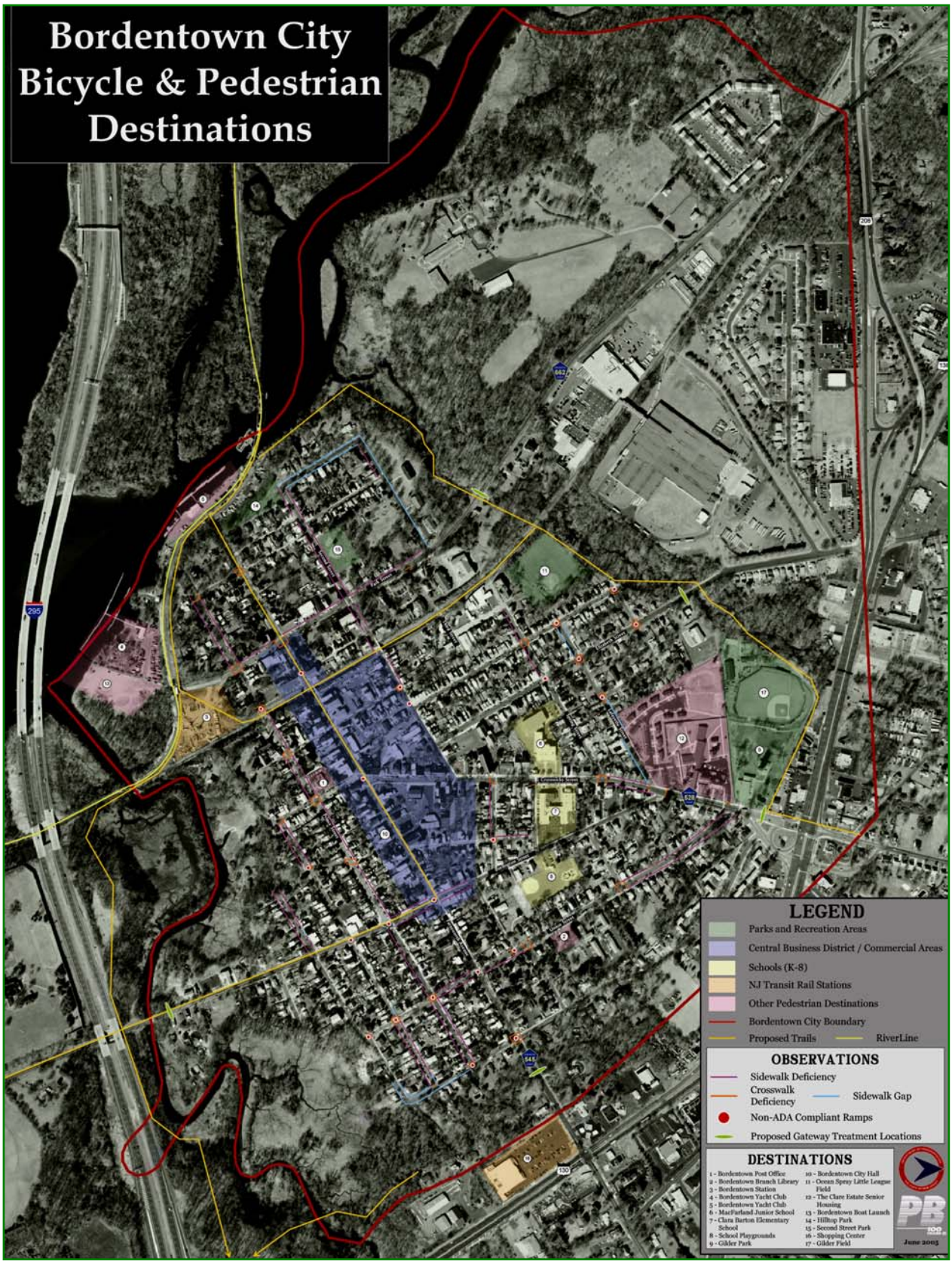
Current bicycle infrastructure within the City consists of a “wave”-type bicycle parking rack at the Post Office on Walnut Street and a “hitch”-type bicycle parking rack in front of the Corner Deli on Farnsworth Avenue.

Bicycle parking rack, Farnsworth Avenue

Major bicycle/pedestrian initiatives in the future include the Delaware River Heritage Trail, which will enter the City via the old Delaware & Raritan Canal path and across the pedestrian bridge beside the RiverLINE bridge, run down Farnsworth Avenue, and extend south through Fieldsboro.

Additionally, walking trails, with interpretative signage, are planned along the proposed Thorntown Creek and Blacks Creek Greenways.

Bordentown City is currently undertaking a Bicycle/Pedestrian Plan, which will include an existing sidewalk inventory and proposed bicycle routes, off-road trails, and traffic calming improvements. The Bicycle/Pedestrian Plan is expected to be completed by December 2005. *See draft map on page 73.*



Bordentown City Bicycle/Pedestrian Plan (DRAFT)

Air Travel

The closest airport to Bordentown City is the Trenton-Mercer Airport. This facility provides regional service to the New England and Mid-Atlantic States, as well as corporate flights. See www.mercercounty.org/airport/index.htm for more information.

Marine Travel

Bordentown City has two marinas: Yapewi Aquatic Club and Bordentown Yacht Club. They are located near each other at the confluence of Crosswicks Creek and the Delaware River. These facilities allow boaters to travel to locations along the Delaware River, as well as access to the Atlantic Ocean and various points along the Atlantic Seaboard. Both facilities have a clubhouse and dockage for member vessels on Crosswicks Creek.

Transit Village: Attributes, Opportunities and Recommendations

With the advent of the RiverLINE light rail service in 2004, Bordentown City satisfies many of the criteria of a Transit Village, a "Smart Growth" strategy that refers to a community with sufficient transit facilities to make it an appealing choice for people to live, work and play, thereby reducing reliance on the automobile. According to the NJ Transit-Transit Village Initiative, a good Transit Village candidate must make a commitment to grow in jobs, housing and population. Bordentown City meets, or is working towards, all of the following criteria:

• A designated Transit Village must have a transit facility. This can be a rail or light rail station, ferry terminal, a bus hub or bus transfer station. (*Qualifies*)
• The candidate for Transit Village designation must have vacant land and/or underutilized or deteriorated buildings within walking distance of transit where redevelopment can take place. (*Qualifies*)
• A Transit Village candidate must have an adopted land-use strategy for achieving compact, transit-supportive, mixed-use development within walking distance of transit. This can be in the form of a redevelopment plan, zoning ordinance, master plan or overlay zone. (*Process ongoing*)
• The candidate must have a strong residential component. This can include mid-rise buildings, townhouses or apartments over first-floor businesses. A wide variety of housing choices within walking distance of transit helps to support transit ridership. (*Qualifies*)
• The candidate will have "ready-to-go" projects. This means at least one transit-oriented project that can be completed within three years. *(Process ongoing)*
• In order for a municipality to succeed as a Transit Village, it should demonstrate pedestrian and bicycle friendliness. This means clear, direct pathways from the transit station to shops, offices, surrounding neighborhoods and other destinations. (*Process ongoing*)
• A good candidate views its transit station as the focal point of the community and uses its station plaza as a gathering place for community activities such as festivals, concerts, public ceremonies and farmers markets. (*Process ongoing*)

• A good candidate includes its transit station in a station area management plan, in a special improvement district (SID), or as part of a Main Street New Jersey designation. (*Process ongoing*)
• A good candidate should strive to minimize automobile use by maximizing the appeal of transit. One example of this is the concierge service in the Metuchen train station. Commuters drop off errands (such as dry cleaning, packages for mailing, etc.) in the morning and pick-up items on the opposite side of the tracks on the way home. (*Process ongoing*)
• The candidate should provide commuter parking for residents and non-residents. A Transit Village should also strive to reduce parking requirements near transit stations and implement shared parking solutions wherever possible. (*Process ongoing*)
• The candidate should support local arts and culture. This brings vibrancy and activity to a community. Designating an arts, antique or restaurant district helps make a Transit Village a destination. (*Qualifies*)
• The candidate should support the historic and architectural integrity of the community by ensuring that new buildings blend in with the existing buildings. This can be done with architectural design guidelines that govern new building facades, window replacements, awnings, lighting and signs. (*Process ongoing*)

RiverLINE Station in Bordentown City

RiverLINE Station parking lot, Park Street

Mode of Transportation to Work *

(# of Workers 16 and over: 2,244)

Number of residents who use public transportation: 54	% of residents
Bordentown City	2.4
NJ	9.6
US	4.7
Number of residents who use car, truck, van or motorcycle: 1,987	**% of residents**
Bordentown City	88.5
NJ	83.6
US	88.0
Number of residents who walk/bike: 130	**% of residents**
Bordentown City	5.8
NJ	3.1
US	2.9
Number of residents who work at home: 47	**% of residents**
Bordentown City	2.1
NJ	2.7
US	3.3

(Source: 2000 US Census)

Commuting Time*

Average travel time to work (minutes):	Minutes
Bordentown City	27
NJ	30
US	26
Average travel time to work using public transportation (minutes):	**Minutes**
Bordentown City	41
NJ	57
US	48
Average travel time to work using other transportation (minutes):	**Minutes**
Bordentown City	26
NJ	27
US	24
Average number of vehicles per person :	
Bordentown City	1.9
NJ	1.63
US	1.64

*Data collected prior to beginning of RiverLINE service in 2004.

History

Historical Overview

The City of Bordentown encompasses a one square mile area, tucked onto the bluffs of the Delaware River approximately 45 miles upstream from Philadelphia. With New York City 75 miles to the north, it is understandable that this small city became a colonial transportation hub. The City started its existence in 1682 with a log cabin on the riverbank and the name Farnsworth Landing. Settled by Quakers, the town was a trading point in colonial America. In 1717 a farmer from Freehold named Joseph Borden settled here, bought up a substantial part of the land and changed the town's name to Borden's Town. He started a packet line from Philadelphia to Bordentown, where travelers would stop to rest and then proceed on Borden's stage line to Perth Amboy, where they would make their connections to New York.

Many of the founding fathers of the country passed through Bordentown, which had become a bustling city of trade by the late 1700s. Francis Hopkinson, signer of the Declaration of Independence, lived in town. His son, Joseph, author of the song “Hail Columbia”, resided here as well. Thomas Paine, through his friendship with Col. Joseph Kirkbride, a veteran of the Revolutionary War, became enchanted with Bordentown and spent much time here, eventually buying a house in town. Bordentown's importance as a crossroads was not lost even on the British. The town was occupied by British forces on three separate occasions during the American Revolution, including in 1778 when two Continental frigates were burned and sunk in Crosswicks Creek as British troops attacked and briefly shelled the City.

Bordentown's historical significance did not end with the Colonial period, as it continued to play a major role in transportation. The first movement by steam on rails in the United States occurred in 1831 on the outskirts of town by the steam engine *John Bull* (now part of the Smithsonian Collection). Bordentown was an important stop on the railroad line between Philadelphia and New York. American Presidents and notables passed through town and some stayed, including Clara Barton, the founder of the Red Cross, who in 1852 established in Bordentown City the first successful free public school in New Jersey. The exiled King of Spain and Naples, Joseph Bonaparte, elder brother of Napoleon, also resided in Bordentown. Given the convenient location to cultural centers and the abundance of unspoiled property, Joseph Bonaparte purchased large tracts of land from Bordentown to Trenton, naming it “Point Breeze”, and built his mansion in Bordentown on the bluffs overlooking the Delaware River valley. Bonaparte brought a European influence to the town, spending 30 years here. While residing in Bordentown he hosted many important contemporary figures, including the Marquis de Lafayette, John Adams, Henry Clay and Noah Webster among others.

Mansion at Point Breeze, Park Street, circa early 1900s

Lock #1 And Locktender's House, Delaware & Raritan Canal, Crosswicks Creek, circa early 1900s

Bordentown's location on the Delaware River, just south of the state capital of Trenton, made it an important river port. Shipbuilding and river trade were prosperous industries. The opening of the Delaware & Raritan Canal in 1834 also played a significant role in the town's growth. But throughout these changes and commercial boom times, Bordentown remained small. The City was incorporated as a borough in 1849 and as a city in 1867. As the town has grown, the architecture has evolved as well. Buildings of Federal, Victorian, and Arts & Crafts styles, from bungalows to stately mansions, document the architecture of the 18th, 19th, and 20th centuries.

Today, much of the City's square mile is a designated Historic District, and numerous properties are on the State and National Historic Register.

Thomas Paine Statue, Prince Street

Quaker Meeting House, circa 1750 (first floor), 1813 (second floor)

Bordentown City Historic Sites

State and National Historic Register Designations

Abbott Farm Historic District (NHL, ID#1654)
National Register: 12/8/1976 (National Register Reference #: 76001158)
State Register: 8/16/1979

Bordentown Historic District (ID#750)
Location: Farnsworth, Second and Third Avenues; Crosswicks, Prince, Walnut, Burlington, Park and Spring streets.
National Register: 6/14/1982 (National Register Reference #: 82003264)
State Register: 7/7/1976

Camden and Amboy Railroad Branch Line Historic District (ID#2969)
Location: Camden and Amboy Branch Line Right-of-way from Bordentown City to Adams Lane, North Brunswick, Middlesex County.

Camden and Amboy Railroad Main Line Historic District (ID#2970)
Location: Camden and Amboy Railroad right-of-way.
Extends through thirty-one municipalities in four counties.

Crosswicks Creek Railroad Bridge (ID#3255)
Location: Camden and Amboy Railroad over Crosswicks Creek.

Crosswicks Creek Site III (28-Bu-329) (ID#753)
National Register: 11/26/1990 (National Register Reference #: 87001795)
State Register: 8/31/1987

Bordentown Timeline

1681 -- Thomas Farnsworth purchased 100 acres; later purchased an additional 448 acres, extending from Crosswicks to Blacks Creek, and the Delaware River to Newbold's Island.
1682 -- Bordentown founded by Thomas' son Samuel; called the settlement Farnsworth Landing.
1717 -- Joseph Borden acquires 50 acres, renaming the area Borden's Ferry.
1725 -- Iron forge built on Blacks Creek, location unknown.
1734 -- First stage line established from Burlington, through Bordentown, to New York.
1741 – First Quaker meeting house constructed.
1750 -- John Imlay built what is now known as the Francis Hopkinson House. It was later the home of Hopkinson, member of the Continental Congress, federal district judge, author, artist, and musician. He designed the Great Seal for the State of New Jersey.
1776 -- Bordentown occupied by 2,000 British and Hessian troops.
1778 -- British attack and destroy much of Bordentown.
1783-86 -- Thomas Paine lives in Bordentown.
1816 -- Joseph Bonaparte, King of Spain, purchases 1,000 acres in Bordentown at Point Breeze.
1830 -- Camden and Amboy Railroad incorporated. The following year, the John Bull locomotive has trial run.
1834 -- Delaware and Raritan Canal completed, connecting Bordentown and New Brunswick.
1849 -- Bordentown incorporated by New Jersey legislature.
1852-3 -- Clara Barton, founder of the American Red Cross, opened her free school, one of the first in NJ.
1872 -- The industrial revolution came to Bordentown with the establishment of a canning and mincemeat factory. This was followed two years later with a shirt manufacturer, shipyard, and in eight years, another shirt factory.
1886 -- African-American Rev. W. A. Rice established a private school, the Manual Training and Industrial School for Colored Youth, in a house on West Street; later moved to Walnut Street.
1898 -- Trenton Transportation Company began running trolleys from Trenton to Bordentown. They were replaced in 1932 with bus service.
1936 -- Hilltop Park renamed William R. Flynn Memorial Park. The newer park was the first Burlington County Works Progress Administration project completed.
1947 -- After several owners, Point Breeze becomes a

Richard Watson Gilder house (ID#4283)
Location: Crosswicks Street.

Francis Hopkinson House (NHL, ID#751)
Location: 101 Farnsworth Avenue.
National Register: 7/17/1971 (National Register Reference #: 71000496)
State Register: 7/17/1971

Francis Hopkinson House, circa 1750

Richard Watson Gilder House, circa 1725

Point Breeze Historic District (ID#752)
Location: US Route 206 and Park Street.
National Register: 8/10/1977 (National Register Reference #: 77000848)
State Register: 10/22/1976

Local Historic Designations:

Both the Farnsworth Avenue Business District and Thompson Street are designated historic districts as part of the Bordentown City Historic Preservation Ordinance. Any development, re-development or rehabilitation of structures within these zones is subject to review by the Historic Preservation Officer. In order to preserve and protect the historic architectural resources, exterior building facades in these areas must adhere to historically correct designs, patterns and colors.

Streetscape on Thompson Street

Land Use

Land in Bordentown City is used in many different ways, with many different uses adjoining or proximate to each other. The chart below shows how the land is used:

Land Use Categories	% of City
Residential: Single Family Detached	25.0
Residential: Single Family Attached	3.8
Residential: Two-Family	2.1
Residential: Three-Family and Up	7.6
Downtown Commercial	1.4
Local Commercial	2.5
Highway Commercial	3.9
Industrial	6.0
Public/Quasi-Public	28.3
Railroad	0.9
Open Space/Parks	6.3
Environmentally Sensitive	8.0
Vacant	4.2
TOTAL	**100.0%**

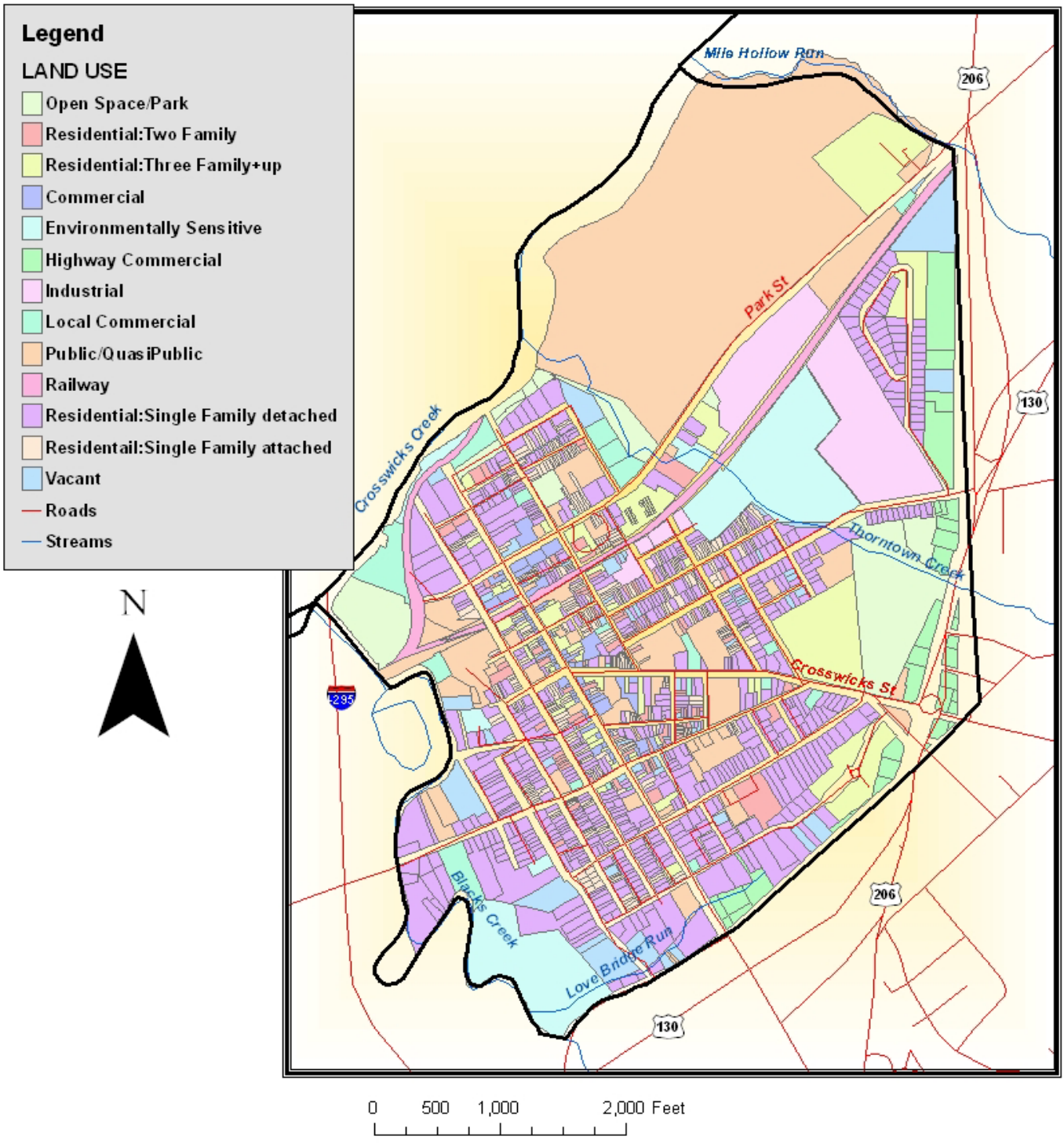
Residential: Residential housing accounts for the largest share of land use, 38.5%, in the City, comprising of a wide range of housing types. Single-family attached and detached houses, multi-family houses, apartment complexes, age-restricted and assisted living facilities, carriage houses/granny flats, and apartments above retail stores offer a mix of housing opportunities to a wide range of household incomes.

