Environmental Resource Inventory

Update – 2012

for

Township of Frelinghuysen

County of Warren

Compiled by

The Land Conservancy of New Jersey
An accredited land trust

with

Township of Frelinghuysen Environmental Commission

June 2012

ENVIRONMENTAL RESOURCE INVENTORY UPDATE- 2012

for

Township of Frelinghuysen
County of Warren

Prepared for:

Township of Frelinghuysen Environmental Commission
and
Township of Frelinghuysen Planning Board

Prepared June 5, 2012 by:

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The original document was appropriately signed and sealed in accordance with Chapter 41, Title 13 of the State Board of Professional Planners.

ENVIRONMENTAL RESOURCE INVENTORY UPDATE - 2012

for

Township of Frelinghuysen
County of Warren

Produced by:

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Alan DeCarolis, Member - Resident
Dale Durling, Sr., Member - Township Committee Representative
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Bottom: Box Turtle, Frelinghuysen Forest Preserve (photograph taken by The Land Conservancy of New Jersey)

EXECUTIVE SUMMARY

Ensuring the high quality of life for the residents of Frelinghuysen Township is a driving force behind this *Environmental Resource Inventory Update*. Documentation of the natural resource base: the geology, hydrology, ecology, and wildlife will convey the scope and condition of the resources upon which the Township relies. This document, in combination with the *2012 Open Space and Recreation Plan Update* and the *2008 Comprehensive Farmland Preservation Plan,* is a guide for the Township's future growth and preservation.

The *2012 ERI Update* is based on available data from federal and state resources, as well as municipal resources, including the *2007 Master Plan*[1] and the *1989 Environmental Resource Inventory (ERI),* where still applicable. Certain elements of the *1989 ERI* have not been included here, since the information has been re-presented in other, more recent documents. For example, the history of Frelinghuysen presented in the *1989 ERI* (*pages 66-74*) has been included in the *Cultural History of Frelinghuysen Township* section *(pages 15-24*) of the *2006 Open Space and Recreation Plan*[2] and in the *Historic Preservation Element (pages 84-95)* of the *2007 Master Plan.* Vegetation was covered extensively in the *1989 ERI,* with a section stressing the importance and benefits of vegetation, plus lists of various types of plants that might be found in the different habitats of Frelinghuysen *(pages 43-58).* A similar listing by habitat was included in the *2007 Master Plan (pages 76-78).* Listings of wildlife and their habitats were similarly presented in the *1989 ERI* (*pages 59-62*). The *Vegetation (pages 43-58), Wildlife (pages 59-62), Birds Sighted (pages 63-64)* and *Plant Inventory at Genesis Farms (pages 86-87)* sections from the *1989 ERI* have been included in the *Appendix* of this document.

Bedrock geology is revisited here because the data has been remapped by the New Jersey Geological Service since the *1989 ERI* and *2007 Master Plan* were published. Similarly, the soils section presents a picture of the soils as updated in 2008 by the National Resources Conservation Service (NRCS), subsequent to the publication of the *2008 Comprehensive Farmland Preservation Plan.* Additional topics not visited in the *1989 ERI* have been added, including sections on public water supply and wellhead protection, flood hazards areas and contaminated sites.

[1] *http://www.frelinghuysen-nj.us/pdf/Frelinghuysen_Master_Plan.pdf*

[2] *http://www.frelinghuysen-nj.us/pdf/2006_Open_Space_and_Recreation_Plan.pdf*

LAND USE

Frelinghuysen Township is a rural community with much of its land, approximately 62.6%, farmland assessed as woodlands or active agricultural use. Another 15.1% of the Township is open space owned by the town, state, and nonprofit land trusts. Residential and commercial uses total 12.5%, while public and private schools, churches, cemeteries and other public property total 2.6%. Land owned by the New Jersey Department of Transportation (NJDOT), primarily along the Lackawanna Cutoff railroad bed, equals 1.2%, and vacant land represents 2.9%.[3] Land that does not fit in any of the other above categories accounts for 3.0% of the land use in Frelinghuysen Township and is noted in *Table 1* as "not classified." *Table 1 (page 2)* presents a summary of land use in Frelinghuysen.

Table 1. Summary of Land Use in Frelinghuysen Township

Land Use	*Acres*	*%*
Preserved Municipal Open Space	170	1.12%
State Parks and Open Space	975	6.38%
Nonprofit Land Trust	1,005	6.58%
Wildlife Preserves	158	1.03%
Farmland Assessed (Unpreserved)	7,908	51.77%
Farmland Assessed (Preserved)	1,659	10.86%
Residential & Commercial	1,909	12.50%
Schools, Church, Cemeteries, Charitable & Other Public Property	397	2.60%
NJDOT	185	1.21%
Vacant Land	448	2.93%
Not Classified	461	3.02%
Total	15,275	100%
Source: 2012 New Jersey County Tax Board Assessor database		

[3] Vacant land is undeveloped land with no structural improvements.

GEOLOGY AND TOPOGRAPHY

Physiographic Regions

New Jersey's landscape is divided into four distinctive regions, each characterized by unique geologic processes and landforms, known as physiographic provinces. Physiographic provinces classify landscapes based on terrain texture, rock type, and geologic structure and history. These attributes play an important role in determining the natural resources of an area. In New Jersey, beginning in the northwest and proceeding to the southeast, these provinces are identified as the Valley and Ridge, Highlands, Piedmont, and Coastal Plain Provinces. Frelinghuysen is located predominantly in the Valley and Ridge Province, with a small portion around Jenny Jump Mountain in the Highlands Province.

The **Valley and Ridge Province** covers approximately 536 square miles in the northwestern 15% of the state. Up to 17 miles wide, it is underlain by faulted and folded sedimentary layers of sandstone, shale and limestone formed from deposits in former seas and floodplains. These originally flat layers, ranging from 374 to 540 million years old, were tilted through compression into northeast-southwest trending steep-sided, linear sandstone ridges and broad shale and limestone valleys, including the main Kittatinny Valley. The limestone in this area often exhibit karst topography, including sinkholes and small caves.

The **Highlands Province** occupies an area of approximately 980 square miles to the east of the Valley and Ridge Province and comprises approximately one-eighth of the state. It is generally characterized as a mountainous belt ranging between 10 to 25 miles wide. The rugged topography of the Highlands consists of a series of discontinuous rounded ridges separated by deep narrow valleys. The Highlands is mainly composed of highly metamorphosed igneous and sedimentary rocks dating from more than a billion years ago. These rocks are relatively resistant to erosion and result in the steep slopes and mountains common in the Highlands. Also found in the Highlands are small areas of slightly younger (about 540 to 900 million years old) metasedimentary rocks and diabase dikes. *(NJGS Information Circular, Physiographic Provinces of New Jersey)*

The *Land Use/Land Cover Map* (*Map 9 in the Maps section*) shows the demarcation line between the two physiographic provinces.

Bedrock Geology

The geology of Frelinghuysen can be classified into two layers: bedrock geology, which is the consolidated, underlying rock that extends deep into the earth's crust, and surficial geology, which is the unconsolidated sedimentary materials overlaying bedrock formations, and which is the parent material for soils. The properties of these layers "determine the physical extent of aquifers and the chemical quality of the water they yield. They also control how groundwater recharges and moves through the aquifers, how contaminants seep into and move through soil and groundwater, and where natural hazards like radon, sinkholes, and seismic instability may occur. Finally, these properties

establish where geologic resources such as sand, gravel, peat, clay, quarry rock, and mineral ores are located. Geologic properties also determine the suitability of an area for the use of septic systems, the management of stormwater and surface runoff, and the stability of foundations for buildings, bridges, tunnels, and other structures" *(New Jersey Geological Survey, Information Circular – Geologic Mapping in New Jersey).*

The underlying bedrock geology changes significantly between the Valley and Ridge and Highlands Provinces. The *Bedrock Geology Map, (Map 1 in the Maps section)* depicts the distribution of bedrock types and *Table 2* (*page 4*) shows the frequency of occurrence. The predominant bedrock types are the Ramseyburg Member (30%), occurring in two large formations; the Bushkill Member (25%); and Allentown Dolomite (20%). Allentown, and the infrequently occurring Leithsville Formation, is more soluble and thus more susceptible to pollution than others. It can also exhibit karst features such as sinkholes, disappearing streams, and caverns. (see *Carbonate Rock [Karst] Topography* discussion on *page 9*). The harder bedrock, the gneisses and granites are scarce in Frelinghuysen and limited to the small Highlands Physiographic Province around Jenny Jump Mountain.

Table 2. Bedrock Geology in Frelinghuysen Township

Formation	*Lithology*	*Acres*	*Percent*
Valley and Ridge Province *Cambrian and Ordovician Periods (444-542 million years ago)*			
Allentown Dolomite - OCa	Very thin to very thick bedded dolomite containing minor orthoquartzite and shale. Oldest beds contain trilobite fauna of early Late Cambrian age; younger beds contain latest Cambrian fauna. Thickness about 1,900 ft.	3,038	19.89%
Beekmantown Group – Lower Part - Obl	Very thin to thick-bedded, interbedded dolomite and minor limestone. Unit is about 600 ft thick.	1,821	11.92%
Beekmantown Group - Upper Part - Obu	Locally preserved upper beds are light- to medium-gray- to yellowish-gray-weathering, medium-light- to medium-gray, aphanitic to medium-grained, thin- to thick-bedded, locally laminated, slightly fetid dolomite. Medium-dark to dark-gray, fine-grained, medium-bedded, sparsely fossiliferous limestone lenses occur locally. Lower beds are medium-dark- to dark-gray, medium- to coarse-grained, mottled surface weathering, medium- to thick-bedded, strongly fetid dolomite that contains pods and lenses of dark-gray to black chert. Cauliflower-textured black chert beds of variable thickness occur	736	4.82%

Table 2. Bedrock Geology in Frelinghuysen Township			
Formation	*Lithology*	*Acres*	*Percent*
	locally. Thickness ranges from 0-800 ft.		
Bushkill Member - Omb	Interbedded medium- to dark gray, thinly laminated to thick-bedded shale and slate and less abundant medium-gray to brownish-gray, laminated to thin-bedded siltstone. Thickness ranges from 4,100 ft in Delaware River Valley to 1,500 ft at New York State line.	3,789	24.81%
Hardyston Quartzite - Ch	Medium- to light-gray, fine- to coarse-grained, medium- to thick-bedded quartzite, arkosic sandstone and dolomitic sandstone. Thickness approximately 1.6-200 ft.	5	0.03%
Jacksonburg Limestone - Oj	Upper part is medium-to dark-gray, laminated to thin-bedded shaly limestone and less abundant medium-gray arenaceous limestone containing quartz-sand lenses. Lower part is interbedded medium- to dark-gray, fine- to medium-grained, very thin to medium-bedded fossiliferous limestone and minor medium- to thick-bedded dolomite-cobble conglomerate having a limestone matrix. Thickness ranges from 135-800 ft.	399	2.61%
Jacksonburg Limestone and Sequence at Wantage undivided - Ojw	Jacksonburg - see above. Sequence at Wantage - Restricted, discontinuous sequence of interbedded limestone, dolomite, conglomerate, siltstone, and shale. Upper part locally absent. Lower part ranges from grayish-red, medium-gray, pale-brown, and greenish-gray to pale-green mudstone and siltstone containing disseminated subangular to subrounded chert-gravel, quartz-sand lenses, and chert-pebble conglomerate. Thickness ranges from 0-150 ft.	176	1.15%
Leithsville Formation - Cl	Thin- to thick-bedded dolomite containing subordinate siliciclastic rocks. Thickness approximately 1,000 ft.	34	0.22%
Ramseyburg Member - Omr	Interbedded medium- to dark-gray, to brownish-gray, fine- to medium-grained, thin- to thick-bedded graywacke sandstone and siltstone and medium- to dark-gray, laminated to thin-bedded shale and slate. Thickness ranges from 2,100 ft in Delaware River Valley, to 5,000 ft near Stillwater.	4,571	29.92%

