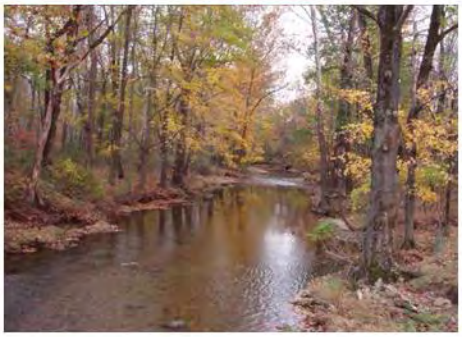
November 2009

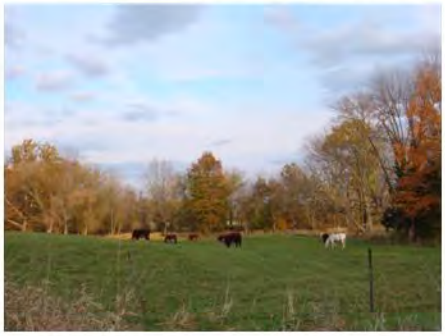
Environmental Resource Inventory

for

Tewksbury Township

Hunterdon County, NJ





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

Prepared for:

Tewksbury Township
Environmental Commission

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

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ENVIRONMENTAL RESOURCE INVENTORY

The Township of Tewksbury

Hunterdon County

New Jersey

Prepared By

Deborah J. Kratzer, Kratzer Environmental Services

For

The Tewksbury Township Environmental Commission

November 2009

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

ACKNOWLEDGMENTS

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PREFACE

This Environmental Resource Inventory is a snapshot in time of the known and mapped elements of Tewksbury Township's environment in the first decade of the 21st Century. As both the environment and patterns of human habitation are dynamic, this snapshot represents a moment in time. Yet, it is also a living document. As you will see from the extensive resources at the end of each section, users of this information can go directly to the source material for the latest update at any time.

The Township's Environmental Commission members hope that this comprehensive document will serve several immediate purposes. First, we hope it will provide a massive and updated data set for the upcoming (and periodic) Master Plan revision. Second, we hope the Township officials will use the data to make informed decisions about whether our town will "opt in" the Planning Area of the township (as defined by the Highlands Water Protection and Planning Act, "Highlands Act", N.J.S.A. 13:20-1 et sec.) to be covered by the strong environmental aegis that applies to the resources in the Preservation Zone (which is 2/3rds of our town). Finally, we hope this document will help guide land use decisions by our town's boards and committees now and for the foreseeable future.

We hope you will agree that this is an extraordinary document. Let us know if you find it useful, and let us know what you would like to see added in future updates.

Christopher J. Teasdale
Chair, Tewksbury Township Environmental Commission

1: INTRODUCTION

A. Ecologically Based Planning

Ecology is defined as the science of the relationships between organisms and their environments. The relationships between and among the physical factors of the environment, including the air, geology, topography, soils, and water, and the biotic environment, including plants, animals and decomposers, are a complex web. Humans are a significant part of the ecosystem of Tewksbury Township, both affecting and being affected by many physical and biological factors. Even in Tewksbury, with a relatively low human density of 180 people per square mile (Hunterdon County website, 2002 population estimate), the cumulative effects of many individual decisions have the potential to alter the environment in ways that cause harm directly to human health, and indirectly through complex environmental functions.

William Honachefsky, in his book Ecologically Based Municipal Land Use Planning, states,

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

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

B. Goal of the Environmental Resource Inventory

The goal of the *Environmental Resource Inventory (ERI)* is to provide a reference and planning tool containing resource information, data and maps that can be used as part of the Master Plan, as a reference when reviewing development proposals, and as a guide in other township activities in order to better protect the township's natural resources and the overall health and welfare of the community.

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

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

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

> "The Environmental Resource Inventory (ERI), also called Natural Resource Inventory (NRI), or Index of Natural Resources, is a compilation of text and visual information about the natural resource characteristics and environmental features of an area. An ERI is an unbiased report of integrated data. It provides baseline documentation for measuring and evaluating resource protection issues. The ERI is an objective listing, rather than an interpretation or recommendation. Identifying significant environmental resources is the first step in their protection and preservation." (ANJEC, no date)

The ERI will principally be used by the Land Use Board and Environmental Commission, but will provide valuable information to anyone interested in the natural resources of Tewksbury Township. Ideally, landowners considering subdivision and development will become familiar with the environmental concerns specific to their property, and thereby have the ability to make resource-sensitive development decisions. Even when subdivision is not an issue, residents may learn to appreciate and maintain our valuable natural resources. Areas of specific concern may emerge which require additional protection strategies, such as further research and monitoring, public outreach and education, habitat restoration, easements, volunteer projects, and/or revised or new ordinances.

C. Methods

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

An inventory of what is currently known about the physical and biotic environment and the human influence on the environment of Tewksbury Township has been compiled for this document. Information sources include the 2003 Master Plan, the 2003 Groundwater Resources Study and others. The most current GIS data has been obtained from the New Jersey Department of Environmental Protection GIS Data Web Site and other sources (see **Appendix A** and **Appendix B)**.

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

> **A Geographic Information System (GIS) is computerized mapping which combines layers of information about a place to provide a better understanding of that place.**

When viewing the digital document (as opposed to a printed copy) maps in PDF[1], clicking on the tab "Layers" at the left side of the screen will allow users to turn on or off the various data layers. Viewing the separate layers in this way is often helpful, especially for complex maps[2].

References and related Internet resources are listed at the end of each section, so that readers may find more information and updates. Please note that Internet sites may change or be temporarily out of service. If an Internet link doesn't work, try the first part of the address. If that works, you may be able to search for the type of information you want. For example, if you click on http://www.state.nj.us/dep/gis/downloadintra.html and the site no longer exists, try http://www.state.nj.us/dep/gis/; if that doesn't work, try http://www.state.nj.us/dep/.

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

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

D. Limitations of the ERI

It should be noted that the ERI is not intended to produce original research and is not meant to replace the primary data sources upon which it is based. Details about each data layer, including the date, scale and methods of developing the data, are provided in **Appendix B**. The ERI is intended for preliminary assessments of projects and *cannot substitute for on-site testing and evaluations*. Most maps are presented at a scale of 1:60,000 in order to fit on 8.5 x 11 inch paper. "Zooming in" to better view individual lots is possible, but should not exceed the scale at which the data was created. Most data layers used for this report were created at 1:24,000 scale (with an accuracy of $\pm$ 40 feet). Data mapped at 1:100,000, such as the geology data layer, have an accuracy of $\pm$ 166.7 feet (Garie, 1998).

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

GIS data from NJDEP and Hunterdon County are used with permission (see the Terms of Agreement in **Appendix A**), with the required "disclaimer" printed on each map which uses their data: "This map was developed using [NJDEP and/or Hunterdon County] GIS digital data, but this secondary product has not been verified by [NJDEP or Hunterdon County] and is not [NJDEP- or county-] authorized."

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

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

E. General Description of Tewksbury Township

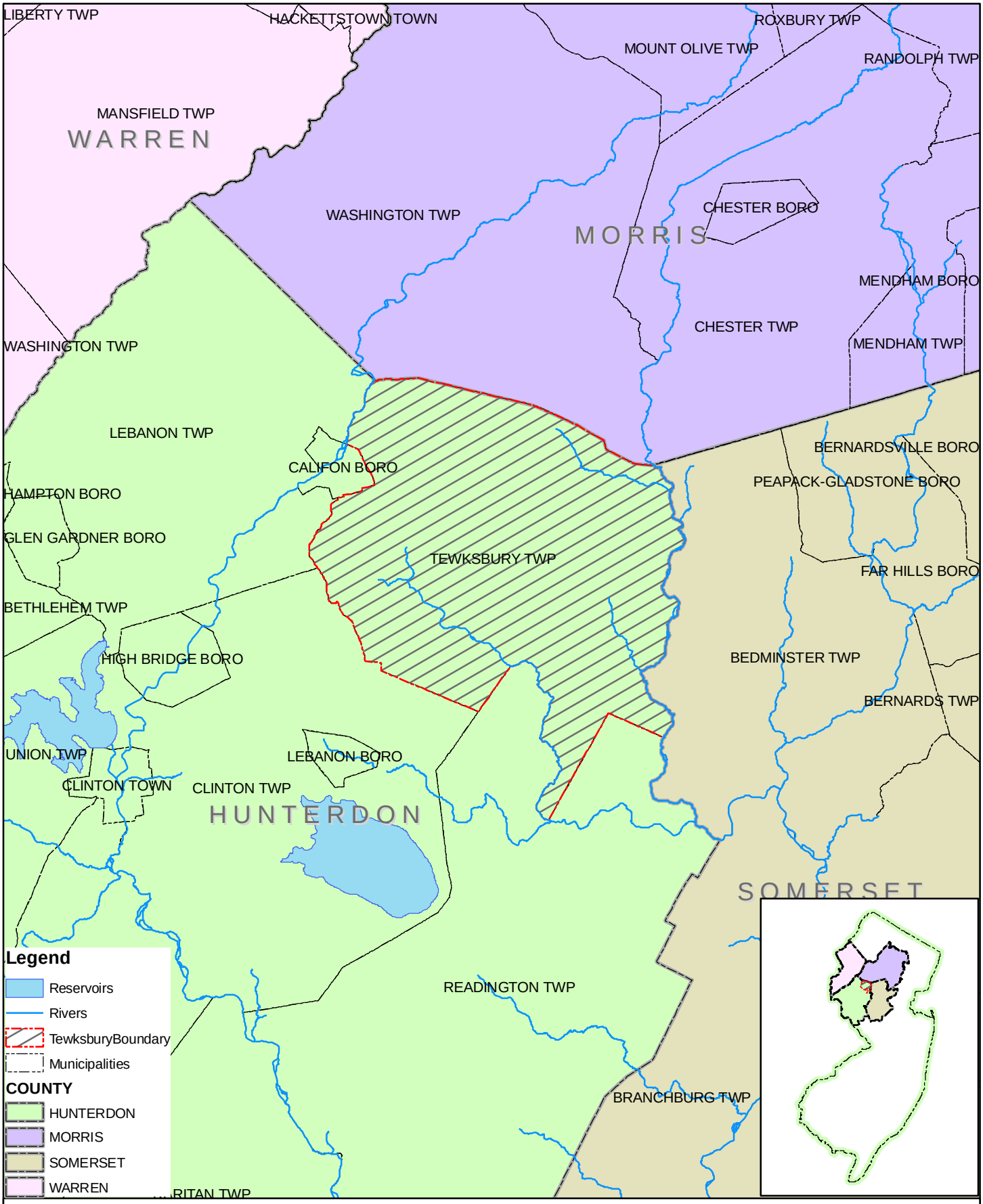
Tewksbury Township is located in the northeastern corner of Hunterdon County, NJ (see **Figure 1a**) and borders on both Morris and Somerset Counties. It was established from a portion of Lebanon Township in 1755 (Hunterdon County website, 2007). Tewksbury Township encompasses 31.8 square miles (20,352 acres) with a population of 5,541 living in 2,052 housing units (2000 census).

Tewksbury contains a wealth of natural and historic resources and has preserved some farmland and open space, funded by a portion of the local tax assessment and other sources.

The township is predominantly a rural municipality (see **Table 1**), relying largely on individual water supply wells and on-site septic systems, with some areas served by public water and sewer. **Figure 1b**

Table 1: Land Use Type Relative Area in Tewksbury

Land Use Type	2002 Percentage
Agriculture	27
Barren Land	Less than 1
Forest	50
Residential/Urban	19
Water	Less than 1
Wetlands	4
Source: NJDEP, 2007 (GIS data 2002 Land use/Land Cover); see USGS 2007 for definitions of land uses	



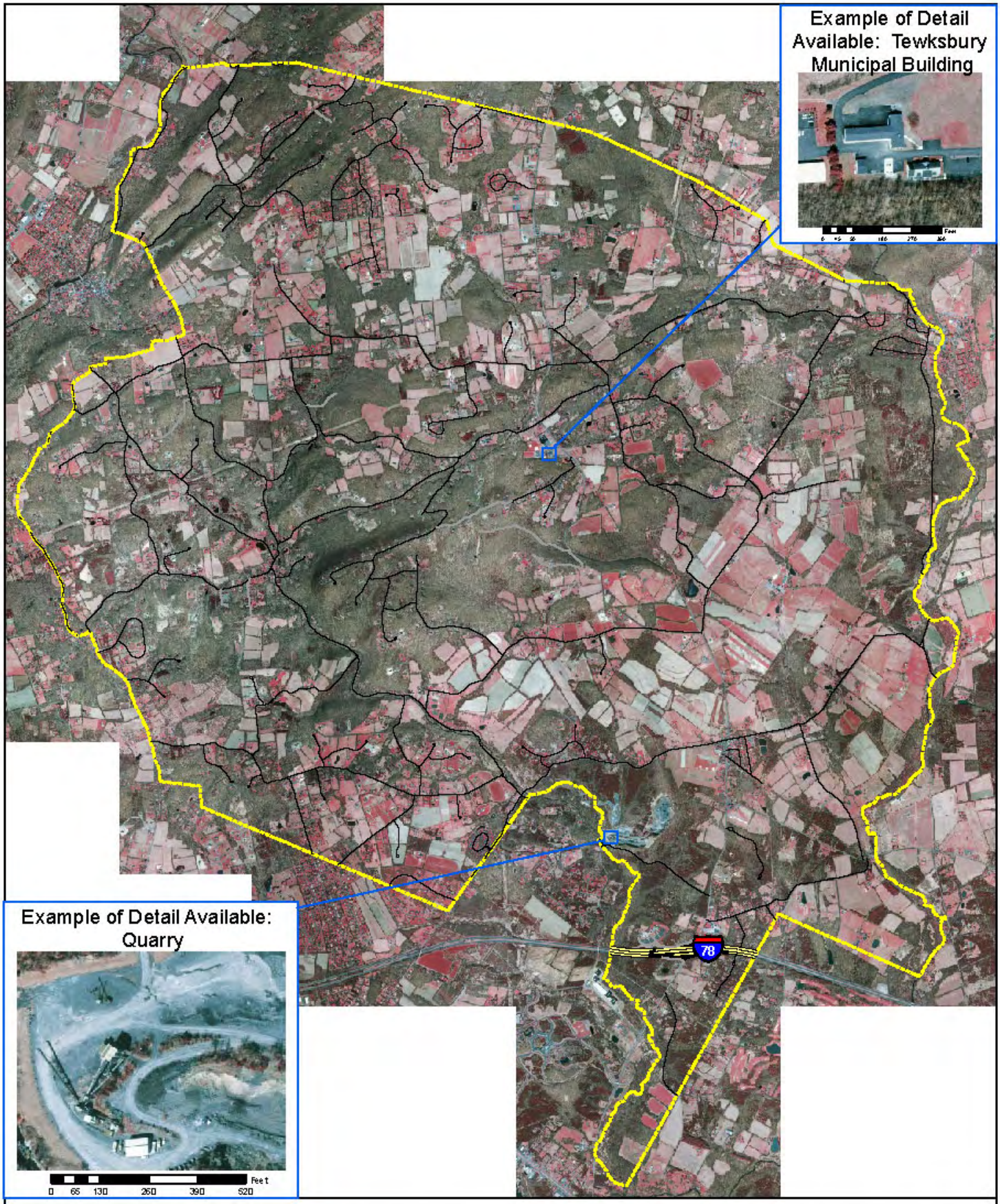
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.5 1 2 3 4 Miles

Figure 1a: Location of Tewksbury Township

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



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N

0 0.25 0.5 1 1.5 Miles

Figure 1b: 2002 Aerial Photos

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

shows aerial photographs of Tewksbury and the surrounding areas taken in 2002[3]. To provide an overview of the township, **Figure 1c** displays named places, roads and tax parcels, while **Figure 1d** shows parcels grouped by block.

NJDEP used aerial photographs taken in 2002 to determine land use, shown in **Figure 1e**. The map does not show changes that have occurred since the aerial photos were taken in 2002, nor does it reflect any anticipated changes due to approved subdivisions. Detailed categories of land use/land cover are shown in **Section 7 (Figures 7a and 7b)** of this report.

Despite the township's pastoral atmosphere, it is influenced by the same variety of environmental issues confronting the region as a whole. Suburban sprawl results in ecological impacts such as further loss of farmland, forests, wetlands, habitat and an increase in impervious surfaces, erosion, pollution, human/wildlife conflicts, light pollution and the local eradication of species. For example, when fields are allowed to lay fallow, aggressive exotic vegetation, such as multiflora rose, and excessive browsing by deer prevent the normal succession to forest growth. Tewksbury Township also contains several point sources of pollution, such as the Cleveland Industrial Site and potential nonpoint sources of pollution, such as storm drains, farms and lawns. In addition, Tewksbury's geology supports a limited water supply that is vulnerable to quantity and quality degradation. These environmental concerns are addressed in detail in the following chapters.

[3] For the aerial photography, much more detail can be seen when the data is viewed at a larger scale than that used in this report (the 2002 data has pixels of 1 square foot; the 1995 data, in contrast, has pixels of 1 square meter). Inset pictures show examples of what level of detail is available.

Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
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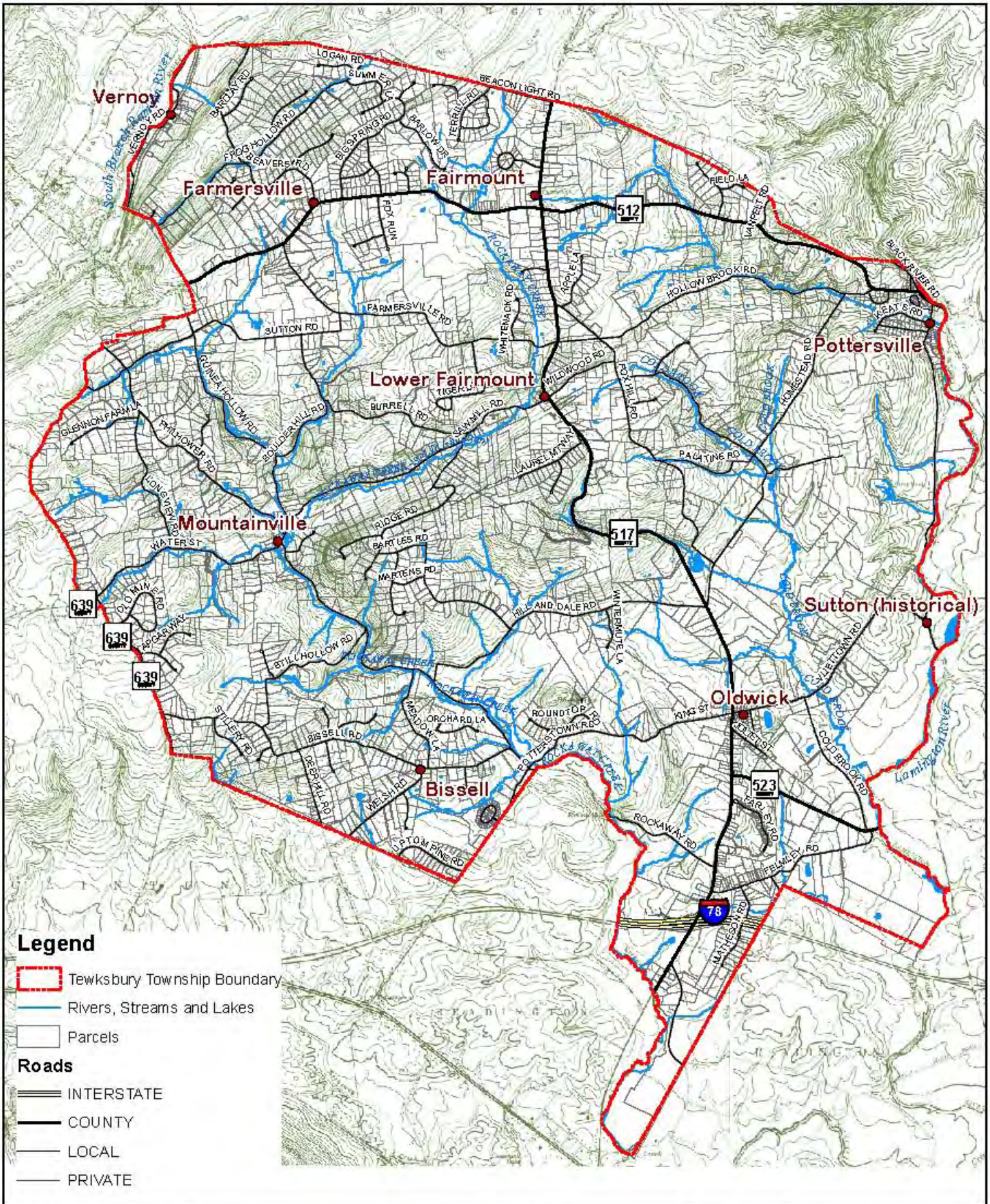
Figure 1c: 2007 Aerial Photos

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

- Tewksbury Township Boundary
- Rivers, Streams and Lakes
- Parcels

Roads

- INTERSTATE
- COUNTY
- LOCAL
- PRIVATE

Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
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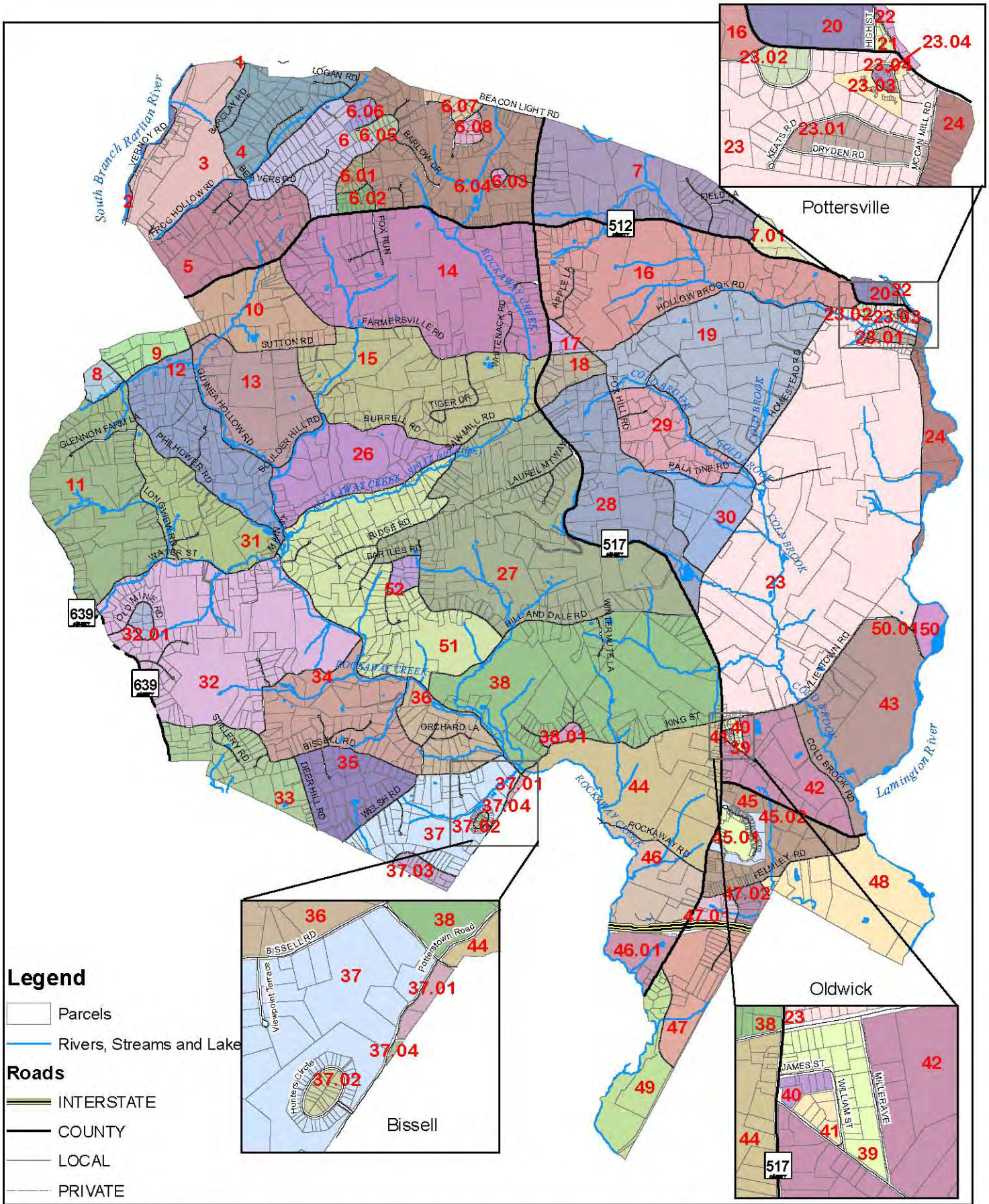
Figure 1d: Named Places & Roads on Topographic Images