Commercial: There are three commercial areas within Bordentown City, comprising 7.8% of land use, including the Downtown and Local Commercial Districts and the Highway Commercial District along Routes 206 and 130.

A small portion of mixed use properties are located mainly in the Downtown District along Farnsworth Avenue, comprising buildings that contain retail shops, restaurants or offices on the ground floor and apartments on the second and third floors.

Industrial: Industrial land use, comprising 6% of the City, consists primarily of the Ocean Spray processing plant located on Park Street. Other small light industrial operations are scattered throughout the City.

Public/Quasi-Public: Public/quasi-public land uses comprise 28.3% of the City, including churches, schools, municipal/government offices, and other tax-exempt properties. A large portion of Public/Quasi-Public land use is the Divine Word Missionaries property.



GIS Map 10. Land Use

Railroad: The RiverLINE light rail and freight rail lines account for 0.9% of City land.

Open Space/Parks: Open space accounts for 4.3% of the land and is owned and managed by a variety of entities. City property includes local parks, such as the Bordentown Beach/Boat Ramp area, Gilder Field, Hilltop Park, and Second Street Park. A few small City-owned properties are undeveloped as parkland and unmanaged. School playgrounds are located at the Clara Barton School and off East Burlington Street. For more details on open space in Bordentown City, see the Bordentown City Open Space Plan on page 85 and the GIS Open Space Map on page 86.

Environmentally Sensitive: 8.0% of City land, primarily along Thorntown and Blacks Creeks, is undeveloped floodplain and wetlands that serve as vital habitat, flood control, and natural buffers to the urbanized areas of the City.

Vacant: A small percentage (4.2%) of City land is vacant. Some of these vacant parcels are scheduled to be acquired for passive open space. Others are buildable lots scattered throughout the City.

Note: Zoning changes adopted in the August 4, 2004 Land Use Element of the Bordentown City Master Plan reflect changes in previous zoning and encourage changes in future land use within the City.

Bordentown Beach park area, mouth of Blacks Creek

Open Space & Trails

Preserved open space within the City is limited to several parks and playgrounds, as well as the Bordentown Beach (*see Land Use section*). Proposals for future open space acquisition and trail networks include the Railroad Avenue Promenade, Lime Kiln Alley Park, Oliver Street Park, Thorntown Creek Greenway, and Blacks Creek Greenway. Completion of these open space projects will significantly increase the passive recreational opportunities for City residents, which is in accordance with the Bordentown City Master Plan's stated goal of preserving urban open space within the City.

Railroad Avenue Promenade will consist of a linear park immediately adjacent to (and above) the freight rail line from Prince Street to Second Street, facilitating off-road pedestrian movement within the central business district and providing the most centralized open space area within the City to date.

Lime Kiln Alley Park is planned for an area along Blacks Creek at the base of Lime Kiln Alley. It will consist of several small parcels, including an area recently remediated by PSE&G (formally a coal-gasification plant at the turn of the century), and offer a non-motorized boat launch area, as well as opportunities for fishing, wildlife viewing, and environmental and historical education for local residents and school children.

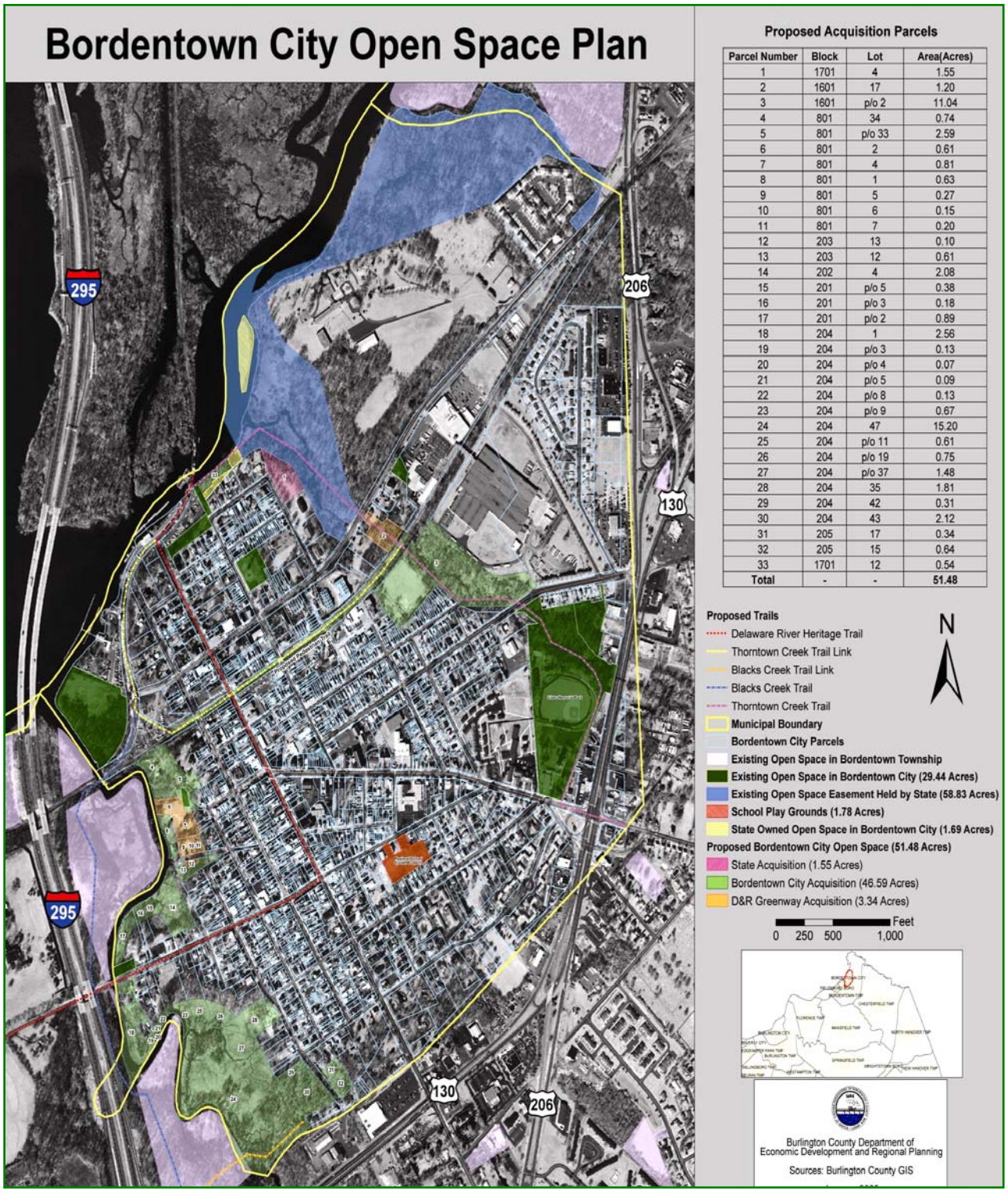
Oliver Street Park is proposed for a three-acre site at the southern end of Oliver Street, providing a passive open space area in the southern section of the City and access to Blacks Creek and the proposed Blacks Creek Greenway trail.

Thorntown Creek Greenway envisions a preserved natural corridor along the creek floodplain, with a pedestrian trail extending from Gilder Field to the mouth of Thorntown Creek where it meets Crosswicks Creek.

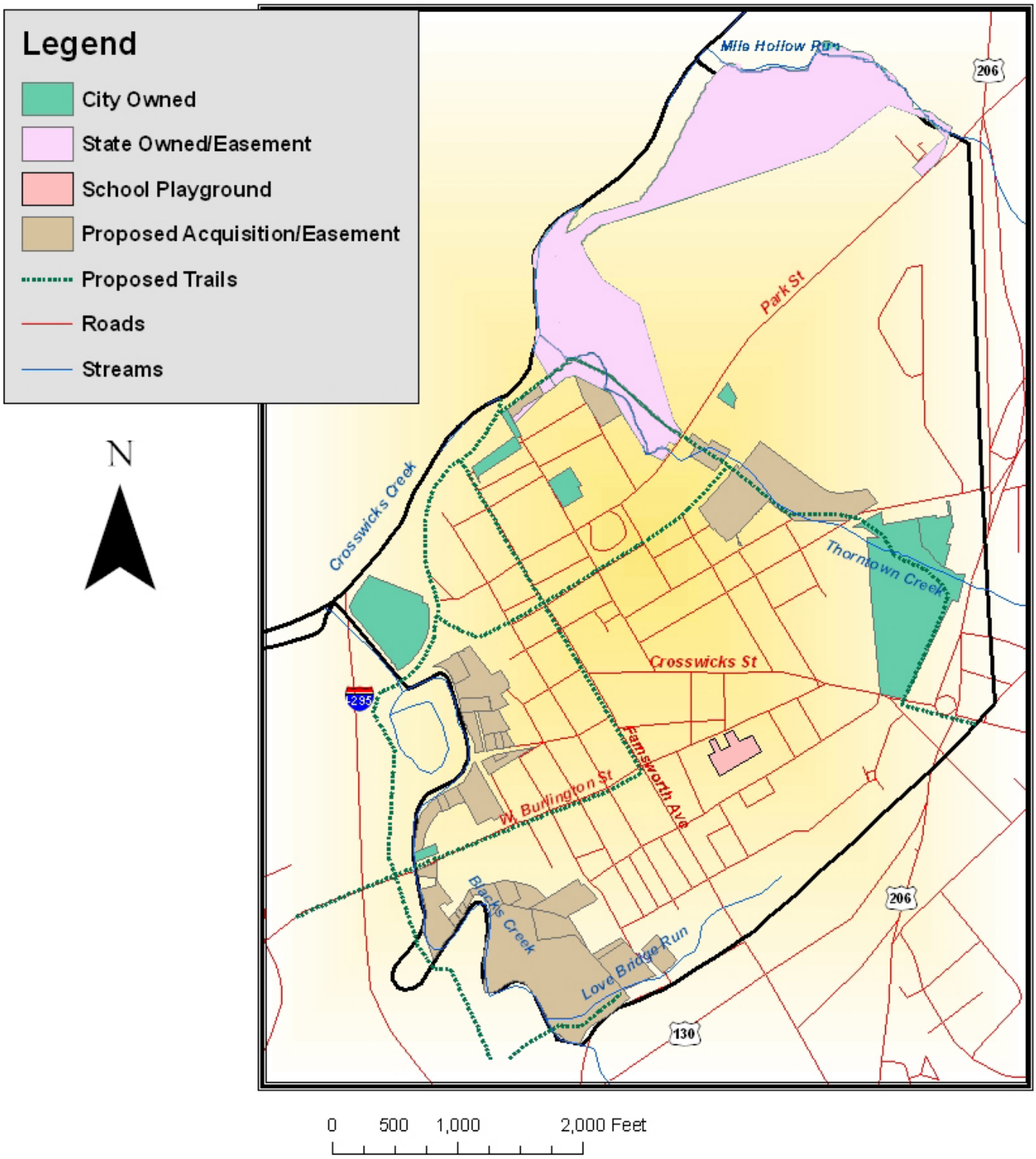
Blacks Creek Greenway is an ambitious open space effort, planned jointly with Bordentown Township, and includes property on both the City and Township sides of the creek. A loop trail is envisioned to extend from the Bordentown Beach area, across Blacks Creek to the Township side, traversing the upland side of the creek in a southerly direction, and re-entering the City across Blacks Creek at the location of the remnant bridge abutments across Mill Street (with a connection to Oliver Street Park).

Both greenways will provide recreational opportunities, including walking, jogging, wildlife viewing, plant identification, and quiet reflection. They will also provide ecological benefits, including: protecting wildlife habitat corridors; providing a critical buffer zone for the protection of water quality; controlling soil erosion and sedimentation; fostering cleaner air through the preservation of mature trees and vegetation; providing an outdoor classroom for environmental and historical education opportunities; and enhancing the ability of residents to travel within the City in a non-motorized fashion.

See the Bordentown City Master Plan: Open Space Plan Map and the GIS Open Space Map below for details.



Bordentown City Open Space Plan: Existing and Proposed Open Space



GIS Map 11. Open Space

Areas of Scenic Value

There are several viewsheds within Bordentown City that merit special recognition for their scenic qualities.

Point Breeze Viewshed

The viewshed along Park Street adjacent to the Divine Word Missionaries property (looking west) is valuable both in terms of its natural beauty and historical significance. The landscape consists of both open lawn and mature forest, very similar to the landscape as it existed during the time of Joseph Bonaparte's Point Breeze Estate.

Point Breeze property, from Park Street

Hilltop Park Viewshed

The viewshed at Hilltop Park is valuable both in terms of its natural beauty and historic significance. From this spot on top of the bluffs, a panoramic view of the mature vegetation of Duck Island, Crosswicks Creek and the Hamilton-Trenton-Bordentown Marsh can be seen in one sweeping gaze. The view also encompasses the Lock #1 area of the Delaware & Raritan Canal and the area that contained the locktender's house, as well as the location of sunken Revolutionary War-era ships.

Hilltop Park

View of Crosswicks Creek and Duck Island

Blacks Creek Viewsheds

Various viewsheds of Blacks Creek are accessible within Bordentown City. These views provide an intimate glimpse into the ecology and wildlife of a tidally influenced stream and marsh. The tidal zone, which is exposed by as much as eight feet twice each day,

offers a dramatic view of the stream channel, changing stream flow, and the rich variety of vegetation and wildlife that exist in this dynamic area. The area is frequented by numerous bird species and is a critical foraging habitat for the Bald Eagle.

Blacks Creek, low tide, looking west from bridge at East Burlington Street

Recreational Waterways

The main recreational waterways in the vicinity of Bordentown City are the Delaware River and Crosswicks Creek. The Delaware River is used for a variety of activities, including powerboats, jet-skis and canoes and kayaks. Crosswicks Creek has a similar usage, although access by larger boats is limited by the RiverLINE bridge. Blacks Creek also offers limited (high tide) access via canoe/kayak.

Kayaker on Crosswicks Creek

Crosswicks Creek, Bordentown Twp.

See Crosswicks Creek Canoe Trail Map in Appendix E for more details.

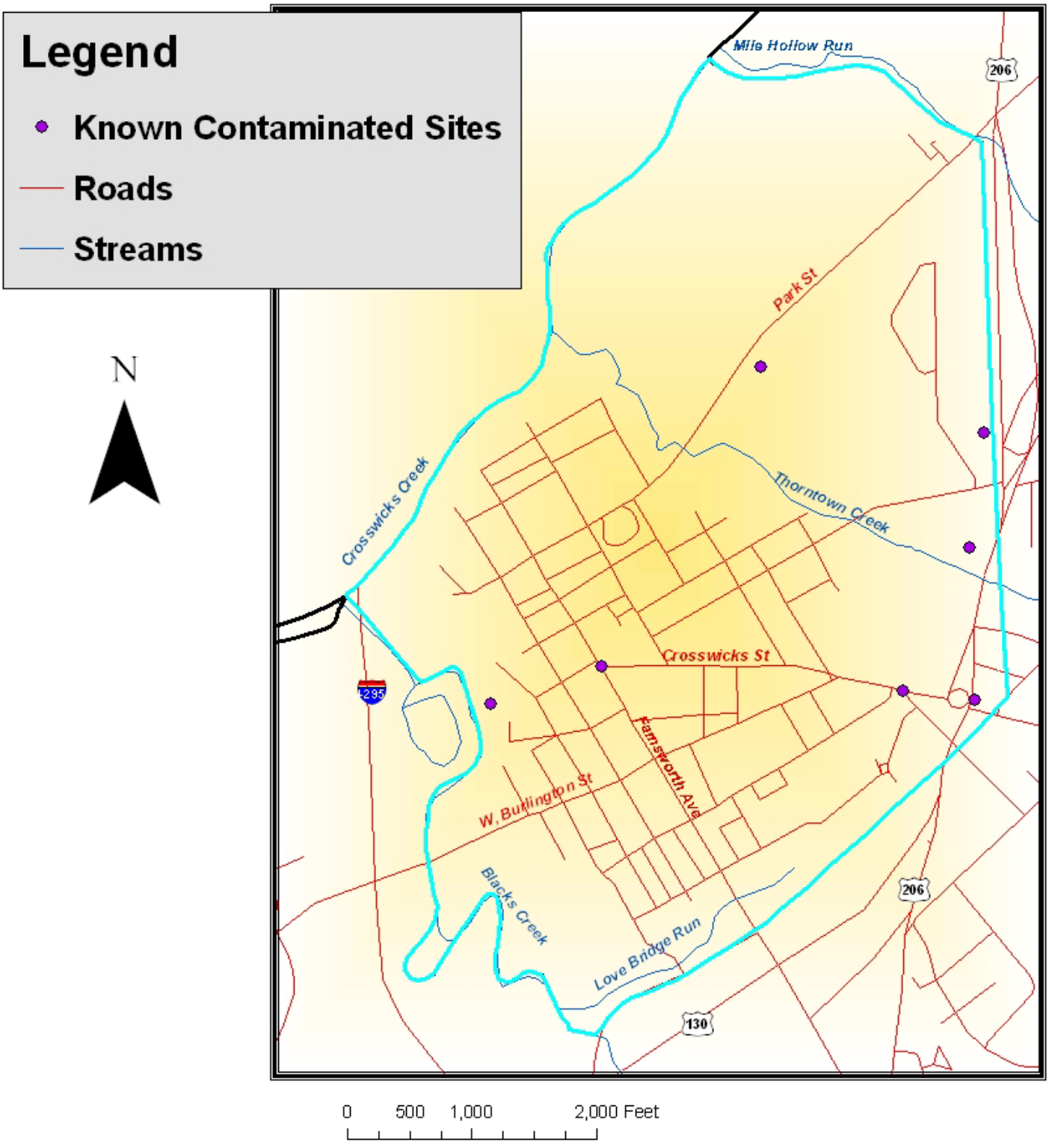
Known Contaminated Sites

The sites below have been identified by the NJ Department of Environmental Protection - Site Remediation Program as having on-site source(s) of contamination. The source of contamination has been identified in soil and/or groundwater at the location identified in the listing. Remedial activities are either underway or required.