Table 2. Bedrock Geology in Frelinghuysen Township			
Formation	*Lithology*	*Acres*	*Percent*
Highlands Province *Middle Proterozoic (1-1.6 billion years ago)*			
Amphibolite Ya	Crystalloblastic metamorphic rock consisting mainly of amphibole and plagioclase with little or no quartz.	24	0.16%
Biotite-Quartz-Feldspar Gneiss - Yb	Gray-weathering, locally rusty, gray to tan or greenish-gray, fine- to medium-coarse-grained, moderately layered and foliated gneiss that is variable in texture and composition. Composed of oligoclase, microcline microperthite, quartz, and biotite. Locally contains garnet, graphite, sillimanite, and opaque minerals.	11	0.07%
Franklin Marble - Yf	White- to light-gray-weathering, white, grayish-white, or, less commonly pinkish-orange, coarse-to locally fine-crystalline calcite marble with accessory amounts of graphite, phlogopite, chondrodite, clinopyroxene, and serpentine.	72	0.47%
Hornblende Granite - Ybh	Pinkish-gray- to medium-buff-weathering, pinkish-white or light-pinkish-gray, medium- to coarse-grained, gneissoid to foliated granite & sparse granite gneiss composed of microcline microperthite, quartz, oligoclase, hornblende.	369	2.42%
Potassic Feldspar Gneiss - Yk	Light-gray- to pinkish-buff-weathering, pinkish-white to light-pinkish-gray, fine- to medium-grained, moderately foliated gneiss and lesser amounts of granofels composed of quartz, microcline, microcline microperthite and local amounts of biotite, garnet, sillimanite, and opaque minerals.	152	1.00%
Pyroxene Gneiss - Yp	White- to tan-weathering, greenish-gray, fine- to medium-grained, well-layered gneiss containing oligoclase, clinopyroxene, variable amounts of quartz, and trace amounts of opaque minerals and titanite. Some phases contain scapolite and calcite. Commonly interlayered with pyroxene amphibolite or marble.	69	0.45%
Quartz-Oligoclase Gneiss - Ylo	White-weathering, light-greenish-gray, medium- to coarse-grained, moderately layered to indistinctly foliated gneiss and	9	0.06%

Table 2. Bedrock Geology in Frelinghuysen Township			
Formation	*Lithology*	*Acres*	*Percent*
	lesser amounts of granofels composed of quartz, oligoclase or andesine, and, locally, biotite, hornblende and (or) clinopyroxene. Contains thin amphibolite layers.		
Total		15,275	100%
Source: NJDEP, NJGS, USGS			

The bedrock types, topography and hydrologic characteristics were included in the *1989 ERI* and the *2007 Master Plan.* The New Jersey Department of Environmental Protection (NJDEP) New Jersey Geologic Survey (NJGS) has since updated their mapping. The *2007 Master Plan* included a discussion of the importance of maintaining a potable subsurface water supply, as the Township is entirely dependent on groundwater:

> "Given the lack of any surface impoundments (reservoirs), the sustained availability of subsurface supplies of potable water is critical to all activities within the Township….Recently, however, the New Jersey Department of Environmental Protection and specifically the New Jersey Geologic Survey, have put a great deal of effort into an analysis of the recharge capabilities for various areas within the state basing the safe sustained yield of water for consumption on the amount [of] water which actually infiltrate the soils and could be expected to reach the aquifer for later withdrawal. This is being coupled with a renewed understanding and concern of potential pollution of these subsurface aquifers." *(2007 Master Plan, page 51)* (See also *Aquifer Recharge Potential Map [Map 7] in the Maps section* and the *Groundwater Recharge Areas* discussion beginning on *page 21*).

From a solubility perspective, the *Master Plan* further states:

> "The least resistant formations include the Leithsville and Allentown Dolomites. These areas lie in the central valley running generally from Dark Moon Road at the Green Township boundary to Interstate 80 at the Hope Township boundary, along with pockets along the Allamuchy Township boundary and a small portion adjacent to Stillwater Township, [and] are bounded by the more extensive Ramseyburg, Beekmantown Members." *(2007 Master Plan, page 56*)

Surficial Geology

Surficial geology is the unconsolidated materials overlaying bedrock formations. *Table 3 (page 8)* details the surficial geology, and the majority of the Township (82%) is covered in Kittatinny Mountain Till, Late Wisconsinan glacial deposits (delta and lake bottom) at 7% and Swamp and Marsh deposits at 4.5%. The *Surface Geology Map* (*Map 2 in the Maps section*) depicts the surficial geology features.

Table 3. Surficial Geology of Frelinghuysen Township			
Name	*Acres*	*%*	*Lithology and Depth*
Kittatinny Mountain Till (Qwtk)	12,395	84.57%	Clayey silt to silty sand with some to many pebbles and cobbles and few to many boulders; olive brown, brown, gray, reddish brown. As much as 150 feet thick, generally less than 40 feet thick.
Late Wisconsinan Glacial Delta Deposits (Qwde)	917	6.26%	Sand, pebble-to-cobble gravel, minor silt; yellowish brown, reddish brown, light gray. As much as 150 feet thick.
Late Wisconsinan Glacial Lake-Bottom Deposits (Qwlb)	193	1.32%	Silt, clay, fine sand; gray, brown, yellowish brown, reddish brown. As much as 200 feet thick.
Netcong Till (Qwtn)	422	2.88%	Silty sand to sandy silt with some to many pebbles and cobbles and some to many boulders; pale brown, yellowish brown, light gray. As much as 200 feet thick, generally less than 30 feet thick.
Postglacial Stream Terrace Deposits (Qst)	37	0.25%	Sand, silt, pebble-to-cobble gravel; yellowish brown to reddish brown. As much as 20 feet thick.
Swamp And Marsh Deposits (Qs)	693	4.73%	Peat and organic clay, silt, minor sand; gray, brown, black. As much as 40 feet thick.
Source: NJDEP NJGS			

Topography and Steep Slope

According to the *2007 Master Plan*, elevations in Frelinghuysen range from 1,135 feet above mean sea level at Jenny Jump Mountain to 475 feet above mean sea level at the intersection of the Paulins Kill with the Blairstown Township boundary. The variation in topography has directed the road network and "greatly affects the degree and severity of stormwater runoff and soil erosion." Together, these factors "affect the rate and type of soil formations." *(2007 Master Plan, page 49)* (See *Topography Map*, *Map 3 in the Maps section*).

Limiting the disturbance of steep slopes is important in preventing soil loss, erosion, excessive stormwater runoff, and the degradation of surface water; as well as maintaining the natural topography and drainage patterns of the land. Disturbing the natural vegetation, topography and drainage patterns of steep slopes often increases the amount and speed of runoff, and can cause erosion, soil creep, slumping (sections of soil shifting down and outward on the slope), and landslides. The combination of unstable slopes and greater runoff means that more water and sediment (silt) enter streams during precipitation events. Increases in water volume entering streams can lead to, or exacerbate flooding downstream. In addition, an increase in the volume entering streams through runoff means less water is percolating through the soil and back into the groundwater to replenish drinking water supplies or provide base flow for streams during

drier periods. The increased water runoff also carries larger loads of sediment compared to predevelopment conditions. Excess sediments in streams can harm aquatic life, accelerate the filling of ponds and wetlands, and decrease a stream's aesthetic appearance.

Steep slope ordinances can help protect a Township from the potential negative effects of development in areas of extreme steep slope. The Township Zoning Code designates steep slopes as a critical area, with the following intent:

1. To prevent soil erosion and stormwater runoff resulting from development.

2. Where slopes over 15% are included in a site plan or subdivision application, the applicant must demonstrate that development will not increase stormwater runoff or create soil erosion.

3. Development shall occur only on the portion of a tract outside the steep slope area, where feasible (*Ord. #2004-01; Ord. #2005-13 §4*).

Carbonate Rock (Karst) Topography

Carbonate rock, such as the dolomites and limestones found in Frelinghuysen Township, is highly soluble and forms the basis for several major aquifers in the United States, including the carbonate aquifers of the Valley and Ridge Province. *(U.S. Geological Survey)* Such a carbonate bedrock aquifer covers more than 6,190 acres in Frelinghuysen, according to a 2000 study, the *Frelinghuysen Township Karst Features Mapping Program (Karst Study),* commissioned by the Environmental Commission *(page 1 of the Karst Study)*. The location of this carbonate rock can be seen on the *Carbonate Rock, Ground Water Recharge and Wellhead Protection Areas in Frelinghuysen Township Map (Figure 1 on page 11)* and the distribution of bedrock aquifers is shown on the *Bedrock and Surficial Aquifers Map (Map 4 in the Maps section)*.

Carbonate aquifers are often known as karst aquifers, referencing the distinctive topographic features that result upon the dissolution of portions of this bedrock. The Township's *Karst Study* notes that "due to its relatively high capacity to dissolve in slightly acid water of natural chemistry, carbonate bedrock is prone to the formation of cavities. The landscape that forms atop cavernous limestone is known as 'karst.' Karst is characterized by the presence of sinkholes, caves, springs, disappearing streams, and an irregular bedrock surface, often with protruding rock outcrops." *(Karst Study, page 2)*

The *Karst Study* also notes that "where the limestone is at a shallow depth, sinkholes, open fractures and solution-enlarged joints allow rapid flow of contamination surface water into the groundwater system." The importance of these limestone aquifers to the residents of Frelinghuysen, who depend entirely on groundwater for their drinking water supply, "cannot be overstated." These karst areas also "present a hazard to individuals within structures, near utility lines, as well as those driving along roadways." *(Karst Study, page 1)* The specific characteristics and hazards of sinkholes, caves and pinnacles are discussed in detail on pages 2 and 3 of the karst study.