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Data Sources: See Appendix B.
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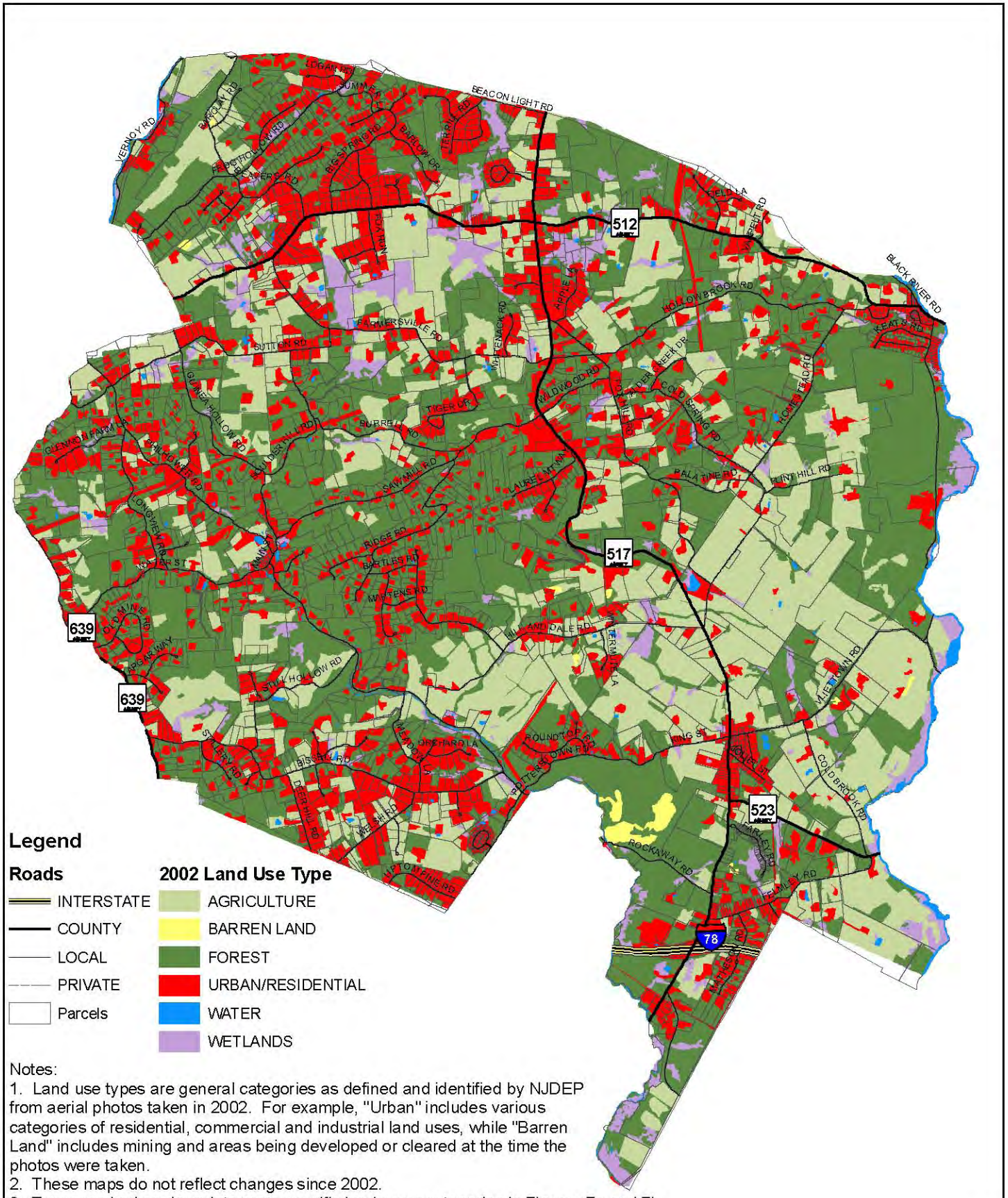
N

0 0.25 0.5 1 1.5 Miles

Figure 1e: Parcels Grouped by Block

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

Roads	2002 Land Use Type
INTERSTATE	AGRICULTURE
COUNTY	BARREN LAND
LOCAL	FOREST
PRIVATE	URBAN/RESIDENTIAL
Parcels	WATER
	WETLANDS

Notes:
1. Land use types are general categories as defined and identified by NJDEP from aerial photos taken in 2002. For example, "Urban" includes various categories of residential, commercial and industrial land uses, while "Barren Land" includes mining and areas being developed or cleared at the time the photos were taken.
2. These maps do not reflect changes since 2002.
3. Types are broken down into more specific land cover categories in Figures 7a and 7b.

Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 1f: Land Use Type from 2002 Aerial Photos

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

References: Introduction

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US Geological Survey (USGS). 2007. Edited by NJDEP, Bureau of Geographic Information Systems (BGIS) 1998, 2000, 2001, 2002, 2005, 2007. NJDEP MODIFIED ANDERSON SYSTEM 2002 derived from: A Land Use and Land Cover Classification System for Use with Remote Sensor Data, U. S. Geological Survey Professional Paper 964, 1976. 43 pages. Anderson2002.doc in zipped file with GIS data.

Internet Resources: Introduction

Environmental Education

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

Free GIS Software

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

GIS Maps for New Jersey on the Internet

i-MapNJ (an on-line environmental mapping tool):
http://www.state.nj.us/dep/gis/newmapping.htm

GIS Data from New Jersey Department of Environmental Protection

(For a complete list of data sources used in this report, see **Appendix B.**)

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

Hunterdon County's Official Home Page: http://www.co.hunterdon.nj.us/

Tewksbury Township's Official Home Page: http://www.tewksburytwp.net/

2: LOCAL & REGIONAL CONDITIONS

A. Climate & Meteorology

Climate

Climate is a major factor in determining the kinds of plants and animals found in an ecosystem. New Jersey has a *temperate climate* because it has mild average temperatures, four seasons, and rainfall distributed throughout the year. The Office of the New Jersey State Climatologist (ONJSC) divides New Jersey into five distinct climate regions. Tewksbury resides in the *Northern Zone*, grouped with the Valley and Ridge, Highlands and part of the Piedmont physiographic provinces (see **Section 2C** for descriptions of physiographic provinces). Since this region is surrounded by land, it can be characterized as having a continental type of climate with minimal influence from the Atlantic Ocean, except when the winds come from the east. The dominant atmospheric circulation is the *prevailing westerlies*, the broad, undulating flow of air from west to east across the middle latitudes of North America. Prevailing winds are from the southwest in summer and from the northwest in winter (ONJSC, 2008).

Climate varies naturally over long periods of time. Climatologists believe that recent changes in climate are the result of human activities, and are attempting to predict the effects and magnitude of future trends. The NJ State Climatologist compiled data for 19 weather stations within New Jersey and created time-series graphs of many variables (e.g. min. and max. temperature, precipitation) for the NJ Climate Report Card (Robinson, 2005). The weather stations nearest to Tewksbury that were evaluated for this climate study were Flemington and Somerville, which have been monitored since 1879 and 1880, respectively (Hartman, 2002).

Precipitation and Temperature

As the prevailing westerlies shift north and south and vary in strength, they bring wet, dry, hot, and cold airstreams. These influence the weather throughout New Jersey, resulting in highly variable daily weather.

The New Jersey Weather and Climate Network maintains weather stations, which transmit real-time data and weather forecasts on the Internet. Of these stations, Teetertown (Hunterdon County) and Chester (Morris County) are nearest to Tewksbury Township. However, historical data are not available for these sites. The nearest weather station with historical data available for precipitation and snow is in Pottersville (Somerset County); and for temperature, precipitation and snow is in Flemington. **Table 2.1** displays monthly average highs and lows and mean temperature, average monthly precipitation, and record highs and lows (and the year it occurred in parentheses).

Measurable precipitation falls in this area on approximately 116 to 120 days per year. In Flemington, annual precipitation has averaged 46.24 inches (for the period 1898-2007), while the Pottersville area is wetter, averaging 52.77 inches (for the period 1968-2007) (see **Table 2.1**).

Rainfall is distributed fairly evenly throughout the year, with February being the driest month. On average, June and July have the most precipitation, but appear drier because evapotranspiration exceeds precipitation (ONJSC, 2008). During the warm season, thunderstorms (which often occur in the evening) are responsible for most of the rainfall. About twice as many thunderstorms occur here as in the coastal zone, where the nearby ocean helps stabilize the atmosphere. Record rainfalls are more likely to occur in the fall, due to tropical storms (see **Table 2.2**).

An average of 31.8 inches of snow falls annually measured at the Flemington station and 26.3 inches at Pottersville (about 10” of snow equals 1” of rain). Each winter, about 11 to 12

days receive snowfall greater than or equal to 0.5” in Tewksbury Township. Days with snowfall greater than 4” occur only about twice per winter in this area (ONJSC, 2008). Measured in Pottersville, the earliest snow on record was on October 28 (in 2008, with 2.5"; previous record was Nov. 12, in 1968, with 2"), and the latest was April 23 (in 1986, with 4") (ONJSC, 2008).

Hunterdon County has a growing season of about 167 days. The average date for the last killing spring frost is April 29th (in one year out of 10, the last freeze may be May 9 or earlier). The first frost in fall is around October 13th (in one year out of 10, the first frost may be October 2 or earlier) (Jablonski, 1974). The exact dates vary within the county as well as from one year to another.

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

Table 2.1: Temperature & Precipitation at Flemington and Pottersville, NJ

Month	Flemington						Pottersville
	Based on data from 1898-2008				Based on data from 1926-2000		Based on data from 1968-2008
	Temperature			Mean Precip.	Temperature		Mean Precip.
	Avg. High	Avg. Low	Mean		Record High	Record Low	
January	38.6°F	20.3°F	29.5°F	3.60 in.	74°F (1932&1950)	-18°F (1984)	3.94 in.
February	40.4°F	20.6°F	30.5°F	3.10 in.	77°F (1930)	-16°F (1934)	2.97 in.
March	50.6°F	28.8°F	39.7°F	3.94 in.	88°F (1998)	-6°F (1984)	4.08 in.
April	62.5°F	37.8°F	50.1°F	3.89 in.	94°F (1976)	14°F (1969)	4.58 in.
May	73.3°F	47.6°F	60.5°F	3.94 in.	99°F (1939)	25°F (1966)	4.89 in.
June	81.7°F	57.1°F	69.4°F	4.05 in.	102°F (1934)	34°F (1978)	5.12 in.
July	86.5°F	62.5°F	74.5°F	4.75 in.	106°F (1936)	41°F (1957)	5.11 in.
August	84.2°F	60.7°F	72.5°F	4.45 in.	104°F (1955)	37°F (1965)	4.41 in.
September	77.8°F	53.6°F	65.7°F	3.94 in.	105°F (1953)	27°F (1963)	4.91 in.
October	66.8°F	42.1°F	54.5°F	3.65 in.	97°F (1941)	18°F (1952)	4.37 in.
November	53.9°F	33.0°F	43.5°F	3.50 in.	84°F (1950)	2°F (1938)	4.41 in.
December	41.8°F	24.0°F	32.9°F	3.82 in.	75°F (1984)	-14°F (1948)	4.18 in.
Average Annual Precipitation:				46.37 in.			53.28 in.
Source: ONJSC, May 2009 and 1968-2000							

Extreme Weather

During the warm season, thunderstorms are responsible for most of the rainfall. Most areas receive 25 to 30 thunderstorms per year. In addition, each year between 1 and 10 nor’easters bring strong winds and heavy rains to the state. Approximately five tornadoes appear each year in New Jersey (usually relatively weak ones). Between 1973 and 2007, a total of 7 tornadoes were reported in Hunterdon County. Hail is not frequent, but can be destructive. On July 18, 2006, 1.25" hail fell in Califon Borough and Tewksbury Township, while on August 17, 2003, 1.75" hail tore down wires and trees in Tewksbury (NOAA, 2009).

Table 2.2 lists some of the highest snow and rainfall received in one day (although multiple day storms can have higher totals), for the period 1968 to 2000 (the most recent data available on the Internet).

Tropical storms and hurricanes can contribute significant rainfall and can cause flooding. Tewksbury's topography is higher than most of the surrounding areas, and thus serves as the headwaters zone for several streams feeding the Raritan River. Some storms which have affected Tewksbury are described here. Hurricane Floyd battered New Jersey on September 16, 1999 and brought with it record breaking amounts of rain and damaging winds. Storm totals of 7.1 inches of rain were recorded in Pottersville (higher in some areas), resulting in the worst flooding of the Raritan basin on record, exceeding previous records set during Tropical Storm Doria on August 28, 1971. A nor'easter that brought 3.95 inches of rain to Tewksbury, and up to

7.25 inches elsewhere, caused widespread flooding on April 15-16, 2007. It caused the worst flooding in the Raritan Basin since Floyd, and, combined with high winds, was the second-worst rainstorm (not related to a hurricane) in the state's history. On June 28, 2006, several days of heavy rains culminated in flooding on the South Branch of the Raritan River at Stanton and High Bridge. Heavy rains on Oct 12, 2005 caused flooding on the South Branch of the Raritan at Stanton; this contributed to October 2005 being recorded as the wettest month in New Jersey since record keeping began in 1895, with a statewide average of 11.91 inches of precipitation. On September 24, 2004, the remnants of Hurricane Jeanne dropped over 4 inches of rain on the area, resulting in flooding of the South Branch of the Raritan at Stanton. A series of thunderstorms on July 27, 2004 resulted in flooding of the South Branch Raritan at Stanton. Heavy thunderstorms between August 12 and 14, 2000 (which in some areas totaled 15") caused widespread flooding, including, in Tewksbury, the Rockaway Creek, as well as the South Branch of the Raritan. The 3rd highest rainfall on record at Pottersville occurred on October 19, 1996, resulting in flooding of the South Branch at both High Bridge and Stanton gaging stations (ONJSC, 1968-2000 and NOAA, 2009).

Table 2.2: Highest Daily Precipitation Measured at Pottersville, NJ

Rank	Greatest one-day snowfall		Greatest one-day rainfall	
	Amount	Date	Amount	Date
1st	22.0 in.	Jan. 1996	7.10 in.	Sept. 1999
2nd	15.0 in.	Feb. 1983	6.86 in.	Aug. 1971
3rd	13.5 in.	Feb. 1979	6.08 in.	Oct. 1996
4th	12.0 in.	Jan. 1978	5.31 in.	June 1972
5th	12.0 in.	Feb. 1995	4.54 in.	July 1984
Source: ONJSC, 1968-2000				

River gage height and forecasts are available in real-time on the internet from USGS and NOAA(see **Internet Resources**).

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

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

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

Significant droughts in recent years included 1997-1999 and 2001-2002. A drought spanning September 1997 through September 1999 included a “snow drought” – one of the least snowy seasons on record. This drought was ended by Tropical Storm Floyd. Another year-long drought occurred between October 2001 and November 2002, when drought was ended by a series of nor’easters that resulted in a wetter than normal November. The drought of record for the region, however, is considered 1963-1965, when three consecutive years included 3 of the 4 driest years since record-keeping began in 1895 (NOAA, 2009).

Table 2.3: Lowest Annual Precipitation*

Rank	Year	Amount (inches)	Deviation from Mean
1st	1965	30.46	-19.33
2nd	1963	33.95	-15.84
3rd	1930	34.60	-15.19
4th	1964	34.65	-15.14
5th	1895	35.22	-14.57
*Average of 10 stations in northern NJ from 1895-2008; with a mean of 46.32 inches annually. ONJSC, 2009			

B. Air quality

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

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

After the passage of the Clean Air Act in 1970, the USEPA set National Ambient Air Quality Standards (NAAQS) for six pollutants, known as the *Criteria Pollutants*, (ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, particulate matter, and lead). These pollutants are addressed throughout the country through a planning process and the concentrations of these pollutants in air have been monitored for compliance with the air quality standards.

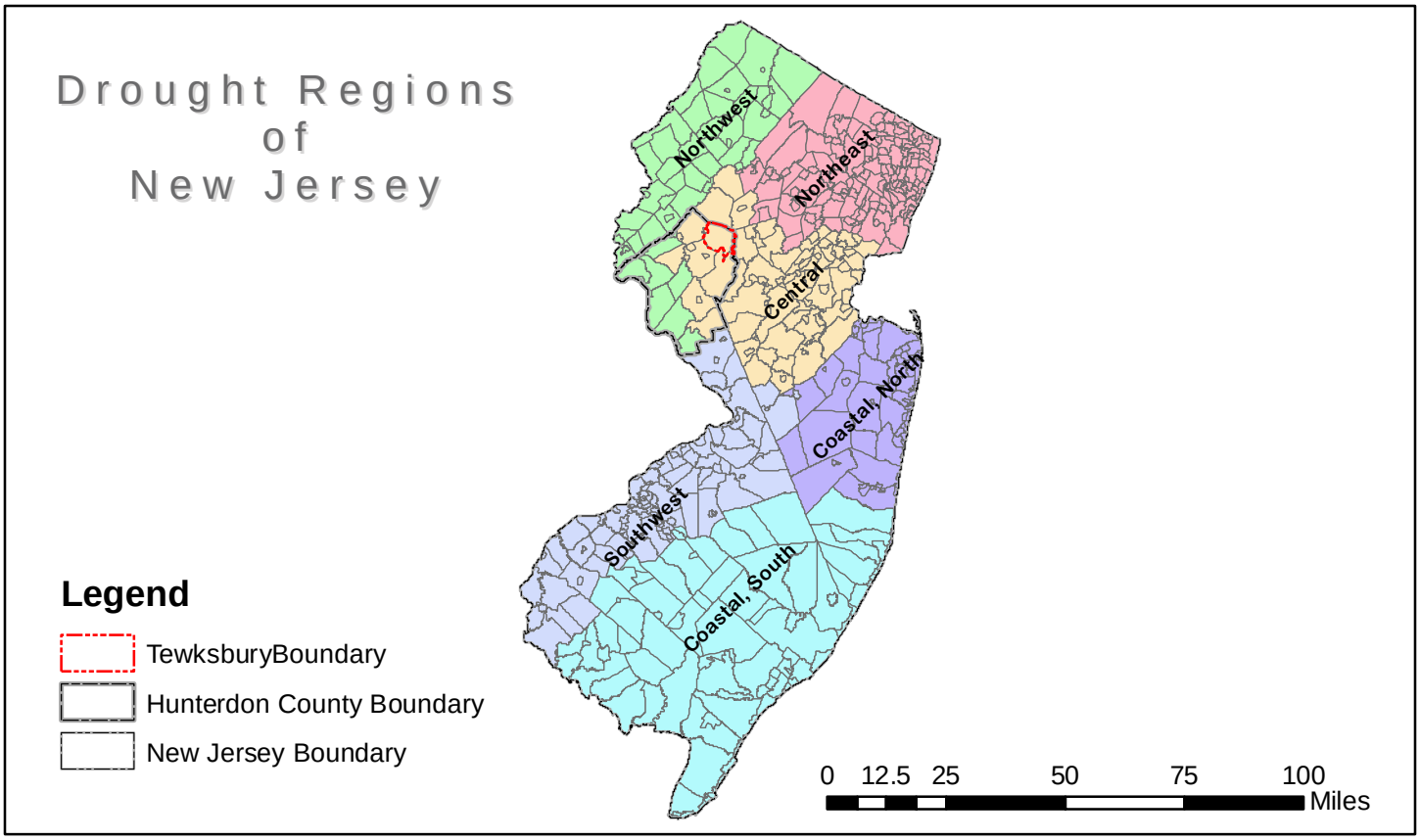
Since 1970, concentrations of these six pollutants have been significantly reduced in New Jersey. The state is now in compliance with all NAAQS, except for ozone. New Jersey Department of Environmental Protection (NJDEP) developed the Air Quality Index (AQI) to provide a descriptive rating and a color code (e.g. green=good) in real-time on the internet for many sites. The site closest to Tewksbury is located in Chester (Morris County), and is monitored for nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2) and meteorological conditions. Flemington is the closest site within the same air monitoring region, the Northern Delaware Valley Region, which includes Hunterdon, Sussex, and Warren Counties. Flemington is currently monitored for ozone (O_3), smoke shade (an indirect measure of particulate pollution) and meteorological conditions (see **Figure 2a**). The Phillipsburg station is also relevant to Tewksbury, and is manually monitored for particulates ($PM_{2.5}$).