Site Name	Address	Case Status	Status Date	Remedial Level
Clare Estates	201 Crosswicks St.	Active	1/10/01	ND
Auto Body Shop (abandoned)	1 1/2 Crosswicks St.	Active	5/17/94	B
PSE&G Coal/Gas	Walnut Street	Active	3/9/90	D
Exxon Service Station	Rt. 130/Crosswicks St.	Active	10/27/88	ND
Sunoco Service Station	Rt.130/Rt.206	Active	10/27/88	C2
Mercantini Ford	Rt. 206/Lucas Dr.	Active	12/3/99	
Mobil Service Station	Rt. 130/Farnsworth Ave.	Active	10/7/97	C1
Ocean Spray Cranberry	104 East Park St.	Active	8/10/93	C2

Definitions

Status Date: For cases with an active status designation, the date provided represents the date the site was assigned to the designated contact bureau. For cases with a pending status designation, the date provided represents the date the pending status was determined.
Active: This status is designated when a contaminated site is assigned to a remedial program and measures such as a preliminary assessment, remedial investigation or cleanup work is underway.
Remedial Levels:
B: No single phase remedial action in emergency response; simple removal activities of contaminants; usually no impact to soil or groundwater.
C1: A remedial action with simple sites; one or two contaminants localized to soil and the immediate spill or discharge area.



GIS Map 12. Known Contaminated Sites

C2: A remedial action with more complicated contaminant discharges; multiple site spills and discharges; more than one contaminant, with both soil and groundwater impacted or threatened.
C3: A multi-phase remedial action with high complexity and threatening sites. Multiple contaminants some at high concentrations with unknown sources continuing to impact soils, groundwater, and possibly surface waters and potable water sources. Dangerous for direct contact with contaminated soils.
D: Same conditions as C3, except that D levels are also usually designated as federal "Superfund Sites".
ND: Not designated.

Note: The PSE&G Coal/Gas site was remediated by PSE&G in 2003.

Noise Factors

Noise negatively affects human health and well-being. Problems related to noise include hearing loss, stress, high blood pressure, sleep loss, distraction and lost productivity, and a general reduction in the quality of life and opportunities for tranquility.

Most areas of Bordentown City's one square mile are exposed to above-average noise levels, due primarily to the local topography and proximity of residential housing to major roads.

Particularly effected are the residential streets on the edges of the City. The most significant noise comes from automobile and, especially, truck traffic on the I-295 bridges over Burlington Street and Crosswicks Creek, as well as noise from Rt. 130 on the southern and eastern edges of the City.

In addition, there are noise issues related to local passenger train service. The introduction of the RiverLINE light rail service in 2004 created new noise issues in the north/northwestern quadrants of the City. The train car rings a bell as it stops at the station located at the end of Park Street, and blows its horn once at the grade crossing at the end of Farnsworth Avenue. Noise from the RiverLINE train is not currently a factor midnight-6:30am on weekdays, and 1am-6:30am on weekends, as the train does not operate during these hours.

The CSX freight train that runs through the City along a roughly northeasterly axis (paralleling Railroad Avenue) during the early morning hours also presents a noise issue. It blows its horn at the grade crossing at the Second Street Alley. This train has no set schedule, but its early morning hours effect nearby residences.

No record of decibel level measurements in any locations within Bordentown City has been found. However, Bordentown City submitted a request in August 2005 to NJ Department of Transportation to measure the local noise levels. Results are pending.

Infrastructure

Water Supply

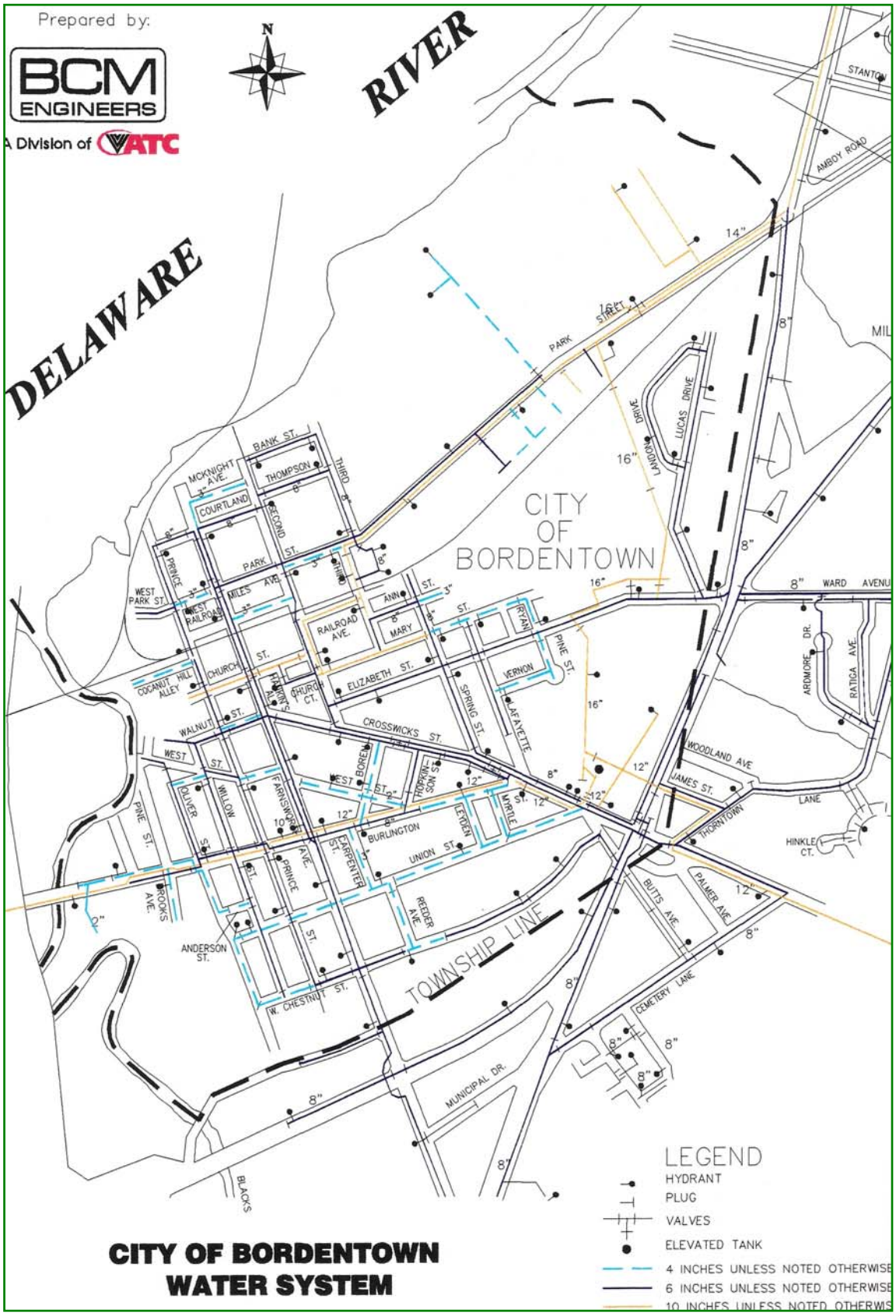
Bordentown Water Department

Potable water for consumption and fire fighting is provided in Bordentown City by an underground piping system, which is owned, operated, and maintained by the City of Bordentown Water Department. In the 1970s a new plant was built in Hamilton Township on property owned by Bordentown City, along Crosswicks Creek between Rt. 206 and South Broad Street. Water is drawn into the system from the Raritan-Magothy aquifer.

One water storage standpipe (capacity 0.8 million gallons) is located at Gilder Field in the City. There is another storage tank in Bordentown Township (capacity 4 million gallons) near the Derby Fire House, behind the Township Public Works garage. The water system serves Bordentown City and Bordentown Township directly, while the Borough of Fieldsboro purchases water at a bulk rate for sale to its residents. The water distribution system consists of 10, 12, 14, and 16-inch transmission mains, with smaller line sizes down to 2 inches. The Water Department currently owns and maintains about 70 miles of water mains in the City and Township.

In the late 1980s and early 1990s, the Water Department undertook a major cement re-lining program to restore the carrying capacity of the 10 and 14-inch transmission mains from the water filtration plant into the City and Township. Over 34,000 feet of 8, 19, 12 and 14-inch diameter water distribution mains were re-lined with cement. The effect of this cement re-lining program improved flow and available pressure, especially in the City and northern portion of the Township.

Water storage standpipe, Gilder Field


Prepared by:
BCM ENGINEERS
A Division of ATC
N
DELAWARE RIVER
CITY OF BORDENTOWN
TOWNSHIP LINE
STANTON
AMBOY ROAD
14"
16"
PARK
LUCAS DRIVE
LANDON DRIVE
8"
WARD AVENUE
ARDMORE DR.
RATICA AVE.
WOODLAND AVE
JAMES ST.
LANE
THORNTOWN
HINKLE CT.
PALMER AVE
BUTTS AVE.
CEMETERY LANE
MUNICIPAL DR.
BANK ST.
MCKNIGHT AVE.
THOMPSON
THIRD
COURTLAND
SECOND ST.
PRINCE
WEST PARK ST.
WEST RAILROAD
MILES AVE
RAILROAD AVE.
MARY
ANN ST.
RYAN
PINE ST.
VERNON
LAFAYETTE
SPRING ST.
CHURCH
CHURCH ALLEY
COCONUT HILL ALLEY
ELIZABETH ST.
CROSSWICKS ST.
WALNUT ST.
WEST ST.
BOREN
TROPIANSON ST.
MYRTLE
LETTEN
BURLINGTON
UNION ST.
FARNSWORTH
OLIVER ST.
WILLOW
PRINCE AVE.
CARPENTER ST.
REEDER AVE.
BROOKS AVE.
ANDERSON ST.
W. CHESTNUT ST.
BLACKS
LEGEND
HYDRANT
PLUG
VALVES
ELEVATED TANK
4 INCHES UNLESS NOTED OTHERWISE
6 INCHES UNLESS NOTED OTHERWISE
10 INCHES UNLESS NOTED OTHERWIS
CITY OF BORDENTOWN
WATER SYSTEM

The City of Bordentown Water Treatment Plant was constructed in 1976 at the site of the original facility. The NJDEP Water Allocation Permit (#5156) allows the Water Department to divert up to 90 million gallons per month at a maximum rate not to exceed 4 million gallons per day (mgd). The water supply consists of the following four wells:

- Well 1 800 gallons per minute (gpm) 1.152 million gallons per day (mgd)
- Well 2 900 gallons per minute (gpm) 1.296 million gallons per day (mgd)
- Well 3 1,100 gallons per minute (gpm) 1.584 million gallons per day (mgd)
- Well 5 740 gallons per minute (gpm) 1.066 million gallons per day (mgd)

Well 5 is an emergency well and not normally used. The condition of each of the 4 wells is good to excellent. Wells 1, 2 and 3 have undergone major maintenance upgrades in the last 10 years and Well 5 is only 8 years old. All of the wells are between 160 and 280 feet deep.

Average daily water demand is about 2.0 mgd. The maximum daily demand is 2.7 mgd. The overall capacity of the plant is 4.2 mgd. The plant operates 12 to 14 hours per day.

The treatment process is as follows:

Incoming water is:
1. pre-chlorinated with chlorine gas;
2. pre-limed with calcium oxide;
3. greensand filtered, air-stripped, and filtered again for removal of iron and manganese;
4. $KMnO_4$ (potassium permanganate, an oxidizer, is added for removal of sulfides
5. limed again;
6. backwash lagoons then discharge to Crosswicks Creek (average 30,000 to 50,000 gpd).

The pH of incoming water is 4.2 (acidic) and is adjusted to 6.6 (neutral).

The local water table has remained steady over past several years. Water quality is tested at QC Labs in Pennsylvania. Water is tested for coliform, Pb (lead), Cu (copper), Fe (iron), Mn (manganese), As (arsenic), pH, Cl (chlorine), radionuclides, and trihalomethane. See page 95 for the 2004 City of Bordentown Water Department's Drinking Water Quality Results.

City of Bordentown Water Department 2004 Drinking Water Quality Results

Contaminant (Unit of measurement)	Violation Yes/No	Level Detected	Range & Sample Date*	MCLG	MCL	Likely Source of Contamination
Disinfection Byproducts						
TTHMs (Total Trihalomethanes) (ppb) Potential Health effects: Some people who drink water containing trihalomethanes in excess of the MCL over many years may experience problems with their liver, kidneys, or central nervous systems, and may have an increased risk of cancer.	No	1.8 (average)	0.21 – 2.46	n/a	80 (a)	By-product of drinking water disinfection
Radioactive Contaminants						
Alpha emitters (pCi/L) Potential health effects: Certain minerals are radioactive and may emit alpha radiation. Some people who drink water containing alpha emitters in excess of the MCL over many years may have an increased risk of getting cancer.	No	12.8 (average, based on quarterly samples)	9.4 – 16	0	15	Erosion of natural deposits
Combined radium (pCi/L) Potential health effects: Some people who drink water containing radium 226 or 228 in excess of the MCL over many years may have an increased risk of getting cancer.	No	1.7 (average, based on quarterly samples)	1.4 – 2.2	0	5	Erosion of natural deposits
Inorganic Contaminants						
Barium (ppm) Potential health effects: Some people who drink water containing barium in excess of the MCL over many years could experience an increase in their blood pressure.	No	0.04	7/2/02 (only one sample required	2	2	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Cadmium (ppb) Potential health effects: Some people who drink water containing cadmium in excess of the MCL over many years could experience kidney damage.	No	1.2	7/2/02 (only one sample required)	5	5	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Copper (ppm)Potential health effects: Copper is an essential nutrient, but some people who drink water containing copper in excess of the action level over a relatively short amount of time could experience gastrointestinal distress. Some people who drink water containing copper in excess of the action level over many years could suffer liver or kidney damage.	No	0.138 (90^{th} percentile)	(none of the 30 samples exceeded the action level)	1.3	AL=1.3**	Corrosion of household plumbing systems; erosion of natural deposits
Lead (ppb) Potential health effects: Infants and children who drink water containing lead in excess of the action level could experience delays in their physical or mental development. Children could show slight deficits in attention span and learning abilities. Adults who drink this water over many years could develop kidney problems or high blood pressure.	No	ND (90^{th} percentile)	(none of the 30 samples exceeded the action level)	0	AL=15**	Corrosion of household plumbing systems, erosion of natural deposits
Nitrate (as Nitrogen) (ppm) Potential health effects: Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	No	0.80	9/2/04	10	10	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Volatile Organic Contaminants						
Trichloroethylene (ppb) Potential health effects: Some people who drink water containing trichloroethylene in excess of the MCL over many years could experience problems with their liver and may have an increased risk of getting cancer.	No	0.55 (average)	0.49 – 0.61	0	1	Discharge from metal degreasing sites and other factories

Sewerage

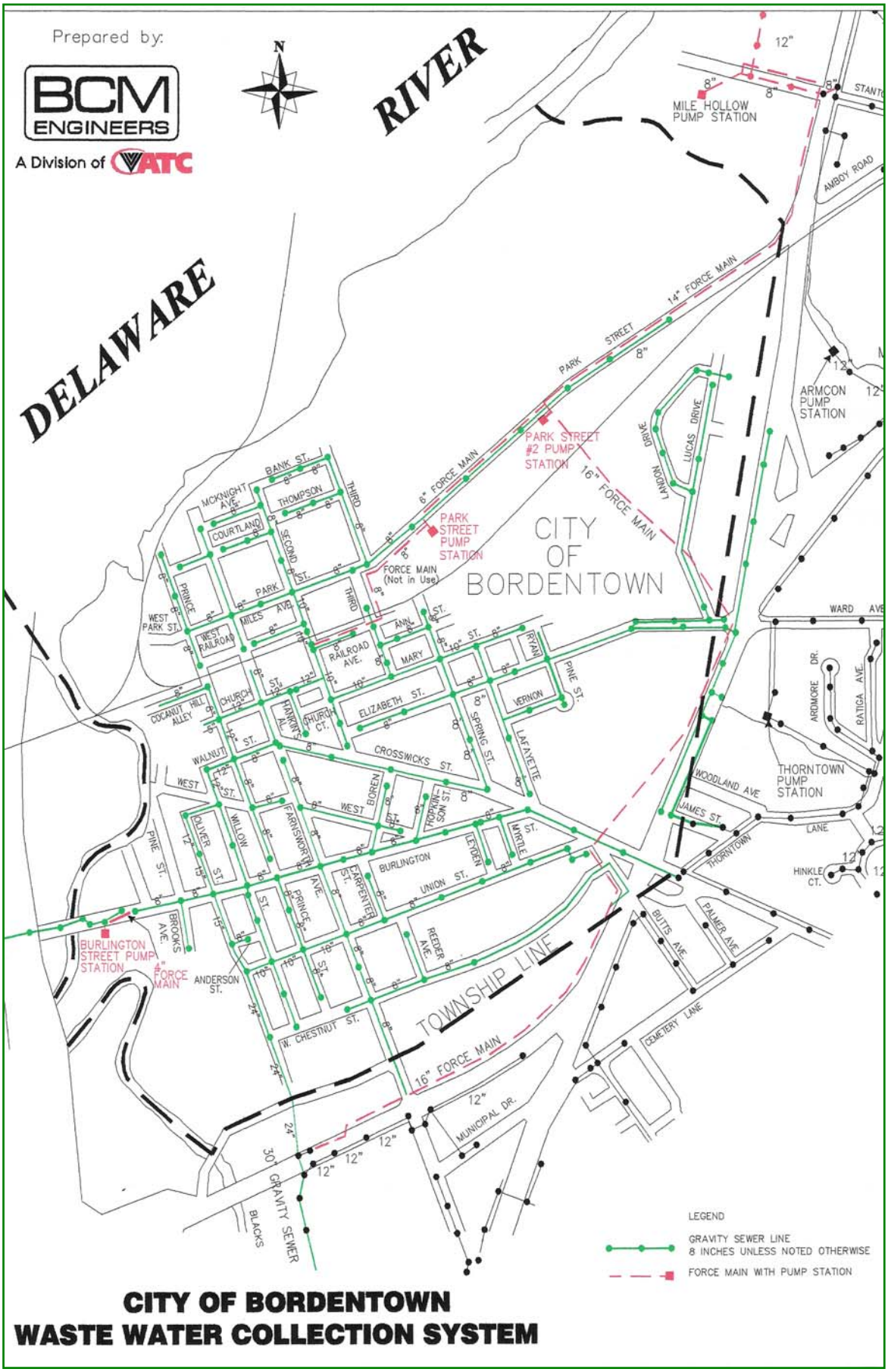
Bordentown Sewerage Authority

In 1986 the Bordentown Sewerage Authority (BSA) was formed to provide a centralized wastewater treatment system for both Bordentown City and Bordentown Township. A 3.0 million gallon per day treatment plant was constructed located along Blacks Creek at the intersection of Route 206 and Farnsworth Avenue in Bordentown Township. The collection system is approximately 60 miles long and at present contains 13 pumping stations.

Directly benefiting from this effort are the residents of Bordentown Sewerage Authority's service area, which includes the territorial boundaries of both the City and Township of Bordentown. Fully operational early in 1991, the plant has successfully been meeting its discharge permit limits ever since. Flows are averaging 1.6 million gallons per day and the plant's rated capacity is 3.0 million gallons per day.