The *Karst Study* includes mapping that breaks down karst areas in Frelinghuysen into three groupings: shallow soils with rock pinnacles, Paleozoic dolomite and limestone and Precambrian marble. The mapping also locates seven specific karst features:

1. Devils Kitchen II – a cave formed along a fault zone;

2. Steven's Camp – a solution-enlarged joint in limestone bedrock, which allows percolation of water to the limestone aquifer and "may promote the downward movement of soil, forming sinkholes";

3. Southtown Sink – a large spring-fed sinkhole pond with no stream outlet, caused by erosion of soils into the underlying cavities;

4. Fridman Farm Spring – typical of springs throughout the Township, providing cold, clear water to local streams;

5. Hamilton Farm Sinkhole Pond – a vernal pond that receives runoff from surrounding land and spring flow and which floods in the spring and dries in the summer (vernal ponds serve as important aquifer recharge points for the limestone aquifer and can flood suddenly during wet years);

6. Devils Kitchen – a cave formed along a soluble strata;

7. Depression – springtime "sinkhole flooding along Shiloh Road," which would not show on a wetlands or floodplain map. *(Frelinghuysen Township Karst Features Mapping Program, page 4)*

The document addresses the issues of planning in karst terrain, including hazards of structural failure and groundwater contamination, with recommendations that include:

- An ongoing program to identify and map additional karst features, particularly sinkholes and large closed depressions;

- Mapping on the Township's drainage master plan of flooded areas resulting from the lack of sinkhole carrying capacity;

- Inclusion of the Karst Features Map in the early planning stages of development projects. *(Frelinghuysen Township Karst Features Mapping Program, page 7)*

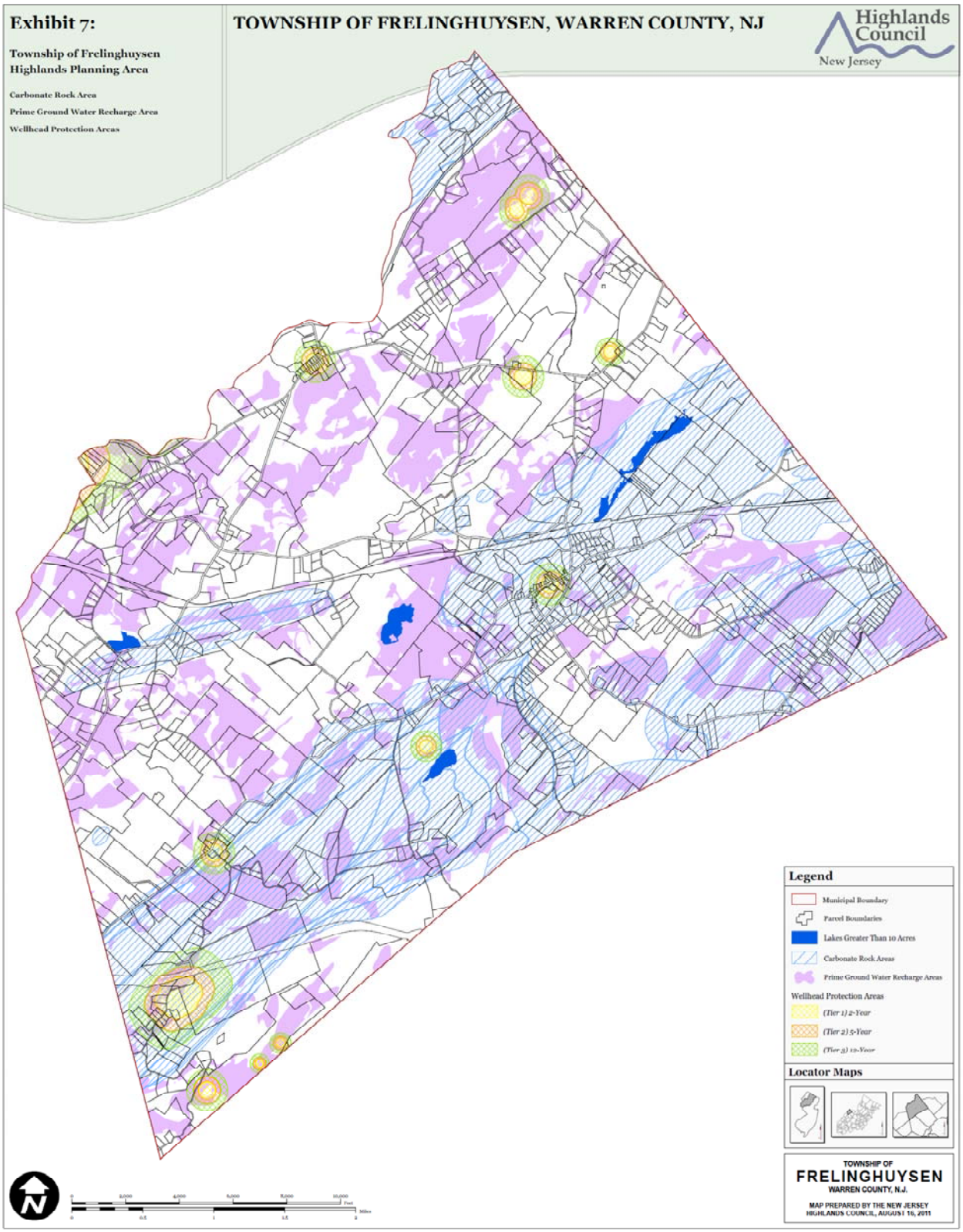

Figure 1. Carbonate Rock, Ground Water Recharge and Wellhead Protection Areas in Frelinghuysen Township

Source: New Jersey Department of Environmental Protection

SOILS

Soil: Overview

Soils play a critical role in the environment. They support an area's vegetation, absorb rainwater, and provide habitat. The physical and chemical properties of soils reflect a large number of variables, including the parent material (bedrock), climate, vegetative cover, animal activities, slopes and drainage patterns, and time. New Jersey's fairly complex bedrock geology, history of glaciations, abundant precipitation, and patterns of human use have led to complex patterns of soil distribution (*NJGS Information Circular, Geologic Mapping in New Jersey*).

The Natural Resources Conservation Service (NRCS) *Soil Survey* was updated in 2008, and the updated survey was officially published in May 2009. The discussion below reflects the current soil survey and supersedes the *2007 Master Plan* and the *2008 Comprehensive Farmland Preservation Plan.* The *Soil Map* (*Map 5 in the Maps section*) depicts distribution of soils within Frelinghuysen. The soils are identified by the abbreviation of their map unit name. According to the NRCS, an agency of the United Sates Department of Agriculture (USDA), "A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils." *Table 4* (*page 12*) provides a summary of soils in Frelinghuysen.

Table 4. Soils of Frelinghuysen Township

Abbv.	*Map Unit Name*	*Acres*	*%*
AhbBc	Alden silt loam, 0 to 8 percent slopes, extremely stony	333.02	2.18%
AhcBc	Alden mucky silt loam, gneiss till substratum, 0 to 8 percent slopes, extremely stony	26.15	0.17%
CatbA	Catden mucky peat, 0 to 2 percent slopes	398.37	2.61%
ChkE	Chatfield-Hollis-Rock outcrop complex, 35 to 60 percent slopes	176.39	1.16%
ChwBc	Chippewa silt loam, 0 to 8 percent slopes, extremely stony	180.36	1.18%
FaxC	Farmington-Rock outcrop complex, 0 to 15 percent slopes	493.08	3.23%
FdwB	Farmington-Wassaic-Rock outcrop complex, 0 to 8 percent slopes	427.09	2.80%
FrdAb	Fredon-Halsey complex, 0 to 3 percent slopes, very stony	875.12	5.73%
GkanCc	Gladstone loam, 8 to 15 percent slopes, extremely stony	23.20	0.15%
GkanDc	Gladstone loam, 15 to 25 percent slopes, extremely stony	11.32	0.07%
HazAs	Halsey silt loam, 0 to 3 percent slopes, occasionally flooded	268.92	1.76%
HdxAb	Hazen-Hoosic complex, 0 to 3 percent slopes, very stony	407.89	2.67%
HdxBb	Hazen-Hoosic complex, 3 to 8 percent slopes, very stony	840.25	5.50%
HncD	Hollis-Rock outcrop-Chatfield complex, 15 to 35 percent slopes	54.41	0.36%
HonCb	Hoosic-Hazen complex, 8 to 15 percent slopes, very stony	449.24	2.94%
HopEb	Hoosic-Otisville complex, 25 to 60 percent slopes, very stony	368.21	2.41%

Table 4. Soils of Frelinghuysen Township			
Abbv.	*Map Unit Name*	*Acres*	*%*
NauBh	Nassau-Manlius complex, 0 to 8 percent slopes, very rocky	395.54	2.59%
NauCh	Nassau-Manlius complex, 8 to 15 percent slopes, very rocky	2032.91	13.32%
NauDh	Nassau-Manlius complex, 15 to 35 percent slopes, very rocky	2165.79	14.19%
NavE	Nassau-Rock outcrop complex, 35 to 60 percent slopes	676.33	4.43%
NetCb	Netcong loam, 8 to 15 percent slopes, very stony	33.04	0.22%
PaoC	Parker gravelly sandy loam, 3 to 15 percent slopes	10.47	0.07%
PaoD	Parker gravelly sandy loam, 15 to 25 percent slopes	20.09	0.13%
PHG	Pits, sand and gravel	16.13	0.11%
RnfC	Rock outcrop-Farmington-Galway complex, 8 to 15 percent slopes	986.30	6.46%
RnfD	Rock outcrop-Farmington-Galway complex, 15 to 35 percent slopes	2274.93	14.90%
RokB	Rockaway-Chatfield-Rock outcrop complex, 0 to 8 percent slopes	17.39	0.11%
RokC	Rockaway-Chatfield-Rock outcrop complex, 8 to 15 percent slopes	93.60	0.61%
RokD	Rockaway-Chatfield-Rock outcrop complex, 15 to 35 percent slopes	131.81	0.86%
TheaAt	Timakwa muck, 0 to 2 percent slopes, frequently flooded	33.03	0.22%
UdaB	Udorthents, 0 to 8 percent slopes, smoothed	48.36	0.32%
UdauB	Udorthents-Urban land complex, 0 to 8 percent slopes	112.10	0.73%
VepBc	Venango silt loam, 0 to 8 percent slopes, extremely stony	307.85	2.02%
VepCc	Venango silt loam, 8 to 15 percent slopes, extremely stony	78.69	0.52%
WusBc	Wurtsboro-Swartswood complex, 0 to 8 percent slopes, extremely stony	178.88	1.17%
WusCc	Wurtsboro-Swartswood complex, 8 to 15 percent slopes, extremely stony	128.96	0.84%
WusDc	Wurtsboro-Swartswood complex, 15 to 35 percent slopes, extremely stony	63.08	0.41%
Water	Water	127.99	0.84%
	Total	15,266	100.00%
Source: NRCS Soil Survey[4]			

Soil Characteristics

Soil characteristics determine land's suitability for development, including its capacity to support foundations without corrosion, limitations for septic and helping to identify areas whose water characteristics, may limit development. The NRCS Soil Survey states:

[4] The acreage of Frelinghuysen Township in the *ERI Update* is calculated using ArcGIS software and may vary based on the data source.

"Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations." *Table 5* (*page 15*) explores the following characteristics:

Depth to restrictive layer — vertical distance from the soil surface to the upper boundary of a restrictive layer that impedes the movement of water and air through the soil or that restricts roots. Examples are bedrock, cemented layers, dense layers, and frozen layers.

Drainage – relative wetness of the soil under natural conditions due to the water table.

Capacity [of most limiting layer] to transmit water – ease with which pores in a saturated soil transmit water and is considered in the design of soil drainage systems and septic tank absorption fields.

Depth to water table – range of expected depth to a saturated zone in the soil, known as a "water table," that occurs during specified months in most years.

Flooding – temporary inundation of an area caused by overflowing streams or by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding.

Ponding – standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation.

Available water capacity – the quantity of water that the soil is capable of storing for use by plants, measured inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water.