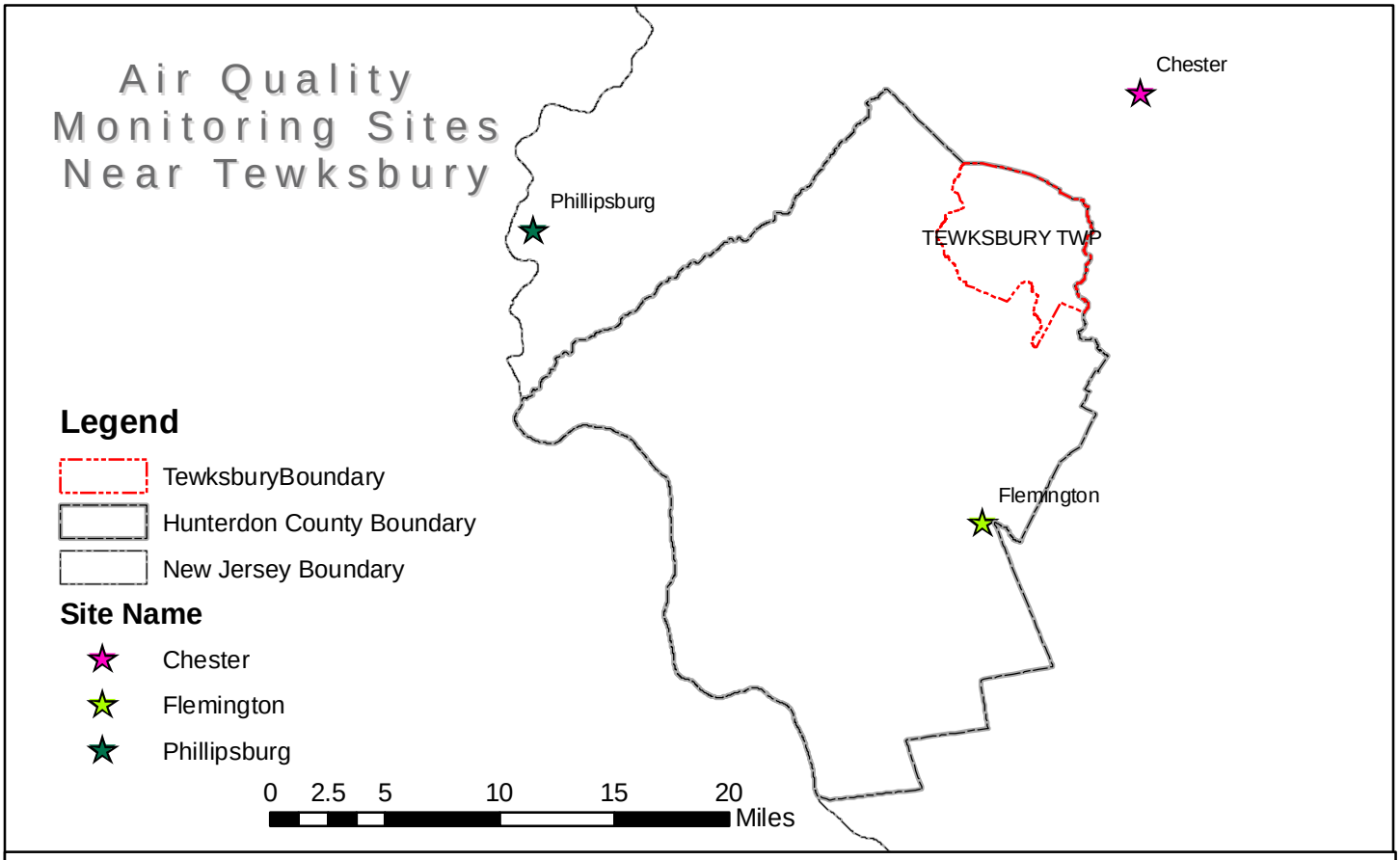
In Tewksbury, the Oldwick Materials, Inc. quarry, owned by Stavola Construction Materials Co., Inc., has had violations of air emissions permits (NJDEP, 2007).

The following summaries for ground-level ozone, particulates, air toxics and atmospheric deposition are summarized from either the 2004 Air Quality Report or the 2005 Air Quality Report (not all sections of the 2005 report are available at the time of this writing) published by the NJDEP Bureau of Air Monitoring (NJDEP Bureau of Air Monitoring web site).

Ground-level Ozone

Ground-level ozone causes serious adverse health and environmental effects. It forms in the air from volatile organic compounds (VOCs) and nitrogen oxides (NO_x) under conditions of high temperature and bright sunlight. Sources include vehicles, power plants and factories. The





Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
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Figure 2a: Drought Regions & Air Quality Monitoring Sites

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

hottest days of summer can yield unhealthy levels of ozone. Ozone is monitored at both the Chester and Flemington air quality stations.

Table 2.4 presents a summary of the number of days the ozone standards were exceeded per year at both the Chester and Flemington stations. The 1-hour ozone standard is an average of 0.12 parts per million (ppm), and the 8-hour ozone standard (that became effective in 1997) is an average of 0.08 parts per million (ppm). According to preliminary data for 2005, there were no exceedances of the 1-hour standard in 2005. However, the 8-hour ozone standard was exceeded 3 times in Chester and 13 times in Flemington. The Clean Air Act requires that all areas of the country be evaluated and then classified as attainment or non-attainment areas for each of the National Ambient Air Quality Standards. Based on the 3-year period from January 2001 through December 2003, the USEPA has designated all of New Jersey as non-attainment with respect to the 8-hour ozone standard (NJDEP Bureau of Air Monitoring, 2004 Air Quality Report).

Table 2.4: Ozone Exceedance Days

Year	Ozone Exceedances (days)			
	Chester		Flemington	
	1-hour averages	**8-hour averages**	**1-hour averages**	**8-hour averages**
1985	1	New ambient air quality standards for ozone became effective July 18, 1997	3	New ambient air quality standards for ozone became effective July 18, 1997
1986	6		4	
1987	4		4	
1988	18		14	
1989	2		3	
1990	3		6	
1991	5		1	
1992	1		0	
1993	0		0	
1994	0		0	
1995	2		1	
1996	1		0	
1997	0		0	
1998	0	22	0	21
1999	0	21	2	23
2000	0	6	0	9
2001	0	15	3	12
2002	2	27	1	19
2003	0	5	0	7
2004	0	0	0	6
2005	0	3	0	13

Source: NJDEP Bureau of Air Monitoring, Historical Ozone data

Particulates

Particulate air pollution consists of both solid particles and liquid droplets suspended in the atmosphere, usually less than 70 microns in diameter. In addition to human health and environmental effects, particulate matter is a major cause of reduced visibility. Particles larger than 10 microns are usually trapped by the human respiratory system before they reach the lungs, whereas coarse particles smaller than 10 microns (PM_{10}) are considered harmful, while fine particles less than 2.5 microns ($PM_{2.5}$) are even more detrimental to human health. Coarse particle sources include windblown dust and industrial sources, while fine particles come from combustion sources or are formed in the atmosphere from gasses.

The nearest monitoring sites for particulates are Phillipsburg (for $PM_{2.5}$), Trenton (for PM_{10}), and Flemington (where "smoke shade" is measured, an indirect measurement of particulates, and used for reporting in the Air Quality Index). In 2004 (the most recent data available), the results at the Trenton site did not exceed the PM_{10} 24-hour maximum standard of 150µg/M^3 [4] or the annual average standard of 50µg/M^3; values were 45µg/M^3 and 18.8µg/M^3 respectively. The annual average at Chester was 10.2µg/M^3, and at Phillipsburg it was 12.2µg/M^3; both below the standard of 15µg/M^3 annual average. PM_{10} 24-hour maximum values of 32.8µg/M^3 in Chester and 37.3µg/M^3 in Phillipsburg were also within the 24-hour maximum standard of 65µg/M^3. Although the particulates sometimes reach "moderate" and "unhealthy for sensitive individuals" levels, the New Jersey standard for Total Suspended Particulates and the

[4] µg/M^3 = micrograms per cubic meter of air (a microgram is one millionth (10^{-6}) of a gram).

NAAQS standards are being met for PM_{10} for annual mean and maximum 24-hour average. However, three years of data are needed to determine compliance with the NAAQS standard for $PM_{2.5}$ (NJDEP Bureau of Air Monitoring, 2004 Air Quality Report).

Air Toxics

In addition to ozone and $PM_{2.5}$, there is increasing concern about a group of air pollutants termed *air toxics*. These pollutants include substances known to cause serious health problems, such as damage to the immune system, neurological, reproductive, developmental and respiratory problems and cancer. Toxic pollutants may also be deposited on soil and water, taken up by plants and consumed by animals.

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

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

The USEPA prepared a comprehensive inventory of air toxics emissions for the entire country as part of the National-Scale Air Toxics Assessment (NATA) in 1996. The study determined that on-road mobile sources are responsible for 35% of the toxic emissions, off-road mobile sources (airplanes, trains, construction equipment, lawnmowers, boats, dirt bikes, etc.) account for 33%; area sources contribute 25% (residential, commercial, and small industrial sources), and major point sources account for the remaining 7%.

The NATA study also estimated levels of pollutants geographically. Although Hunterdon is estimated to have lower levels of air toxics than the more populated and industrial areas of the state, it falls within an area expected to have concentrations of benzene at 5-10 times the health benchmark. NJDEP has determined that 19 of the chemicals were predicted to exceed their health benchmarks in one or more counties in 1996. Pollutants of statewide concern include benzene, 1,3-butadiene, carbon tetrachloride, chloroform, diesel particulate matter, ethylene dibromide, ethylene dichloride and formaldehyde. Pollutants of concern in parts of the state include acrolein, polycylic organic matter, chromium compounds, acetaldehyde, perchloroethylene, 7-PAH, arsenic compounds, cadmium compounds, nickel compounds, beryllium compounds and hydrazine.

The NJDEP has established four comprehensive air toxics monitoring sites. They are located in Camden, Elizabeth, New Brunswick and Chester. The Chester site, which is closest to Tewksbury Township, has been measuring air toxics since 2001. Pollutant concentrations are trending downward, but many of them still exceed the NJDEP health benchmarks. At Chester, these include acetaldehyde, acrylonitrile, benzene, carbon tetracholoride, chloromethane, and formaldehyde (NJDEP Bureau of Air Monitoring, 2004 Air Quality Report).

In 2003, NJDEP adopted revisions to the Emissions Statements rule (NJAC 7:27-21), which require additional facility-wide information on 36 toxic air pollutants.

Atmospheric Deposition

Pollution that is deposited on land or water from the air is called *atmospheric deposition.* Wet deposition is washed from the air by precipitation, while dry deposition refers to particulates that settle out of the atmosphere during dry weather. Sources include motor vehicles, power plants, and incinerators. The major pollutants of concern are sulfur dioxide (SO_2), nitrogen

oxides (NO_x), mercury (Hg), and volatile organic compounds (VOCs). In addition, the presence of these pollutants changes the pH of the precipitation which can harm plants and aquatic life (trout are particularly sensitive) and deplete nutrients from soils. Of the 2 sites where atmospheric deposition was monitored in 2005 in New Jersey, the one in Washington Crossing is closest to Tewksbury. This site is also part of the National Atmospheric Deposition Program. Results for 2005 show a mean pH value of 4.47 (normal rainfall has a pH of about 5.6). This is very acidic, but is a slight improvement from the 1980's and early 1990's, when pH averaged around 4.3 (NJDEP Bureau of Air Monitoring, 2005 Air Quality Report and Steering Committee of the New Jersey Comparative Risk Project. March 2003).

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

Radon

Radon is a radioactive gas that is naturally occurring in New Jersey rocks, soil and ground water. Radon gas can become concentrated indoors, where it can increase risks of lung cancer. Because there is no known safe level of exposure to radon, the US EPA strongly recommends taking measures to reduce indoor radon if your radon test shows 4 pCi/L (picocuries per liter of air) or more, and to consider remediation if your test shows between 2 and 4 pCi/L. New Jersey requires new construction to be tested for radon (NJDEP Radon Program, 2009).

Tewksbury Township is rated Tier 1, which means it has High Radon Potential (NJDEP Radon Program, 2009). The average radon level in Hunterdon County is 6 pCi/L (Hunterdon County Department of Health, 2000). In a 1994 study[5], among 26 homes in Tewksbury tested for radon, 73% had radon levels between 4 and 19 pCi/L (Rahman et al., 1994).

C. Existing Infrastructure

Public Water and Sewer Areas

Public Community Water Supply (PCWS) Wells are wells that supply potable water to public communities, and serve at least 15 connections used by year-round residents or which serve at least 25 year-round residents. Public water purveyors may be government agencies, private companies, or quasi-government groups. A *Well Head Protection Area* (WHPA) in New Jersey is a map area calculated around each PCWS well in New Jersey that delineates the horizontal extent of ground water captured by a well pumping at a specific rate over a two-, five- and twelve-year period of time for unconfined[6] wells (Tier 1, Tier 2 and Tier 3, respectively). WHPA delineations are conducted in response to the Safe Drinking Water Act Amendments of 1986 and 1996 as part of the Source Water Area Protection Program (SWAP). The delineations are the first step in defining the sources of water to a public supply well. Within these areas, potential contamination will be assessed and appropriate monitoring will be undertaken as subsequent phases of the NJDEP SWAP.

[5] It should be noted that the objective was to study clusters of homes with high radon, and the results may or may not be representative of radon levels in the entire township.

[6] An unconfined aquifer is where groundwater is not under pressure; therefore the water level in a well is the same as the water table outside the well. An unconfined aquifer's direct connection to the earth's surface makes it easily recharged, but also easily contaminated. A confined aquifer is where groundwater is located within impermeable layers; therefore the water is at pressure.

There are 4 PCWS wells in Tewksbury Township (see **Figure 2b**) and parts of two additional Well Head Protection Areas for public wells that are located within Califon and Clinton. Areas served by these wells are shown as "Water Purveyor Areas" on **Figure 2b**. According to the description of the GIS data layer, the boundaries mapped are those of the actual water delivery or service area, but do not include areas with legal rights for future service.

The public Sewer Service Areas (SSA) mapped on **Figure 2b** show the planned method of wastewater disposal for specific areas. Areas not designated as SSAs are planned for service by individual subsurface disposal system discharging less than 2,000 gallons per day (gpd). This mapping is used by NJDEP, together with the Water Quality Management Plan (WQMP), to make consistency determinations under the Water Quality Management Planning rules found in N.J.A.C. 7:15.

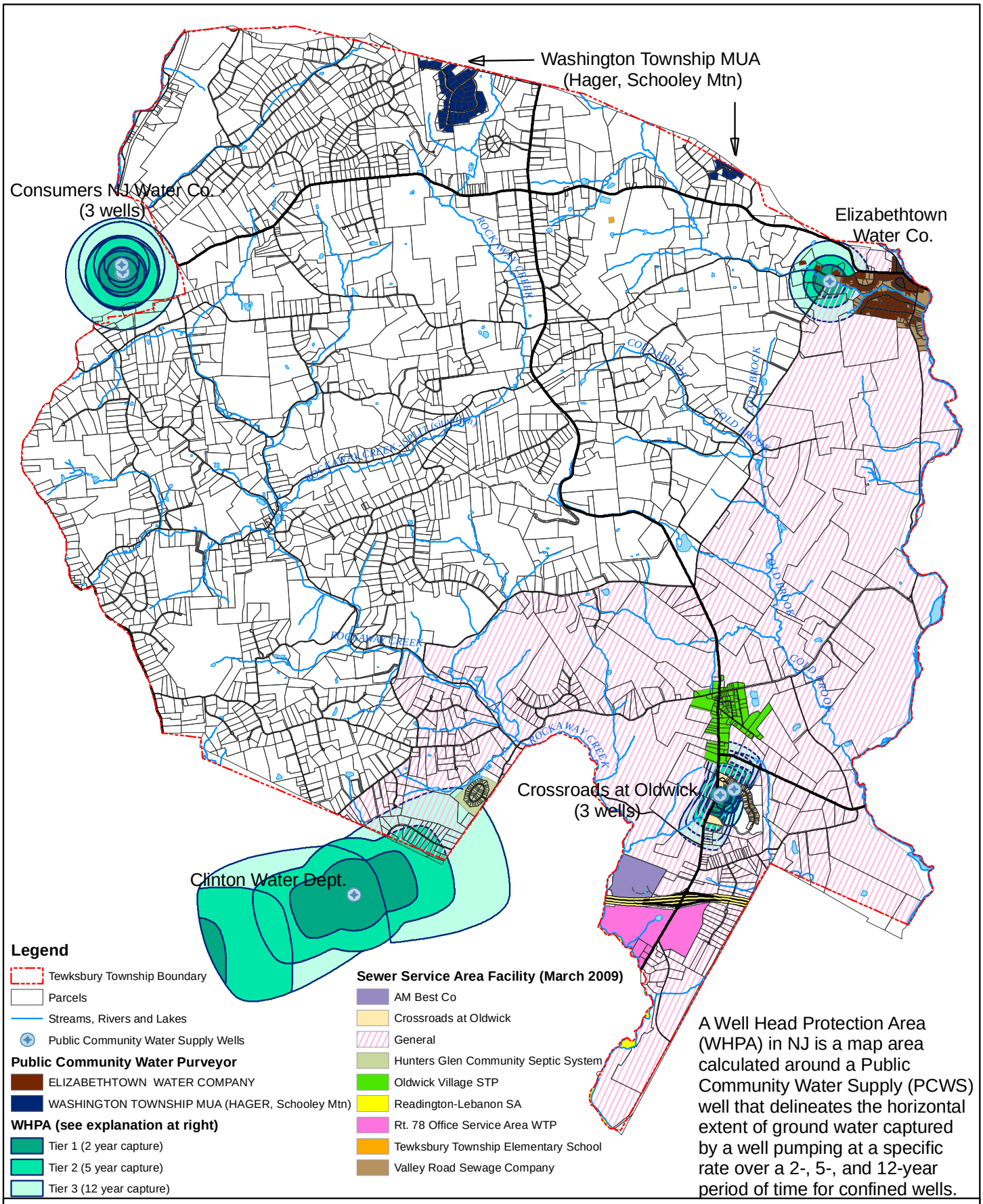
In 2000, a Tewksbury Township intern began gathering information about well and septic system locations. Sources included Hunterdon County records and archived township building records. The township requires "as-built" plans any time a building permit is applied for, and from this the location of the well, septic system and septic drainage area was plotted. For some wells, additional information such as depth, capacity and static head was also collected and placed in the Excel spreadsheet. This data may represent approximately 20-25% of the number of actual wells, septic systems, and septic drainage fields in existence in the township. In addition, the parcel map used to locate the features was sometimes off by tens of feet and the building records kept by the township do not contain field verified information. Despite these limitations, these maps (**Figures 2c and 2d**) can provide a rough template for future testing and analysis (Goodchild, 2008).

Scenic Roads

The Scenic Roads Commission is charged with monitoring the preservation of 33 Township designated scenic roads. Scenic roads are shown on **Figure 2e**.

Table 2.5: Designated Scenic Roads (alphabetical list)

Beavers Road (upper portion)	Flint Hill Road	Philhower Road
Bissell Road	Fox Hill Road	Potterstown Road (portion of)
Black River Road	Frog Hollow Road	Ridge Road
Boulder Hill Road	Guinea Hollow Road	Rockaway Road
Burrell Road	Hill and Dale Road	Saw Mill Road
Church Street	Hollow Brook Road	Still Hollow Road
Cold Brook Road	Homestead Road	Sutton Road (portion of)
Cold Spring Road	McCan Mill Road	Vliettown Road
Deer Hill Road	Meadow Lane	Water Street
Farmersville Road	Mountain Road	Welsh Road
Felmley Road (portion of)	Palatine Road	Wildwood Road



Data Sources: See Appendix B.
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Figure 2b: Public Water and Sewer Infrastructure

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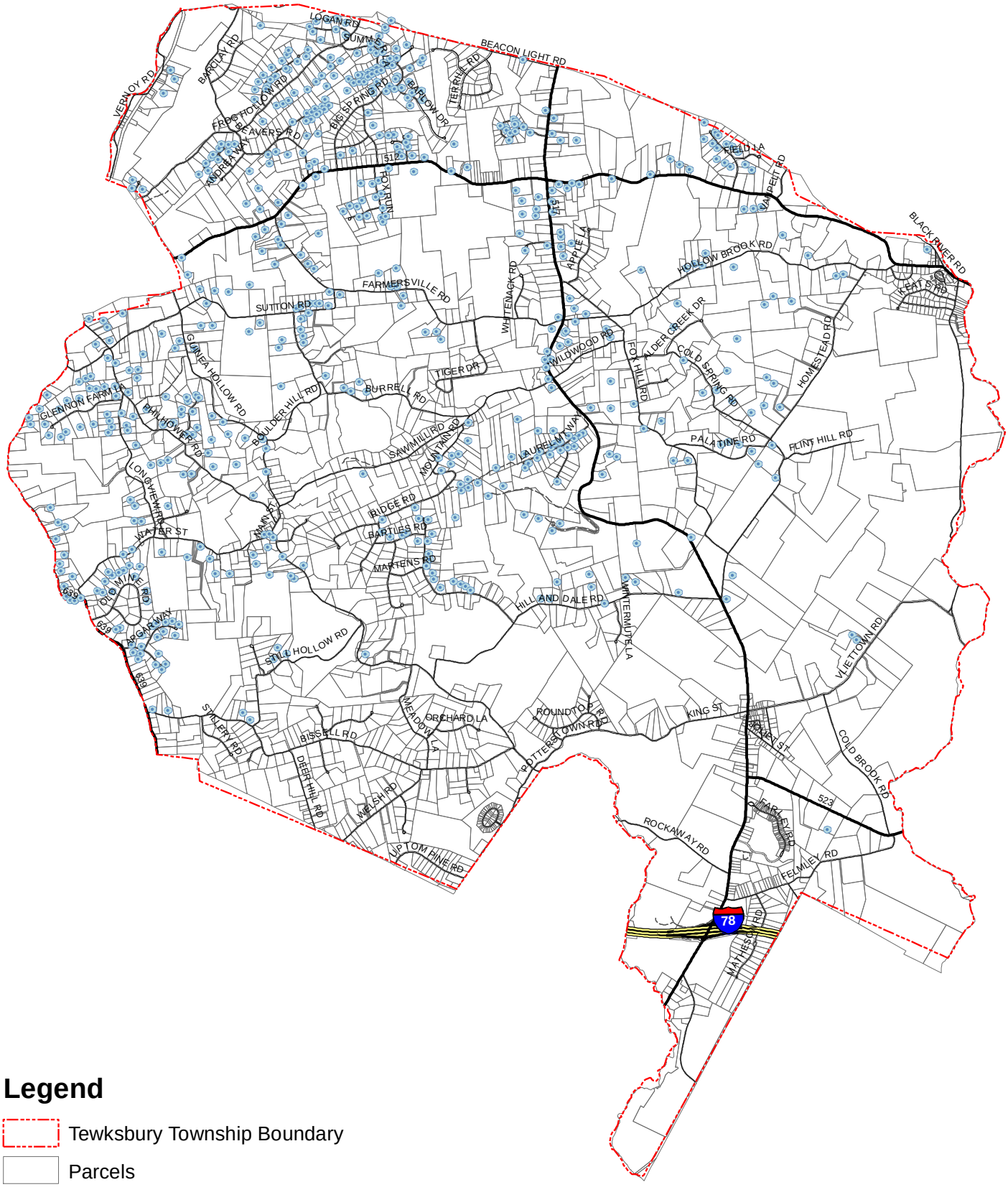


Legend

- Tewksbury Township Boundary
- Parcels
- mapped private wells (partial list)