Sewage enters the wet well of the screw pump station, which raises the water high enough to flow via gravity through the rest of the plant. From there it travels to the Bar Screen/Grit Building. Here, an automatically cleaned bar screen protects the comminutor. A bypass channel is provided for alternate operations. Sewage then flows into an aerated grit chamber that is cleaned with a screw conveyor/bucket, elevator/grit washing mechanism and delivered to the dumpster on the outside of the building. The flow continues to a splitter box to evenly distribute the flow to two (2) primary clarifiers. Sludge from the one that is in operation at this time is pumped by progressive cavity pumps housed in the primary sludge pump station. Scum collection and pumping is handled here also. Primary sludge and scum are directed to storage tanks in the Sludge Thickening Building. The plant's flow travels to the oxidation ditch area where two (2) 1.1 million gallon volume ditches are aerated with disc aerators. Secondary clarifiers settle the activated sludge for return to the ditches via return pumps in the basement of the Sludge/Chemical Building. Sludge wasting pumps located there also deliver to storage tanks in the Sludge Thickening Building. Sieve drum concentrators there thicken sludge before being sent to the liquid sludge loading station located at the far end of the Sludge/Chemical Building or to belt presses where a sludge cake is produced, which in turn is sent to the Burlington County Composting Facility. Wastewater then proceeds to the chlorine contact tanks for disinfection, with the chlorine being supplied by on-site chlorine generation and sodium hypochlorite. Dechlorination takes place in the next tank, using sulfur dioxide being supplied in ton containers. After dechlorination, post aeration tanks are available to provide sufficient dissolved oxygen in the effluent. Lastly, flow is measured in the Parshall flume and discharged to Blacks Creek.

Electricity supplied by PSE&G is transformered down from 13,200 volts to usable 480 volts in the central power substation, and distributed to the various buildings' motor control centers. A 1.25 million watt standby generator has been provided for emergency use.



CITY OF BORDENTOWN
WASTE WATER COLLECTION SYSTEM

All tanks have drains built into them for dewatering purposes and all drains collect at the central drain pump station for delivery to the head of the plant, thereby eliminating the need for portable pumps for dewatering.

Bordentown Sewerage Authority treatment facility

Soda ash, used for alkalinity control, is purchased in bulk and stored in the sixty (60) foot tall silo along side the Sludge/Chemical Building.

Local government wastewater management planning is controlled by the NJDEP through review and approval of regional Water Quality Management Plans. Burlington County is the regional agency responsible to NJDEP for City of Bordentown's Water Quality Management Plan (a.k.a. the "201 Plan" from its legislative authorization). Water quality planning includes protective measures for both surface waters and groundwater. The conveyance, treatment, and re-entry of treated wastewater to the environment are addressed regionally by the Water Quality Planning process, and locally in the City's approved 201 Plan.

The initial 201 Water Quality Management Plan for the region was revised in 1983 and focused on Bordentown City and Bordentown Township. The Plan proposed the construction of a new wastewater treatment plant (WWTP) at the site of the existing City facility to handle flows from both municipalities. Since the proposed construction was confined to the City and Township, it was agreed that a new authority appointed by the two impacted municipalities would best serve the interest of the communities. On April 22, 1986, the Local Finance Board of the New Jersey Department of Community Affairs approved the creation of the Bordentown Sewerage Authority (BSA). BSA is the implementing agency responsible for the recommendations of the 201 Plan. The newly constructed WWTP startup and training were completed by the end of July 1991.

The BSA currently provides wastewater treatment for residents of the City of Bordentown and a large portion of the Township at its Blacks Creek WWTP. A six-member board conducts Authority business. Three members are appointed by the City and three members are appointed by the Township. One key provision in the BSA Charter is that any site that either wholly or partially contains wetlands will not be serviced by public sewer.

There is also an additional wastewater treatment facility located in the City. It is the Ocean Spray Cranberries, Inc. pretreatment plant located on Park Street in the City. It treats industrial wastewater prior to discharging into the BSA's collection system. The Ocean Spray facility is regulated under NJDEP's indirect industrial discharger regulations and meets the BSA pretreatment standards.

Wastewater Conveyance

The sewerage system within the City was essentially constructed in 1908, with several short extensions added as needed. It is composed of approximately 15 miles of pipe ranging in size from 8-inch to 15-inch, 275 manholes and three pump stations. Almost all of the system is gravity-fed, except for one section, which is force main. Almost the entire City is serviced by the BSA, with only the following few locations still utilizing septic systems:

- 356 Park Street
- 200 Lime Kiln Alley
- 215 Lime Kiln Alley
- 216 Lime Kiln Alley
- Water Street (no address)
- 100 Walnut Street (Shipps Coal Yard)
- Bordentown Yacht Club
- Yapewi Yacht Club
- Riverview Studios (end of Farnsworth Avenue)

There are three wastewater pumping stations that convey sewage from the City to the WWTP. They are the Park Street #1 Pumping Station, the Park Street #2 Pumping Station (located at the Ocean Spray Facility), and the Burlington Street Pumping Station.

Currently wastewater conveyance systems in the City are in good condition.

Sewerage rates are based upon water consumption.

Wastewater Treatment

The BSA WWTP was fully operational in early 1991. The facility has a hydraulic design of 3 mgd. The plant can be expanded to 4.5 mgd (ultimate design capacity) if the need arises. The WWTP has an administration building, which houses the billing office,

conference room, laboratory, various administrative and plant offices, and a maintenance shop/garage area. The raw sewage enters the facility from the collection system where it is pumped (lifted) up to the treatment units via the screw pump lift station. The forward flow then moves by gravity through the rest of the treatment units, which include (in order): bar screen and grit removal process, primary clarifiers (2), oxidation ditch treatment process, secondary clarifiers (2), and the final disinfection and metering process prior to final discharge of effluent to Blacks Creek. The sludge processing train includes sludge thickening and dewatering units prior to offsite sludge disposal. The WWTP is operated efficiently and economically. The facility has received the highest USEPA award for operations excellence.

The City of Bordentown's wastewater is conveyed from the City's conveyance piping to a BSA trunk line and then to the WWTP. The BSA wastewater flow is approximately 1.8 million gallons per day and continues to slowly increase as commercial and residential development continues in the approved public sewer service area of the Township. There is very little flow increase attributable to the City since almost all developable land has already been developed. There is no reservation of capacity for future development specifically in the City.

Current BSA treatment plant capacity values are:

Plant permitted capacity	3,000,000 gpd
Actual flow	1,800,000 gpd

As mentioned previously, the Ocean Spray WWTP provides wastewater treatment for its industrial process and discharges the effluent to the BSA sewer system on Park Street. Ocean Spray’s wastewater discharge is regulated by both the NJDEP and BSA.

Stormwater

Stormwater is a nonpoint source of a variety of pollutants that travel from lawns, roads, parking lots and other impervious surface areas into local waterways. Stormwater drains to all waterways in Bordentown City through a number of outfall pipes, which are connected by dozens of storm drains throughout the City.

Stormwater initially flows into the stormwater system through a storm drain. These are frequently located along the curbs of parking lots and roadways. The grate that prevents larger objects from flowing into the storm sewer system is called a catch basin. Once below ground, the stormwater flows through pipes that lead to an outfall where the stormwater enters a stream, river or lake. In most areas of New Jersey, the stormwater sewer goes directly to a local waterway without any treatment.

Storm Drain Catch Basin with stencil, Farnsworth Avenue

In some areas of the state, the outfall may lead to a stormwater management basin. These basins control the flow of stormwater and can also improve water quality, depending on how they are designed. These basins are frequently seen in newer commercial and residential areas.

In some older urban areas of the state, the stormwater and sanitary sewer systems may be combined. Here both stormwater and sewage from households and businesses travel together in the same pipes. Both stormwater and sewage are treated at sewage treatment plants, except during heavy rains. During these occasions, both the stormwater and untreated sewage may exceed the capacity of the treatment plant. In this case, overflow is directed into local waterways.

Stormwater outfall pipe, slope of Thorntown Creek floodplain, behind Third Street

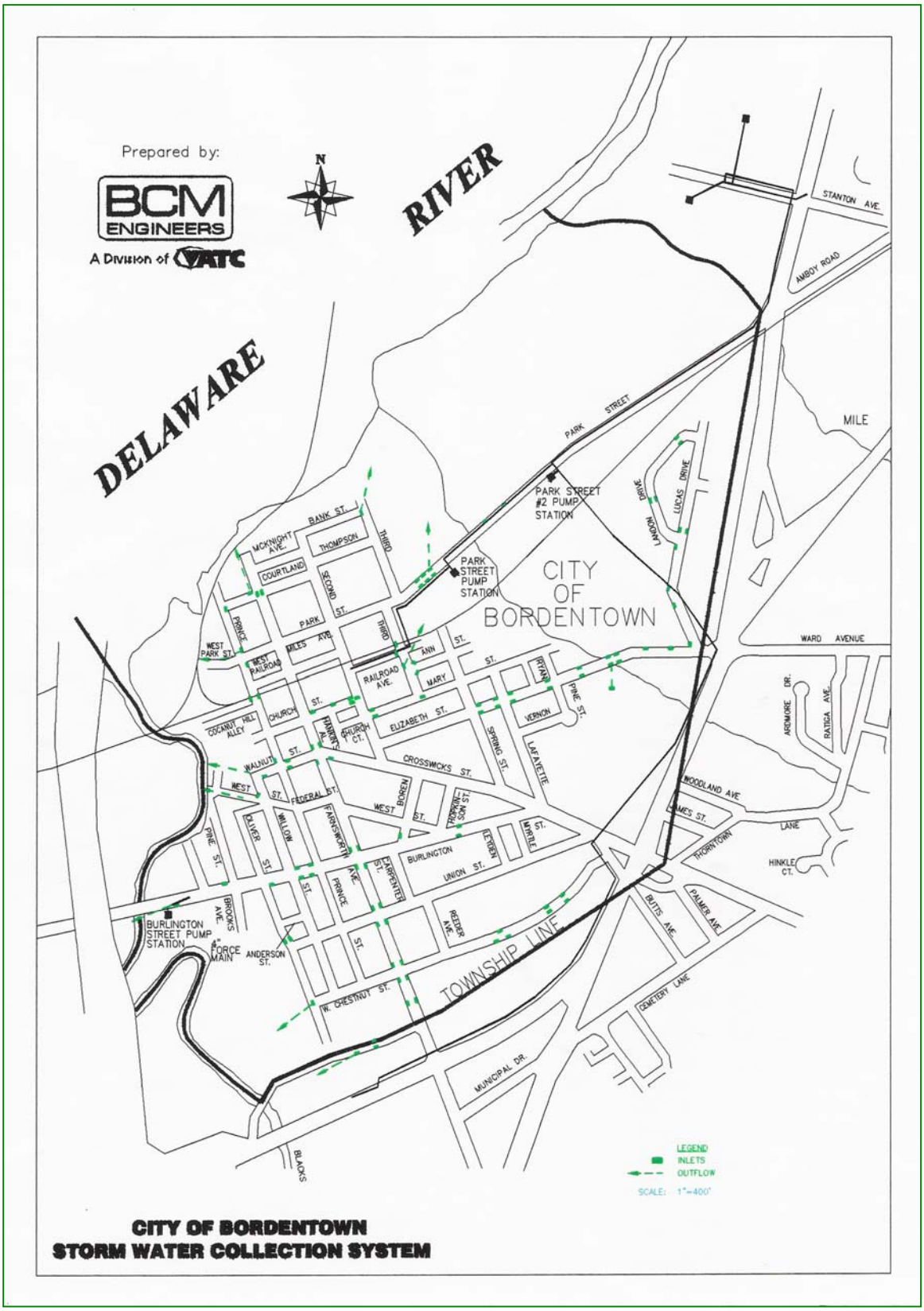
The City of Bordentown is located adjacent to the Delaware River. Topography for the City slopes gently from east to west (towards the Delaware River). Precipitation falling in the western and southern portions of the City runs off to water-courses that flow to the Delaware River (Blacks and Thorntown Creeks). The precipitation events generate stormwater which, until 2003, was not required to be permitted. As a result of the United States Environmental Protection Agency's (USEPA) Phase II Rules, the NJDEP has developed the Municipal Stormwater Regulation Program. This program addresses pollutants entering our waters from certain storm drainage systems owned or operated by local, county, state, interstate or federal government agencies. These systems are called "municipal separate storm sewer systems" or MS4s. Bordentown City received its general permit No. NJ0088315 in October 2004. The City is considered a Tier A Municipality.

Twelve municipal outfall pipes have been identified in Bordentown City, at the following locations (with evidence of scouring noted): Pine Street (scouring present), Thorntown Creek (no scouring), East Park Street (no scouring), Bank Street (no scouring), Stoney Hill (no scouring), RiverLINE Light Rail bridge (some scouring), Walnut Street (no scouring), Federal Street (no scouring), Blacks Creek (no scouring), West Union Street (no scouring), West Chestnut Street (scouring present), and Love Bridge Run (scouring present). Additionally, an NJDOT outfall pipe is located on East Chestnut Street. See map on page 104 for location of stormwater inlets and outfall pipes in Bordentown City.

Detention basin outfall (from Ocean Spray property), Thorntown Creek

Under the NJPDES Municipal Stormwater Regulation Program, the City has met the following requirements:

- The City has prepared and implemented a written Stormwater Pollution Prevention Plan (SWPP) that describes the City's stormwater program and serves as a mechanism for the implementation of the statewide basic requirements (SBRs).
- The City has adopted a stormwater management (SWM) plan in accordance with N.J.A.C. 7:8-4.
- The City has adopted a stormwater control ordinance in accordance with N.J.A.C. 7:8-4.
- The City, in conjunction with the Bordentown City Environmental Commission (BCEC), has copied and distributed an educational brochure (provided by NJDEP) annually to residents and businesses, and conducted an educational event in 2005.
- In accordance with the NJDEP Municipal Stormwater regulation program, the following ordinances were adopted in September 2005: Pet Waste Ordinance; Improper Disposal of Waste; Litter Ordinance; Yard Waste Ordinance; Wildlife Feeding Ordinance; and Prohibition of Illegal connections to the MS4.


Prepared by:
BCM ENGINEERS
A Division of VATC
N
DELAWARE
RIVER
STANTON AVE.
AMBOY ROAD
MILE
PARK STREET
PARK STREET #2 PUMP STATION
LUCAS DRIVE
LAGOON DRIVE
PARK STREET PUMP STATION
CITY OF BORDENTOWN
WARD AVENUE
BANK ST.
MCKNIGHT AVE.
THOMPSON
COURTLAND
SECOND ST.
THIRD
PARK
PRINCE
WEST PARK ST.
MILES AVE
WEST RAILROAD
RAILROAD AVE.
ANN
MARY
RITTAR
VERNON
PINE ST.
ARDMORE DR.
RATICA AVE.
COCONUT HILL ALLEY
CHURCH
CHURCH CT.
ELIZABETH ST.
SPRING ST.
LAFAYETTE
WALNUT
CROSSWICKS ST.
WEST
FEDERAL ST.
WEST BORON
THORNTON ST.
WOODLAND AVE.
JAMES ST.
LANE
THORNTOWN
HINKLE CT.
OLIVER ST.
WILLOW
FARNSWORTH
BURLINGTON
UNION ST.
REBER
MYRTLE
CARPENTER
BROOKS AVE.
BURLINGTON STREET PUMP STATION
6" FORCE MAIN
ANDERSON ST.
W. CHESTNUT ST.
TOWNSHIP LINE
BUTTS AVE.
PALMER AVE.
CEMETERY LANE
MUNICIPAL DR.
BLACKS
LEGEND
INLETS
OUTFLOW
SCALE: 1"=400'
CITY OF BORDENTOWN
STORM WATER COLLECTION SYSTEM

Energy

Electricity

PSEG Fossil LLC responds to all levels of energy demand, from base load to times of peak energy usage. Fossil is currently comprised of operating generating stations that are spread across New Jersey, Pennsylvania, Connecticut, New York and Ohio.

The electric utility servicing Bordentown City is Public Service Electric & Gas (PSE&G).

Electric District: Southern - L
Gas District: Trenton
COF Dist: Southern
Capacity: more than 13,000 MW
Percent of PJM capacity: about 20%

Local facilities include:

Oliver Street Substation,
Bordentown City

The PSE&G substation at the corner of Union and Oliver Streets transforms 26 kilovolts (KV) subtransmission voltage to 4KV distribution voltage. This is accomplished by means of large transformers in the station yard. The 4KV distribution voltage is then delivered to local residents via wood poles and underground cables to smaller transformers that lower the voltage to various levels, including the 120/240 volt household level.

Mercer Generating Station

Location: Hamilton Township
Fuel: Coal, Gas, Distillate Oil
Technology: Steam and Combustion Turbines
Market: Load Following Peaking

Energy Conservation

With the price of fuel reaching an all-time high in 2005, conservation of existing energy resources, efficient use of heating and cooling systems and appliances, and use of non-fossil fuels for power generation will take on more importance over the next decade. The New Jersey Board of Public Utilities (BPU) is responsible for instituting policies and programs affecting energy use in the State. The BPU's New Jersey Clean Energy Program provides information and financial incentives to help New Jersey residents, businesses and communities reduce their energy use, lower costs, and protect the environment. The major form of conserving fuel with conventional facilities is the Energy Star program. Products using gas and electricity must meet or exceed energy-efficient guidelines established by the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE). New Jersey provides incentives such as rebates and discounts to use products with the Energy Star designation. Businesses can apply for loans and financing to purchase energy-efficient products and renewable-energy systems.

Solar and wind power have been in existence for centuries, and geothermal energy has been used for over 20 years, but advances in technology have made them more efficient and reliable in the 21st Century. These alternates to fossil fuels can stabilize or reduce energy costs; generate a clean renewable supply of energy; provide backup power in case of outages; and in general play a role in creating a cleaner environment without the pollution problems arising from power generation using fossil fuels. Solar electric technology converts sunlight directly into electricity whenever sunlight interacts with the semiconductor material in the solar electric cells. The New Jersey Clean Energy Program provides financial incentives to reduce the cost and installation of a solar system.

Lower-cost techniques to save energy include insulating and ventilating a house; turning down the thermostat; lowering the water heater thermostat; changing the filters on heaters; and using landscaping techniques to make the most use of sun and shade to heat and cool a house.

Source: New Jersey Board of Public Utilities

The Mercer Generating Station is a three-unit, 777-megawatt plant located on Duck Island, just downstream from the tidehead of the Delaware River, four miles south of Trenton and 3 miles north of Bordentown City. The Mercer plant was built to meet the growing electric demands of South Jersey, and when it began operation, it was the largest plant in the PSEG system. The first steam generator came on line in December 1960 and the second in June 1961. Each unit is primarily fueled by coal, but can also run on natural gas. A distillate oil combustion turbine was added in 1967.

The plant uses state-of-the-art environmental control technology, including electrostatic precipitators to remove particulates and selective non-catalytic reduction (SCR) for nitrogen oxide control. To further reduce NOx emissions, it also utilizes amine-enhanced fuel lean gas reburn (AEFLGR) technology. This is anticipated to be replaced shortly by a selective catalytic reduction (SCR). The plant is located on 114 acres of land on Duck Island in the Trenton-Hamilton-Bordentown Marsh.