Potential for frost action – the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

Risk of corrosion – potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

Septic limitations: All of the soils in Frelinghuysen are classified by the NRCS as "very limited," which indicates that the soil has at least one feature that is unfavorable for such use, with the expectation of poor performance and high maintenance. Most Frelinghuysen soils are classified as very limited based on low rankings for filtering capacity and bottom layer seepage; additionally, many are limited because they are on slopes that are too steep. *(USDA NRCS)*

Table 5. Characteristics of Soils in Frelinghuysen Township									
Soil Abbrev.	*Depth to Restrictive Features (In)*	*Drainage*	*Capacity to Transmit Water (in/hr)*	*Depth to Water Table (in)*	*Flooding/ Ponding*	*Available Water Capacity (in)*	*Frost Action Potential*	*Corrosion Risk: Steel/ Concrete*	*Septic Limitations*
AhbBc	>80	Very poor	ML-NH 0.06-.57/hr	0	None/ Frequent	High (9.9)	High	H/L	Very limited
AhcBc	>80	Very poor	ML-NH 0.06 to 0.57	0	None/ Frequent	High (9.4)	High	H/L	Very limited
CatbA	>80	Very poor	MH-H 0.20 to 5.95	0	None/ Frequent	VH 26.8	High	H-L	Very limited
ChkE*	C: 20-40 Bedrock H: 10-20 bedrock	Well Well	L-H 0.01 to 1.98 L-H 0.01 to 1.98	>80 >80	None/ None None/ None	Low (4.8) Very low 2.9	Mod Mod	L/M L/H	Very limited
ChwBc	8-20 Fragipan	Poor	VL-MH 0.00 to 0.20	0	None/ Frequent	Very low 2.4	High	H/M	Very limited
FaxC	10-20 Bedrock	Well	VL-MH 0.00 to 0.60	>80	None/ None	Very low 2.2	Mod	L/M	Very limited
FdwB	10-20 Bedrock	Well	VL-MH 0.00 to 0.60	>80	None/ None	Very low 2.2	Mod	L/M	Very limited
FrdAb*	F: 22-40 stratification H: 20-40 Stratification	Somewhat poor Very poor	MH-H 0.20 to 1.98 MH-H 0.57 to 5.95	6-18 0	None/ None None/ Frequent	Low 4.1 Low 3.7	High High	L/L HL	Very limited
GkanCc	40 Bedrock	Well	MH-H 0.60 to 2.00	>80	None/ None	Low 4.4	Mod	L/H	Somewhat limited
GkanDc	>80	Well	MH-H 0.60 to 2.00	>80	None/ None	Mod 6.5	Mod	L/H	Very limited
HazAs	20-40 stratification	Very poor	MH-H 0.60 to 2.00	0-6	Occasional/ None	Low 5.5	High	H/L	Very limited

Table 5. Characteristics of Soils in Frelinghuysen Township									
Soil Abbrev.	*Depth to Restrictive Features (In)*	*Drainage*	*Capacity to Transmit Water (in/hr)*	*Depth to Water Table (in)*	*Flooding/ Ponding*	*Available Water Capacity (in)*	*Frost Action Potential*	*Corrosion Risk: Steel/ Concrete*	*Septic Limitations*
HdxAb* HdxBb*	Ha: >80 Ho: >80	Well Somewhat excessively	MH-H 0.57 to 5.95 H-VH 1.98 to 19.98	>80 >80	None/None None/None	Low 4.9 Low 4.5	Mod Low	L-L L-H	Very limited
HncD*	H: 10-20 Bedrock C: 20-40 Bedrock	Well Well	L-H 0.01 to 1.98 L-H 0.01 to 1.98	>80 >80	None/ None None/ None	Very low 2.9 Low 4.8	Mod Mod	L/H L/M	Very limited
HonCb*	Ho: >80 Ha: >80	Somewhat excessively Well	H-VH 1.98 to 19.98 MH-H 0.57 to 5.95	>80 >80	None/None None/ None	Low 4.5 Low 4.9	Low Mod	L-H L-L	Very limited
HopEb	>80	Somewhat excessive	H-VH 1.98 to 19.98	>80	None/ None	Low 4.5	Low	L/H	Very limited
NauBh* NauCh* NauDh*	N: 10-20 Bedrock M: 20-40 Bedrock	Somewhat excessive Well	VL-ML 0.00 to 0.06 VL-ML 0.00 to 0.06	>80 >80	None/ None None/ None	Very low 1.7 Very low 2.9	Mod Mod	L-H L-M	Very limited
NavE	10-20 Bedrock	Somewhat excessive	VL-ML 0.00 to 0.06	>80	None/ None	Very low 1.9	Mod	L-H	Very limited
NetCb	>80	Well	MH-H 0.60 to 2.00	>80	None/ None	Low 6.0	Low	L-M	Very limited
PaoC PaoD	48-99 Bedrock	Somewhat excessive	High 2.00 to 6.00	>80	None/ None	Low 5.1	Mod	L-H	Very limited
PHG	--	--	--	--	--	--	--	L-H	Not rated
RnfC* RnfD*	10-40 Bedrock	Well	VL-MH 0.00 to 0.06	>80	None/ None	VL-L 2.2-3.8	Mod	L-M	Very limited

Table 5. Characteristics of Soils in Frelinghuysen Township									
Soil Abbrev.	*Depth to Restrictive Features (In)*	*Drainage*	*Capacity to Transmit Water (in/hr)*	*Depth to Water Table (in)*	*Flooding/ Ponding*	*Available Water Capacity (in)*	*Frost Action Potential*	*Corrosion Risk: Steel/ Concrete*	*Septic Limitations*
RokB* RokC* RokD*	R: 18-40 fragipan C: 20-40 Bedrock	Well Well	VL-MH 0.00 to 0.20 L-H 0.01 to 1.98	18-40 >80	None/None None/None	Low 3.3 Low 4.8	Mod Mod	L-H L-M	Very limited
TheaAt subsidence	>80	Very poor	MH-H 0.20 to 5.95	0	Frequent/ Frequent	VH 18.0	High	H-M	Very limited
UdaB	>80	Well	ML-MH 0.06 to 0.20	>80	None/ None	Mod 6.7	Mod	M-H	Very limited
UdauB*	U: >80 --	Well --	ML-MH 0.06 to 0.20 --	>80 --	None/ None --	Mod 6.7 --	Mod None	M-H L-M	Very limited Very limited
VepBc VepCc	14-28 Fragipan	Somewhat poor	VL-MH 0.00 to 0.20	6-18	None/ None	Low 3.1	High	H-H	Very limited
WusBc* WusCc* WusDc*	W: 17-28 Fragipan S: 20-36 Fragipan	Moderately well Well	ML-MH 0.06 to 0.20 ML-MH 0.06 to 0.57	15-26 20-36	None/ None None/ None	Low 3.1 VL 2.4	Mod Mod	H-H L-H	Very limited

*Soil Complexes (ChKE: Chatfield-Hollis; FrdAb: Fredon-Halsey; Hdx: Hazen-Hoosic: HncD: Hollis-Chatfield; Hon: Hoosic-Hazen; Nau: Nassau-Manlius; Rnf: Farmington-Galway; Rok: Rockaway-Chatfield; UdauB: Udorthents-Urban land; Wus: Wurtsboro-Swartswood)
The capital letter suffixes A-E in the soil abbreviation indicate steepness, with A being nearly level and E being very steep; the small letter suffixes indicate other attributes such as whether the soil is very or extremely stony (b,c), very rocky (h) or rarely or occasionally flooded (r,s).

Source: USDA-NRCS Web Soil Survey (Version 7, Feb 24, 2010)

WATER RESOURCES

Watersheds

"A watershed is a topographic area within which apparent surface water runoff drains into a specific point on a stream or to a waterbody such as a lake." *(EPA, Ecoregions and Watersheds, 1997)* A watershed-based approach to natural resource management is considered by state and national agencies to be the most appropriate unit for managing complex environmental problems. The NJDEP has divided the state into Watershed Management Areas (WMAs). Frelinghuysen lies entirely within WMA 1, also known as the Upper Delaware WMA, which covers 746 square miles and includes 54 municipalities in northwestern New Jersey. This WMA represents the area drained by six major drainage basins: the Delaware River, Flat Brook, Lopatcong and Pohatcong River Drainage, Musconetcong River, and the Paulins Kill and Pequest River basins, where Frelinghuysen is located. According to the NJDEP, these drainage basins provide outstanding recreational resource for trout production and maintenance, as well as habitat for wildlife. While still a rural area, WMA 1 has been impacted by suburban development in recent years. The Paulins Kill watershed has the most developed centers, but is also known for its agriculture and forested areas. Water quality ranges from fair to good. Land use in the Pequest watershed is heavily forested and agricultural. Pollution from crop lands and animal holdings has been on the decline, but is often offset by the effects of suburban runoff, resulting in increased stream temperatures and elevated levels of sediment, bacteria and phosphorus. According to the NJDEP Division of Watershed Management, Bureau of Watershed Planning fact sheet on WMA 1, a regional watershed plan for the Paulins Kill, which will set goals and establish management measures and detail specific projects, is under development. *(NJDEP)*

Every WMA is composed of multiple watersheds and subwatersheds. The United States Geological Survey (USGS) has mapped and identified watersheds using a hierarchal numbering system. This system identifies watersheds using a hydrological unit code (HUC) consisting of up to 14 digits for the smallest watersheds. The majority of Frelinghuysen lies within five of these HUC14 watersheds, with very small portions of two other subwatersheds extending minimally into the Township. These watersheds are depicted in the *Watershed and Surface Water Map (Map 6 in the Maps section)* and they are listed in *Table 6. HUC 14 Watersheds in Frelinghuysen Township* on *page 19*, along with their net water availability. The majority of Frelinghuysen Township lies in HUC14 watersheds where net water availability, measured in millions of gallons per day, is positive, an indication that there is water available beyond existing demands.

Table 6. HUC14 Watersheds in Frelinghuysen Township			
HUC14	*Acres*	*%*	*Net Water Availability (MGD*)*
Paulins Kill (Blairstown to Stillwater)	4,022	26.3%	0.00 to 0.04
Beaver Brook (above Hope Village)	1,948	12.8%	0.00 to 0.04
Union Church Trib (Beaver Brook)	3,424	22.4%	0.00 to 0.04
Bear Creek	4,468	29.3%	0.05 to 0.09
Bear Brook (Sussex/Warren County)	1,350	8.8%	-0.09 to -0.01
Pequest River (below Bear Swamp)	44	0.3%	-0.99 to -0.10
Pequest River (Bear Swamp & above)	18	0.1%	0.05 to 0.09
(*) Million Gallons Per Day *Source: NJDEP*			

Surface Waters

Surface water is water that collects on the ground or in a stream, river, lake, wetland, or ocean. Surface waters within Frelinghuysen include several lakes and water bodies.

Most notably, Frelinghuysen includes the Johnsonburg Natural Area, which is part of the Pequest Watershed. The Area includes Mud Pond and its outlet stream, Bear Creek, to the Erie Lackawanna Railroad trestle, north of Johnsonburg. New Jersey's Surface Water Quality Standards (SWQS) (N. J. A. C. 7:9) classify it as Fresh Water 1 (FW1), the highest level of classification, which is defined as:

> "those fresh waters, as designated in N.J.A.C. 7:9B-1.15(j), that are to be maintained in their natural state of quality (set aside for posterity) and not subjected to any manmade wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance or exceptional fisheries resource(s)."