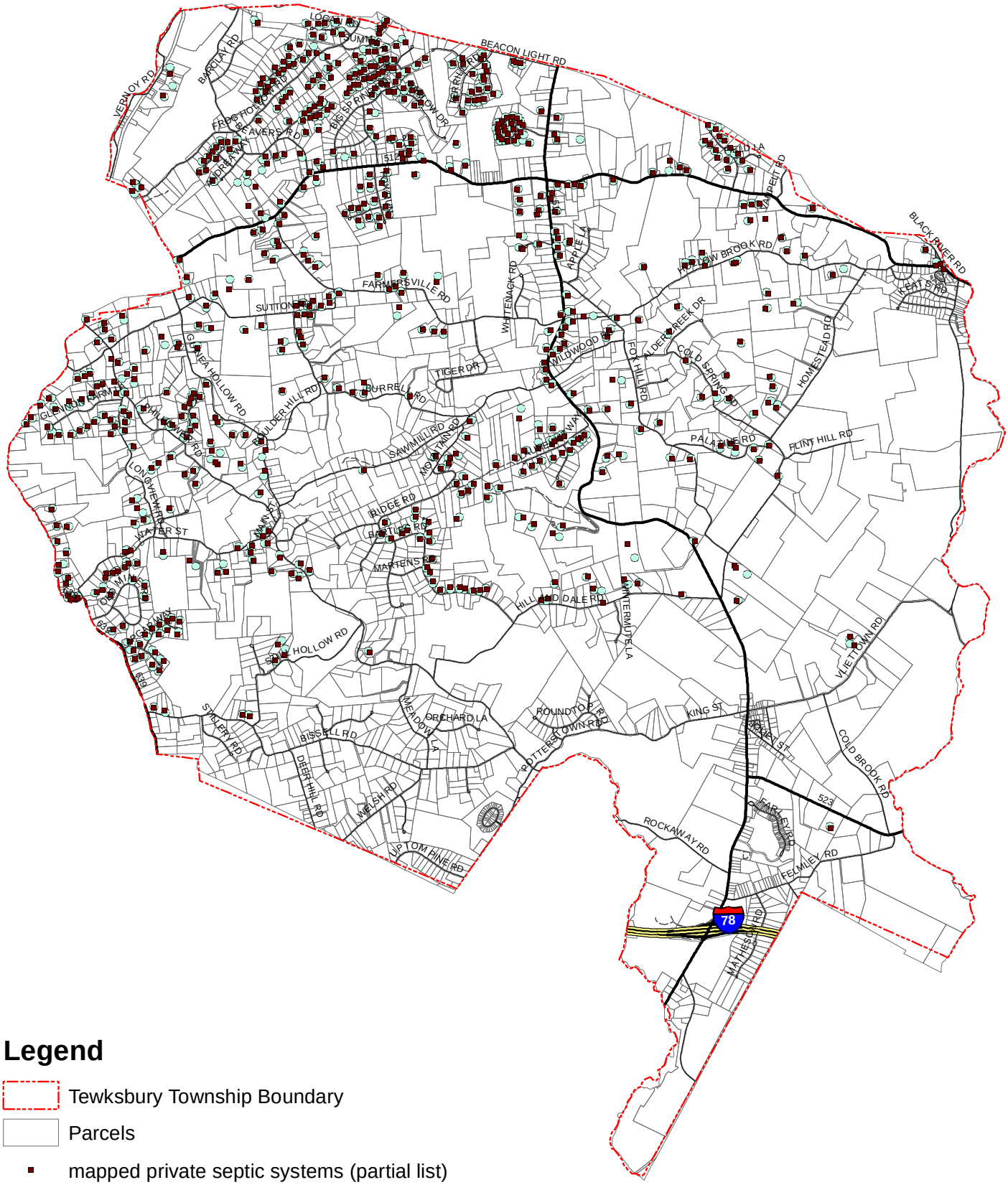
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 2c: Mapped Private Wells (partial list)

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

- Tewksbury Township Boundary
- Parcels
- mapped private septic systems (partial list)
- mapped private septic drainage field (partial list)

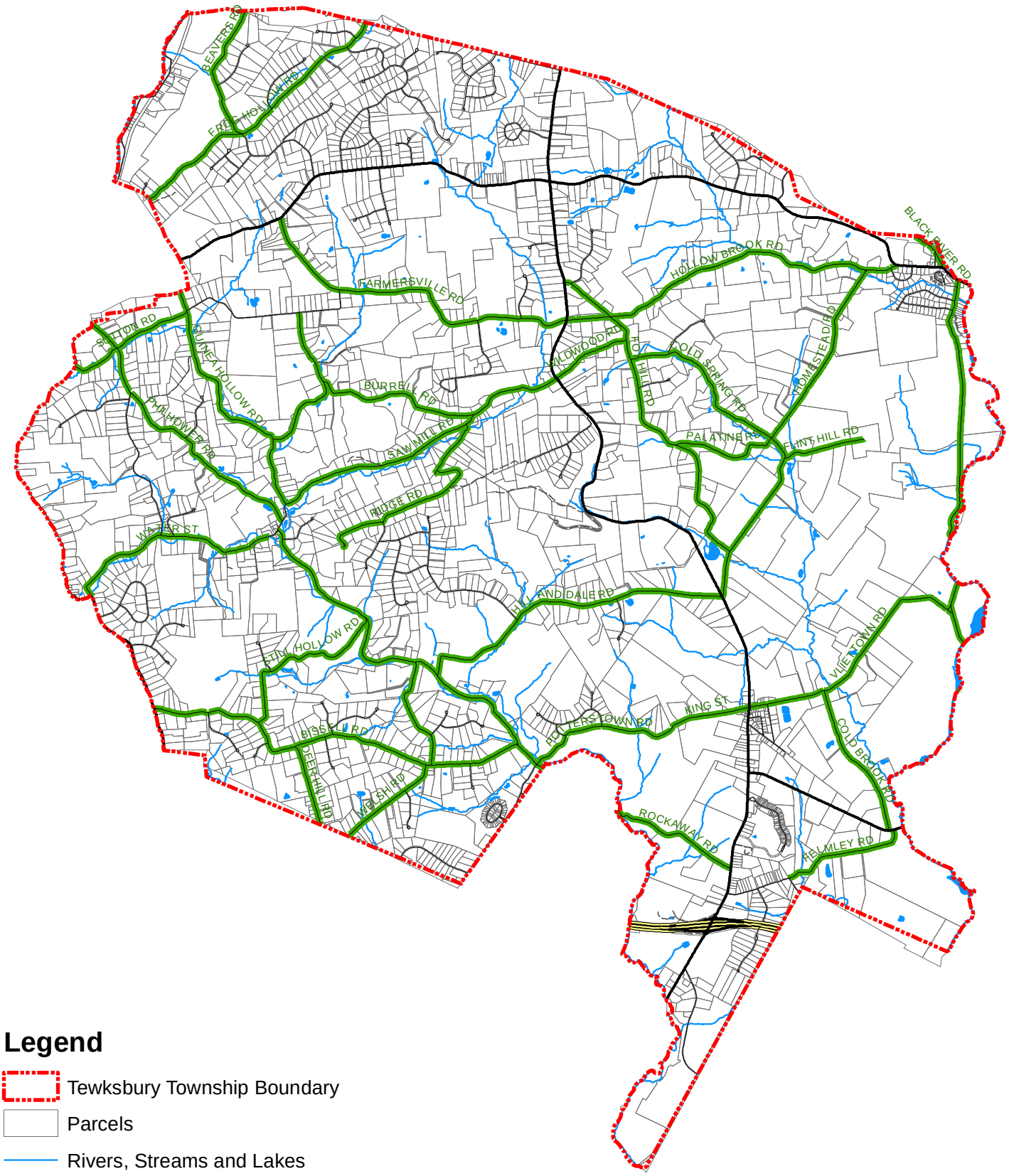
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 2d: Mapped Private Septic Systems (partial list)

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

- Tewksbury Township Boundary
- Parcels
- Rivers, Streams and Lakes
- Scenic Roads

Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
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N

0 0.25 0.5 1 1.5 Miles

Figure 2e: Scenic Roads

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

D. Noise and Light Pollution

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

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

Tewksbury Township is impacted by a number of sources of light pollution. First, the general glow from the New York metropolitan area is visible in the night sky. Local sources include light from the Plukemin Hills housing development, increasing business and residential development along the Route 22 corridor in Readington, and night glow from development in the Clinton area. Transient traffic along both routes 22 and 78 provide a minimal source of light pollution. Additional sources include street lamps along exits on Route 78, exterior lights around our schools and municipal buildings, and unshielded outdoor lights on residences in Tewksbury.

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

Federal highway noise criteria (which apply only to federal highways) range from 57 to 72 decibels (depending on adjacent land use) (USDOT, FHA, 2006). New Jersey's Noise Control Act of 1971 authorized the NJDEP to develop regulations relating to the control and abatement of noise. While these regulations do not specify noise criteria, a sample municipal ordinance is provided with sound level standards of 50 decibels during nighttime (10:00 p.m. to 7:00 a.m.) and 65 decibels during daytime (NJDEP, 2008).

Tewksbury is subjected to noise pollution, such as from cars and trucks on Route 78 (Hunterdon County Planning, 2008) and noise from quarry operations at Oldwick Materials, Inc.

E. Physiography

New Jersey can be divided into four regions, known as *physiographic provinces*, which are areas with similar sequences of rock types, geologic structures and a common geologic history (see **Figure 2f**). The northwestern section of New Jersey is part of the *Valley and Ridge Province*, which is characterized by long, parallel ridges and valleys formed by folded and faulted limestones, shales and sandstones of early and middle Paleozoic age. Erosion-resistant sandstone and siltstone bedrock lie beneath the ridges of the Appalachian Mountains, while shale and limestone underlie the valleys.

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

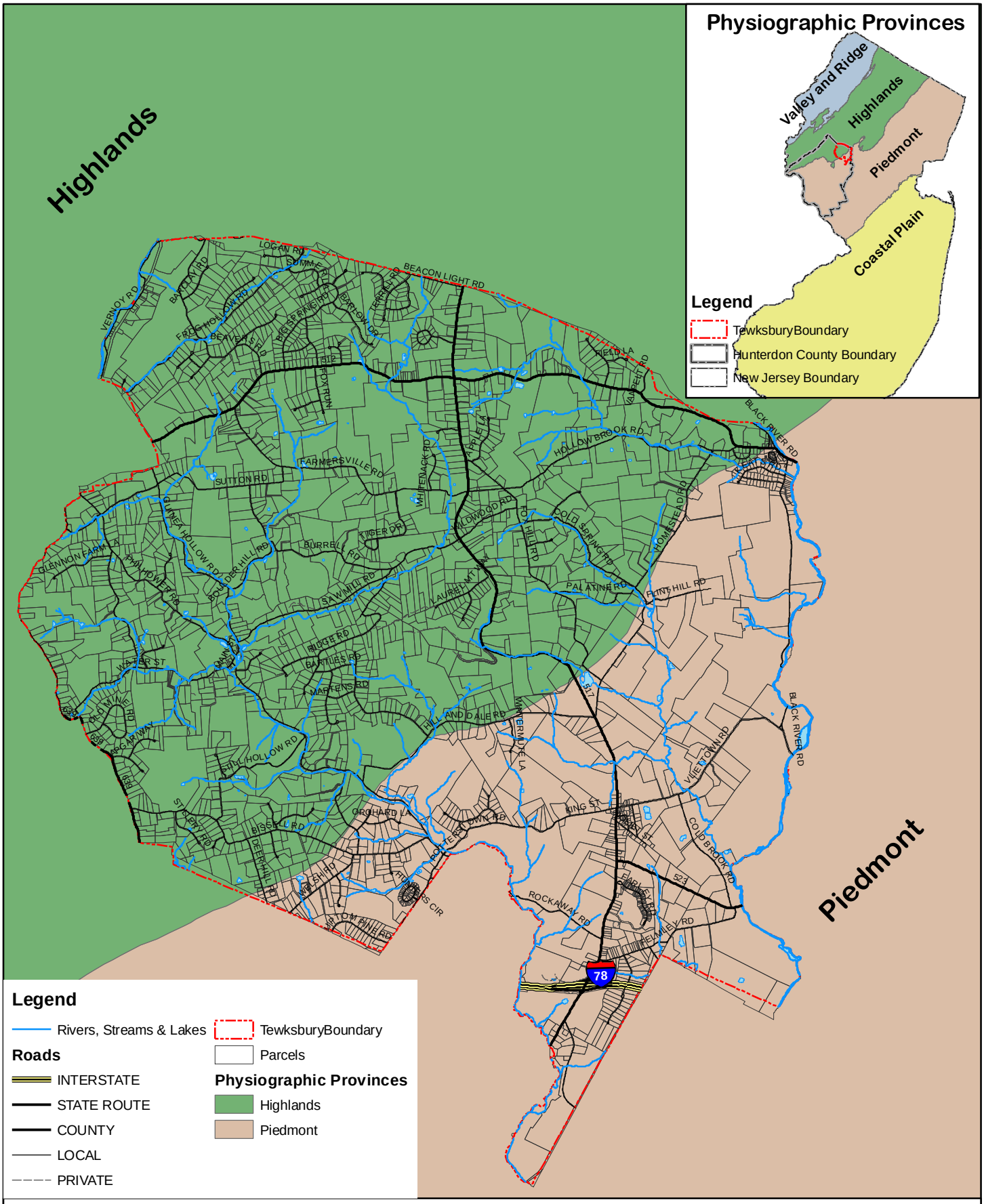
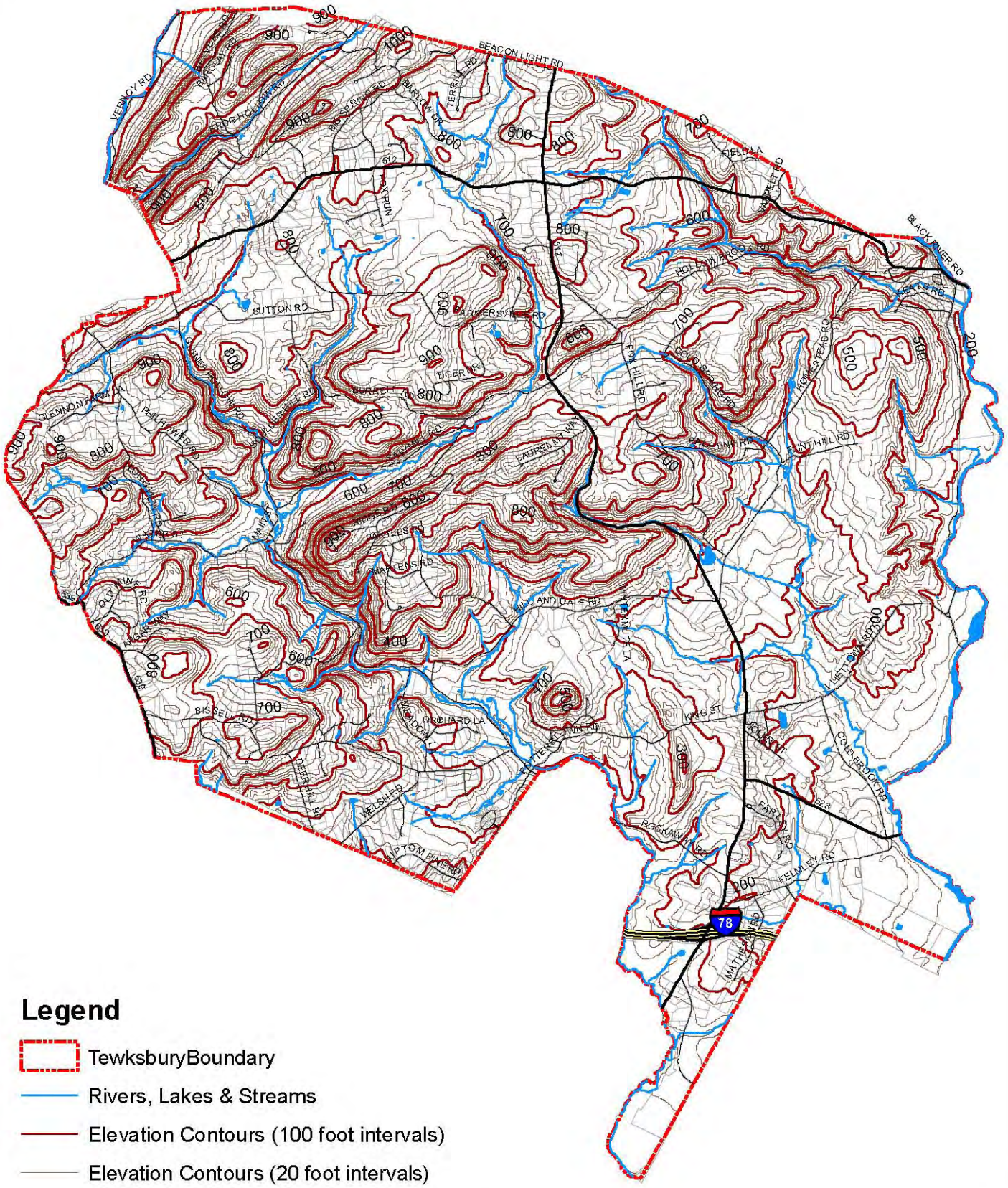


Figure 2f: Physiographic Provinces

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

- TewksburyBoundary
- Rivers, Lakes & Streams
- Elevation Contours (100 foot intervals)
- Elevation Contours (20 foot intervals)

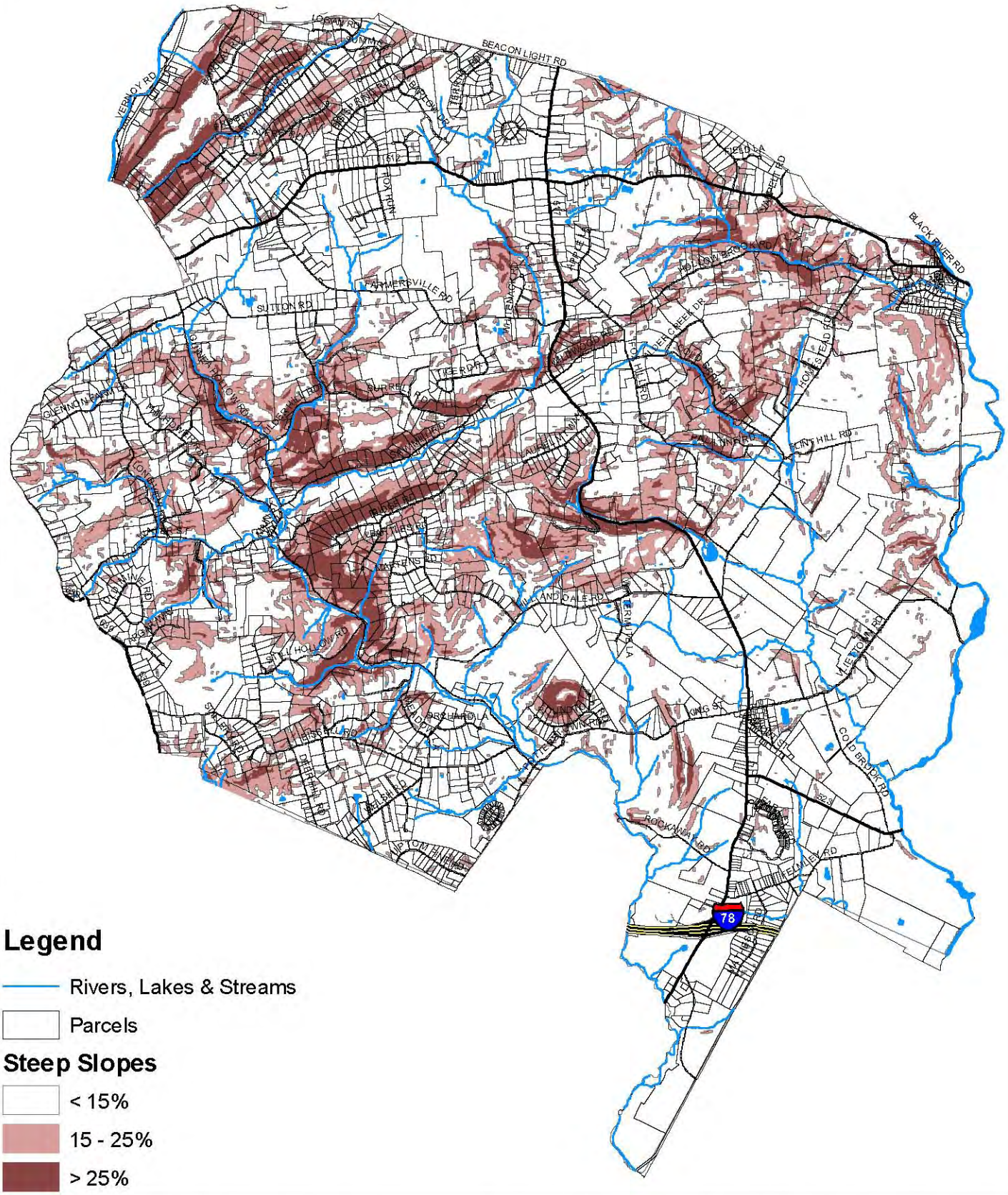
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 2g: Elevation Contours

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

Rivers, Lakes & Streams

Parcels

Steep Slopes

< 15%

15 - 25%

> 25%

Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
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N

0 0.25 0.5 1 1.5 Miles

Figure 2h: Steep Slopes

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

The Highlands Province is separated from the *Piedmont Province* by a series of major faults that cross Tewksbury Township, running diagonally from the southwest to the northeast (see **Figure 2f** and **3a**). The Piedmont Province is characterized by gently rolling hills. The rocks of the Piedmont are of Late Triassic and Early Jurassic age. As sediments eroded from adjacent uplands, and were deposited along rivers and lakes within the basin, they became compacted and cemented to form conglomerate, sandstone, siltstone and shale. *Diabase* is a rock formed by the cooling of magma at some depth in the crust (i.e. the magma did not erupt at the surface), while basalt formed when the magma was extruded onto the surface. Both basalt and diabase are more resistant to erosion than the surrounding sandstone and shale; therefore they form the ridges and uplands. Overlapping the Piedmont Province to the southeast lies the relatively flat terrain of the *Coastal Plain Province*, which consists of unconsolidated sedimentary formations, such as sands, clays, and marls.

F. Topography

Topography depicts the relief features of an area. The elevation in the township ranges from about 120 feet above mean sea level (adjacent to the Lamington River) to over 1,020 feet (at the end of Lenore Road)(see **Figure 2g**). The Highlands portion of Tewksbury tends to have greater elevation and greater elevation differences (therefore more steep slopes). The fault line which separates the Highlands from the Piedmont resulted in a steep escarpment, which runs through Tewksbury. When traveling from south to north, Route 517 and Cokesbury Road both ascend this escarpment (Hintz, 2003).