Burlington Generating Station

Location: Burlington City
Fuel: Gas and Distillate Oil
Technology: Simple-Cycle
Market: Peaker

The Burlington Generating Station, located on the Delaware River in Burlington City, is a 557 megawatt station consisting of eight single-cycle peaker units. The three oldest simple-cycle peaking units still in use were installed between 1967 and 1972 and run on distillate oil. Five newer simple-cycle peaking units run on natural gas were also installed in 2000 and 2001.

Burlington Station was also the site of one of the company's, and the country's, first investigations into alternative energy with pioneering wind power experiments in 1930. Unfortunately, winds at the location (and elsewhere in New Jersey) were determined to "not blow long enough or hard enough" to make wind energy generation effective.

Natural Gas

PSE&G supplies natural gas to Bordentown City. Williams' Transco pipeline delivers natural gas to area customers through its 10,500-mile pipeline system, extending from South Texas to New York City. The Transco pipeline system is a major provider of natural gas to the northeastern and southeastern states. Williams will be expanding the capacity of the pipeline in order to deliver additional natural gas to the Northeast region. The expansion will require approximately 3.5 miles of new 36-inch pipeline near the company's existing mainline system in Burlington County. This section traverses Bordentown Township, essentially following the existing PSE&G electrical transmission wires near the Turnpike. The project is expected to be completed by the end of 2005.

Solid Waste Management & Recycling

Hazardous Waste Management

The Burlington County Office of Solid Waste Management and Recycling is located on the 2nd floor of the EcoComplex at 1200 Florence-Columbus Road in Mansfield. It is one-half mile east of the Resource Recovery Complex.

The Solid Waste Division plans for, implements, and operates facilities located at the 522-acre Resource Recovery Complex for the environmentally sound management of residential and commercial solid waste, the recycling and reuse of tires, construction material and old appliances, and the processing of sewage sludge into compost fertilizer.

At the Household and Small Quantity Hazardous Waste Facility oil based paints, pesticides, thinners, household and car batteries, antifreeze, used motor oil, fluorescent lights, and other items that contain hazardous substances are accepted from Burlington County residents and conditionally exempt small businesses.

The Office of Solid Waste Management and Recycling oversees operation of the regional recycling program that provides for collection of recyclables at the curb and at drop-off sites located throughout the county. It also provides assistance to businesses, institutions, and multi-family complexes in establishing recycling programs.

Hazardous Waste

Burlington County operates a permanent facility, open year-round, to collect hazardous waste from County residents and small businesses.

Recycling

Burlington County Regional Recycling Program offers curbside pickup of household recyclables every second Monday. Accepted materials include paper (including cardboard), aluminum and steel/tin food and beverage cans, glass bottles and jars, and plastic bottles (only those with a neck and #1 or #2 on the bottom)

Bordentown City Public Works Department accepts drop-off of recyclable materials at its Recycling Center at the Gilder Field Complex. The hours are Wednesday, noon-4pm and Saturday, 8am-noon. Accepted materials include used motor oil, household paint (oil-based and latex), cans, bottles, paper/cardboard, grass, leaves, branches and stumps, appliances and scrap metal. No commercial contractors are permitted. Proof of City residency is required.

Schools

School age students in Bordentown City are served by the Bordentown Regional School District. City residents currently attend Clara Barton Elementary and MacFarland Junior School, allowing students to attend school within the City limits through Grade 8. However, a new High School is currently being constructed on Ward Avenue in Bordentown Township, which will shift the grades at each facility. Once the new High School is completed, City school-age children will be able to attend schools in the City through Grade 5, and then attend Middle School and High School in Bordentown Township.

The following is a list and description of the educational facilities within Bordentown City, as well as facilities that serve Bordentown City residents within the Bordentown Regional School District:

Bordentown Regional High School
50 Dunns Mill Road, Bordentown Township
Grades: 9 - 12
School Enrollment (2004-2005): 692

MacFarland Junior School
87 Crosswicks Street, Bordentown City
Grades: 7 - 8
School Enrollment (2004-2005): 321

Clara Barton Elementary
100 Crosswicks Street, Bordentown City
Grades: Kindergarten - 6
School Enrollment (2004-2005): 342

Peter Muschal Elementary
323 Ward Avenue, Bordentown Township
Grades: Kindergarten - 6
School Enrollment (2004-2005): 698

City Services

Shade Trees

The Bordentown City Shade Tree Committee oversees the maintenance and planting of shade trees on City property. The current Bordentown City Community Forestry Management and Street Tree Master Plan, which includes a street tree inventory, was adopted in 1999, and is expected to be revised in 2006. The street tree inventory includes approximately 1,000 trees, consisting of 20-30 different species. A minimum of 20 new street trees are currently planted each spring, primarily ash, oak and maple species. In

addition to planting street trees, the Shade Tree Committee has been responsible for the reforestation of City parks and historic sites in recent years, including Bordentown Beach, Hilltop Park, Second Street Park, Gilder Field, and the Clara Barton House. Bordentown City is a Tree City USA community.

Fire and Emergency

Two fire companies serve Bordentown City. Station #601 (Consolidated) is located on Crosswicks Street. Station #602 (Hope Hose Humane) is located on West Burlington Street. Each company has a ladder truck and engines, and there are two rescue boats that are shared between the two companies.

Medical emergencies in Bordentown City are handled by Station #609 Hope Hose Humane First Aid & Rescue, located on West Burlington Street.

Police

The Bordentown City Police Department employs 9 officers, including 1 Chief, 1 Lieutenant, 3 Sergeants, 1 Class 2 special officer, 3 Class 1 special officers; and 6 patrolmen. In addition, one Emergency Medical Technician is on staff.

Police Department equipment includes 3 patrol cars and 1 SUV, as well as 2 bicycles. The Police Station is located in the lower level of City Hall.

Library

The Bordentown Public Library is located at 18 East Union Street. It has been closed for construction since March 1, 2003. A temporary facility is currently located in the nearby Fieldsboro Town Hall until construction is complete. The expanded library is expected to re-open at the East Union Street location in Bordentown City in Spring 2006.

Facilities include:
Internet Access
Word Processing
Job Searching
Periodicals Databases

With the additional space at the library, the facility will be able to provide increased space for computers, more shelf space and library materials, and expanded programs for adults and children. The expansion plan also includes handicapped accessible features, children's study areas and a meeting room for library staff and local organizations. The current library building was constructed in 1941 with funds from the Carnegie Foundation and has been a county branch since 1971.

THE ENVIRONMENT AND PLANNING FOR THE FUTURE

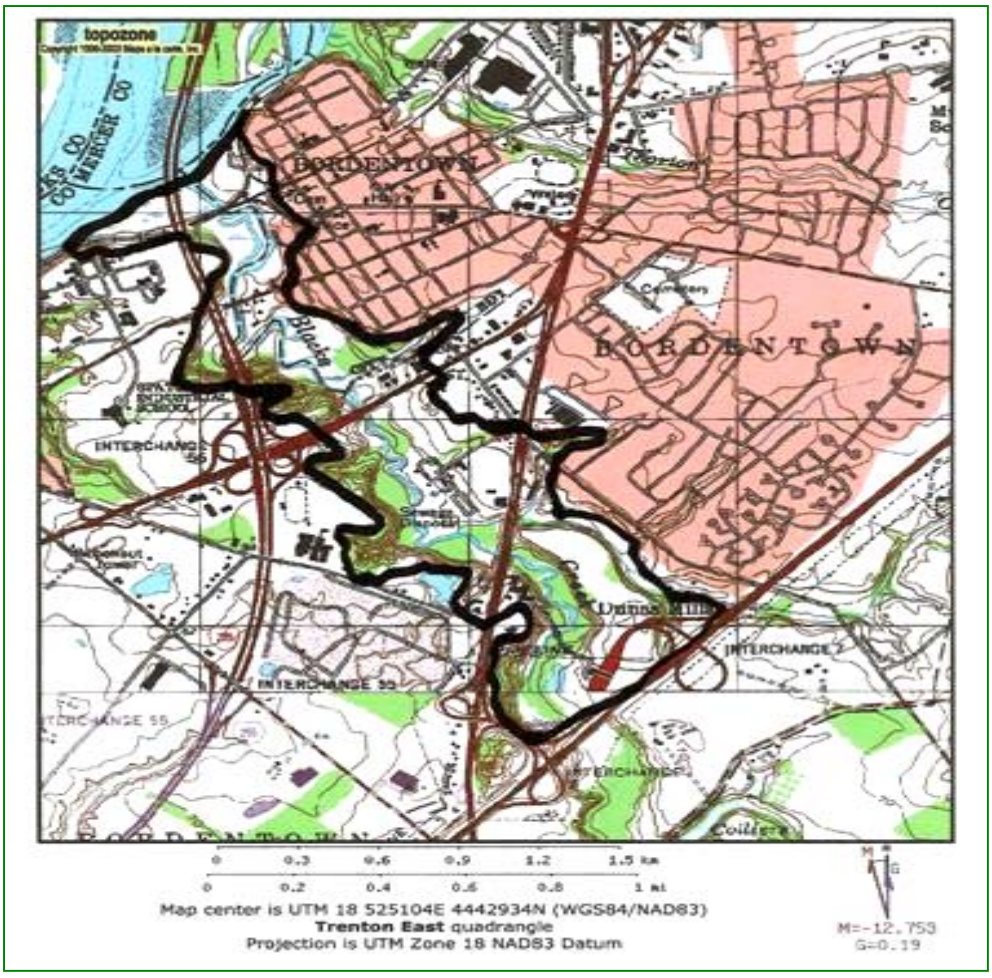
Regional Relations

Bordentown City is involved in a number of regional planning efforts, at the local, county and state levels, including the following:

Local

Blacks Creek Greenway

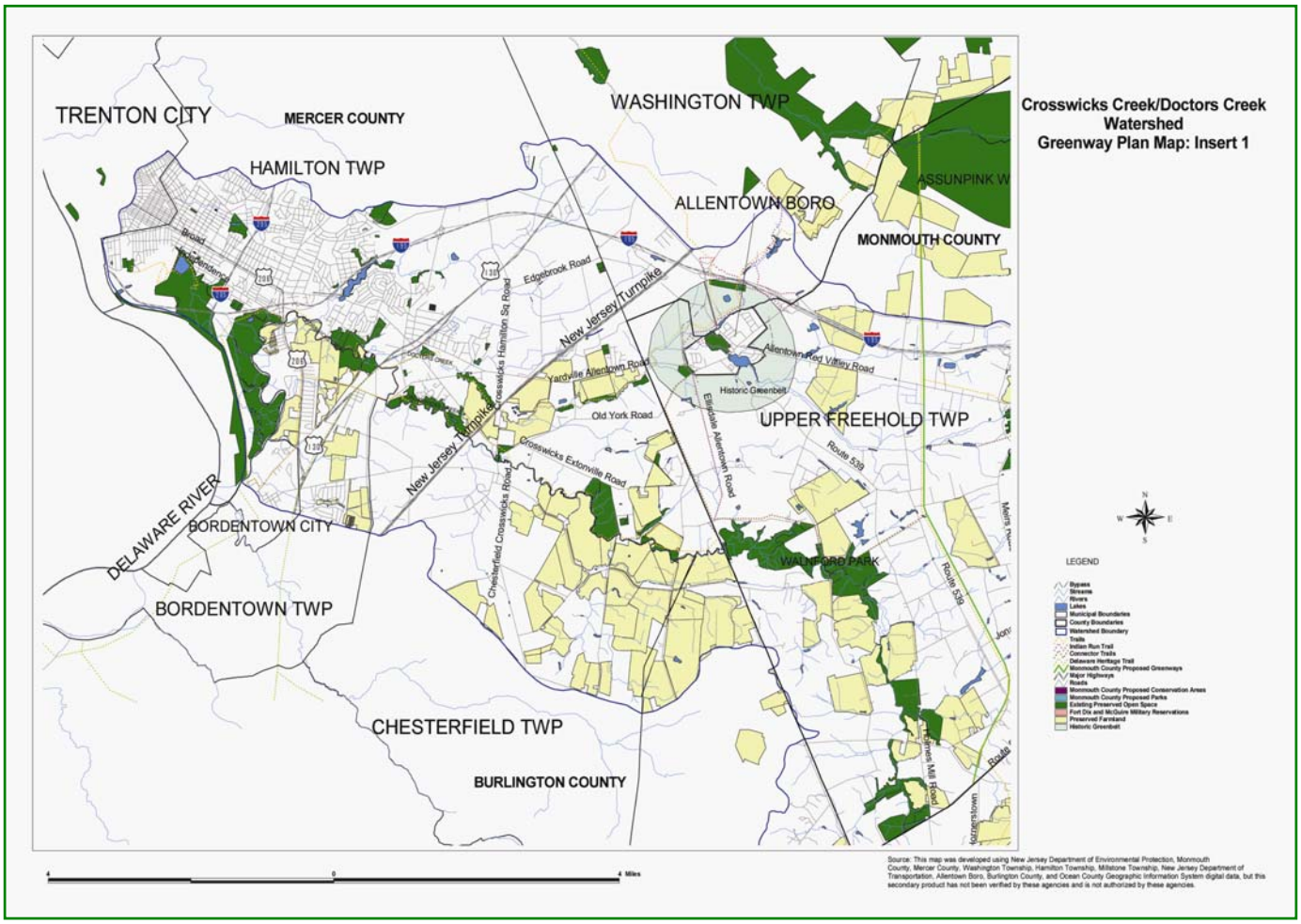
Bordentown City and Bordentown Township are currently working together to protect and preserve land along the Blacks Creek stream corridor. These efforts entail studies of the ecology of the area, and envision future trails and interpretive signage.
(See Appendix C for more details)



Blacks Creek Greenway Study Area

Crosswicks Creek/Doctors Creek Regional Greenway

This effort, initiated by the Crosswicks Creek/Doctors Creek Greenway Planning Group, includes municipalities along these two waterways in Mercer, Burlington and Monmouth counties. Bordentown City, located at the terminus of the study area on Crosswicks Creek, seeks to play a role in this planning process by actively preserving land and creating trails that will connect with other regional trail systems.

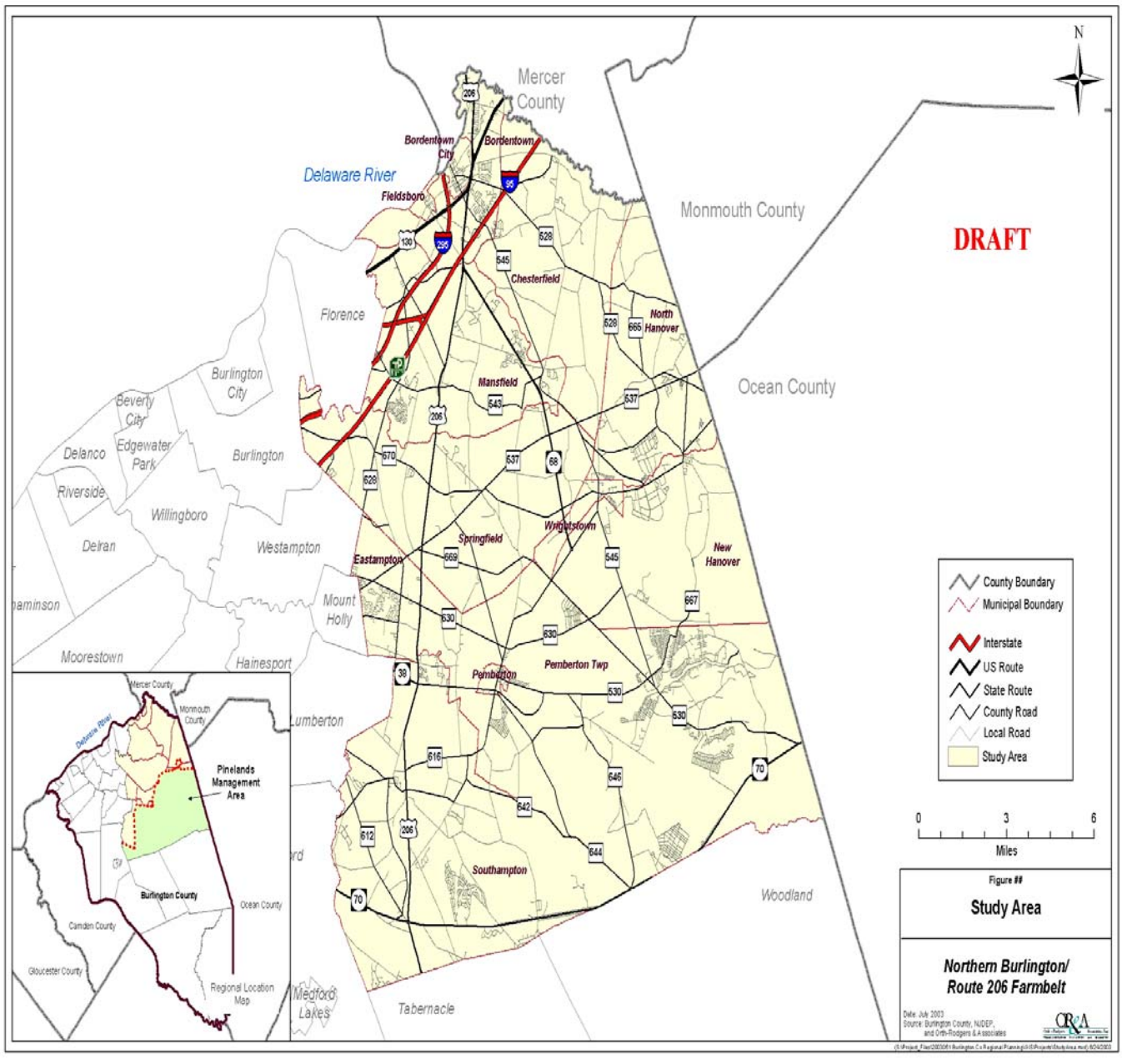


Crosswicks Creek/Doctors Creek Regional Greenway Study Area

Burlington County

Burlington County Route 206 Corridor Study

Bordentown City is one of thirteen municipalities involved in this process, which was initiated by the Burlington County Department of Economic Development and Regional Planning Issues including transportation, land use, agricultural viability and open space preservation are currently being studied.