The general classification for the other fresh waters in the State is Fresh Water 2 (FW2). Further classifying these water bodies, the presence of trout in a stream means that the waters are relatively free of chemical or biological contaminants. A stream can be classified as Trout Production (TP), Trout Maintenance (TM) or Non-Trout (NT). Trout production waters are waters designated "for use by trout for spawning or nursery purposes during their first summer." Trout maintenance waters support trout throughout the year. Waters classified as Non-Trout (NT) do not support trout, either because of their physical nature or due to biological or chemical characteristics. Additionally, Category One (C1) waters are FW2 waters that have been identified for protection from measurable changes in water quality based on exceptional ecological, recreational or water supply significance, or exceptional fisheries resource(s). Part of the protection process is a regulation implementing a 300-foot buffer on each bank of a C1 stream.

Table 7 (page 20) is a list of rivers and streams that are located wholly or in part in Frelinghuysen, along with their SWQS classifications:

Table 7. Water Body Classifications in Frelinghuysen Township	
Water Body	*SWQS Classification*
Bear Brook	FW2-TP(C1)
Bear Creek • Mud Pond to the Erie-Lackawanna Railroad trestle north of Johnsonburg • Erie-Lackawanna Railroad trestle to confluence with Trout Brook (Allamuchy), including all unnamed and unlisted tributaries	 FW1(TM) FW2-TM(C1)
Beaver Brook	FW2-NT
Mud Pond	FW1
Trout Brook (Hope)	FW2-TM
Paulins Kill	FW2-TM
Source: NJDEP	

The quality of surface waters can be affected by point sources and non-point sources of pollution as well as from erosion and sedimentation. Point source means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged (*Clean Water Act, 1972*). This includes discharges from sewage treatment plants and factories, stormwater runoff, illegal dumping, and malfunctioning underground storage tanks and septic systems. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

As opposed to point source pollution, non-point source pollution comes from many different sources. As rainfall or snowmelt moves over and through the ground, it picks up and carries natural and human-made pollutants (such as fertilizers, herbicides and motor oil) and deposits them into surface and groundwater.

The effects of pollutants on specific waterways can vary, but are manifested in drinking water supplies, recreation, fisheries, and wildlife. One of these effects is eutrophication. Eutrophication in freshwater systems is the addition of substances, either human-made or natural, to a waterbody, affecting the primary productivity of that waterbody. Substances such as nitrates and phosphates promote excessive algae and phytoplankton growth. These "blooms" can have negative effects on the ecosystem. These negative impacts include a clouding of the water, which limits sunlight, stopping the growth of plants deeper in the water. Additionally, eutrophication can lead to anoxia, a condition where a waterbody has depleted levels of oxygen, which is the result of the decomposition of dead phytoplankton.

As stated in the *1989 ERI* on *page 36*,

> "Sediment from erosion is the largest pollutant of surface waters. Sediments fill in stream channels thereby reducing their ability to carry storm waters. Not only is sediment a primary pollutant, it also carries absorbed pollutants such as pesticides, as well as oils and leads from road run-off. Sediment-loaded streams and brooks not only affect water quality but also aquatic life by damaging bottom organisms on the stream bed that are essential to their survival.
>
> Erosion in our area occurs most often from the action of running water (as rain or snow) or wind. Many soils, once eroded, have a lower infiltration rate than in their uneroded state, thereby reducing groundwater recharge."

Over 60% of Frelinghuysen's soils have been classified by the NRCS as highly erodible.

Groundwater Recharge Areas

Ground water is the primary drinking and agricultural water source for the residents of Frelinghuysen Township. Groundwater recharge is the process in which surface water, from lakes, streams, rainwater runoff, flows or seeps downwards beneath ground surface, saturating soil or rock. Ground water is contained in porous rocks and sediments. Where such water-holding rocks or unconsolidated materials can yield a usable quantity of water, it is called an aquifer, the source from which drinking water is drawn through wells. Protecting the land's capacity to recharge its aquifers, and limiting development to stay within the capacity of local water resources, is critical to maintaining our water supply.

Aquifer-recharge potential was calculated through the combination of a standardized statewide aquifer ranking system and the particular groundwater recharge coverage in the area of interest, in this case, Warren County. Aquifer recharge or recharge to water-bearing geologic units is defined as the groundwater that reaches the water table in the uppermost geologic unit with a thickness of 50 feet or greater. Groundwater recharge potential is ranked by average annual infiltration. The composite aquifer/groundwater recharge potential rank highlights the multiple relationships between the groundwater-recharge area ranks (indicative of the infiltration rate) and the underlying water-table aquifer ranks (indicative of the aquifer's capacity to absorb, transmit and supply water). *Table 8* (*page 21*) outlines the ranking system for Warren County.

Table 8. Aquifer and Groundwater Rankings for NJ/Warren County

Groundwater Rank	*Avg. Annual Infiltration (In/Yr)*	*Aquifer Rank*	*Median Well Yield (Gallons/Minute)*
A	17- 21	A	>500
B	14- 16	B	>250-500
C	11- 13	C	>100-250
D	1-10	D	25-100
E	0	0	<25

There are also hydric soils (L/L), wetlands and open water (W/W) and instances where no recharge is calculated (X/X). Source: NJDEP NJGS

Table 9 (page 22) and the *Aquifer Recharge Potential Map (Map 7 in the Maps section)* show the distribution of rankings for Frelinghuysen Township. Approximately 13% of Frelinghuysen is identified as hydric soils, wetlands and open water. Aquifer rankings for more than half of the Township fall in the D (25-100 gpm) range, with the remaining areas ranked B (250-500 gpm). Groundwater rankings in much of the Township range from A through D, but fall largely in the B range (14-16 in/yr). Approximately 26% of Frelinghuysen has a combined groundwater/aquifer ranking of B/B. Because the amount of groundwater recharge that becomes aquifer recharge is controlled by the ability of the underlying aquifer to transmit water, a lower groundwater rank combined with a higher aquifer rank (e.g., D/B) has a greater aquifer recharge potential than an area where a higher groundwater rank is combined with a lower aquifer rank (e.g., B/D).

Table 9. Aquifer Recharge Rankings in Frelinghuysen Township

Rank Groundwater/Aquifer	*Acres*	*%*
A/B	405	3%
B/B	3,940	26%
C/B	769	5%
D/B	8	0%
A/D	281	2%
B/D	4,860	32%
C/D	2,920	19%
D/D	36	0%
L/L	320	2%
W/W	1,711	11%
X/X	16	0%
Total	15,266	100%

Source: NJDEP[5]

Aquifer Identification

An aquifer is an underground formation of permeable rock or unconsolidated materials that can yield significant quantities of water to wells or springs. As discussed in the prior section, the rate of recharge is not the same for all aquifers, and that must be considered when pumping water from a well. Pumping too much water too fast draws down the water in the aquifer and eventually causes a well to yield less and less water and even run dry.

Aquifers are typically equated to the type of geologic formation in which they exist. Aquifers in New Jersey are classified as either bedrock or surficial. Bedrock aquifers consist of rock formations while surficial aquifers are formed from unconsolidated

[5] The total acreage of Frelinghuysen Township is calculated using the ArcGIS computerized mapping software and the data used is based on different primary resources used for various purposes throughout this study and therefore varies, dependent upon the data source utilized.

materials such as sand or gravel or glacial sediment. Bedrock aquifers in the Valley and Ridge and Highlands regions contain water in fractures within the rock while surficial aquifers contain water primarily in the spaces between sand and gravel particles.

Bedrock aquifers in Frelinghuysen Township, as shown in the *Bedrock and Surficial Aquifers Map (Map 4 in the Maps section),* have different yields depending on the type of bedrock. In areas where carbonate rock such as Jacksonburg limestone is present, the aquifers are ranked by the New Jersey Geological Survey (NJGS) as level C-B, with a median high-capacity, or industrial, well yield between 100 and 500 gallons per minute (gpm). In the areas where the underlying bedrock is harder and less soluble, such as the igneous and metamorphic rock in the vicinity of Jenny Jump or the Martinsburg Formation and Jutland Sequence in other areas of the Township, the aquifer ranking is D, with a yield of 25 to 100 gpm. (*NJDEP/NJGS*)

Surficial aquifers in northern New Jersey consist of glacial sediment exceeding 50 feet in thickness. Two surficial aquifers have been identified in Frelinghuysen: the largest one, composed of sand and gravel, straddles CR 661 in the vicinity of Mud Pond and the Johnsonburg Historic District and is given a rank of B, with well yield between 251 and 500 gpm. The tip of another, composed of lake bottom sediment, protrudes into Frelinghuysen in the vicinity of Glovers Pond Preserve and Bear Creek and is ranked at level E, or less than 25 gpm (*NJDEP/NJGS*). See *Bedrock and Surficial Aquifers Map (Map 4 in the Maps section)*

Sole Source Aquifers (SSA), according to the NJDEP are: "aquifers that contribute more than 50% of the drinking water to a specific area and the water would be impossible to replace if the aquifer were contaminated. Sole-source aquifers are defined with guidelines set forth by the U.S. Environmental Protection Agency (EPA) as authorized in section 1424(e) of the Safe Drinking Water act of 1974. Any federally-funded project in an area that could affect ground water in a sole-source aquifer must be reviewed by the USEPA. This 'project review area' includes the aquifer's 'recharge zone' and its 'stream-flow source zone.' The recharge zone is the area through which water recharges the aquifer. The source zone is the upstream area that contributes recharge water to the aquifer. Seven sole-source aquifers are defined in New Jersey and their project review areas cover most of the state." *(NJDEP, Sole Source Aquifers in New Jersey, 2001)*

Frelinghuysen lies completely within the Northwest New Jersey SSA. Bedrock aquifer coverage was used to define this SSA. The Northwest New Jersey SSA is formally known as the "Fifteen Basin aquifer system of New Jersey." The recharge zone is defined by the outside boundaries of the Delawanna Creek watershed, the Flat Brook watershed, the Lopatcong Creek watershed, the Musconetcong River watershed, the North Branch Raritan River watershed, the Papakating Creek watershed, the Paulins Kill watershed, the Pequest River watershed, the Pochuck Creek watershed, the Pohatcong Creek watershed, the South Branch Raritan River watershed, the Shimmers Brook watershed, the Van Campens Brook watershed and the Wallkill River watershed. It also includes that part of the Millstone River watershed outside the Coastal Plain. Its stream-flow source zone is same as recharge zone. The EPA's project review area is the same as the recharge zone.

The *2007 Master Plan* provides a clear statement that the zoning change approved in the *2007 Master Plan* (from four to six acres) was based upon water quality concerns as a direct result of the 2005 *Nitrate-Dilution Based Carrying Capacity Assessment for Frelinghuysen Township*. As referenced from the *Master Plan* (*page 107*) under *Recommended Land Use Policies*:

> "The Land Use Plan Element and the respective zoning regulations are revised to indicate the amendments of the entire AR-4 zone district as an AR-6 zone district requiring a minimum gross density of one (1) dwelling unit per six (6) acres. These Land Use Plan Element and zoning ordinance changes are being made to be consistent with the following planning studies and policy objectives:
>
> a. To implement the recommended average carrying capacity of 5.8 acres per septic system based on the findings of the Nitrate-Dilution Based Carrying Capacity Assessment for Frelinghuysen Township (2005).
>
> b. To implement a reduced residential density more consistent with the policy objectives of farmland preservation, environmental protection and rural heritage conservation of Frelinghuysen Township, water resource protection and the State Development and Redevelopment Plan.
>
> c. No zoning changes are recommended for VN-1, VN-2, NC, PO, ROM zone districts because these zoning districts comprise a small percentage of the Township's total land area and are substantially built-out."