In **Figure 2g**, each line represents 20 feet of elevation, and is drawn to follow the contour of the land. The closer the contour lines are spaced to each other, the steeper the topography is. Slopes greater than 15% are generally considered "steep slopes" (see **Figure 2h)**. Steep slopes are poor locations for septic systems, and present difficulties for driveway construction and for usable areas around a house. In addition, steeper slopes are more vulnerable to erosion. As the gradient or percent of slope increases, the velocity of runoff water increases, which increases its erosive power. A doubling of velocity of runoff water increases the erosive power fourfold and causes 32 times the amount of material of a given particle size that can be carried (Foth, 1978).

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

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National Oceanic & Atmospheric Administration (NOAA)
2008, NOAA web site: http://www.ncdc.noaa.gov/oa/ncdc.html
2009, Extreme Weather: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~storms

2005, Frost/Freeze Occurrence: http://www5.ncdc.noaa.gov/climatenormals/clim20supp1/states/NJ.pdf

Office of the New Jersey State Climatologist (ONJSC)
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May 2009, Monthly Data: http://climate.rutgers.edu/stateclim_v1/monthlydata/index.html
1968-2000, Normals & Extremes. http://climate.rutgers.edu/stateclim/?section=njcp&target=NJCnormex
2009, Precipitation 1895-2009: http://climate.rutgers.edu/stateclim_v1/data/north_njhistprecip.html

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NJDEP Bureau of Air Monitoring
2004 Air Quality Report: http://www.state.nj.us/dep/airmon/04rpt.htm
2005 Air Quality Report: http://www.state.nj.us/dep/airmon/05rpt.htm
Air Monitoring web site: http://www.state.nj.us/dep/airmon/
Historical Ozone data: http://www.state.nj.us/dep/airmon/histdata.htm

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http://www.wcnctf.org/docs/Volume_II_Final_Report.pdf

Physiography & Topography

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

Internet Resources: Local & Regional Conditions

Climate and Meteorology

Office of the New Jersey State Climatologist (ONJSC)

ONJSC Home Page: http://climate.rutgers.edu/stateclim/
NJ Drought Watch: http://www.njdrought.org/
Drought Status of Central Region: http://www.njdrought.org/status.html#central
Weather and Climate Network: http://climate.rutgers.edu/njwxnet

National Weather Service Advanced (NOAA) Hydrologic Prediction Service (flood predictions):
http://newweb.erh.noaa.gov/ahps2/index.php?wfo=phi&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6

National Weather Service Forecast Pottersville, NJ
http://forecast.weather.gov/MapClick.php?site=phi&FcstType=text&site=PHI&map.x=205&map.y=68

United States Environmental Protection Agency Climate Change: http://epa.gov/climatechange/index.html

USGS Real-Time Flow Stations:

USGS 01397000 South Branch Raritan River at Stanton NJ
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01397000&PARAmeter_cd=00065,00060

USGS 01396500 South Branch Raritan River near High Bridge NJ
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01396500&PARAmeter_cd=00065,00060

USGS 01399670 South Branch Rockaway Creek at Whitehouse Station NJ
http://waterdata.usgs.gov/nwis/uv?01399670

USGS 01399500 Lamington (Black) River near Pottersville NJ
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01399500&PARAmeter_cd=00065,00060

Air Quality

Current Air Quality:

Air Now - Northern NJ: http://www.airnow.gov/index.cfm?action=airnow.showlocal&CityID=160
Chester: http://www.state.nj.us/dep/airmon/che.htm
Flemington: http://www.state.nj.us/dep/airmon/fle.htm

NJDEP Bureau of Air Monitoring

Home Page: http://www.state.nj.us/dep/airmon/
Reports: http://www.state.nj.us/dep/airmon/reports.htm
Air Toxics in New Jersey: http://www.state.nj.us/dep/airmon/airtoxics/overview.htm
What you can do to reduce air toxics? http://www.state.nj.us/dep/airmon/airtoxics/youcan.htm

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

NJDEP Radon Section: http://www.nj.gov/dep/rpp/radon/index.htm

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

Existing Infrastructure

NJ Astronomical Society - Light Pollution: http://www.njaa.org/light.html

Simple Scale for Evaluating sky darkness: http://darkskyinitiative.org/links/how_dark_my_sky.html

Physiography & Topography

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

3: GEOLOGY

A. Geologic history

The geologic history of New Jersey is summarized in **Table 3.1**.

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

In the Mesozoic Era (the time when dinosaurs lived), New Jersey was part of the super-continent Pangaea. Flashfloods eroded the mountains, dropping mud and silt in extensive floodplain deposits, gradually filling the valleys. This is known as the "Newark episode," which lasted between about 15 and 23 million years. The rate of deposition averaged between 215 and 325 millimeters per 1,000 years, keeping pace with the rate of basin sinking. Shallow lakes formed at the bottom of the desert basin (known as playa lakes). The sediments became rock under the pressure of each successive layer of mud, silt or sand. Dinosaurs walked on these mudflats, leaving footprints that occasionally became fossilized. Fossils of coelacanths and other fish have also been found in these rock formations (Gallagher, 1997).

Roughly 200 million years ago, the supercontinent broke apart, and the Atlantic Ocean was born. This was accompanied by volcanic activity, which resulted in magma flowing at or near the surface. These exist today as the erosion resistant basalt and diabase outcrops found in the Watchung Mountains, the Palisades, and the Sourland Mountains. When the diabase intruded, the surrounding sedimentary rocks were hardened by heat and pressure, and are known as hornfels rocks, or traprock, which is quarried commercially.

Within the past two million years, the climate alternated between cold and warm. During periods of glaciation, the glaciers came as far south as Belvidere, NJ, and the area below that became a cold tundra. Receding glaciers deposited till. At times, the shoreline of the Atlantic Ocean may have been near Tewksbury Township, while at other times, it may have receded a hundred miles from the present shore.

Table 3.1: Summary of New Jersey's Geologic History

Period	Million Years Ago	Description of Climate and Fossils Found in Corresponding Bedrock
Precambrian Era		
	Up to 544	**Climate:** New Jersey was under the sea. **Fossils:** stromatolites; most life forms were soft bodied and left no fossils
Paleozoic Era		
Cambrian Period	544 – 505	**Climate:** New Jersey was close to the equator, covered by warm tropical seas. **Fossils:** trilobites, brachiopods, stromatolites, worm burrows
Ordivician Period	505 – 440	**Climate:** New Jersey continued to be underwater, as the sea above deepened to oceanic depths. **Fossils:** trilobites, brachiopods, coral, nautiloids, clams, crinoids, and snails
Silurian Period	440 – 410	**Climate:** The sea level rose and fell, with New Jersey remaining at the sea floor. **Fossils:** coral, brachiopods, clams, brine shrimp, primitive fish, eurypterids (sea scorpions), arthrophycus (fossilized feeding burrow made by a worm-like animal)
Devonian Period	410 – 360	**Climate:** Europe collided with North America, forming the mountains which are now the Ridge and Valley and Highlands provinces of New Jersey. The fossils found continued to be aquatic life forms. **Fossils:** brachiopods, clams, trilobites, nautiloids, crinoids, coral, snails, stromatoporoids, ostracodes, bryozoa

Table 3.1: Summary of New Jersey's Geologic History

Period	Million Years Ago	Description of Climate and Fossils Found in Corresponding Bedrock
Mississippian, Pennsylvanian & Permian Periods	360-248	**Climate:** No geologic record of these time periods is present in New Jersey. At some point, the sea subsided, and New Jersey became dry land, at least in part. **Fossils:** none
Mesozoic Era		
Triassic Period	248 – 200	**Climate:** New Jersey was next to Morocco, part of the supercontinent Pangaea. In the dry interior of the continent, the area experienced greater daily and seasonal fluctuations than the coasts. The rugged landscape consisted of high young mountains and deep valleys formed by faults. The brief rainy seasons' flashfloods dropped mud and silt in low areas, where playa lakes formed. In the end of the Triassic the climate became desert-like. The lakes began to dry up and became salty, resulting in an environment where brine shrimp flourished. When a lake went dry, some fish and other aquatic life became fossils. **Fossils:** dinosaur footprints, thecodonts, fish (including coelacanths), phytosaurs, amphibians, insects, plants
Jurassic Period	200 – 145	**Climate:** The breakup of Pangaea resulted in the beginning of the Atlantic Ocean. Igneous intrusions (molten rock forced into earlier rock formations) formed diabase and basalt bedrock. Because the terrain was mountainous, the net geologic action was erosion, not deposition. **Fossils:** There are no late Jurassic deposits in New Jersey; therefore no fossils exist from this period. However, the fauna probably consisted of the same dinosaurs as the American West, including sauropods, armored dinosaurs, ornithopods (forerunner of hadrosaurus), tenontosaurus (relative of the iguanadon). True flowering plants (angiosperms) appeared at this time.
Cretaceous Period	145 – 65	**Climate:** Northern New Jersey was above sea level, while southern New Jersey experienced flooding and ebbing. The sea level changed cyclically from deeper to shallower water in this tropical environment. During flooding, greensand marl (glauconite) was formed. During ebbing, clay and sand were deposited. **Fossils:** Fossil phytoplankton, clams, snails, crustaceans, ammonites, oysters, reptiles, sharks, burrows, worm tubes and vertebrates such as mosasaurs have been found in New Jersey's coastal plain. The fossil dinosaurs found include hadrosaurus (which probably washed downstream during a flood), ornithomimus, *Dryptosaurus aquilunguis* (a 17' predator with a great hand claw), *Hadrosaurus foulkii*, and *Hadrosaurus minor*.
Cenozoic Era		
Tertiary Period	65 – 1.8	**Climate:** The climate was warm, and the sea level was higher, covering the Outer Coastal Plan. **Fossils:** Fossils of land animals include birds, such as the diatryma (a giant flightless bird), tillodont (an extinct mammal the size of a bear, but with rodent-like teeth) and possibly others similar to those found in the South Dakota badlands, such as brontotherium, ancestral horses, entelodonts (resembled giant warthogs), diceratherium (semi-aquatic rhinoceros), peccary, prosynthetoceras (a camal), anchitherium (horse), and a primitive doglike carnivore. Fossils found in the Outer Coastal Plain include brachiopods, corals, sponges, clams, sharks, mollusks, crinoids, mammals (probably washed to the sea in floods), crocodiles, snakes, and early whales.
Quaternary Period	1.8 - present	**Climate:** The climate alternated between cold and warm, resulting in four intervals of glaciation. The glaciers covered northern New Jersey, reaching as far south as Belvidere on the Delaware River. South of the glacial ice, treeless, frozen tundra existed. When water was frozen in glaciers, the sea level was lower, resulting in a shoreline over a hundred miles east of the present coast. **Fossils:** Fossils of many familiar and some extinct animals have been found in nearby areas. There were insects, turtles, and snakes. Herbivores included squirrels, groundhogs, porcupines, beaver, muskrats, voles, mice, eastern cottontail rabbits, white-tailed deer, peccaries, tapirs, giant ground sloth, the elk-moose, giant beaver, American mastodon, and mammoth. Carnivores

Table 3.1: Summary of New Jersey's Geologic History

Period	Million Years Ago	Description of Climate and Fossils Found in Corresponding Bedrock
		included otters, skunks, bobcats, foxes, black bears, coyotes, jaguars, jaguarundi, short-faced bear and a saber-toothed cat.
Sources: Gallagher, 1997; University of California Museum of Paleontology et al., 2003; USGS, 2002		

B. Bedrock Geology of Tewksbury Township

Bedrock is the solid rock beneath the soil and surficial rock. The geology of Tewksbury Township is complex, containing 21 different types of bedrock (see **Table 3.2** and **Figure 3a**). The effects of the rifting that occurred in the Triassic-Jurassic periods are evident in the faults that cross Tewksbury from the northeast to the southwest. One of these border faults crosses Tewksbury from Pottersville to Bissell. North of this fault, the township lies within the Highlands Physiographic Province and is dominated by Precambrian rocks. The Piedmont Physiographic Province lies south of this fault and consists of the sedimentary and igneous rocks of the Triassic and Jurassic Periods of the Mesozoic Era (Mulhall, 2003).

Table 3.2: Characteristics of Bedrock Types Found in Tewksbury Township

Abbre-viation	Geologic Formation	Lithology (physical character of the rocks)	Area of Twp.
Triassic-Jurassic (Mesozoic Era: 248 to 65 million years ago)			
Jp	Preakness Basalt	dark-greenish-gray to black, very fine-grained, dense, and hard former magma flows	0.16%
Jf	Feltville Formation	brownish-red to light gray-red, fine to coarse-grained sandstone; gray and black coarse siltstone; and silty mudstone	1.98%
Jo	Orange Mountain Basalt	hard, dense, fine to very-fine grained greenish-gray to greenish-black rocks	1.30%
Jd	Jurassic Diabase	hard, dense, poorly fractured, medium to coarse grained, dark greenish gray to black rocks	0.27%
JTrp	Passaic Formation	red-brown shales, siltstones, and sandstones	16.50%
JTrpsc	Passaic Conglomerate and Sandstone facies	sand, gravel, pebble, and cobble-sized materials cemented with finer grained carbonate or quartz material	2.33%
JTrpcq	Passaic Quartzite-clast Conglomerate facies		4.73%
JTrpcl	Passaic Limestone-clast Conglomerate facies		6.60%
		Total Area Underlain by Triassic-Jurassic Formations:	*33.87%*
Cambrian-Ordovician (Paleozoic Era: 544 to 248 million years ago)			
Cl	Leithsville Formation	dolomite, carbonate minerals	0.40%
Ch	Hardyston Quartzite	tightly cemented, dense, sedimentary rock	0.33%
		Total Area Underlain by Cambrian-Ordovician Formations:	*0.72%*
Precambrian (Precambrian Era: billions to 544 million years ago)			
Ybh	Hornblende Granite	Granites have medium to course grained structure, are hard and tough	28.37%
Yba	Microperthite Alaskite	a granitic rock containing few, if any, dark minerals.	0.52%
Yps	Pyroxene Syenite	an ultramafic igneous rock consisting essentially of mineral of the pyroxene group.	3.01%
Yk	Potassium Feldspar Gneiss	Gneiss is a medium to coarse-grained banded metamorphic rock; characterized by a layered appearance caused by the minerals from quartzo-feldspathic minerals in discontinuous layers. The ferromagnesian minerals are commonly biotite and/or hornblende with pyroxene being less common.	0.89%
Yb	Biotite-Quartz-Feldspar Gneiss		10.22%
Yp	Pyroxene Gneiss		0.89%
Ye	Epidote Gneiss		0.01%
Ylo	Quartz-Oligoclase Gneiss		12.85%
Ylb	Biotite-Quartz-Oligoclase Gneiss		0.15%
Yd	Diorite	grey to dark grey intermediate intrusive igneous	6.63%

Abbre-viation	Geologic Formation	Lithology (physical character of the rocks)	Area of Twp.
		rock	
Ya	Amphibolite	Amphiboles are minerals of either igneous or metamorphic origin, typically dark-colored and heavy, with a weakly foliated or flaky structure. The small flakes of black and white in the rock often give it a salt-and-pepper appearance.	1.86%
		Total Area Underlain by Precambrian Formations:	*65.41%*
Sources: Mulhall, 2003; NJGS Bedrock Geology GIS data; Van Houten, 1969; USGS, 2002			

Precambrian Era – Igneous and Metamorphic Rocks

The Precambrian igneous and metamorphic rocks of the Highlands province are the oldest in NJ, formed between 1.3 billion and 750 million years ago by melting and recrystallization of sedimentary rocks that were deeply buried, subjected to high pressure and temperature, and intensely deformed. These rocks, mainly granites and gneisses, are resistant to erosion and produce a hilly upland cut by the deep steep-sided valleys of major streams (NJGS, 1999). Despite the fact that these rocks have undergone several episodes of tectonic deformation due to continental collisions and separations, they are poorly fractured except at locations near major faults such as the Fairmount and Tanners Brook Faults. Near these faults, the southeastern block, which moved downward with respect to the northwestern block, is usually more fractured as a result of this past movement. These normal faults were formed as a result of tensional forces pulling apart or rifting the Newark Basin (Mulhall, 2003).

The relative lack of faulting is due to the nature of these rocks, which allows for the attenuation of tectonic forces within the minerals. These rocks generally behave in a plastic or malleable manner in comparison to more brittle sedimentary rocks such as dolomite and shale. Because of the nature of the Precambrian igneous and metamorphic rocks, fractures not associated with major faults are often not highly interconnected or closely spaced (Mulhall, 2003).

Precambrian igneous and metamorphic rocks underlie most of the north-western two-thirds of Tewksbury Township. These are primarily comprised of *granite* and *gneiss* with some *diorite*, *syenite*, and *amphibolite* (Mulhall, 2003).

Paleozoic Era

The Ordovician Period experienced a period of uplift, followed by another invasion of a warm sea (Lucey, 1970). The rocks laid down during this era in what is now Tewksbury Township are Cambrian sedimentary rocks, which underlie less than 1% of the township. The Cambrian sedimentary units are comprised of the Hardyston Quartzite and Leithsville dolomite (Mulhall, 2003).

The *Hardyston Quartzite* crosses the northern portion of Tewksbury near Vernoy as a narrow band of tightly cemented, dense, sedimentary rock. The *Leithsville Formation* also forms a thin band across the northern portion of the township near Vernoy. The Leithsville is a dolomite, which is comprised of carbonate minerals that are susceptible to slow dissolution from acidic rainwater. This process produces cavities, caves, caverns and other solution openings in the rock. Within Tewksbury Township, the Leithsville Formation has very limited extent. However, this formation extends to the northeast into Long Valley where water entering the aquifer system may ultimately flow beneath the valley toward Tewksbury Township (Mulhall, 2003).

Gradually, as the basin deepened, more and more silt was deposited, cutting off the deposition of limestone. At the end of this period, the Taconic mountain building occurred,

which raised, moved, folded and faulted Precambrian formations eastward, eventually depositing them on top of these younger Paleozoic formations (Lucey, 1970).

Mesozoic Era – conglomerate, siltstone and shale

The Triassic Border Fault formed as a result of shearing between the Precambrian thrust sheet and the existing Paleozoic rocks. This resulted in block mountains with basins on either side. The Border Fault is nearly vertical where it outcrops, but flattens with depth.

Erosion from the high mountains gradually filled the basins with sediments, forming the Late Triassic Newark Group. The Newark Group lies in a southwest-trending basin that extends from Rockland County, New York, to northeastern Lancaster County, Pennsylvania. This is the largest of the Triassic rift valleys that extend from Nova Scotia to North Carolina. The Newark Group consists of non-marine sedimentary rocks 16,000-20,000 feet thick, and associated intrusions of volcanic rocks. Older rocks, which lie beneath the Newark Group, are exposed to the north in the Highlands and Ridge and Valley Provinces. Younger strata overlap the Newark Group in the Coastal Plain Province to the southeast. The layers generally dip 10 – 20° northwest. In contrast to the Precambrian rocks, which are poorly fractured except in the immediate vicinity of the border faults, the Triassic-Jurassic sedimentary rocks exhibit two types of fracturing. Bedding fractures resulted from changes in the characteristics of the sediments at the time of deposition. In addition, fracturing occurred when weak sedimentary layers were pulled apart as the continents separated. Often these fractures will have a vertical or near vertical orientation and will extend a few inches to a few feet across (Van Houten, 1969; Mulhall, 2003).

Near the Triassic Border Fault, fast flowing streams surged down the steep mountains, depositing alluvial fan sediments and quartzite and limestone boulders up to three feet in diameter on the valley floor. These resulting Triassic conglomerates are dominated by quartzite, which is more resistant to erosion. As the streams flowed away from the mountains, the velocity slowed and, having already dropped the larger boulders and pebbles, carried and deposited the smaller particles farther from the mountains, which became sandstones, shale and mudstones. The rocks of the Passaic Formation furthest from the Highlands contain grey-bed sequences of thin-bedded to finely laminated shale and siltstone that include lake deposits (Lucey, 1970).

The portion of Tewksbury Township within the Piedmont Physiographic Province is underlain by Triassic-Jurassic sedimentary, igneous, and metamorphic rocks, which were formed 245 to 145 million years ago. Together, these Triassic-Jurassic rocks are encountered beneath approximately 34% of Tewksbury Township. The thickness of the combined Passaic Formation and associated facies may exceed 11,000 feet (Mulhall, 2003).

The Passaic Formation Conglomerate Facies are comprised of three mapped units within Tewksbury Township. *The Passaic limestone-clast conglomerate* unit is located along the border fault from the township's western boundary to east of the intersection of Homestead and Flint Hill Roads and extending south to Oldwick. The *Passaic quartzite-clast conglomerat*e unit is located to the east of the limestone conglomerate and extends to the township's eastern boundary near Pottersville. The *Passaic Conglomerate & Sandstone* unit extends along the Township's eastern boundary. Together, these three conglomerate units are located beneath about 14% of the Township. The conglomerate units are comprised of sand, gravel, pebble, and cobble-sized materials deposited by high-velocity streams in a series of alluvial plains at the base of mountains located to the north and west in the present day Highlands Province. These coarse-grained deposits were later cemented with finer grained carbonate or quartz materials. Based on the topography of Tewksbury in areas underlain by the conglomerates, these rocks most likely remain tightly cemented because they continue to form steep slopes and high hills (Mulhall, 2003).

The *Passaic Formation* is encountered in Tewksbury Township southeast of the border faults and the conglomerates. The red-brown shales, siltstones, and sandstones of the Passaic

Formation encompass approximately 3,350 acres or 16.5% of Tewksbury Township (Mulhall, 2003).

Mesozoic Era – diabase, basalt and sedimentary rocks

Volcanic activity was associated with the rifting of the continent as the Atlantic Ocean formed, which allowed magma to flow through the resulting fractures. Diabase is a rock formed by the cooling of magma below the surface of the earth. Basalt is formed by magma that has been extruded onto the surface as lava, where the magma cools much more quickly in the open air, and there is little time for the growth of crystals. Both are more resistant to erosion than the surrounding sandstones and shales, and therefore form ridges and uplands (NJGS, 1999).

In the northeastern section of Tewksbury Township, near Pottersville, an area of *diabase* intruded into the older Passaic Formation. These sheets, dikes and sills cooled slowly into hard, dense, poorly fractured, medium- to coarse-grained, dark greenish-gray to black rocks. Near the margins of the intrusions, the diabase is usually fine to very-fine grained. The magma's heat metamorphosed the surrounding Passaic Formation rocks within 1,000 feet in all directions, turning the red-brown shales into metamorphic bluish-gray hornfels. Sheet-like diabase intrusions may exceed 1,200 feet in thickness and the dikes may range from 10 to 50 feet thick. Based on the USGS mapping, in Tewksbury Township, diabase is found on 54 acres between Keats and Homestead Roads, which is about 0.27% of the township (Mulhall, 2003).