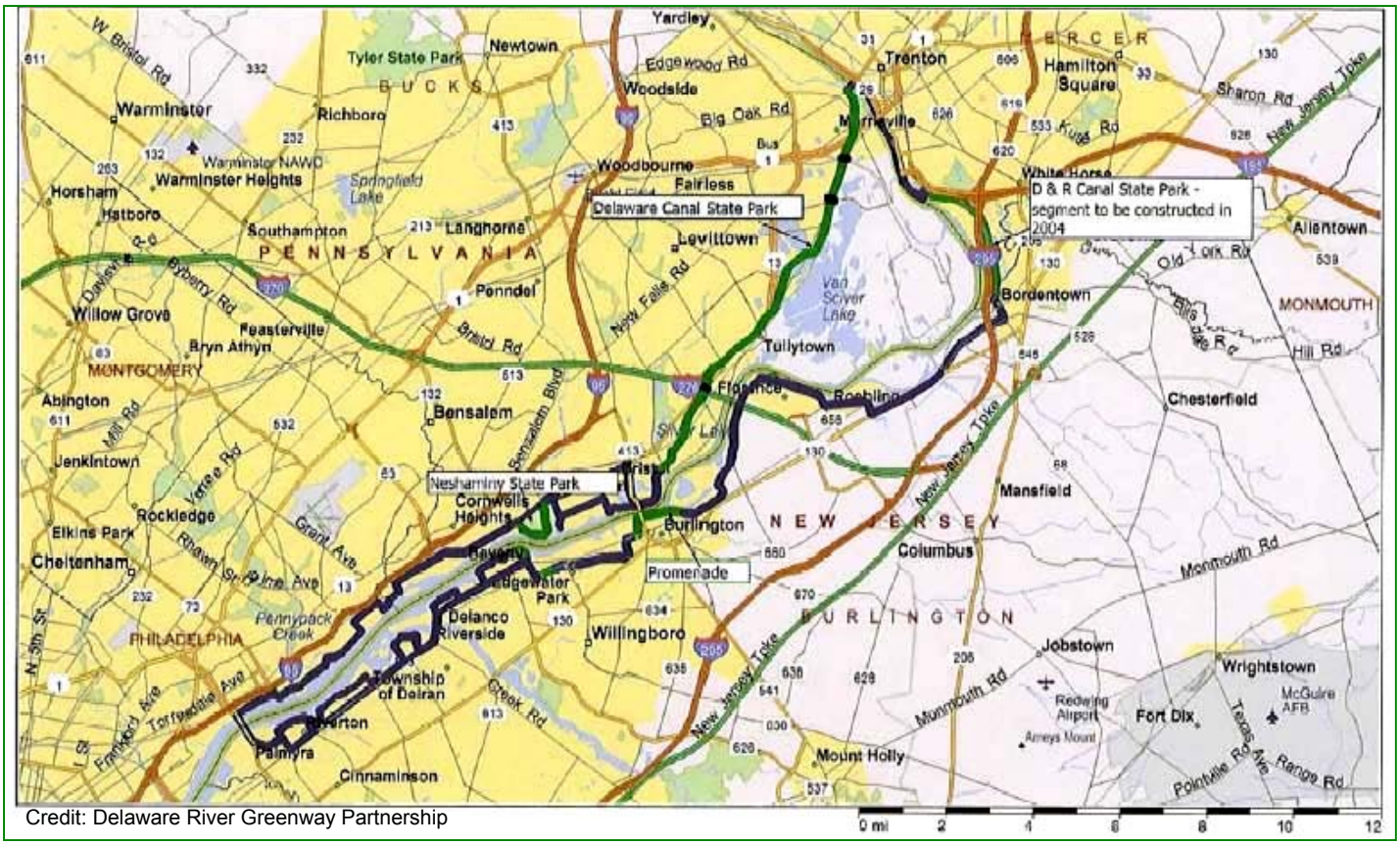


Burlington County Route 206 Corridor Study Area

Regional

Delaware River Heritage Trail

Initiated by the Delaware River Greenway Partnership, this project entails an on- and off-road loop trail from Trenton to Palmyra in New Jersey, and from Philadelphia to Morrisville in Pennsylvania. It will highlight the cultural, historical and ecological resources of the Delaware River region in this area. The alignment of the trail through Bordentown City will begin from the Delaware & Raritan Canal towpath in the Hamilton-Trenton-Bordentown Marsh, crossing the RiverLINE light rail bridge, continuing along Farnsworth Avenue, and proceeding south along West Burlington Street towards Fieldsboro. Improvements will include wayfinding and interpretative signage, as well as bicycle infrastructure.

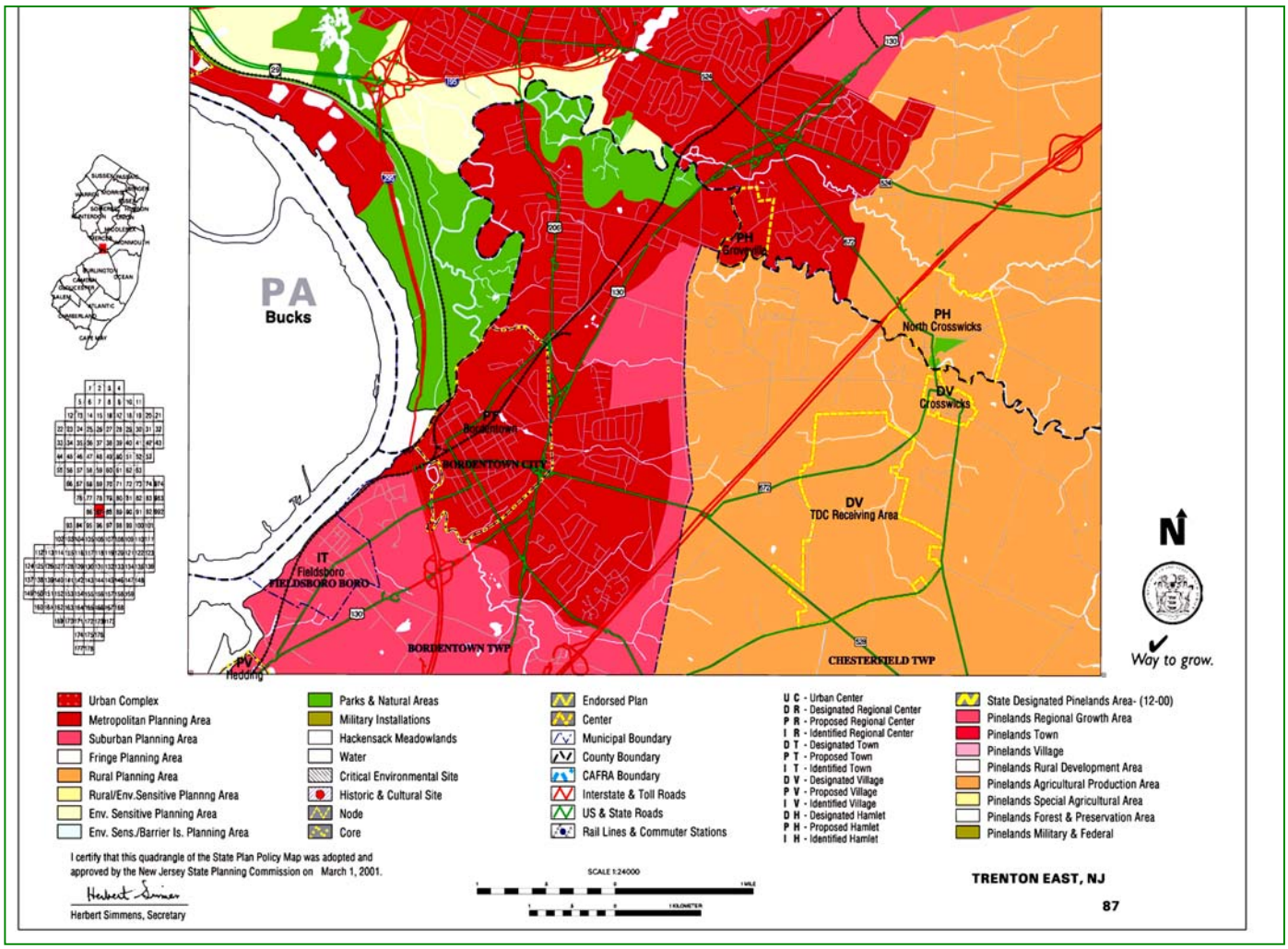


Delaware River Heritage Trail

State of New Jersey

New Jersey State Development and Redevelopment Plan

According to this document, adopted by the New Jersey State Planning Commission in 2001, Bordentown City falls into the PA1 (Metropolitan Planning) Area. A PA1 area is defined as an urban and fully developed area. Local examples include Trenton, Princeton Borough and Burlington City. They are primarily older communities, densely populated, containing full infrastructure and mostly built out, but are in need of redevelopment. Urban open space is a priority in these areas.



Development Pressures

Bordentown City faces increasing development pressure, as people begin to re-think their sprawling suburban lifestyles and reconsider the benefits and charms of older, human-scaled communities. The early part of the 21st century has seen a surge in the demand for housing in Bordentown City, and a related rise in development applications for the few remaining undeveloped parcels that exist. Some of these undeveloped lots are within the built-up areas and can be characterized as *infill development*. Development of this nature is in keeping with the City's Master Plan and New Jersey's smart growth policies, which seek to promote a more vibrant and sustainable utilization of urbanized areas.

Most of these undeveloped lots, however, are located adjacent to the stream corridors that bound or traverse the City, small, often irregularly-sized parcels along the edges of town that suddenly have value for their views and exclusivity. However, given the environmental constraints such as wetlands, steep slopes and critical foraging habitats that are commonly found in these areas, development in these areas is ill-advised and contrary to the goals of the Bordentown City Master Plan.

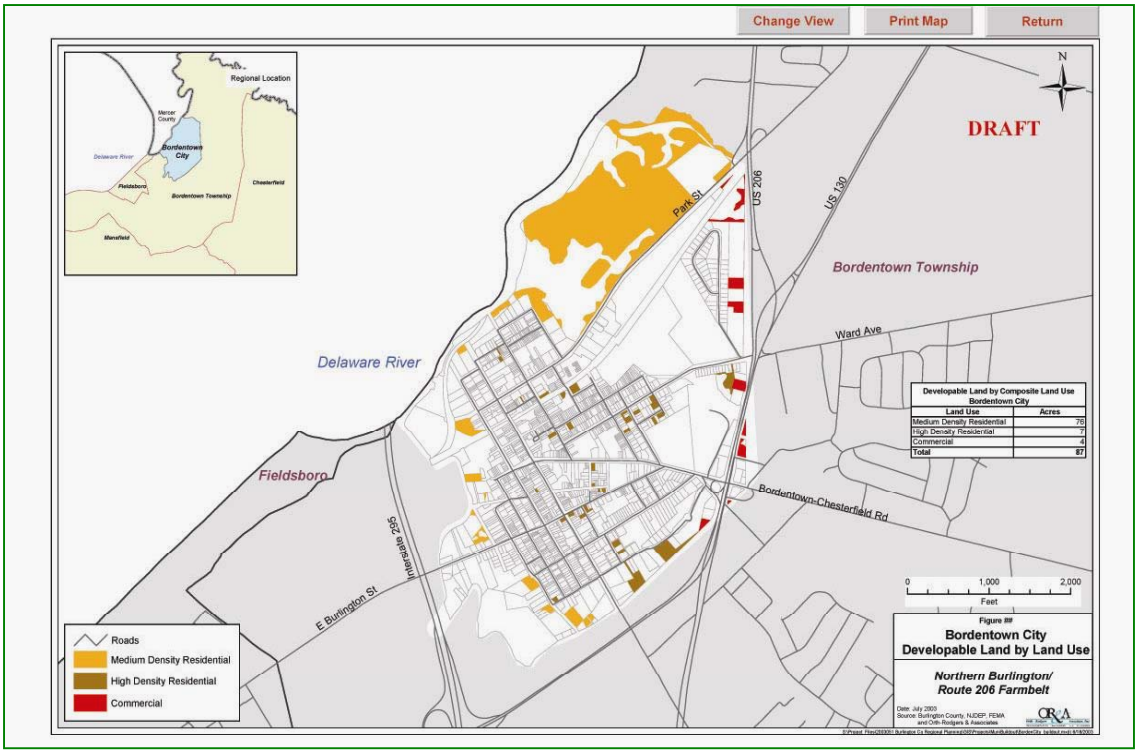
Redevelopment of vacant or underutilized properties within the City has also begun to occur. In addition to the rehabbing of existing residential properties, developers have increasingly begun to explore the adaptive reuse of existing structures, many of them large older buildings that are incompatible with their previous uses. A recent example of this sort of adaptive reuse is the Poor Clare Estates on Crosswicks Street, a conversion from a monastery to an assisted-living facility, with the addition of new apartments for affordable senior housing. Other potential candidates for redevelopment within Bordentown City will be outlined in the forthcoming Bordentown City Redevelopment Plan.

Bordentown City is currently completing both a Redevelopment Study and a Housing Plan Element, both of which will be incorporated into the Master Plan. These documents are expected to be completed by 2006 and will serve as useful guides for appropriate future development and redevelopment efforts in Bordentown City.

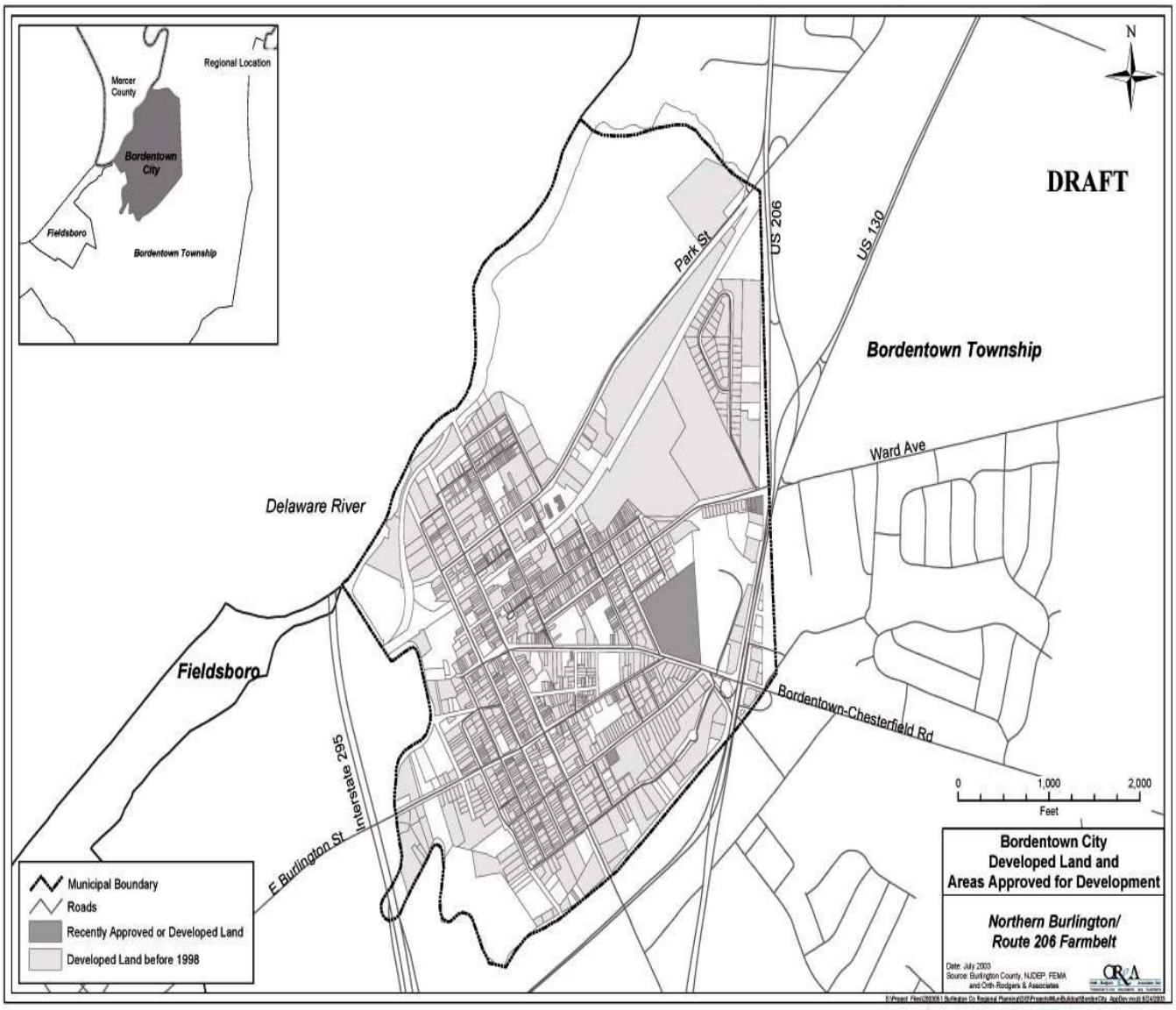
Limitations to Development/Build-out Analysis

Most developable land in Bordentown City has already been developed. Any future growth will likely be achieved chiefly through redevelopment of existing parcels. The constraints to development consist primarily of local environmental features such as wetlands, floodplains and steep slopes. A buildout analysis was included in the Rt. 206 Corridor Study conducted by Burlington County in 2004. The results of the study, performed by the Delaware Valley Regional Planning Authority (DVRPC), indicate that Bordentown City's population is expected to increase from 3,969 in 2000 to 4,280 (7.8%) in 2015 and 4,500 (13.4%) in 2025. Although these projections were based on the assumption that the Divine Word Missionaries parcels were zoned for residential, when in fact they have recently been re-zoned to non-residential, the usage of developed land is still expected to intensify, resulting in a greater (and more sustainable) density. Existing density of 4,137 persons/square mile (or 6.5 persons/acre) can be expected to increase in the future. Present planning efforts that focus on accommodating this increased density in the most sustainable manner possible (including the acquisition of key open space parcels; the introduction of architectural design codes; the emphasis on transit-oriented development and other measures) can be expected to yield positive results. Increased density, when properly planned and executed, contributes to a more vibrant, more fine-grained urban fabric.

The map below notes developable land in Bordentown City. However, since the map was created in 2004, a large portion of the Medium Density Residential area, chiefly the area between Park Street and Crosswicks Creek occupied currently by the Divine Word Missionaries, has been re-zoned for Light Industrial.



The map below indicated land that has been approved for development or developed since 1998.