Glacial Sediments

According to the *2007 Master Plan*, Frelinghuysen has significant areas of glacial sediments located generally along Allamuchy Johnsonburg Road and within the Village of Johnsonburg itself (see *Glacial Sediment Deposits Map, Figure 3 on page 26*). Glacial sediments are important because they may serve as aquifers. "Some of the state's most prolific sources of drinking water are the many coarse-textured stratified glacial deposits laid down during the last ice age." (NJGS) The material also provides economic benefits, as it is often mined. As stated in the *1989 ERI*, "several productive wells in the township draw water from the glacial drift." Stratified drift is identified as a source of surficial aquifers by the USGS.

Public Water Supply and Wellhead Protection

The 1986 Federal Safe Drinking Water Act Amendments (*Section 1428, P.L. 93-523, 42 USC 300 et. Seq*) direct all states to develop a Well Head Protection Program (WHPP) Plan for both public community (CWS) and public non-community (NCWS) water-supply wells. A component of the WHPP is the delineating of Well Head Protection Areas. According to the NJGS *Guidelines for Delineation of Wellhead Protection Areas in New Jersey*, "A Wellhead Protection Area is the area from which a well draws its water within a specified time frame."This delineation is the first step in defining the sources of water to a public water supply. Once delineated, these areas become a priority for prevent and clean-up of groundwater contamination.

Well Head Protection Areas are delineated for both public community and non-community wells in two, five, and twelve-year tiers. Each tier represents the horizontal extent of groundwater captured by a well pumping at a specific rate over those periods of time (NJDEP).

The latest (2007) NJDEP i-MapNJ Geology mapping shows two public community supply wells in the southern part of Frelinghuysen. These wells are associated with the Forest Manor Retirement Home on State Park Road, according to the NJGS Wells Database (updated July 11, 2011). In addition, there is a wellhead protection area for two public community supply wells in Blairstown on East Crisman Road, managed by the Blairstown Township Water Department. The Tier 3 radius for this area extends into Frelinghuysen. There are also well head protection areas for nine non-community wells.

The *Wellhead Protection Areas in Frelinghuysen Township and Vicinity Map* (*Figure 2, page 25)* pinpoints these areas.

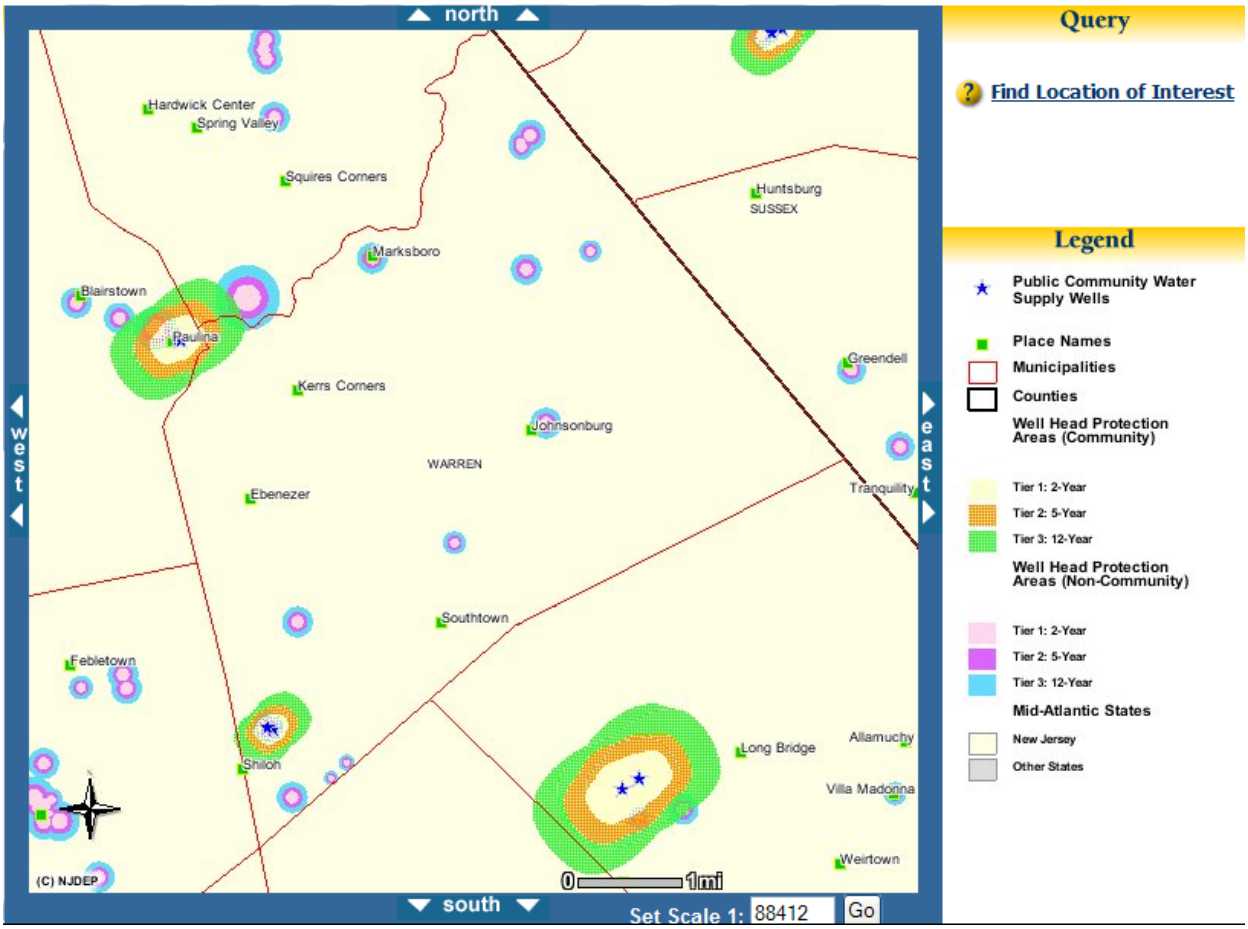

Figure 2. Wellhead Protection Areas in Frelinghuysen Township and Vicinity

Source: NJDEP

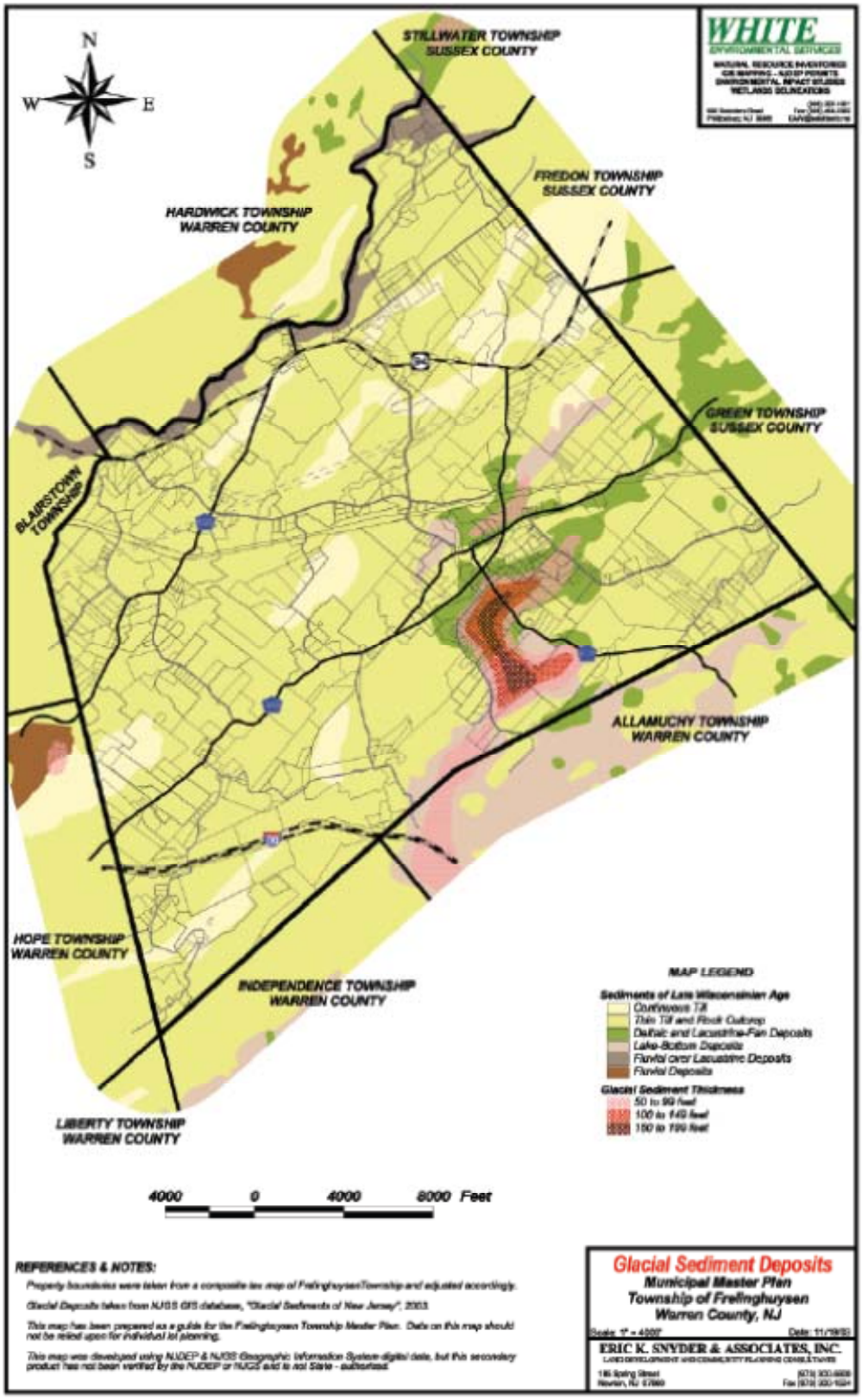

Figure 3. Glacial Sediments in Frelinghuysen Township

Flood Zones

A floodplain is land adjacent to a stream or river which experiences flooding during periods of high discharge. The floodplain includes both the floodway, which is the stream channel, and adjacent areas that are mathematically determined to be required to carry and discharge floodwaters resulting from the 100-year flood under certain conditions, and the flood fringe, which experiences flooding, but not the strong current found in the floodway. The floodplain is an important part of a river ecosystem. It provides habitat for aquatic species, helps improve water quality, and allows for recharge of groundwater.