The *Orange Mountain Basalt* and *Preakness Basalt* form the base and peak of Round Top, which is between Bissel and Oldwick. The Orange Mountain Basalt is primarily comprised of three flows separated by thin layers of red siltstone. These igneous extrusions cooled rapidly on the surface of the earth into hard, dense, fine to very-fine grained greenish-gray to greenish-black rocks. At some locations, the flows exhibit characteristic basalt features such as columnar joints, pillows and pahoehoe (lava flow with rope-like or glassy outer surface), which formed as a result of rapid cooling. The Orange Mountain Basalt may reach a thickness of almost 600 feet and within Tewksbury Township encompasses approximately 265 acres near Potterstown, Rockaway, and Bissel Roads. The peak of Round Top consists of the Preakness Basalt. Similar to the older Orange Mountain Basalt, the Preakness Basalt is comprised of dark-greenish-gray to black, very fine-grained, dense, and hard former magma flows. The Preakness is also composed of three major basalt flows. The Preakness Basalt is encountered beneath approximately 32 acres or 0.16 % of the Township at the peak of Round Top (Mulhall, 2003).

The *Feltville Formation* is the youngest sedimentary bedrock formation in Tewksbury Township and is mapped northeast of Bissel, surrounding the base of Round Top. Geologically, the Feltville is very similar to the Passaic Formation and is comprised of brownish-red to light gray-red, fine to coarse-grained sandstone; gray and black coarse siltstone; and silty mudstone. The Feltville Formation may exceed 500 feet in thickness. Within Tewksbury, these rocks are encountered on 402 acres, approximately 2% of the township (Mulhall, 2003).

Mining

Seven abandoned mines exist in Tewksbury Township, five of which mined magnetite, and two mined graphite (see **Figure 3a** and **Table 3.3**) (NJGS, 2006).

Magnetite is a valuable source of iron ore and is the most magnetic mineral on Earth (Wikipedia, 2008). Beginning as early as the 1600's until about 1996, iron ore (magnetite) was mined extensively in the Highlands region and created a once-thriving industry of national importance (NJGS, 1999; Volker & Witte, no date). Within Tewksbury, the mine located at Cokesbury, on the western edge of the township, operated the longest – a period of 97 years from 1776 to 1873. All of the magnetite mines within Tewksbury had ceased operations by 1883 (NJGS, 2006).

Graphite was mined from about 1848 to 1941 at 13 locations in the Highlands, including two in Tewksbury. Total production figures for the graphite mines are not available; however, apparently they could not compete financially with other sources of graphite. The chemical composition of graphite (organic carbon) provides indirect fossil evidence of life that existed 1.3 billion years ago in the Precambrian sea. The graphite likely formed from metamorphosed remains of algae that had accumulated in an oxygen deficient part of the marine environment (Volker & Witte, no date).

Table 3.3: Abandoned Mines in Tewksbury Township

Name	Year Began	Year Ended	Mineral
Cokesbury Mine	1776	1873	magnetite/iron
Burrell Mine	1878	1878	magnetite/iron
Sutton Farm Graphite Mine			graphite
Sutton Farm Mine	1873	1881	magnetite/iron
Fox Hill Mine	1873	1880	magnetite/iron
Fisher Mine			graphite
Welch Farm Exploration	1883	1883	magnetite/iron
Source: NJGS GIS data, 2006.			

Currently, Stavola Quarries, LLC operates a quarry for crushed stone in the Jurassic Orange Mountain Basalt.

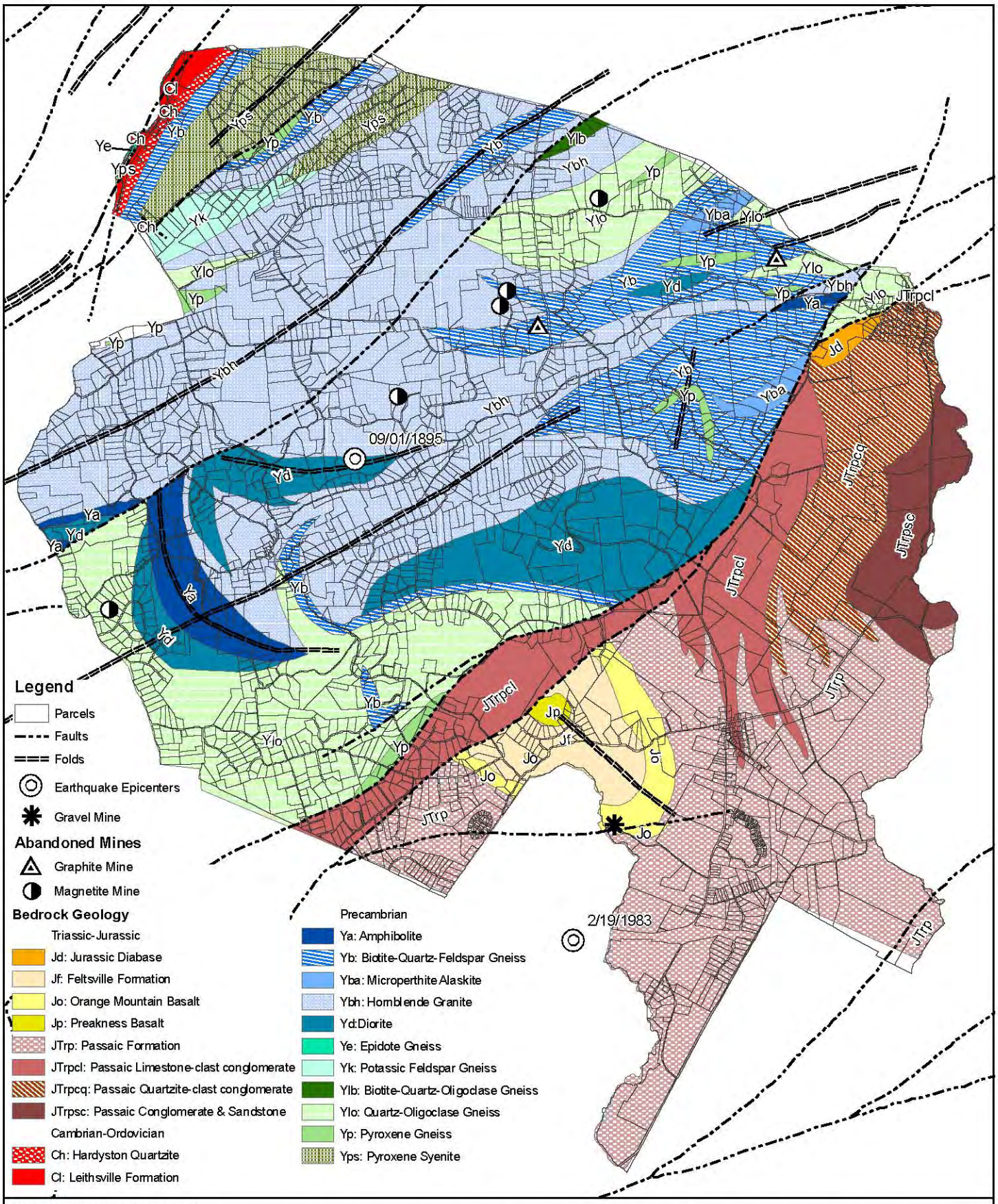
Earthquakes

Damaging earthquakes are rare in Tewksbury Township, but possible. Soils influence the potential for damage from earthquakes. Most areas of Tewksbury have shallow depth to bedrock, which dampens the movement of earthquakes (NRCS, 2006). However, soft soils (e.g. silt, clay, and fine sand) amplify the motion of earthquake waves, increasing ground shaking, while wet sandy soils can liquefy (Stanford, 2003).

An earthquake occurring September 1, 1895 had its epicenter in Tewksbury Township. It had a magnitude of 4.1 – the second most powerful earthquake of known magnitude recorded in New Jersey (see **Figure 3a)**. On February 19, 1983 an earthquake with a magnitude of 2.7 was recorded in Califon, just outside of Tewksbury. A number of other earthquakes have occurred in the vicinity, all with magnitudes of 2.9 or less (NJGS, 2007).

C. The Surficial Geology of Tewksbury Township

Surficial materials are the unconsolidated sediments that overlie bedrock formations and that are the parent material for soils. In Hunterdon County they include stream, wetland, glacial, windblown, and hillslope sediments and weathered bedrock material. The weathered bedrock



Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

Figure 3a: Bedrock Geology, Faults, Folds, Mines & Earthquakes

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

material may be as much as 200 feet thick, although most are generally less than 20 feet thick. The size of particles in the surficial materials ranges from coarse gravel to clay and peat. Surficial materials affect the movement of ground water from the surface into underlying bedrock aquifers, and some are aquifers themselves (See **Figure 3b** and **Table 3.4**).

Table 3.4: Types of Surficial Geology Found in Tewksbury Township

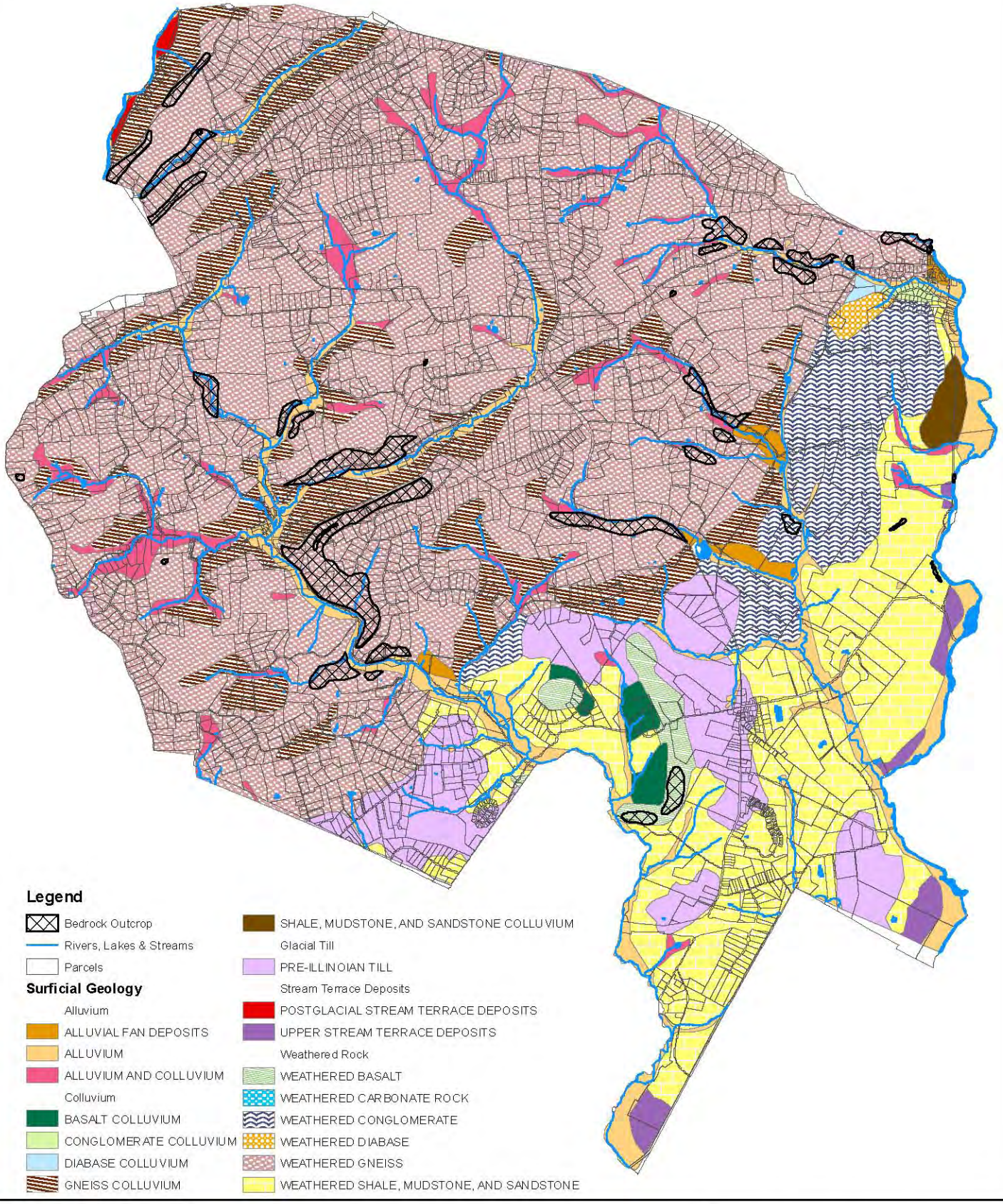
Deposit Type	Definition
Alluvium	any sediment deposited by flowing water
Alluvium Fan Deposits	deposited by rivers and streams; soil textures have high sand and silt contents
Bedrock Outcrop	a more or less solid layer of rock found on the surface of the land or below the soil
Eolian deposits	transported by wind; are not typically deep deposits, but may exist as a thin deposit overlying another type of parent material; soil textures dominated by medium and fine sands
Colluvium	transported down-slope by gravity; soil textures dependent on particle-size of colluviated parent material
Glaciofluvial Deposits	deposits of glacial origin, but transported and deposited by river and streams; soil textures dominated by high sand, gravel and silt contents
Stream terrace deposits	alluvial deposits on a stream terrace
Till	glacial deposits; soil textures dominated by high sand and gravel contents
Weathered rock	the bedrock near the surface has been subjected to physical and chemical changes by atmospheric agents (i.e. the weather); soil textures depend on type of rock from which the soil is weathered
Source: NRCS Soils Online Study Guide: http://www.nj.nrcs.usda.gov/partnerships/envirothon/soils/	

During the beginning of the Cenozoic Era (the current era), erosion continued along the Triassic Border Fault, exposing the underlying Paleozoic rocks. During the last million years of geologic history, Continental ice sheets invaded New Jersey at least three times. The first of these glaciation events, the pre-Illinoian, occurred about 800,000 years ago and covered all of what is now Tewksbury Township. The ice of the Illinoian and the late Wisconsinan glaciers did not reach Tewksbury Township (Lucey, 1970; Witte, 1998).

Sediment that was deposited directly by the pre-Illinoian glacier, known as *glacial till*, exists in the south eastern part of Tewksbury Township (see **Figure 3b**). It occurs as erosional remnants of sandy to silty till on flat upland areas, to a maximum thickness of 30 feet. It is too thin to be an aquifer, and the fine particles may actually retard the movement of surface water into the underlying bedrock (NJGS, 2002).

The rest of the township is covered with non-glacial surficial material including weathered bedrock, colluvium (gravity transported), and alluvium (water transported). Throughout New Jersey, weathered bedrock may be as thick as 300 feet on carbonate bedrock and 100 feet on gneiss and conglomerate bedrock but is generally less than 20 feet thick elsewhere. Colluvium occurs in wedge-shaped deposits at the base of hillslopes, and may be as much as 50 feet thick. Alluvium occurs in floodplains and terraces along streams and is generally less than 30 feet thick. Weathered gneiss and conglomerate may be a local unconfined aquifer where thick and sandy. Otherwise, non-glacial materials are too thin to be aquifers (NJGS, 2002).

Bedrock outcrops may be found in Tewksbury along some of the stream channels and at the gravel mine (see **Figure 3b**).



Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 3b: Surficial Geology

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

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

4: SOILS

A. Soil Survey Maps

The *soil* is the unconsolidated mineral material on the immediate surface of the earth and that serves as the medium for growth of land plants. The characteristics of each soil type have developed over time (usually many thousands of years) under the influence of the parent material (the bedrock that has broken down into small fragments to form the soil), climate (including moisture and temperature regimes), macro- and microorganisms, and topography. Soil is a basic resource for food production, in addition to its essential role in collecting and purifying water before it enters the ground water (USDA NRCS, 2006). However, soil itself can be a pollutant as dust in the air or as sediment in water.

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

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

The NRCS prepared a soil survey of Hunterdon County in 1974 (Jablonski, 1974), which was updated in 1986 and digitized into GIS in 1999. The objective of soil mapping is to separate the landscape into segments that have similar use and management requirements. Therefore, this data set is not designed for use as a primary regulatory or management tool, but may be used as a broad scale reference source. According to the Soil Survey Geographic Database (also known as SSURGO) information, field investigations and data collection were carried out in sufficient detail to name map units and to identify accurately and consistently areas of about 5 acres. As with other GIS data sets, enlargement of the maps to a scale greater than the accuracy of the data can cause misinterpretation of the data. Onsite sampling, testing, and detailed study of specific sites is essential for determining intensive uses, and managing farms and wetlands (USDA NRCS, 2006).

Beginning in 2005, the NRCS made its soil surveys available online (USDA NRCS, 2006). This provides the means for keeping the information current and available to the public. Users specify a geographic "area of interest" (must be less than 10,000 acres) and then may view a wide variety of tables of soil properties and soil interpretations. However, for this report, the entire SSURGO (Soil Survey Geographic Database) spatial data and tabular data for Hunterdon County were downloaded for use in the GIS (USDA NRCS, 2006) [7].

B. Soil Series and Map Units

Soil characteristics vary from place to place in slope, depth, drainage, erodibility and other characteristics that affect management. A *soil series* is a basic unit of soil classification consisting of soils that are essentially alike, except that they may differ in surface texture, stoniness, slope or some other attribute. A *map unit* is the area delineated on a soil map,

[7] The maps in this report are the most recent available as of February 2008 (Tabular Data Version 5, 12/7/2006; Spatial Data Version 1, 1/6/2005; Spatial Format=ArcView Shapefile; Coordinate System=UTM Zone 18, Northern Hemisphere (NAD 83)); SSURGO version 2.2; Template database version 32.

representing an area dominated by one major kind of soil, and is named according to the classification of the dominant soil or soils. However, soils are natural systems, with natural variability, and the range of some observed properties may extend beyond the limits defined for the class. In addition, small areas of contrasting soils may not be visible on the maps. The databases included with the soils data describe the characteristics of each soil map unit. The NRCS has included both estimated and measured data on the physical and chemical soil properties and soil interpretations for engineering, water management, recreation, agronomic, woodland, range and wildlife uses of the soil.

There are 40 soil series found in Tewksbury, such as Parker, Patenburg and Gladstone. A total of 66 different map units are present in Tewksbury[8]. These map units are listed in **Table 4.2**, along with several important properties of these soils, and shown on **Figure 4a**. **Figures 4b** through **4h** illustrate the distribution of some soil characteristics. A large portion of the soils in Tewksbury have limitations due to shallow depth to bedrock. Some areas have poor drainage, high water table or steep slopes.

C. Characteristics of Tewksbury Township Soils

Depth to Restrictive Layer (Bedrock and Fragipan)

According to NJDEP (1999), *bedrock* is defined as "any solid body of rock, with or without fractures, which is not underlain by soil or unconsolidated rock material."

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

For the most part, Tewksbury Township has shallow depths to bedrock, ranging from zero (bedrock is exposed at the surface, with no soil above it) to 116 inches. There are some soil units in Tewksbury that are not restricted by bedrock, including the Gladstone, Califon and Raritan. **Figure 4b** shows the minimum depths to bedrock for the majority of each soil unit (see **Table 4.2** and **Figure 4b**).

In some cases, a fragipan layer is encountered with or without the presence of shallow bedrock. A *fragipan* is a subsoil layer, typically high in clay, which is a higher density than the soil above it. A fragipan layer becomes cemented and very hard when dry, and brittle when moist. The layer is low in organic matter and slowly or very slowly permeable to water and also restricts root growth (Soil Science Society of America, 2008). When present in Tewksbury, the fragipan layer varies in depth between 15 and 40 inches in depth (see **Figure 4b**).

Depth to Seasonal High Water Table

The *depth to seasonal high water table* (SHWT) is the distance between the ground surface and the top of the water surface in the saturated part of a water-bearing zone. A SHWT of less than one foot severely constrains development, while SHWT between 1 and 3 feet also provides obstacles to development. On-site investigation will often reveal that these areas are actually wetlands or floodplains. High water tables impact the effectiveness of septic systems, and the freeze/thaw cycles cause frost heaving, which damages structures and roads (Hintz, 2003).

The majority of Tewksbury Township does not have concern with a seasonal high water table (see **Figure 4c**). Areas that do have a shallow depth to SHWT are primarily located near

[8] Note that nomenclature, some attribute categories, and some interpretations have changed since previous reports, such as the 2004 Master Plan.

streams. Flooding typically occurs in certain soils, including the Bowmansville, Fluvaquent, Udifluvent, Raritan and Rowland units (see **Figure 6b for floodplains**).

Hydrologic Soil Group

The *hydrologic soil grouping* describes a group of soils having similar runoff potential under similar storm and cover conditions (how much would run off compared to the rate that water would infiltrate into the ground). The majority of the township has moderate to slow infiltration rates, while some areas have very slow infiltration rates (see **Figure 4d**). The definitions of the hydrologic soil groups are shown in **Table 4.1**.

Table 4.1: Hydrologic Soil Grouping

Class	Definition
A	High infiltration rates. Soils are deep, well drained to excessively drained sands and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well drained soils that have moderately course textures.
B/D	Drained/undrained hydrology class of soils that can be drained and are classified. Moderate to very slow infiltration rates.
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils that have moderately fine or fine textures.
C/D	Drained/undrained hydrology class of soils that can be drained and classified. Slow to very slow infiltration rates.
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.
Source: USDA NRCS Soil Survey Geographic (SSURGO) Database, January 20, 2006.	

Septic Suitability

The NRCS SSURGO database provides an interpretation of limitations of each soil for *septic suitability*. The interpretation shown in **Figure 4e** is based on the N.J.A.C. 7:9A Standards for Individual Subsurface Sewage Disposal Systems, Subchapter 10 Disposal Fields. Factors which may affect the functioning of the system, and therefore limit septic suitability, are excessively coarse substratum (which allows effluent to percolate to ground water too rapidly); presence of water (including depth to high water table, flooding, and hydric soils); depth to restrictive layer (bedrock or restrictive substratum) and steep grades over 25%. N.J.A.C 7:9A prohibits septic systems in soils subject to flooding, which in Tewksbury includes Bowmansville, Fluvaquents, Raritan and Rowland. In addition, septic disposal fields are prohibited in locations with the combination of slope greater than 10% and less than 50 feet upslope of any bedrock outcrop where signs of ground water seepage can be detected (NJDEP, 1999).

In Tewksbury, the suitability of soils for septic tank absorption fields is very limited. Portions of some soil units have areas where septic system disposal fields would not be permitted due to flooding, hyrdic soils, or steep slopes; while some areas have no technical limitations and some areas were not rated (such as the quarry and rough broken land). These general suitability guidelines would need to be used in combination with on-site testing, the SSURGO interpretation report "Sewage Disposal (NJ)," and N.J.A.C.7:9A subchapter 10 to determine what types of disposal field installations would be appropriate in any given situation. In soils with more than one limiting factor, a disposal field must be a type approved as an acceptable option for each of the soil suitability classes that apply (NJDEP, 1999).