Appendices

Appendix A: NJ Statewide/Burlington County Averages: 1996 NATA Modeled Air Concentrations Compared to Health Benchmarks

New Jersey Statewide Average 1996 NATA Modeled Air Concentrations Compared to Health Benchmarks								
Pollutant	Modeled Air Concentration (ug/m^3)	Health Benchmark (ug/m^3)	Risk Ratio	% Contribution by Source Category				
				Point	Area	Onroad Mobile	Nonroad Mobile	Back-ground
Acetaldehyde	1.3	0.45	**3**	0.03%	11%	49%	41%	0%
Acrolein	0.17	*0.02*	***9***	0.04%	10%	46%	45%	0%
Acrylonitrile	0.0024	0.015	0.2	72%	28%	0%	0%	0%
Arsenic compounds	0.00017	0.00023	0.7	24%	70%	1%	6%	0%
Benzene	1.7	0.13	**13**	4%	4%	43%	21%	29%
Beryllium compnds	0.000035	0.00042	0.08	6%	94%	0%	0.2%	0%
1,3-Butadiene	0.075	0.0036	**21**	0.01%	1%	79%	20%	0%
Cadmium compnds	0.00028	0.00029	1	6%	94%	0%	0.4%	0%
Carbon tetrachloride	0.88	0.067	**13**	0.0005%	0.1%	0%	0%	100%
Chloroform	0.10	0.043	**2**	8%	10%	0%	0%	81%
Chromium compd.	0.0037	0.00025	**15**	6%	85%	2%	7%	0%
Coke oven emiss.	0.0000094	0.0016	0.01	100%	0%	0%	0%	0%
1,3Dichloropropene	0.16	0.25	0.6	0%	100%	0%	0%	0%
Diesel partic. Matter	4.4	0.5	**9**	0%	0%	24%	76%	***
Ethylene dibromide	0.0077	0.0045	**2**	0.01%	0.03%	0%	0%	100%
Ethylene dichloride	0.068	0.038	**2**	9%	0.3%	0%	0%	90%
Ethylene oxide	0.0064	0.011	0.6	17%	83%	0%	0%	0%
Formaldehyde	1.9	0.077	**25**	0.3%	6%	31%	50%	13%
Hexachlorobenzene	0.000093	0.0022	0.04	0%	0.3%	0%	0%	100%
Hydrazine	0.00013	0.0002	0.7	20%	80%	0%	0%	0%
Lead compounds	0.011	*0.1*	*0.1*	2%	39%	1%	59%	0%
Manganese comps	0.0032	*0.05*	*0.06*	3%	88%	1%	8%	0%
Mercury compnds	0.0028	*0.3*	*0.01*	3%	42%	0.04%	2%	53%
Methylene chloride	0.68	2.1	0.3	10%	68%	0%	0%	22%
Nickel compounds	0.0035	0.0032	1	12%	74%	2%	12%	0%
Perchloroethylene	0.34	0.17	**2**	3%	56%	0%	0%	41%
Polychlor. Biphenyls	0.00038	0.01	0.04	0%	0.5%	0%	0%	99%

Polycyclic org. mat.	0.13	0.018	**7**	5%	95%	0.2%	0.1%	0%
7-PAH *	0.0069	0.0051	1	0.02%	98%	2%	0.3%	0%
Propyl. dichloride	0.00015	0.053	0.003	69%	30%	0%	0%	0%
Quinoline	0.0000023	0.00029	0.01	0%	100%	0%	0%	0%
1,1,2,2-Tetrachlor.	0.0011	0.017	0.06	88%	11%	0%	0%	0%
Trichloroethylene	0.19	0.5	0.4	19%	38%	0%	0%	43%
Vinyl chloride	0.0049	0.11	0.04	87%	13%	0%	0%	0%

Burlington County Average 1996 NATA Modeled Air Concentrations Compared to Health Benchmarks

Pollutant	Modeled Air Concentration (ug/m^3)	Health Benchmark (ug/m^3)	Risk Ratio	% Contribution by Source Category				
				Point	Area	Onroad Mobile	Nonroad Mobile	Back-ground
Acetaldehyde	1.1	0.45	**2**	0.1%	10%	59%	31%	0%
Acrolein	0.14	*0.02*	*7*	0.02%	13%	53%	34%	0%
Acrylonitrile	0.0021	0.015	0.1	84%	16%	0%	0%	0%
Arsenic compounds	0.00012	0.00023	0.5	22%	55%	1%	22%	0%
Benzene	1.5	0.13	**11**	5%	4%	42%	16%	32%
Beryllium compnds	0.000017	0.00042	0.04	7%	92%	0%	1%	0%
1,3-Butadiene	0.050	0.0036	**14**	0.01%	6%	71%	23%	0%
Cadmium compnds	0.00027	0.00029	0.9	8%	91%	0%	1%	0%
Carbon tetrachloride	0.88	0.067	**13**	0.0003%	0.1%	0%	0%	100%
Chloroform	0.089	0.043	**2**	1%	5%	0%	0%	93%
Chromium compnds	0.0049	0.00025	**20**	6%	88%	1%	5%	0%
Coke oven emiss.	0	0.0016	0	0%	0%	0%	0%	0%
1,3-Dichloropropene	0.11	0.25	0.4	0%	100%	0%	0%	0%
Diesel particulate	3.1	0.5	**6**	0%	0%	30%	70%	***
Ethylene dibromide	0.0077	0.0045	**2**	0.01%	0.01%	0%	0%	100%
Ethylene dichloride	0.10	0.038	**3**	39%	1%	0%	0%	61%
Ethylene oxide	0.0040	0.011	0.4	2%	98%	0%	0%	0%
Formaldehyde	1.5	0.077	**19**	0.3%	7%	36%	40%	17%
Hexachlorobenzene	0.000093	0.0022	0.04	0%	0.2%	0%	0%	100%
Hydrazine	0.00000024	0.0002	0.001	14%	86%	0%	0%	0%
Lead compounds	0.0054	*0.1*	0.05	3%	61%	1%	35%	0%
Manganese compd	0.0029	*0.05*	0.06	11%	80%	1%	8%	0%
Mercury compunds	0.0024	*0.3*	0.01	8%	29%	0.03%	2%	62%
Methylene chloride	0.47	2.1	0.2	2%	66%	0%	0%	32%

Nickel compounds	0.0035	0.0032	1	4%	68%	1%	26%	0%
Perchloroethylene	0.26	0.17	**2**	1%	46%	0%	0%	54%
Polychlor. biphenyls	0.00039	0.01	0.04	0%	3%	0%	0%	97%
Polycyclic org. mattr	0.099	0.018	**5**	9%	91%	0.3%	0.1%	0%
7-PAH	0.0051	0.0051	1	0.04%	97%	3%	0.4%	0%
Propylene dichlorid	0.00011	0.053	0.002	82%	19%	0%	0%	0%
Quinoline	0.0000010	0.00029	0.003	0%	100%	0%	0%	0%
Tetrachloroethane	0.00089	0.017	0.05	95%	5%	0%	0%	0%
Trichloroethylene	0.17	0.5	0.3	22%	31%	0%	0%	47%
Vinyl chloride	0.0054	0.11	0.05	85%	15%	0%	0%	0%

Appendix B: 1999 Emissions of Criteria Pollutants by Facility in Burlington County

Facility	Pollutant	Tons	Rank	Pollutant	Tons	Rank	Pollutant	Tons	Rank	Pollutant	Tons	Rank	Pollutant	Tons	Rank
PSE&G	Carbon monoxide	3,500	1	Nitrogen oxides	27000	1	PM-10	.03	-	Sulfur dioxide	.23	11	Volatile org. comp.	1,100	1
US Pipe & Foundry	Carbon monoxide	87	2	Nitrogen oxides	120	2	PM-10	4	6	Sulfur dioxide	.18	12	Volatile org. comp.	330	2
National Gypsum Co.	Carbon monoxide	9.7	3	Nitrogen oxides	15	9	PM-10	4	5	Sulfur dioxide	.12	14	Volatile org. comp.	.99	24
Occidental Chemical	Carbon monoxide	7.4	4	Nitrogen oxides	13	11	PM-10	3	8	Sulfur dioxide	.14	13	Volatile org. comp.	140	6
Landfill & Devel. Co.	Carbon monoxide	7.2	5	Nitrogen oxides	31	3	PM-10	5	3	Sulfur dioxide	36	4	Volatile org. comp.	2.6	22
Ocean Spray Cran.	Carbon monoxide	5.9	6	Nitrogen oxides	24	5	PM-10	2	10	Sulfur dioxide	.08	16	Volatile org. comp.	.46	-
Stephan Chemical	Carbon monoxide	5.1	7	Nitrogen oxides	20	7	PM-10	1.45	-	Sulfur dioxide	82	2	Volatile org. comp.	13	16
Mt. Holly Sewerage	Carbon monoxide	4.8	8	Nitrogen oxides	19	8	PM-10	.51	-	Sulfur dioxide	32	5	Volatile org. comp.	.46	-
General Electric	Carbon monoxide	3.9	9	Nitrogen oxides	13	10	PM-10	1.29	-	Sulfur dioxide	.75	10	Volatile org. comp.	14	14
Hercules Inc.	Carbon monoxide	3.1	11	Nitrogen oxides	26	4	PM-10	15	1	Sulfur dioxide	97	1	Volatile org. comp.	.51	-
Sybron Chemicals	Carbon monoxide	2.0	12	Nitrogen oxides	22	6	PM-10	10	2	Sulfur dioxide	63	3	Volatile org. comp.	78	8
Conwed Bonded Fbr.	Carbon monoxide	0.78	14	Nitrogen oxides	10	13	PM-10	5	4	Sulfur dioxide	29	6	Volatile org. comp.	.05	-
NJ Dept. Human Srv.	Carbon monoxide	.70	16	Nitrogen oxides	7.8	16	PM-10	2	9	Sulfur dioxide	22	8	Volatile org. comp.	.17	-
US Air Force	Carbon monoxide	-	-	Nitrogen oxides	8.6	14	PM-10	.84	14	Sulfur dioxide	.04	17	Volatile org. comp.	158	5
US Army	Carbon monoxide	.04	20	Nitrogen oxides	.13	21	PM-10	-	-	Sulfur dioxide	1.96	9	Volatile org. comp.	-	-
Yates Industries	Carbon monoxide	.78	-	Nitrogen oxides	8.4	15	PM-10	4	7	Sulfur dioxide	24	7	Volatile org. comp.	.12	-
DRG Medical Pkg.	Carbon monoxide	0	-	Nitrogen oxides	0	-	PM-10	0	-	Sulfur dioxide	0	-	Volatile org. comp.	230	3
Del Val Ink & Color, Inc.	Carbon monoxide	0	-	Nitrogen oxides	0	-	PM-10	0	-	Sulfur dioxide	0	-	Volatile org. comp.	120	7
Atlantic Cheinco	Carbon monoxide	0	-	Nitrogen oxides	0	-	PM-10	0	-	Sulfur dioxide	0	-	Volatile org. comp.	53	9
Griffin Pipe Products	Carbon monoxide	0	-	Nitrogen oxides	0	-	PM-10	0	-	Sulfur dioxide	0	-	Volatile org. comp.	210	4

Appendix C: Blacks Creek Greenway Study (Executive Summary)

Blacks Creek Greenway Study:
Natural Resources Inventory and Management Recommendations
Executive Summary, October 2005

Prepared for Delaware River Greenway Partnership: Delaware River Heritage Trail
Prepared by Patricia Ann Quigley, Inc.

Under a grant from the National Fish and Wildlife Foundation, the Delaware River Greenway Partnership (DRGP) undertook this overview level study of Blacks Creek, a tidal tributary of Crosswicks Creek, in turn an important tidal creek system within the Delaware River estuary. The DRGP is working in close partnership with Bordentown City's Environmental Commission and with Bordentown Township's Open Space Advisory Committee to develop regional watershed level protection strategies for Blacks Creek which passes through these municipalities. The purpose of the study is to provide baseline characterization of the natural and geologic resources of the tidal reach of Blacks Creek to serve as the basis for potential acquisition and protection of sensitive resources and for the establishment of an interpretive educational program. In the long term, the goal of the DRGP is to develop a nature trail along Blacks Creek, which would be linked to the Delaware River Heritage Trail system, a bi-state trail system on both sides of the Delaware River that promotes the natural and cultural heritage of the river.

The baseline study included research of available background documents pertaining to the natural resources of the creek and floodplain, compilation of existing maps of the study area, site specific field investigations to identify and classify existing natural communities along the creek corridor, identification of significant natural resources recommended for protection, and the development of general recommendations for protection strategies for identified significant natural resources.

Based on the PAQ research and field investigation conducted summer and fall of 2004, eight major natural community types were identified:

- Floodplain Forest
- Tidal Freshwater Marsh
- Tidal Freshwater Shrub Forest
- Beech-Oak Forest with Rhododendron
- Beech-Oak Forest
- Mixed Oak Forest
- Successional Community

All identified cover types and specific sample sites were grouped into three broad categories based on geology, landscape position and human disturbance: those associated with Blacks Creek tidal floodplain, those associated with the steep bluffs, and those

found in disturbed edges and rights-of-way. To provide baseline information on site significance, all sites were evaluated for their degree of "native biodiversity" using a range of criteria including species diversity, native community rarity and representativeness (locally and regionally), site size, presence or absence of invasive species, presence and sensitivity to human disturbance. The major findings of the baseline natural communities inventory and ecological assessment were:

- An extensive number of native natural community types occur along the Blacks Creek corridor;
- Several sites were assessed as high quality, with high native biodiversity, high wildlife value and low to moderate disturbance; the majority of the highest ranked sites were [north-facing] bluff forest types [within Bordentown Township];
- Other sites showed varying degrees of degradation from human disturbance, especially from uncontrolled stormwater runoff and associated erosion/sedimentation;
- Many sites were being colonized by aggressive invasive species, which appear to be displacing native species especially in the shrub and groundcover strata;
- Tidal freshwater wetland sites [in Bordentown City and Bordentown Township] were comparable to the celebrated Hamilton Marshes and warrant special protection;
- Many opportunities for restoration and site enhancement were observed during the field survey; site management focus should be on the control and management of stormwater to sensitive and highly erodible bluff sites and the control of invasive species;
- Unique site geology and soils provide compelling natural history education about the local bluffs.

Study findings should be considered preliminary since they are based on single season of field survey. Prior to further trail development and design, this report outlines a number of additional investigations and evaluations.

Appendix D: Thorntown Creek Riparian Open Space Assessment and Recommendation Report (Executive Summary)

Thorntown Creek Riparian Open Space Assessment and Recommendation Report
Executive Summary, October 2005

Prepared for the Bordentown City Environmental Commission
Prepared by Dan Salas, Restoration Program Manager, Delaware Riverkeeper Network

The Bordentown City Environmental Commission (BCEC) invited staff from the Delaware Riverkeeper Network (DRN) to review open space areas along Thorntown Creek in Bordentown City to assess conditions and provide recommendations related to the stream, riparian restoration, and a planned trail corridor. The Bordentown City Open Space Plan (2005) proposes land acquisition along Thorntown Creek and creation of a trail within the stream corridor.

The DRN staff first assessed the Site Characteristics, including the location of Thorntown Creek within the watershed area; land ownership; geologic characteristics; and an overview of site disturbances within the area.

For the purpose of Problem Assessments, the Creek is divided into upper (Route 206 to Elizabeth Street/Elizabeth Street to Railroad), middle (Railroad to Park Street) and lower (Park Street to Thorntown/Crosswicks Creek Marsh) reaches.

Within each of these reaches, specific Areas of Concern are identified regarding various aspects of the riparian corridor. These include vegetation composition and communities, habitat, riparian conditions, aquatic habitat and stability of the stream channel. DRN staff uses an integrated stream assessment method to evaluate the health and quality of the aquatic and riparian habitats as well as the stability of the channel along the Creek, and assigns scores to reflect the conditions found. Total scores indicate the general conditions overall. Habitat is evaluated for riparian width, riparian condition, in-stream cover, fish barriers and pool variability. Stability is evaluated for bank erosion, bank vegetation protection, bank angle, leaning trees, and channel alterations.

Key findings include:

- Land ownership consist of three main entities: the City of Bordentown, Ocean Spray Corporation, and Divine Word Missionaries, plus several single family residences located just upstream of Park Street.
- Site disturbance occurs throughout the stream corridor as a result of historic industrial and recreation uses, including three impoundments (BMI Pond, City Pond and the lake at Pointe Breeze); channel straightening and armoring; dumping of debris; stormwater outfalls; gravel mining; and BMX biking and paintball activities.

- Several distinct habitats occur within the study area, including early-successional woodlands, isolated pockets of mature woodlands, and relatively undisturbed woodlands near Crosswicks Creek. The Route 206 to Railroad reach is characterized by early successional habitat, with a mix of native, exotic and invasive species co-dominant. The Railroad to Park Street reach contains a fragment of mature woods and is an "American Beech-Sweet Birch-Tuliptree-Sugar Maple Forest". The Park Street to Thorntown/Crosswicks Marsh reach contains relatively intact riparian woods that form an "American Beech-Sweet Birch-Tuliptree-Sugar Maple Forest" that transitions to an "American Beech-Sweet Birch-(White Oak, Northern Red Oak)/Ironwood Forest along the slope surrounding the Thorntown Crosswicks Marsh area.
- Fifty-two (52) native plant species, eleven (11) exotic species, and twelve (12) invasive plant species were identified. Species diversity and richness is fair to poor along upper and middle reaches, but good to excellent in the lower reach.
- Star Chickweed (*Stellaria pubera*), a state endangered plant species, was identified in the lower reach near Crosswicks Creek.
- Aquatic habitats have been degraded by erosion and fish barriers (including the railroad bridge and the Park Street bridge, where concrete channels at periods of low flow do not allow fish to pass upstream.
- Areas of specific concern regarding stability and erosion include: the Route 206 to Elizabeth Street reach (impacted by stormwater and former City Pond); the BMI Pond dam area; and the Railroad to Park Street reach, where private residential use has led to an almost complete loss of riparian buffer and severe erosion.

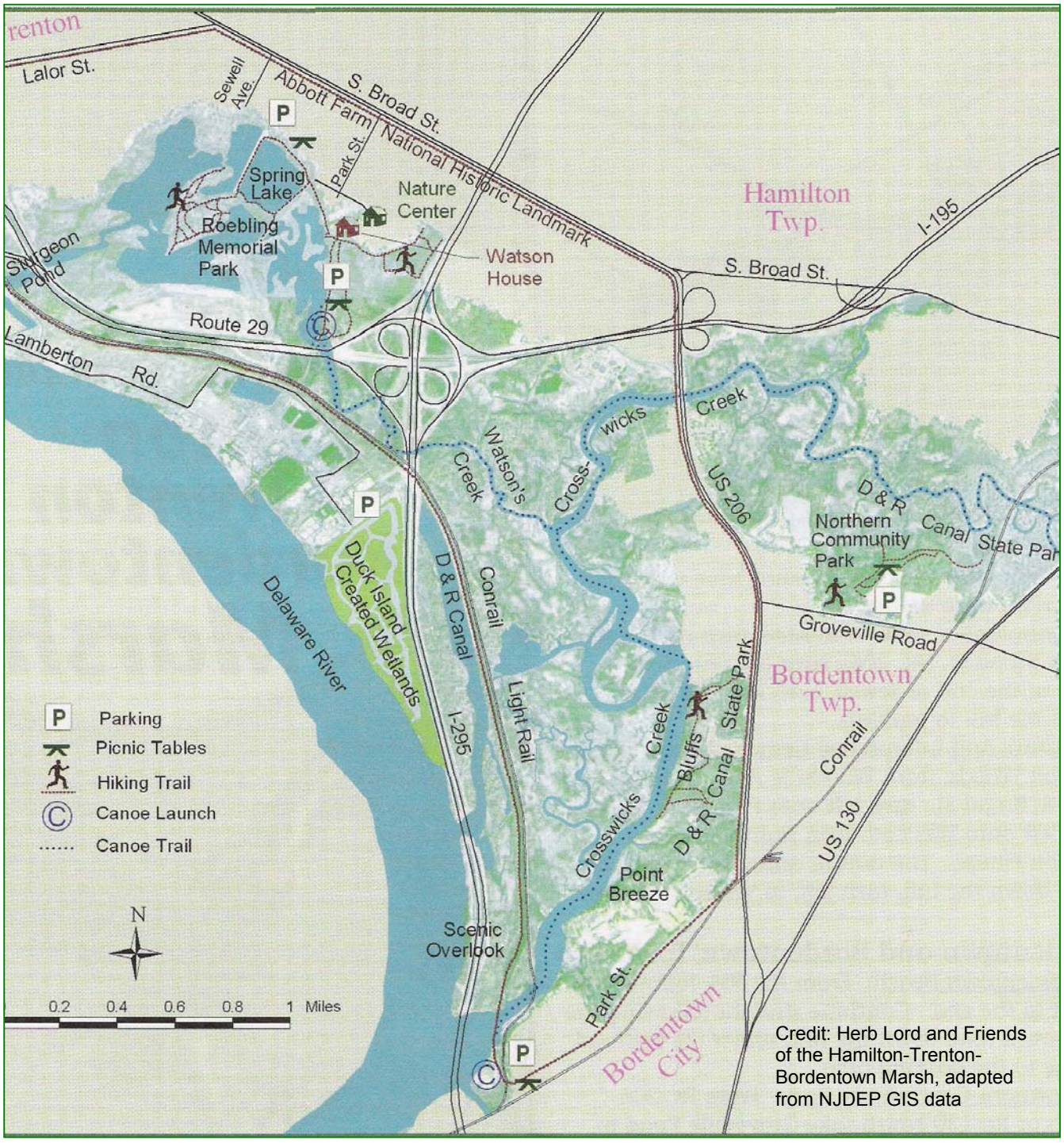
The report makes the following recommendations:

Planning and Policy Recommendations
#1: Develop a restoration vision for Thorntown Creek.
#2: Organize a local conservation initiative strategy.
#3: Purchase property of easements along riparian properties.
#4: Minimize disturbances in public use locations and design.
#5: Plan community events to encourage stewardship.