In 1994, the Township of Frelinghuysen commissioned the *Water Surface Profile Analysis for Frelinghuysen Floodplain Study*. This analysis gauged water velocity and other factors at five stations along the Paulins Kill to determine 100-year flood depth. Information regarding the flow, flood hazard depth, normal depth and drainage area associated with each station was then mapped on a *Stream Corridor & Wetlands Map*, along with the 100-year floodplain per the Insurance Rate Map. The *Stream Corridor & Wetlands Map* also identified then-existing and proposed drains and storm sewers, areas of local flooding and the Bear Creek 100-year floodplain, as well as flood depths and drainage areas for other stations within the Township, including along Bear Creek and Trout Brook. The mapping of the 100-year (Special Flood Hazard Area) floodplain areas in Frelinghuysen has been updated using Federal Emergency Management Agency (FEMA) data from 2011.

The Special Flood Hazard Area (SFHA) is the floodplain as regulated by the FEMA. FEMA undertakes the mapping of Special Flood Hazard Areas throughout the United States. Development within these mapped areas is subject to increased regulation in an attempt to avoid loss of life and property as well as to reduce the amount of structures that can displace water and exacerbate flooding. The SFHA is represented on maps as the base flood, or 100-year floodplain. This represents the land area where there is a 1% chance of flooding being equaled or exceeded in a single year. The base, or 100-year flood, is the national standard used by the National Flood Insurance Program (NFIP) and all Federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development. The SFHA is considered a high-risk area and in communities that participate in the NFIP, such as Frelinghuysen, it is mandatory with some types of mortgages to purchase flood insurance in these zones. FEMA also maps the 500-year floodplain; these areas have 0.2% annual chance of flooding and are considered to be at moderate risk, but Frelinghuysen has only 1.2 acres identified as 500-year floodplain. These 1.2 acres are located along the southern border of the Township, adjacent to Allamuchy and east of Bear Creek. The latest Digital Flood Insurance Rate Maps (DFIRMs) were finalized for Warren County and its municipalities by FEMA effective September 29, 2011. Generally, SFHAs exist along the Paulins Kill, along a small section of Trout Brook where it crosses into Hope Township, along Bear Creek from approximately the point where it crosses Bear Creek Road south into Allamuchy Township and along Bear Brook from the point where it crosses Allamuchy Road south to its confluence with Bear Creek. This data is displayed in the *Watershed and Surface Water Map* (*Map 6 in the Maps Section*) and displayed in *Table 10 Flood Hazard Areas* on *page 28*.

Table 10. Flood Hazard Areas in Frelinghuysen		
Flood Hazard	Acres	% of Total Municipal Area
100-year Floodplain (SFHA)	244.2	2%
500-year Floodplain	1.2	0%
Source: FEMA DFIRM		

Riparian Zones

In order to better protect the public from the hazards of flooding, preserve the quality of surface waters, and protect wildlife and vegetation, the NJDEP has adopted Flood Hazard Area Control Act rules (N.J.A.C. 7:13) in order to incorporate more stringent standards for development in flood hazard areas and riparian zones. A riparian zone is land and vegetation within and adjacent to surface waters.

Activity within the regulated area of the flood hazard area and the riparian zone may be restricted if it includes or results in one or more of the following:

1. The alteration of topography through excavation, grading and/or placement of fill;
2. The clearing, cutting and/or removal of vegetation in a riparian zone;
3. The creation of impervious surface;
4. The storage of unsecured material;
5. The construction, reconstruction and/or enlargement of a structure; and
6. The conversion of a building into a private residence or a public building.

In most areas of New Jersey, Category 1 waters required a 300-foot buffer, while other surface waters, such as those classified as FW2-NT are subject only to a regulated 50-foot riparian zone, measured from the top of the bank, along both sides of all waters.

WETLANDS

Wetlands are important natural resources that contribute significantly to an area's social, economic, and environmental health. Among the services they provide are filtration of chemicals, pollutants, and sediments from water, flood control, critical habitat for wildlife, recreation and tourism. The NJDEP defines a freshwater wetland as "an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation; provided, however, that the Department, in designating a wetland, shall use the three-parameter approach (that is, hydrology, soils and vegetation) enumerated in the 1989 Federal Manual." (*N.J.A.C. 7:7A)* NJDEP has adopted this manual as the technical basis for identifying and delineating wetlands. The NJDEP regulates virtually all activities in a wetland, including removing vegetation, filling, and placing obstructions. Depending on the environmental value of a particular wetland, there may also be a transition area, or buffer, around the wetland that will require a waiver issued by the NJDEP for any activity within that zone. For example, a wetland containing endangered species habitat would require a 150-foot wide transition area, whereas a small wetland in a ditch might not require any transition area at all. Most freshwater wetlands require a 50-foot transition area.

Wetlands in New Jersey are classified into three different values; exceptional resource value, ordinary resource value, or intermediate resource value. The criteria for these classifications are described below.

Exceptional Resource Value Wetland

- Discharges into FW-1 water and FW-2 trout producing waters and their tributaries;
- Is a present habitat for threatened or endangered species; or
- Is a documented habitat for threatened or endangered species, and which remains suitable for breeding, resting, or feeding by these species during the normal period these species would use the habitat.

Ordinary Resource Value Wetland

- A freshwater wetland which does not exhibit any of the characteristics of a Exceptional Resource Value Wetland which is:
- An isolated wetland, as defined at *N.J.A.C. 7:7A-1.4*, which:
- Is smaller than 5,000 square feet; and
- Has the uses listed below covering more than 50% of the area within 50 feet of the wetland boundary. In calculating the area covered by a use, the Department

will only consider a use that was legally existing in that location prior to July 1, 1988, or was permitted under this chapter since that date:

- Lawns
- Maintained landscaping
- Impervious surfaces
- Active railroad rights-of-way
- Graveled or stoned parking/storage areas and roads
- A drainage ditch
- A swale or
- A detention facility created by humans in an area that was upland at the time the facility was created regardless of the wetland resource classification of the wetland under these rules, or the classification of the body of water, as FW-1 or FW-2 trout production, to which it discharges.

Intermediate Resource Value Wetland

- A freshwater wetland of intermediate resource value is any wetland not defined as exceptional or ordinary.

According to the NJDEP 2007 Land Use/Land Cover data, there are approximately 1,608 acres of wetlands within Frelinghuysen, occupying more than 10% of the Township. *Table 11* (*page 31*) presents a summary of wetlands by type. The *Wetlands Map (Map 8 in the Maps Section)* shows the locations of the five most ubiquitous wetland types in Frelinghuysen. The most prevalent type of wetland in Frelinghuysen is deciduous wooded wetlands – swampy or marshy areas dominated by the deciduous tree species associated with watercourses, such as red maple, ash, sycamore, black willow. Deciduous wooded wetlands comprise 68% of the Township's wetlands, followed by herbaceous wetlands at 10%, deciduous scrub/shrub wetlands (8.5%), agricultural wetlands (8.5%), and mixed scrub/shrub wetlands, deciduous dominated (2%). Though this information is based on NJDEP mapped wetlands, unmapped wetlands, which are still subject to NJDEP regulation, may exist in Frelinghuysen. Wetlands would require a professional delineation before a regulated activity could occur in or around these them. (NJDEP)

Table 11. Wetlands in Frelinghuysen		
Type of Wetlands	*Acres*	*%*
Agricultural Wetlands (Modified)	137	8.52 %
Coniferous Scrub/Shrub Wetlands	2	0.12%
Coniferous Wooded Wetlands	1	0.06%
Deciduous Scrub/Shrub Wetlands	138	8.58%
Deciduous Wooded Wetlands	1,088	67.66%
Disturbed Wetlands (Modified)	5	0.31%
Former Agricultural Wetland (Becoming Shrubby, Not Built-Up)	7	0.44%
Herbaceous Wetlands	162	10.07%
Managed Wetland In Maintained Lawn Greenspace	1	0.06%
Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	7	0.44%
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	34	2.11%
Mixed Wooded Wetlands (Coniferous Dom.)	2	0.12%
Mixed Wooded Wetlands (Deciduous Dom.)	18	1.12%
Phragmites Dominate Interior Wetlands	4	0.25%
Wetland Rights-Of-Way	2	0.12 %
Total	1,608	100.00%
Source: NJDEP		

LAND COVER, HABITAT AND VEGETATION

Since 1986, the NJDEP has mapped land use within the state through their Land Use/Land Cover (LU/LC) data sets. Areas are delineated using color infrared images. The latest update of this data occurred in 2007. The NJDEP also maps critical habitat for imperiled and priority species through the Landscape Project, which is a pro-active, ecosystem-level approach to the long-term protection of these habitats, and rare plant species and ecological communities through the Natural Heritage Database.

Land Cover

The NJDEP identifies six LU/LC categories: agriculture, barren land, forest, urban, water, and wetlands. Forested area represents more than half of Frelinghuysen's land cover, providing critical habitat for wildlife. Agricultural land covers another 23%, providing additional corridors for wildlife. Urban land, which has been developed for residential or commercial use, accounts for another 10%, as do wetlands. Water, including Mud Pond, French Lake and many smaller lakes and ponds that dot the community, is under 2% of the land cover. Together, wetlands and streams such Bear Brook, Bear Creek and tributaries of the Paulins Kill, provide riparian corridors providing a different type of habitat for wildlife species.

Table 12 (page 32) shows the percentage of Frelinghuysen covered by each land cover type and the *Land Use/Land Cover Map (Map 9 in the Maps Section)* shows their distribution throughout the Township.

Table 12. Land Cover Type in Frelinghuysen Township

Type	*Acres*	*Percent*
Agriculture	3,495	22.88%
Barren Land	31	0.20%
Forest	8,363	54.75%
Urban	1,537	10.06%
Water	241	1.58%
Wetlands	1,608	10.52%
	15,275	100.00%

Source: NJDEP Land Use/Land Cover data (2007)

Wildlife Habitat

There are areas within Frelinghuysen Township that may provide habitat that is suitable for threatened or endangered species. The Landscape Project (*Version 3.1 2012*) ranks patches of habitat using a numeric system (0 through 5), for the purpose of identifying habitat that may be suitable for threatened and endangered species. Habitat identified as Ranks 3 through 5 is considered environmentally significant by the NJDEP. The following is a description of each rank.

Rank 5 is assigned to species-specific patches containing one or more occurrences of wildlife listed as endangered and threatened pursuant to the Federal Endangered Species Act of 1973.

Rank 4 is assigned to species-specific patches with one or more occurrences of State endangered species.

Rank 3 is assigned to species-specific patches containing one or more occurrences of **State threatened** species.

Rank 2 is assigned to species-specific patches containing one or more occurrences of species considered to be species of special concern (this rank represents "rare species" of wildlife as defined in the *Highlands Water Protection and Planning Act* rules).

Rank 1 is assigned to species-specific patches that meet habitat-specific suitability requirements such as minimum size criteria for endangered, threatened or priority wildlife species, but that do not intersect with any confirmed occurrences of such species.

Rank 0 is assigned to species-specific patches that do not contain any species occurrences and do not meet any habitat-specific suitability requirements.