Erodibility

Erosion is the wearing away of the land surface by running water, wind, ice, or other geological agents. Erosion is often accelerated as a result of human activities. The *erodibility* takes into account the affects of infiltration rate, permeability and total water capacity and factors

that resist the forces of the rainfall and runoff. The majority of Tewksbury Township is rated "potentially highly erodible," while a large portion is "highly erodible," and small areas are considered not highly erodible (see **Figure 4f)**. Map units that are described as "eroded" are also displayed on this map (SSURGO, 1991)

Soil Drainage Class

Soil Drainage Class is a code identifying the natural drainage condition of the soil and refers to the frequency and duration of periods when the soil is free of saturation or partial saturation during soil formation, and does not refer to saturation due to recently altered drainage (manmade or natural). The categories are as follows: well drained, moderately well drained, excessively drained, somewhat excessively drained, poorly drained, and somewhat poorly drained. For the most part, Tewksbury Township has well drained soils. The steeper slopes and rocky soils tend to be somewhat excessively drained, while small patches are moderately well drained, somewhat poorly drained or poorly drained (see **Figure 4g).**

Prime Farmland Soils

Prime Farmland Soils include soils that have the best combination of physical and chemical characteristics for economically producing sustained high yields of crops when treated and managed according to acceptable farming methods and is also available for these uses. These soils have the soil quality, growing season, and moisture supply needed; they are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding (USDA NRCS NJ, 2006).

Farmlands of statewide importance include those soils with characteristics that are nearly Prime Farmland. They economically produce high yields of crops when treated and managed according to acceptable farming methods. Some may produce yields as high as Prime Farmland if conditions are favorable (USDA NRCS NJ, 2006). Tewksbury Township has a high proportion of prime farmland soils and farmland of statewide importance, which include many of the loamy soils with low slopes, such as Annandale gravelly loam 3 to 8% slope, Gladstone gravelly loam 3 to 6% slope, Pattenburg gravelly loam 2 to 6% slope, and Raritan silt loam 0 to 3 and 3 to 8% slope (see **Figure 4h).**

Other

Annual flood frequency is a descriptive term used to describe the frequency of flooding that is likely to occur in a year. **Frequent** is > 50% chance of flooding in a given year; **occasional** is 5 to 50%; **rare** is 0 to 5% chance of flooding. For those soils that experience frequent or occasional flooding, duration of annual flooding in a normal year and the months during which flooding occurs in a normal year are also noted (see **Table 4.2**; shown in **Figure 6b** with floodplains).

Potential Frost Action is an interpretation rating of the susceptibility of the soil to frost heaving. Most soils within Tewksbury are moderately susceptible to frost action. The remainder is highly susceptible, with the exception of the map unit Fluvaquents and Udifluvents, 0 to 3 percent slopes, frequently flooded, which is rated low, and quarry and rough broken land, which are not rated for frost action.

Hydric soils are those soils that are wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants. For delineation of hydric soils the ponding event must last greater than seven days. Hydric Soils are noted in **Table 4.2**, and are shown with wetlands in **Figure 6c**.

References: Soils

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US Department of Agriculture, Natural Resources Conservation Service (NRCS). 2006. Soil Data Mart (Hunterdon County data (tabular data version 5, December 12, 2006). http://soildatamart.nrcs.usda.gov/

US Department of Agriculture, Natural Resources Conservation Service, NJ (NRCS NJ). 2006. Soils Online Study Guide: Geology of New Jersey. http://www.nj.nrcs.usda.gov/partnerships/envirothon/soils/geology.html

US Department of Agriculture, Natural Resources Conservation Service (NRCS). 2005. Soil Survey Geographic Data: SSURGO version 2.2, Template Database Version 32. http://soildatamart.nrcs.usda.gov/

Internet Resources: Soils

Hunterdon Soil Conservation District: http://www.nj.gov/agriculture/divisions/anr/nrc/conservdistricts.html

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

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

NRCS Soil Data Mart (download soils data for GIS): http://soildatamart.nrcs.usda.gov/

NRCS Soils Online Study Guide: http://www.nj.nrcs.usda.gov/partnerships/envirothon/soils/

Web Soil Survey Site (soils online): http://websoilsurvey.nrcs.usda.gov/app/

Web Soil Survey: How to Use it: http://websoilsurvey.nrcs.usda.gov/app/Help/WSS_HomePage_HowTo.pdf

Table 4.2: Characteristics of Soil Types Found in Tewksbury Township[9]

Map Unit Symbol	Map Unit Name	Depth to Restrictive Features (inches)	Seasonal High Water Table Depth (inches)	Annual Flood Frequency, Duration, Months	Hydrologic Group	Potential Frost Action	Drainage Class	Hydric Soil?	Prime Farmland?	Septic Limitations (NJ)
AbrB	Abbottstown silt loam, 2 to 6 percent slopes	F: 15-30 B: 40-60	6	none	C	HIGH	somewhat poorly		SI	*Very Limited:* DTWT, RS, RH, ECS
AnoB	Annandale gravelly loam, 3 to 8 percent slopes	F: 24-36 B: 73-79	>60	none	C	MODERATE	WELL		P	*Very Limited:* RS, RH, DTB
AnoC2	Annandale gravelly loam, 8 to 15 percent slopes, eroded	F: 18-30	>60	none	C	MODERATE	WELL		SI	*Very Limited:* RS, RH
ANWTB	Annandale and Gladstone gravelly loams, 3 to 8 percent slopes	F: 24-36 B: 40-48	>60	none	C	MODERATE	WELL		P	*Very to Somewhat Limited:* RS, RH, ECS
ANWTC	Annandale and Gladstone gravelly loams, 8 to 15 percent slopes	F: 24-36 B: 40-48	>60	none	C	MODERATE	WELL		SI	*Very to Somewhat Limited:* RS, RH, ECS
AtdB	Athol gravelly loam, 2 to 6 percent slopes	B: 69-81	>60	none	B	MODERATE	WELL		P	*Somewhat Limited:* DTB
AtdC2	Athol gravelly loam, 6 to 12 percent slopes, eroded	B: 69-81	>60	none	B	MODERATE	WELL		SI	*Somewhat Limited:* DTB
AtdD2	Athol gravelly loam, 12 to 18 percent slopes, eroded	B: 69-81	>60	none	B	MODERATE	WELL			*Somewhat Limited:* DTB
BefB	Bedington Channery silt loam, 2 to 6 percent slopes	B: 54-66	>60	none	B	MODERATE	WELL		P	*Somewhat Limited:* ECS
BhnA	Birdsboro silt loam, 0 to 2 percent slopes	none	>60	none	B	MODERATE	WELL		P	*Not limited*
BhnB	Birdsboro silt loam, 2 to 6 percent slopes	none	>60	none	B	MODERATE	WELL		P	*Not limited*

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

Map Unit Symbol	Map Unit Name	Depth to Restrictive Features (inches)	Seasonal High Water Table Depth (inches)	A nnual Flood Frequency, Duration, Months	Hydrologic Group	Potential Frost Action	Drainage Class	Hydric Soil?	Prime Farmland?	Septic Limitations (NJ)
BoyAt	Bowmansville silt loam, 0 to 2 percent slopes, frequently flooded	none	6	FREQUENT Brief Nov.-May	B/D	HIGH	poorly	yes	SI	*Very Limited:* DTWT, F, H
BucB	Bucks silt loam, 2 to 6 percent slopes	B: 40-53	>60	none	B	MODERATE	WELL		P	*Very Limited:* RS, ECS
BucC2	Bucks silt loam, 6 to 12 percent slopes	B: 40-60	>60	none	B	MODERATE	WELL		SI	*Very Limited:* RS, ECS
CakA	Califon loam, 0 to 3 percent slopes	F: 20-30	18	none	C	HIGH	moderately well		P	*Very Limited:* RS, RH, DTWT
CakB	Califon loam, 3 to 8 percent slopes	F: 20-30	18	none	C	HIGH	moderately well		P	*Very Limited:* RS, RH, DTWT
CanBb	Califon gravelly loam, 0 to 8 percent slopes, very stony	F: 20-30	18	none	C	HIGH	moderately well			*Very Limited:* RS, RH, DTWT
ChcB	Chalfont silt loam, 2 to 6 percent slopes	F: 15-30 B: 42-72	12	none	C	HIGH	somewhat poorly		SI	*Very Limited:* DTWT, RS,RH, ECS
CoaA	Cokesbury loam, 0 to 3 percent slopes	F: 20-30	6	none	D	HIGH	poorly	yes		*Very Limited:* DTWT, RS, RH, H
CoaBb	Cokesbury loam, 0 to 8 percent slopes, very stony	F: 20-26	6	none	D	HIGH	poorly	yes		*Very Limited:* DTWT, RS, RH, H
DufC2	Duffield silt loam, 6 to 12 percent slopes, eroded	B: 48-60	>60	none	B	MODERATE	WELL		SI	*Somewhat Limited:* DTB
FmhAt	Fluvaquents, loamy, 0 to 3 percent slopes, frequently flooded	none	15	FREQUENT	B/D	HIGH	somewhat excessively	yes		*Very Limited:* DTWT, F, H
FNAT	Fluvaquents and Udifluvents, 0 to 3 percent slopes, frequently flooded	none	24	FREQUENT very brief -brief Dec.-May	C	LOW	moderately well			*Very Limited:* DTWT, F
GkaoB	Gladstone gravelly loam, 3 to 8 percent slopes	none	>60	none	B	MODERATE	WELL		P	*Not limited*

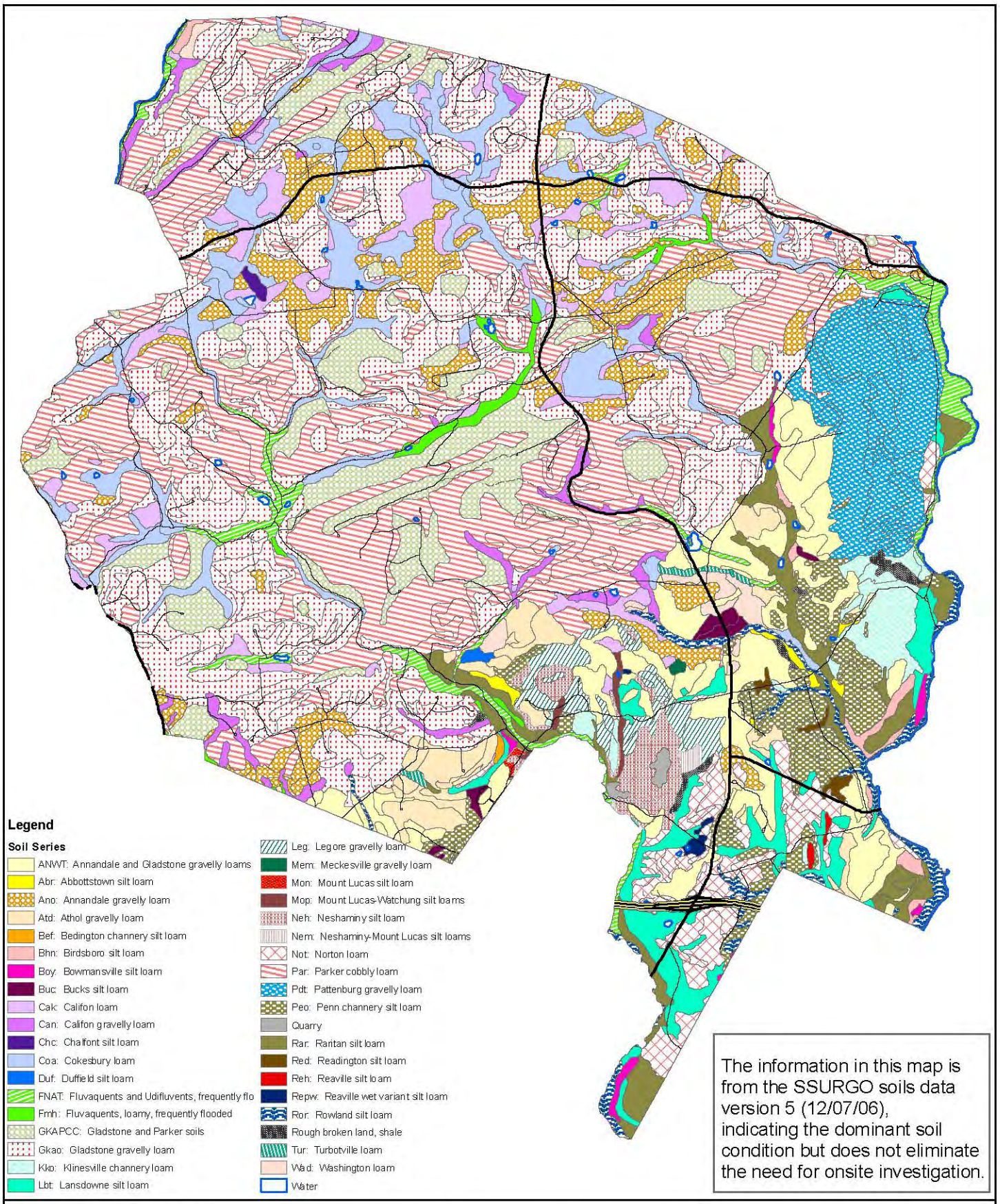
Map Unit Symbol	Map Unit Name	Depth to Restrictive Features (inches)	Seasonal High Water Table Depth (inches)	A nnual Flood Frequency, Duration, Months	Hydrologic Group	Potential Frost Action	Drainage Class	Hydric Soil?	Prime Farmland?	Septic Limitations (NJ)
GkaoC2	Gladstone gravelly loam, 8 to 15 percent slopes, eroded	B: 40-60	>60	none	B	MODERATE	WELL		SI	*Somewhat Limited:* ECS
GkaoD	Gladstone gravelly loam, 15 to 25 percent slopes	none	>60	none	B	MODERATE	WELL			*Not limited*
GKAPCC	Gladstone and Parker soils, 8 to 15 percent slopes, extremely stony	B: 40-60	>60	none	B	MODERATE	WELL			*Somewhat to Very Limited:* ECS, DTB
KkoC	Klinesville channery loam, 6 to 12 percent slopes	B: 10-20	>60	none	D	MODERATE	somewhat excessively			*Somewhat Limited:* ECS
KkoD	Klinesville channery loam, 12 to 18 percent slopes	B: 10-20	>60	none	D	MODERATE	somewhat excessively			*Somewhat Limited:* ECS
LbtB	Lansdowne silt loam, 2 to 6 percent slopes	B: 54-66	21	none	C	HIGH	somewhat poorly		SI	*Very Limited:* RS, RH, DTWT, ECS
LegB	Legore gravelly loam, 2 to 6 percent slopes	B: 48-60	>60	none	B	MODERATE	WELL		P	*Somewhat Limited:* ECS, RS
LegC	Legore gravelly loam, 6 to 12 percent slopes	B: 48-60	>60	none	B	MODERATE	WELL		SI	*Somewhat Limited:* ECS, RS
LegD	Legore gravelly loam, 12 to 18 percent slopes	B: 39-51	>60	none	B	MODERATE	WELL			*Very Limited:* RS, ECS
MemC2	Meckesville gravelly loam, 6 to 12 percent slopes, eroded	F: 26-40 B: 54-66	>60	none	C	MODERATE	WELL		SI	*Very Limited:* RS, RH, DTB
MonB	Mount Lucas silt loam, 2 to 6 percent slopes	B: 48-99	18	none	C	HIGH	moderately well		P	*Very Limited:* DTWT, DTB
MopBb	Mount Lucas-Watchung silt loams, 0 to 6 percent slopes, very stony	none	18	none	C	HIGH	moderately well			*Very Limited:* DTWT
NehCb	Neshaminy silt loam, 6 to 12 percent slopes, very stony	none	>60	none	B	moderate	WELL			*Not limited*

Map Unit Symbol	Map Unit Name	Depth to Restrictive Features (inches)	Seasonal High Water Table Depth (inches)	A nnual Flood Frequency, Duration, Months	Hydrologic Group	Potential Frost Action	Drainage Class	Hydric Soil?	Prime Farmland?	Septic Limitations (NJ)
NehDb	Neshaminy silt loam, 12 to 18 percent slopes, very stony	B: 54-66	>60	none	B	MODERATE	WELL			*Somewhat Limited:* DTB
NehEb	Neshaminy silt loam, 18 to 35 percent slopes, very stony	B: 54-66	>60	none	B	MODERATE	WELL			*Very Limited:* S, DTB
NemCb	Neshaminy-Mount Lucas silt loams, 6 to 12 percent slopes, very stony	B: 48-99	>60	none	B	MODERATE-HIGH	WELL			*Somewhat Limited:* DTB
NotB	Norton loam, 2 to 6 percent slopes	B: 63-76	>60	none	C	MODEATE	WELL		P	*Very Limited:* RS, RH
NotC2	Norton loam, 6 to 12 percent slopes, eroded	B: 77-91	>60	none	C	MODERATE	WELL		SI	*Very Limited:* RS, RH
NotD2	Norton loam, 12 to 18 percent slopes, eroded	B: 77-91	>60	none	C	MODERATE	WELL			*Very Limited:* RS, RH
ParC	Parker cobbly loam, 3 to 15 percent slopes	B: 35-47	>60	none	B	MODEARTE	somewhat excessively			*Very Limited:* DTB
ParD	Parker cobbly loam, 15 to 25 percent slopes	B: 36-47	>60	none	B	MODERATE	somewhat excessively			*Very Limited:* DTB
ParEe	Parker cobbly loam, 18 to 40 percent slopes, extremely stony	B: 39-47	>60	none	B	MODERATE	somewhat excessively			*Very Limited:* DTB, S
PdtB	Pattenburg gravelly loam, 2 to 6 percent slopes	B: 54-66	>60	none	B	MODERATE	WELL		P	*Somewhat Limited:* DTB, RS
PdtC2	Pattenburg gravelly loam, 6 to 12 percent slopes, eroded	B: 54-66	>60	none	B	MODERATE	WELL		SI	*Somewhat Limited:* DTB, RS
PdtD	Pattenburg gravelly loam, 12 to 18 percent slopes	B: 54-66	>60	none	B	MODERATE	WELL			*Somewhat Limited:* DTB, RS
PdtE	Pattenburg gravelly loam, 18 to 40 percent slopes	B: 54-66	>60	none	B	MODERATE	WELL			*Very Limited:* S, DTB, RS

Map Unit Symbol	Map Unit Name	Depth to Restrictive Features (inches)	Seasonal High Water Table Depth (inches)	A nnual Flood Frequency, Duration, Months	Hydrologic Group	Potential Frost Action	Drainage Class	Hydric Soil?	Prime Farmland?	Septic Limitations (NJ)
PdtmB	Pattenburg gravelly loam, moderately wet, 2 to 6 percent slopes	B: 54-66	>60	none	C	HIGH	moderately well		P	*Somewhat Limited:* DTB, RS
PeoB	Penn channery silt loam, 2 to 6 percent slopes	B: 20-40	>60	none	C	MODERATE	WELL		P	*Somewhat Limited:* ECS
PeoC2	Penn channery silt loam, 6 to 12 percent slopes, eroded	B: 20-40	>60	none	C	MODERATE	WELL		SI	*Somewhat Limited:* ECS
PeoD	Penn channery silt loam, 12 to 18 percent slopes	B: 20-40	>60	none	C	MODERATE	WELL			*Somewhat Limited:* ECS
QY	Quarry	B: 0	>60	none	--	---	--			--
RarAr	Raritan silt loam, 0 to 3 percent slopes, rarely flooded	F: 22-33	18	RARE Brief Nov.-March	C	HIGH	moderately well		P	*Very Limited:* RS, RH, F, DTWT
RarB	Raritan silt loam, 3 to 8 percent slopes	none	18	none	C	HIGH	moderately well		P	*Very Limited:* DTWT
RedB	Readington silt loam, 2 to 6 percent slopes	F: 24-36 B: 40-60	27	none	C	MODERATE	moderately well		P	*Very Limited:* RS, RH, ECS, DTWT
RehB	Reaville silt loam, 2 to 6 percent slopes	B: 20-33	18	none	C	HIGH	somewhat poorly		SI	*Very Limited:* DTWT, ECS
RepwA	Reaville wet variant silt loam, 0 to 2 percent slopes	B: 18-33	6	none	D	HIGH	poorly	yes		*Very Limited:* DTWT, RS, RH, H, ECS
ROPF	Rough broken land, shale	B: 0	>60	none	D	NONE	WELL			--
RorAt	Rowland silt loam, 0 to 2 percent slopes, frequently flooded	none	24	FREQUENT Brief Nov-Mar	C	HIGH	moderately well			*Very Limited:* F, DTWT

Map Unit Symbol	Map Unit Name	Depth to Restrictive Features (inches)	Seasonal High Water Table Depth (inches)	A nnual Flood Frequency, Duration, Months	Hydrologic Group	Potential Frost Action	Drainage Class	Hydric Soil?	Prime Farmland?	Septic Limitations (NJ)
TurB	Turbotville loam, 2 to 6 percent slopes	B: 80-116	12	none	C	HIGH	somewhat poorly		P	*Very Limited:* DTWT, RS, RH, DTB
WadB	Washington loam, 3 to 8 percent slopes	none	>60	none	B	MODERATE	WELL		P	*Not limited*
WadC2	Washington loam, 8 to 15 percent slopes, eroded	none	>60	none	B	MODERATE	WELL		SI	*Not limited*
Water	Water	--	0			--				--

Depth to Restrictive Features: **F**=Fragipan; **B**=Bedrock
Hydrologic Group: see **Table 4.1**
Farmland: **P**=Prime; **SI**=Statewide Importance
Septic Limitations (NJ): Very limited, somewhat limited, not limited, not rated
ECS=Excessively Coarse Substratum; **DTB**=Depth to Massive Bedrock; **DTWT**=Depth to Water Table; **F**=Flooding; **H**=Hydric soil; **RS**=restrictive substratum; **RH**=restrictive horizon; **S**=Too Steep



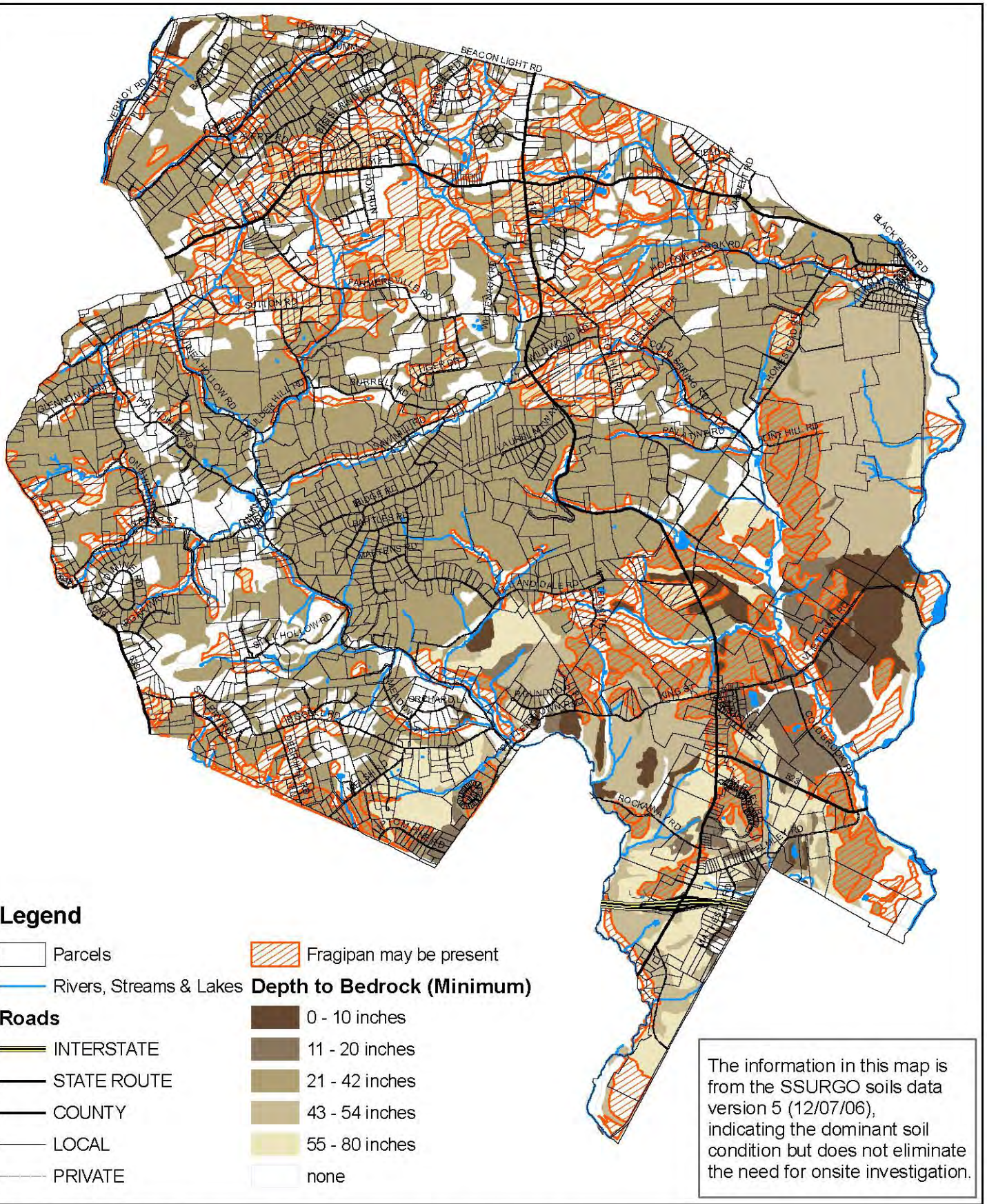
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 4a: Soil Series

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

- Parcels
- Rivers, Streams & Lakes

Roads

- INTERSTATE
- STATE ROUTE
- COUNTY
- LOCAL
- PRIVATE

- Fragipan may be present

Depth to Bedrock (Minimum)

- 0 - 10 inches
- 11 - 20 inches
- 21 - 42 inches
- 43 - 54 inches
- 55 - 80 inches
- none

The information in this map is from the SSURGO soils data version 5 (12/07/06), indicating the dominant soil condition but does not eliminate the need for onsite investigation.