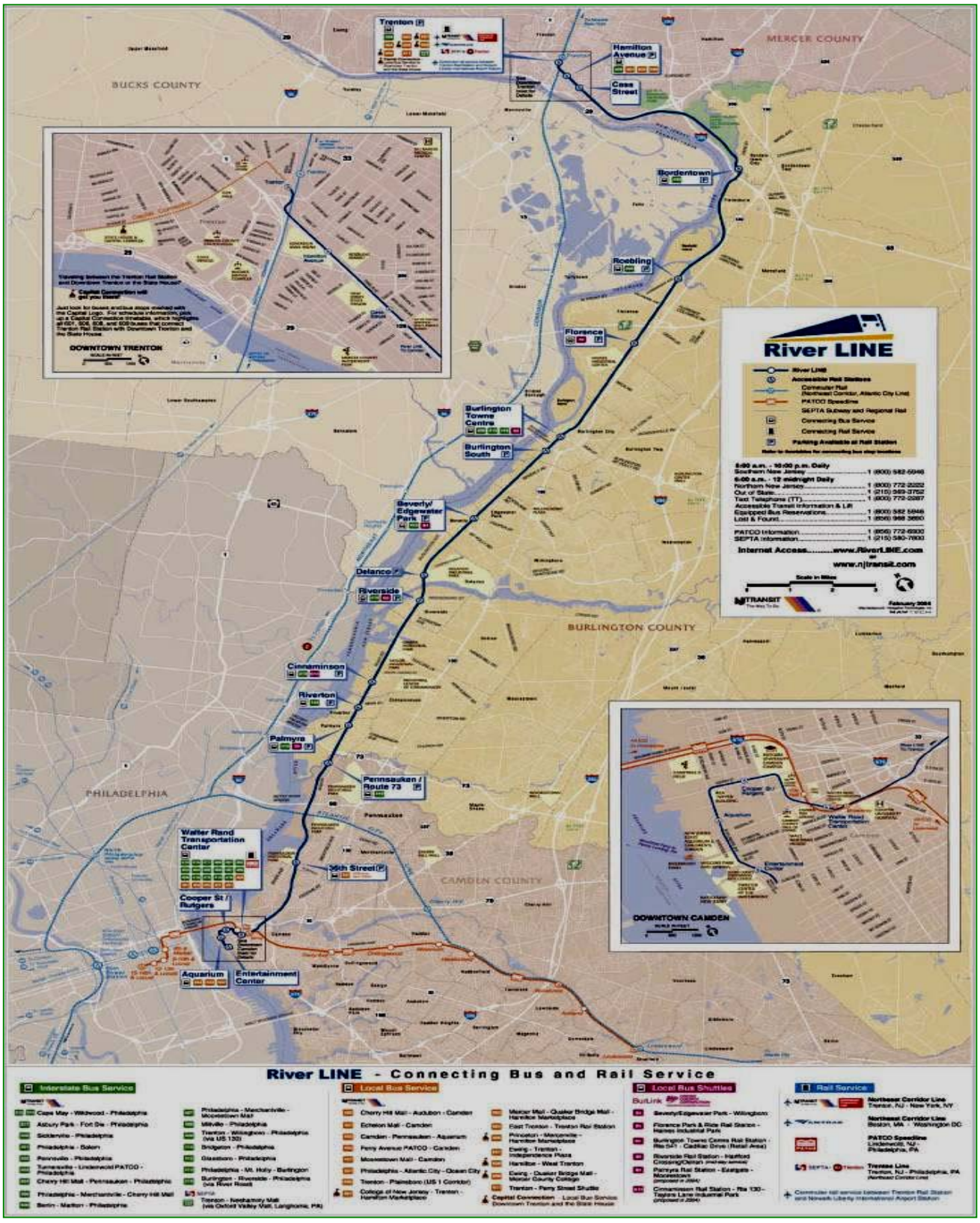
Stream Corridor Management and Monitoring Recommendations
#1: Control invasive species.
#2: Stabilize banks.
#3: Develop and implement conservation plan.
#4: Encourage changing private residence riparian practices.
#5: Install bank monitoring pins.
#6: Recruit and maintain park volunteers.

Potential funding sources are recommended, including:
Delaware Riverkeeper Network Restoration Assistance Provider Project
US Fish & Wildlife Service Partners for Conservation
US Natural Resource Conservation Service Wildlife Incentives Program
National Fish and Wildlife Foundation Delaware Estuary Grants

Appendix E: Hamilton-Trenton-Bordentown Marsh Water Trail Map



Appendix F: RiverLINE System Map



Glossary

Climate

Atmosphere: The mass of air surrounding the earth and bound to it more or less permanently by the earth's gravitational attraction.
Convection: The transfer of heat within the air by its movement. The term is used specifically to describe vertical transport of heat and moisture, especially by updrafts and downdrafts in an unstable atmosphere.
Cumulonimbus Cloud: A vertically developed cloud, often capped by an anvil-shaped cloud. Also called a thunderstorm cloud, it is frequently accompanied by heavy showers, lightning, thunder, and sometimes hail or gusty winds.
Frost: The process of deposition of frozen atmospheric water vapor on surfaces whose surface air temperature is below 32^{o} F. A frost can occur at any time the surface air temperature falls to 32^{o} F or less.
Frost Free Period: The number of consecutive days when the surface air temperature does not fall below 32^{o} F.
Frost, First: The first date following the growing season that the minimum temperature drops below an index temperature, usually 32^{o} F.
Frost, Last: The last date preceding the growing season that the minimum temperature drops below an index temperature, usually 32^{o} F.
***Normal*:** An average of any of the climatic elements calculated for a specific time period. The beginning and ending years of the normal period are established by the World Meteorological Organization. This organization has defined the current standard averaging period for "Normals" as 1971 through 2000. Normals have been established as the standard period that will be used in analysis of climatic data to allow for comparable descriptive information representative of average conditions over the time period.
Thunderstorm: A storm with lightning and thunder produced by a cumulonimbus cloud, usually producing gusty winds, heavy rain and sometimes hail.
Tornado: A violent rotating column of air, in contact with the ground, suspended from a cumulonimbus cloud. A tornado does not require the visible presence of a funnel cloud. It has a typical width of tens to hundreds of meters and a lifespan of minutes to hours.
Wind: The motion of air relative to the surface of the earth. Wind speed and direction, the two primary elements, are usually measured with an anemometer and wind vane, respectively. Wind speed is generally measured in miles per hour; direction is measured in degrees.

Geology and Soils

Anaerobic: A term used to describe a system in the absence of molecular oxygen, or refers to an organism which is found in the absence of molecular oxygen.
Available water capacity: The amount of water held by a soil that is available for use by most plants. The units of expression are either percent by volume, or inches of water per inch of soil.

Drainage Class: Refers to the frequency and duration of wet periods under conditions similar to those under which the soil developed. Classes include:

Excessively and somewhat excessively drained: The seasonal high water table is rarely higher than 60 to 72 inches from the surface for any significant period during the growing season. Most of these soils are coarse-textured.

Well drained: The seasonal high water table is rarely higher than 40 inches from the surface for any significant period during the growing season.

Moderately well drained: The seasonal high water table is between 18 and 40 inches below the surface for a significant period during the growing season.

Somewhat poorly drained: The seasonal high water table is between 6 and 18 inches below the surface for a significant period during the growing season.

Poorly drained: The seasonal high water is at, or within 6 inches below the surface for a significant period during the growing season. These soils may be ponded for brief periods outside of the growing season.

Very poorly drained: The seasonal water table is at, or ponded above, the surface for a significant period during the growing season.

Formation*:* The fundamental unit in the local distribution and of an igneous, sedimentary, or metamorphic rock, or unconsolidated deposit, which exhibits a distinctive set of identifiable features over a limited area, and tends to represent a fairly uniform environment at the time of formation or deposition.

Geologic Time Scale

Era	Period	Epoch	Time (Million Years Ago)
Cenozoic	Quaternary	Holocene	Present to 0.01
		Pleistocene	0.01 to 1.6
	Tertiary		1.6 to 65
Mesozoic	Cretaceous		65 to ~130
	Jurassic		130 to 208
	Triassic		208 to 245
Paleozoic			245 to 544
Precambrian			544 to 4400

Glauconite**:** A micaceous clay mineral, generally found as a green to black sand-sized pellet in the greensand deposits of the Inner Coastal Plain. It has a high water and nutrient holding capacity, and has been long used as a soil amendment. Soils formed in greensand are classified by glauconite content into low (2-10%), medium (10-40%), and high (>40%) groups. High contents in soils bring low permeability and impeded drainage. Even medium concentrations (>10%) can be problematic for septic treatment beds, when the clay pellets begin to disperse.

Hydrologic Soil Group**:** A soil interpretation or rating system for runoff potential. The chief consideration is the inherent capacity of the bare soil to permit infiltration. The soil properties that influence this potential are depth to a seasonal high water table, the infiltration rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The slope and the kind of plant cover are not a factor, but are separate factors in predicting runoff. The classes are:

A – Soils with low runoff potential and high infiltration rates even when thoroughly wet. Deep, well to excessively drained sand or gravel with very rapid and rapid permeability.

B – Soils with moderate infiltration rates when thoroughly wet; moderately deep to deep, moderately well drained to well drained soils with moderately fine to moderately coarse textures, and moderately rapid to moderate permeability.

C – Soils with low infiltration rates when thoroughly wet; soils with a layer that impedes downward movement of water and soils with moderately fine to fine textures and moderately slow and slow permeability.

D – Soils with high runoff potential and very low infiltration rates when thoroughly wet. Clayey soils with a high swelling potential, soils with a high water table, soils with a claypan or clay layer near the surface, and shallow soils over nearly impermeable materials.

Illinoian*:* The third of four glacial stages recognized in North America, extending from 400,000 to 550,000 years ago, when mean annual temperatures were estimated to be 2 to 3 ^{o}C cooler than today.

Marsh**:** A wet area, periodically inundated with standing or slow moving water, with grassy or herbaceous hydrophytic vegetation and often some peat accumulation; the water may be salt, brackish or fresh.

Miocene*:* Fourth of the five epochs of the Tertiary Period, extending from 23.3 to 5.2 million years ago.

Peat**:** Slightly decomposed organic soil material in which the original plant parts are recognizable.

Permeability**:** The ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass of soil or a layer of soil. The permeability classes are:

	(in hr^{-1})	($\mu m\ s^{-1}$)
Very rapid	≥20	≥141
Rapid	6-<20	42-141
Moderately rapid	2-<6	14-42
Moderate	0.6-<2	4-14
Moderately slow	0.2-<0.6	1.4-4
Slow	0.06-<0.2	0.42-1.4
Very Slow	0.0015-<0.06	0.01-0.42
Impermeable	0.00-<0.0015	0.00-0.01

Particle size separates: (USDA) for mineral soil include:

sand - 2 to 0.05 millimeters - gritty feel - can be seen with eye.

silt - 0.05 to .002 millimeters - smooth feel- can be seen with microscope.

clay - less than .002 millimeters -sticky feel- can be seen with electron microscope.

Sand and silt (mostly quartz) are relatively inert; they form the 'soil skeleton.' Clay particles (layer silicates & oxides) are the reactive portion of the mineral soil; they have an electrical charge and a high surface area resulting in a high attraction for water, nutrients, and other clay particles.

Pliocene*:* Last of the five epochs of the Tertiary Period, extending from 5.2 to 1.64 million years ago.

Reaction (soil reaction, pH): A measure of the acidity or alkalinity of a soil, expressed in pH values. The reaction classes are:

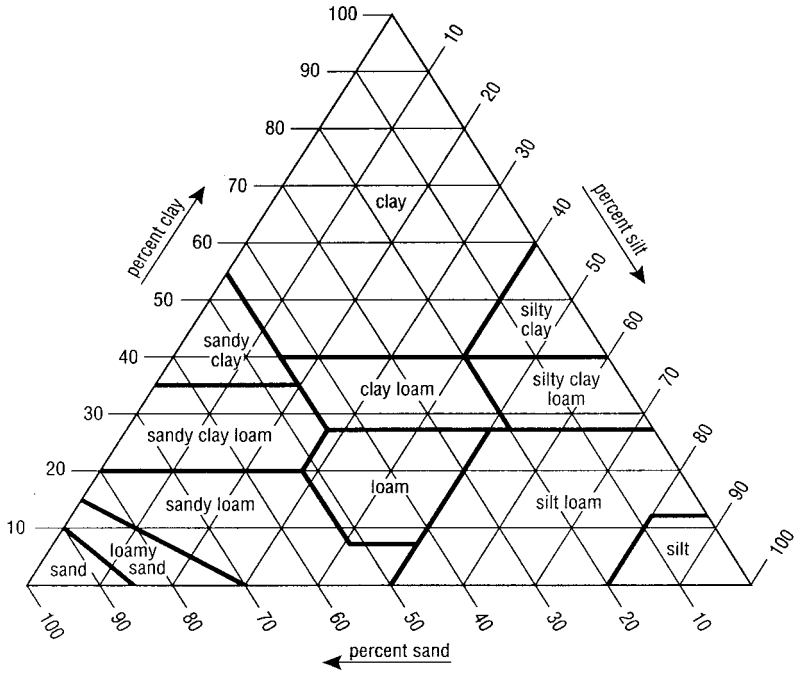
Extremely acid – pH value below 4.5.
Very Strongly acid - pH value between 4.5 to 5.0.
Strongly acid - pH value between 5.1 to 5.5.
Moderately acid - pH value between 5.6 to 6.0.
Slightly acid - pH value between 6.1 to 6.5.
Neutral - pH value between 6.6 to 7.3.
Mildly alkaline - pH value between 7.4 to 7.8.
Moderately alkaline - pH value between 7.9 to 8.4.
Strongly alkaline - pH value between 8.5 to 9.0.
Very strongly alkaline - pH value of 9.1 and higher.

***Solum*:** The upper part of a soil profile in which the processes of soil formation are active.

***Subsoil*:** That active portion of the soil profile below the topsoil and above the substratum or parent material.

***Substratum*:** The layers below the depth of noticeable soil development; often the parent material of the soil above.

***Texture*:** Refers to the relative amounts of the three particle size separates in mineral soil material. Varying proportions of each size give the soil a 'texture.' Soil scientists use 12 textural classes (see triangle below):



Soil Texture Classes

Texture groups (soil): Broad groups or classes of soil texture.

Coarse-textured: Sands (coarse sand, sand, fine sand, very fine sand) and loamy sands (loamy coarse sand, loamy sand loamy fine sand, loamy very fine sand).

Moderately coarse-textured: Coarse sandy loam, sandy loam, fine sandy loam.
Medium-textured: Very fine sandy loam, loam, silt loam, silt.
Moderately fine-textured: Clay loam, sandy clay loam, silty clay loam.
Fine-textured: Sandy clay, silty clay, clay.

Hydrology

***Broad-leaved Deciduous*:** A plant (usually a tree or shrub) that sheds its leaves at the end of the growing season.
***Dissolved Oxygen**:* The concentration of oxygen dissolved in water, expressed in mg/l or as percent saturation, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature.
***Ecosystem*:** A community of plants and animals interacting with one another and with their physical environment.
Emergent: Refers to objects or organisms that are partly in water and partly exposed, such as plants that are rooted in water but whose upper parts are aerial or floating. Emergent wetland vegetation includes erect, rooted, herbaceous vegetation, such as sedges, rushes, and grasses.
***Floodplain*:** The flat area of land adjacent to a stream; stores and dissipates floodwaters.
***Forested*:** Consisting of trees whose canopy covers more than 60% of the ground area.
***Herbaceous*:** Soft-stemmed plant, not woody.
***Hydrology*:** The study of the properties, distribution and effects of water on the Earth's surface, in soils and underlying rocks, and in the atmosphere, including the source of the supply and flow regime for surface and ground water.
Intermittent Stream: A stream that flows only during certain times of the year. Seasonal flow in an intermittent stream usually lasts longer than 30 days per year.
Nitrate: A nutrient (along with phosphate) that comes from both natural sources and human activities (fertilizers, detergents, wastewater). These nutrients determine the productivity of a water body, and are needed at some level to provide good aquatic habitat. However, pollution from manure, fertilizer, and wastewater can bring excessive nutrient levels and cause algae to grow out of control, reducing light and oxygen for fish.
***Non-tidal*:** Those areas not influenced by tidal fluctuations that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.
***Open Water*:** Deeper, normally perennial pools within wetlands and shallow portions of lakes and rivers.
***Palustrine*:** Freshwater, shallow wetlands that are not riverine or lacustrine, such as marshes or bogs. All non-tidal wetlands that are substantially covered with emergent vegetation-trees, shrubs, moss, etc. Most bogs, swamps, floodplains and marshes fall in this system, which also includes small bodies of open water (< 20 acres), as well as playas, mudflats and salt pans that may be devoid of vegetation much of the time. Water chemistry is normally fresh but may range to brackish and saline in semiarid and arid climates.
Perennial: Contains water year round during a year of normal rainfall, with the aquatic bed of the waterbody located below the water table for most of the year.

***Persistent*:** Vegetation that remains past the growing season.
***pH*:** A measure of the acidity or alkalinity of water, important in understanding the chemical balance of the water. pH values below 7 indicate acid conditions, while those above 7 indicate alkaline conditions. pH is a strong determinant of the solubility and availability of both nutrients and pollutants. Most natural water bodies will have pH values close to 7, depending on the local geochemistry. Very low values (less than 5) can come from acid rain, industrial sources, or mine drainage.
Phosphate: A nutrient (along with nitrate) that comes from both natural sources and human activities (fertilizers, detergents, wastewater). These nutrients determine the productivity of a water body, and are needed at some level to provide good aquatic habitat. However, pollution from manure, fertilizer, and wastewater can bring excessive nutrient levels and cause algae to grow out of control, reducing light and oxygen for fish.
***Recharge*:** When water flows or seeps from the wetland into the surrounding groundwater.
***Riverine*:** A freshwater system associated with a river; riverine wetlands are those that occur within the river channel and are dominated by emergent vegetation that remains only through the growing season.
***Saturated*:** A portion of the soil or rock profile in which all pores are filled with water.
***Scrub/Shrub*:** Includes all areas having a predominance of shrubs that lose their leaves or needles at the end of the frost-free season or at the beginning of the dry season.
Tidal: Portion of a water body subject to tidal flows.
***Unconsolidated Bottom*:** Includes all wetland and deepwater habitats with at least 25% cover of particles smaller than stones, and a vegetative cover less than 30%. Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded.
***Uplands*:** The elevated, typically forested lands beyond the lowlands that border rivers and coasts.
***Watershed*:** An area of land that drains to a particular body of water.

Vegetation and Wildlife

New Jersey Endangered Species Act
Endangered Species: Those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination. Assistance is needed to prevent future extinction in New Jersey.
Threatened Species: Those who may become endangered if conditions surrounding them begin to or continue to deteriorate.
Species of Special Concern: Applies to 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.

Federal Endangered Species Act
Endangered Species: An animal or plant species in danger of extinction throughout all or a significant portion of its range.
Threatened Species: An animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Water Supply

Parts per million (ppm): One part is equivalent to a single penny in ten thousand dollars
Parts per billion (ppb): One part per billion is equivalent to a single penny in ten million dollars.
Action level: The concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.
Picocuries per liter (pCi/L): A measure of radioactivity. The curie was originally chosen to approximate the activity of 1 gram of radium-226. A picocurie is 1×10^{-12} curies.
Maximum Contaminant Level Goal (MCLG): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
Maximum Contaminant Level (MCL): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available technology.

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