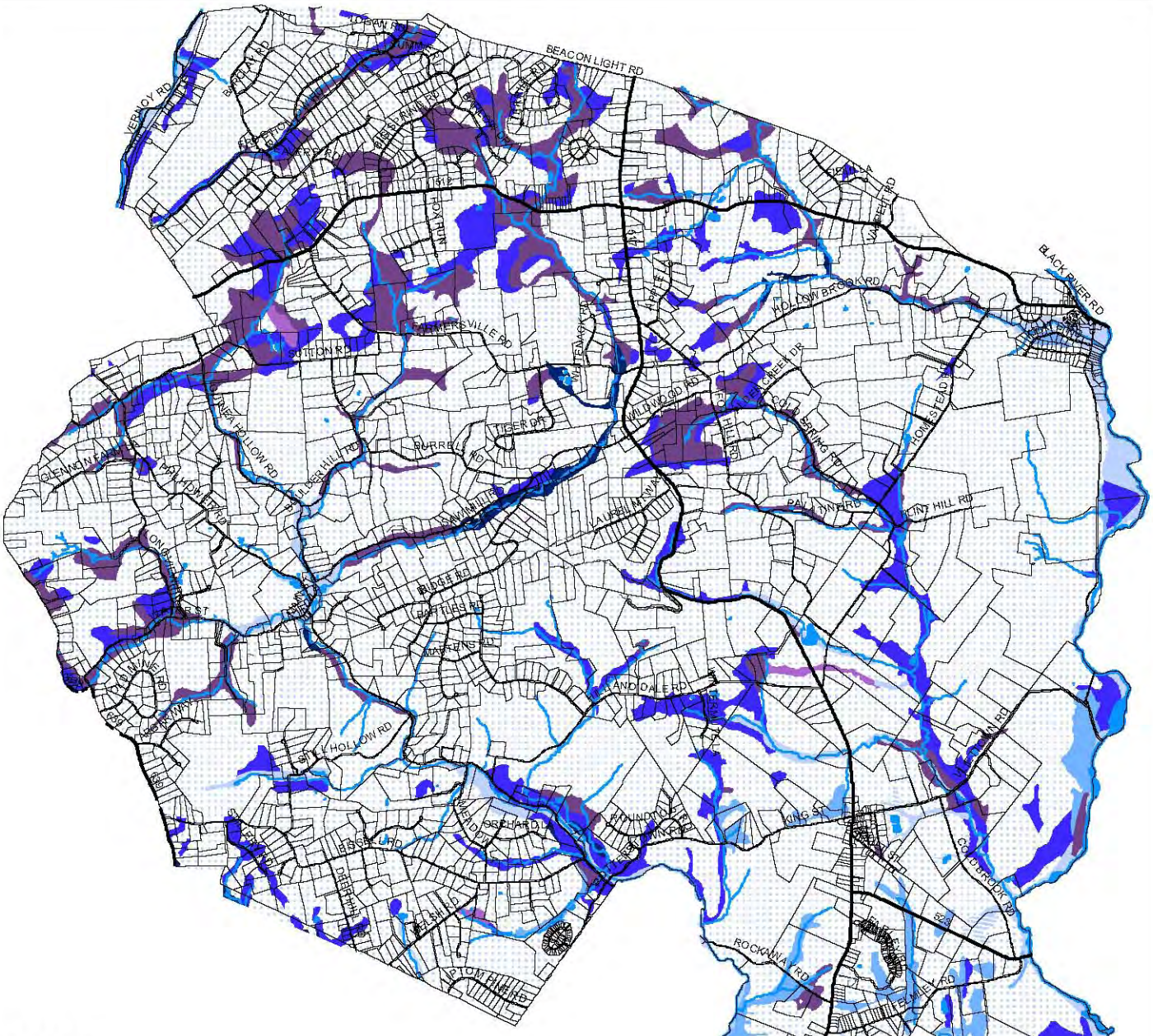
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 4b: Soils - Depth to Restrictive Layer (Bedrock or Fragipan)

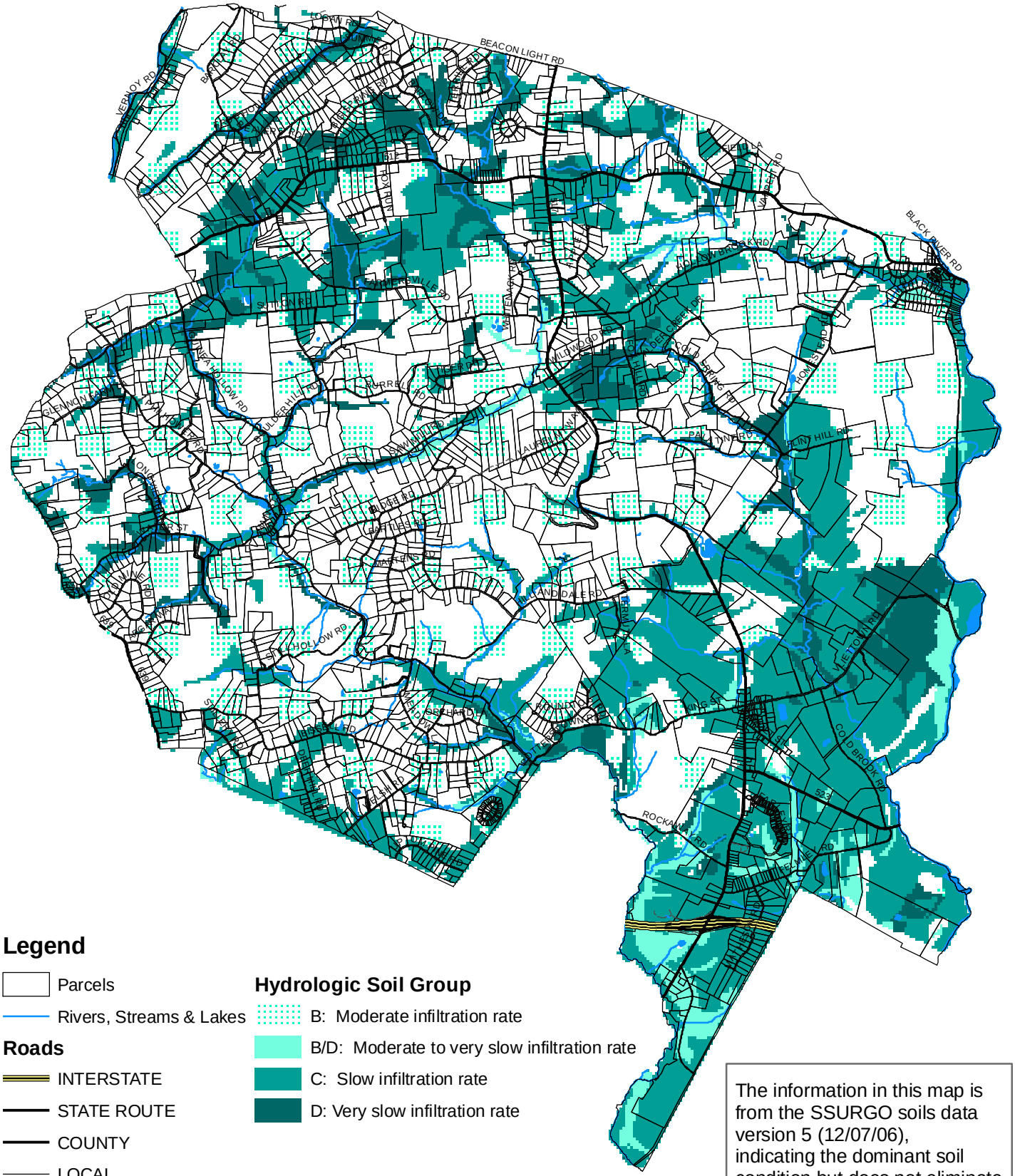
Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

Figure 4c: Soils - Seasonal High Water Table Depth

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Legend

- Parcels
- Rivers, Streams & Lakes

Roads

- INTERSTATE
- STATE ROUTE
- COUNTY
- LOCAL
- PRIVATE

Hydrologic Soil Group

- B: Moderate infiltration rate
- B/D: Moderate to very slow infiltration rate
- C: Slow infiltration rate
- D: Very slow infiltration rate

The information in this map is from the SSURGO soils data version 5 (12/07/06), indicating the dominant soil condition but does not eliminate the need for onsite investigation.

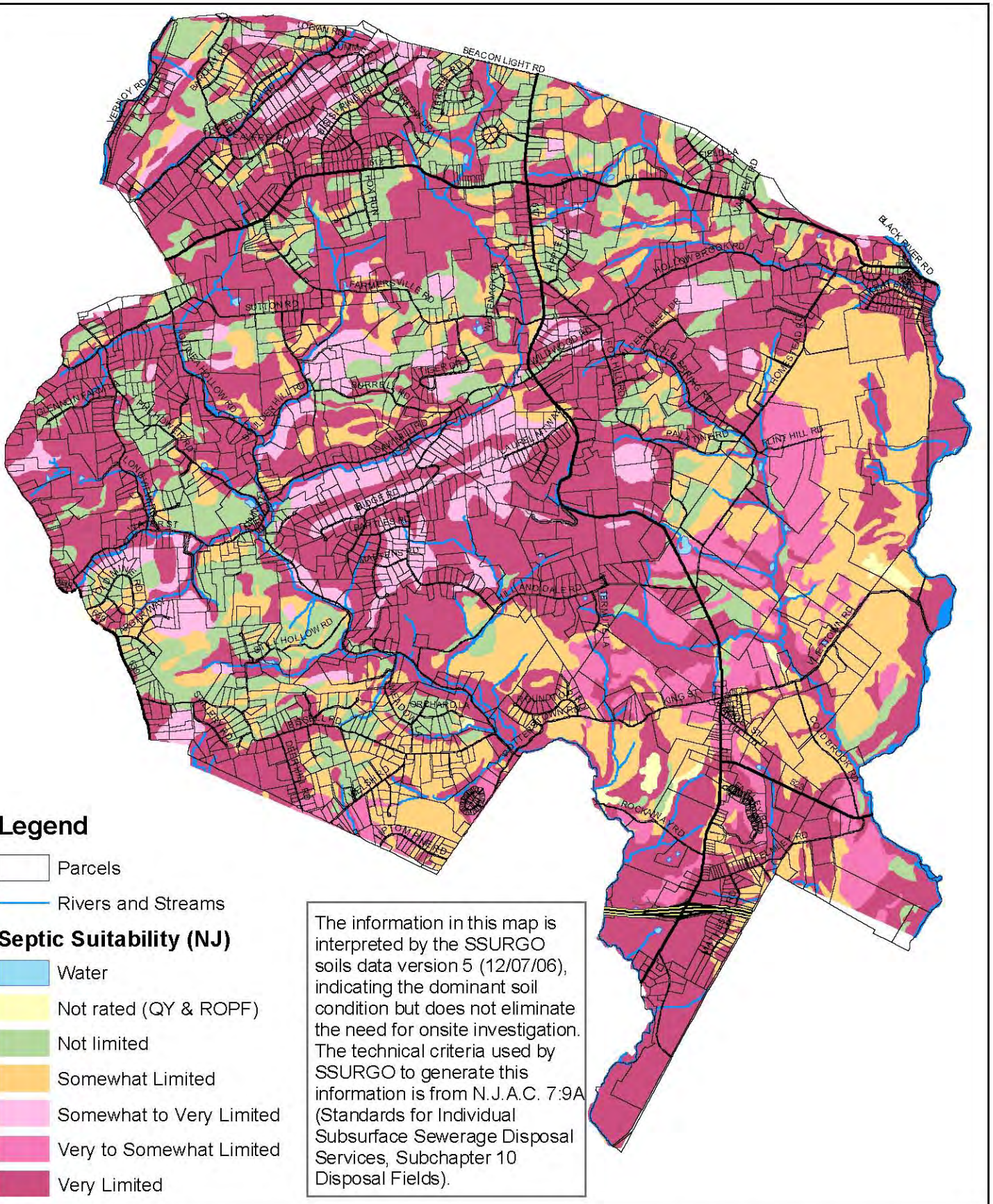
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 4d: Soils - Hydrologic Soil Grouping

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



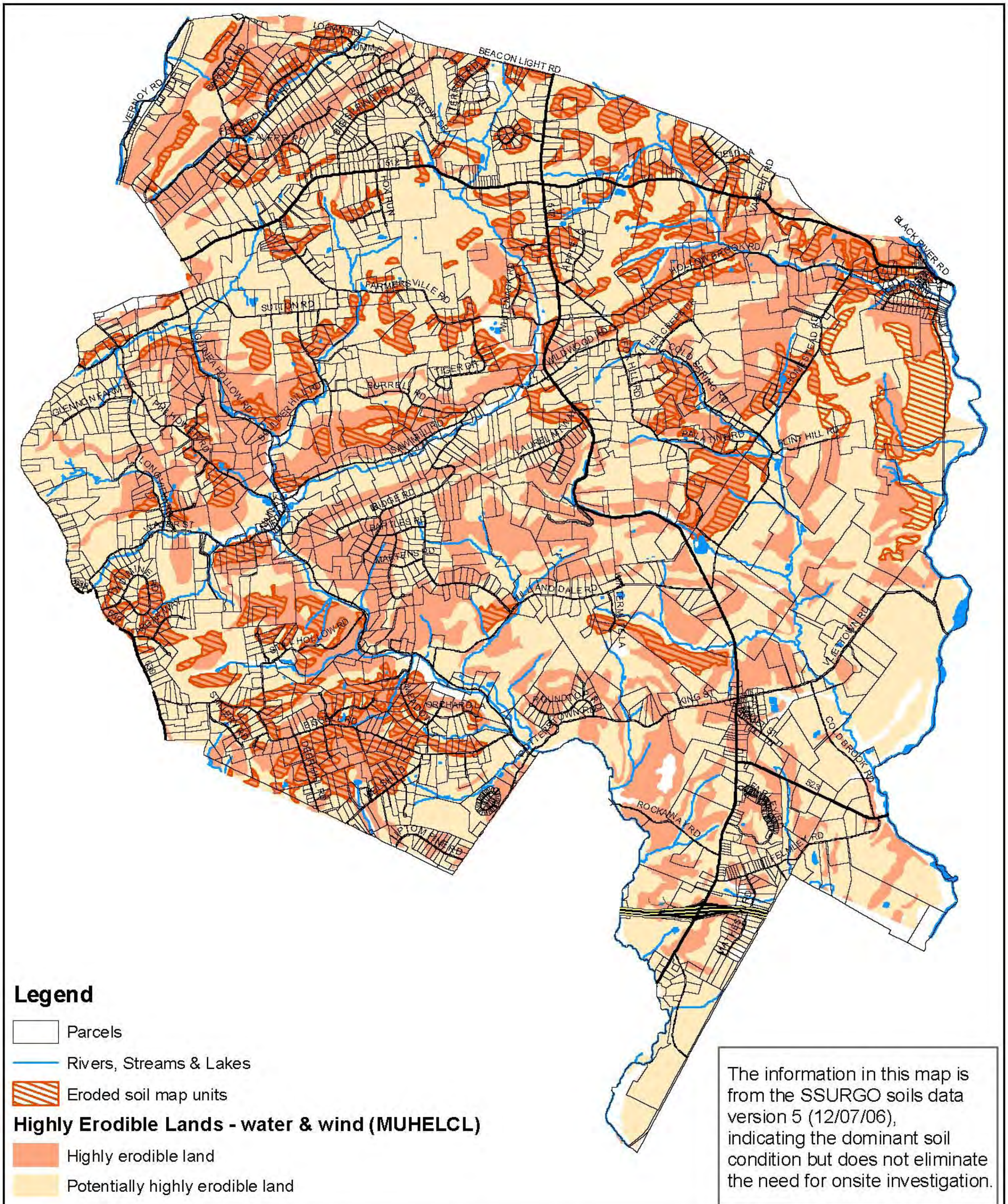
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 4e: Soils - Septic Suitability (NJ)

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



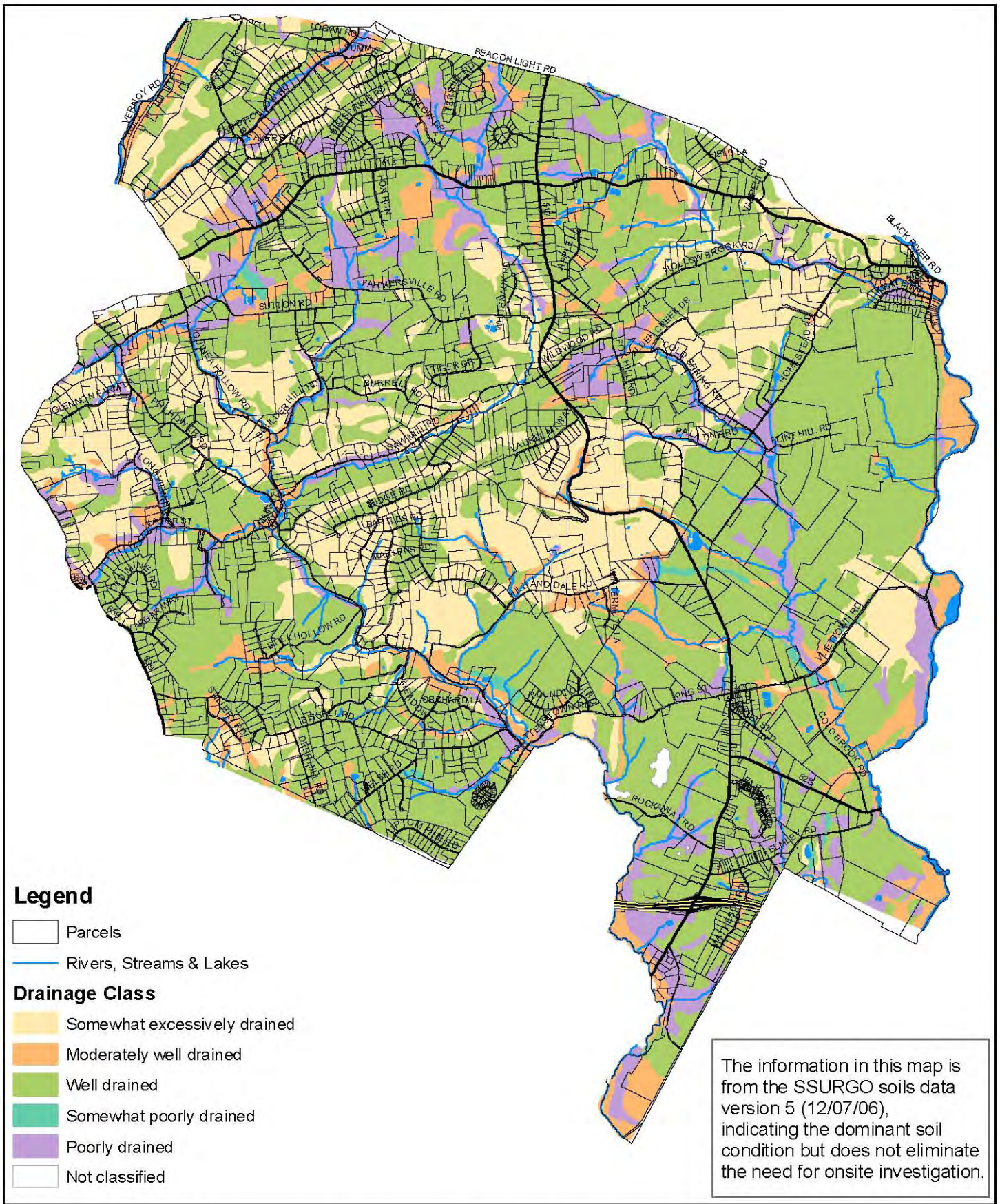
Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

N

0 0.25 0.5 1 1.5 Miles

Figure 4f: Soils - Erodible and Eroded Soils

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services



Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

Figure 4g: Soils - Drainage Class

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services

Data Sources: See Appendix B.
Note: Map accuracy is limited to the accuracy and scale of the original data sets; see Appendix B.
Disclaimer: This map was developed using NJDEP and Hunterdon County GIS digital data, but this secondary product has not been verified by NJDEP or Hunterdon County and is not NJDEP or county authorized.

Figure 4h: Soils - Prime Farmland Soils

Tewksbury Township ERI, 2009
Prepared by Kratzer Environmental Services