Frelinghuysen contains habitat patches of all ranks. The *1989 ERI* included a list of birds sighted in Frelinghuysen Township and that list is included in the *Appendix* of this document. According to the *NJDEP Landscape Project*, the Township contains 10,851 acres of Critical Wildlife Habitat suitable to support populations of rare, threatened, and endangered species. This includes habitat that supports the species reported in *Table 13 Species Supported by Frelinghuysen Township Habitat (page 33).*

Table 13. Species Supported by Frelinghuysen Township Habitat	
Species	*Landscape Rank*
Great Blue Heron Forage	2
Jefferson Salamander	2
Spotted Salamander	2
Zebra Clubtail	2
Barred Owl	3
Bobolink	3
Cooper's Hawk	3
Longtail Salamander	3
Red-headed Woodpecker	3
Savannah Sparrow	3
Wood Turtle	3
American Bittern	4
Blue-spotted Salamander	4
Bobcat	4
Red-shouldered Hawk	4
Bog Turtle	5
Source: NJDEP	

Vegetation

The *1989 ERI* included an informative overview of the importance of vegetation and a list of plants inventoried at Genesis Farm in 1987. Those sections are included in *Appendix* of this document.

Recognizing the importance of its trees, the Township applied for and received a grant to commission a five-year (2009-2013) *Community Forestry Management Plan* to guide its efforts to "manage, protect and sustain a vigorous, healthy and safe tree resource" on Township properties, streets and public rights of way. The Plan includes goals and objectives, which include creating a Community Forestry Management Team, training Township employees and volunteers in the science of and State program requirements for Community Forestry, enhancing public safety and educating residents.

For plants and ecosystems at risk, the Natural Heritage Priority Sites (NHP) identify areas hosting endangered plant species and ecological communities. Natural Heritage Priority Sites are sites that have been identified by the NJDEP as critically important areas for protecting biodiversity within the state of New Jersey. Frelinghuysen Township has been identified as containing all or parts of six sites as shown in *Table 14 Natural Heritage Priority Sites (page 34)* and on the *Natural Heritage Priority Sites Map (Map 10 in the Maps section).*

Table 14. Natural Heritage Priority Sites in Frelinghuysen Township

Name	*Description*	*Biodiversity Rank*
Ghost Lake	Lake at base of wooded ridge (aquatic habitat plus upland buffer). Contains excellent occurrence of a state-imperiled plant species. The Ghost Lake Natural Heritage Priority site is located within Frelinghuysen, Independence, and Allamuchy Townships. Although, the lake itself is not located in Frelinghuysen, 92 acres of the NHP site are designated in Frelinghuysen Township.	B4V3
Glovers Pond	Rich limestone upland forest, limestone wetlands, and lake. Globally rare ecological community and state critically imperiled species.	B3V1
Greendell Marsh	Calcareous forest on dolomite outcrops, series of hydrologically linked karst features, wetlands habitat. Globally critically imperiled and rare ecological communities; state critically imperiled, imperiled and rare plant species.	B2V1
Greendell Ridge	Extensive dolomite ridge supporting a matrix of mature, rich calcareous forest and karst features, wetland community. Globally rare forest community, state imperiled and rare plant species.	B3V2

Name	*Description*	*Biodiversity Rank*
Luse Pond	Small pond over limestone with sedges, open border. Occurrence of state critically imperiled plant species.	B5V2
Southtown Sinkhole	Sinkhole pond and adjacent wooded limestone uplands draining towards pond. Occurrence of state critically imperiled plant species.	B4V1
Source: NJDEP		

Biodiversity rank is determined as follows: Global rankings range from B1 (outstanding significance) to B5 (of general biodiversity interest). Additionally, in the Highlands, NHPs are given a ranking on a state level, with V1 representing outstanding significance (only known or best occurrence or concentrations of occurrences) and V5, any other occurrence of a state rare element not covered by the other rankings.

CLIMATE

Temperature, Precipitation and Growing Season

New Jersey is divided into five climate zones, with Frelinghuysen lying in the Northern Zone. According to the New Jersey State Climatologist publication "The Climate of New Jersey," the Northern Climate Zone usually has the shortest growing season, about 155 days. The average date for the last killing spring frost is May, and the first frost in the fall occurs around October 7. These dates vary from year to year and from place to place within the region. Valley locations may have killing frost in mid-September and as late as mid-June. The average number of freeze free days in the northern highlands is 163. Snow may fall from about October 15 to April 30, and annual snowfall averages 40 to 50 inches. In addition,

> "The highlands and mountains in this area play a role in making the climate of the Northern Zone different from the rest of the state. Clouds and precipitation are enhanced by orographic effects. For instance, following a cold frontal passage, air forced to rise over the mountains, produces clouds, and even precipitation, while the rest of the state observes clear skies." (*Office of New Jersey State Climatologist)*

The Office of New Jersey State Climatologist at Rutgers University also maintains temperature and precipitation data for northern New Jersey (including Warren County) from 1895-2010. The values are calculated from an average of monthly temperatures recorded at around ten stations throughout northern NJ. The graphs below show an overall upward trend in mean temperature and show that in the last couple of decades this area is comparatively in both warmer and wetter historical periods.

Two of the stations for which the Office of the New Jersey State Climatologist maintains records are located relatively close to Frelinghuysen: Belvidere and Newton. *Table 15 Temperature Information for Belvidere and Newton* (*page 37*) shows the maximum, minimum and mean temperatures normals; precipitation normals; heating degree days and cooling degrees days reported by these stations based on data from 1981-2010. Heating degree days are the number of degrees the average daily temperature is below 65^{o}F. Cooling degree days are the number of degrees the average daily temperature is above 65^{o}F. *Figure 4 Mean Temperatures for Belvidere and Newton (page 37)* shows this information graphically.

Table 16 Precipitation and Snowfall Information for Belvidere and Newton (page 38) provides detailed information on the weather events for these stations and *Figure 5 (page 38)* shows this graphically.

Table 15. Temperature Information for Belvidere and Newton 1981-2010													
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Avg*
Temperature Normals													
Belvidere Bridge Maximum	37.2	40.8	49.4	61.4	71.7	80.1	84.6	83.1	76.3	65.1	53.6	41.6	62.1
Minimum	18.9	20.6	27.7	37.2	46.9	56.5	61.5	60.1	52.3	40.5	32.3	23.9	39.9
Mean	28.1	30.7	38.5	49.3	59.3	68.3	73.1	71.6	64.3	52.8	42.9	32.7	51.0
Newton Maximum	36.4	39.7	48.3	60.6	71.1	79.3	83.8	82.5	74.6	63.6	52.5	40.8	61.1
Minimum	16.7	19.0	27.2	37.3	47.1	56.3	61.1	59.2	51.2	39.1	31.4	23.0	39.1
Mean	26.5	29.3	37.8	48.9	59.1	67.8	72.4	70.8	62.9	51.3	42.0	31.9	50.1
Heating Degree Days													
Belvidere	1145	960	820	475	210	40	3	9	96	385	662	1000	5805
Newton	1192	998	845	487	217	46	5	14	126	428	692	1026	6076
Cooling Degree Days													
Belvidere	0	0	~0	4	33	139	252	213	75	7	~0	0	723
Newton	0	0	~0	6	34	130	236	195	63	5	~0	0	669

Source: NJ State Climatologist, Rutgers University
Note: Newton Station data reflects sporadic reporting 2006-2010; station closed.

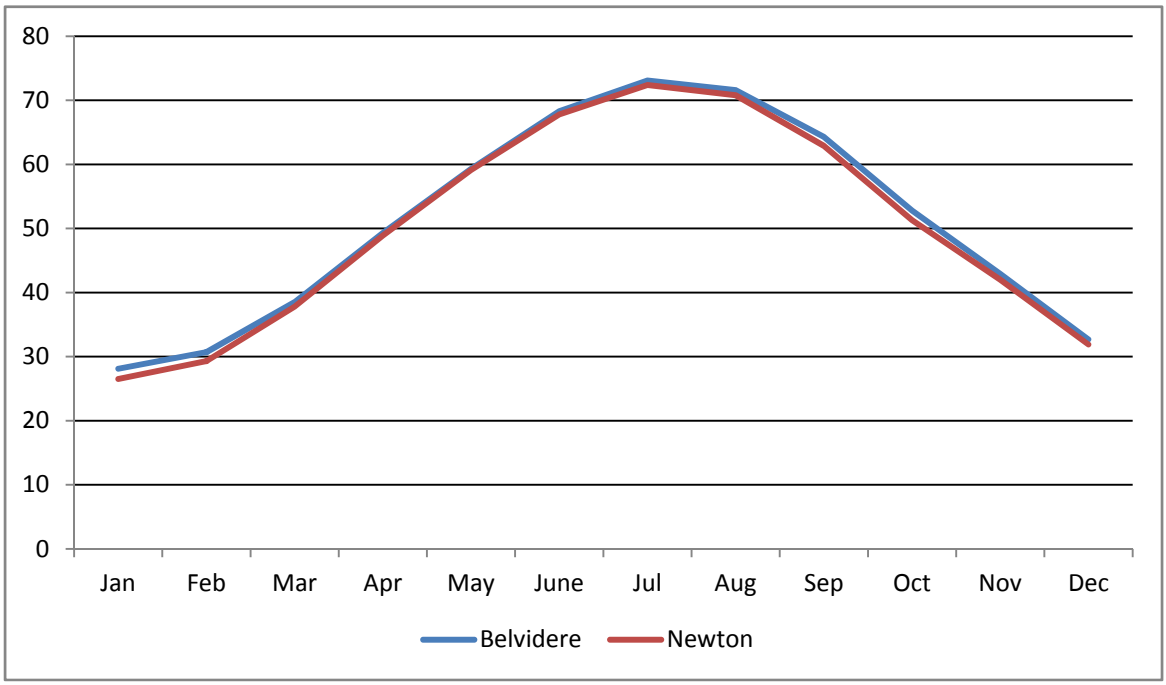

Figure 4. Mean Temperatures for Belvidere and Newton (^{o}F)

Table 16. Precipitation and Snowfall Information for Belvidere and Newton													
Precipitation Normals													
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*
Belvidere/Belvidere Bridge (station move in 1982) max/min: 1892-2010; mean: 1982-2010													
Max	9.97	7.05	7.73	10.06	10.19	11.20	13.86	14.26	14.31	18.21	8.51	8.99	69.93
Min	0.55	0.21	0.43	0.74	0.40	1.01	0.77	0.87	0.14	0.13	0.08	0.34	29.09
Mean	3.05	2.31	3.73	3.91	4.26	4.37	4.63	4.06	4.65	4.44	3.56	3.49	45.30
Newton 1892-2009 (sporadic reporting from 1990-2009)													
Max	10.51	7.77	7.61	8.97	9.28	12.83	12.52	15.19	10.52	9.99	9.33	8.06	61.00
Min	0.62	0.54	0.99	0.83	0.28	0.43	0.38	1.04	0.19	0.15	0.67	0.51	27.79
Mean	3.20	2.82	3.42	3.74	3.92	4.38	4.59	4.45	3.93	3.41	3.42	3.39	44.82
Snowfall (inches0													
Belvidere Bridge (Max/Min 1892-2011; Mean 1982-2011)													
Max	50.0	41.3	25.0	11.5	0.0	0.0	0.0	0.0	0.0	2.8	19.0	29.5	78.0
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
Mean	8.3	8.6	3.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.1	21.5
Newton (1892-2005; sporadic 1990-2005)													
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Season*
Max	39.0	32.0	27.3	16.0	0.0	0.0	0.0	0.0	0.0	2.0	20.6	24.0	80.3
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2
Mean	10.7	10.9	7.0	1.8	0.0	0.0	0.0	0.0	0.0	0.1	2.2	7.4	37.2
Source: NJ State Climatologist, Rutgers University													

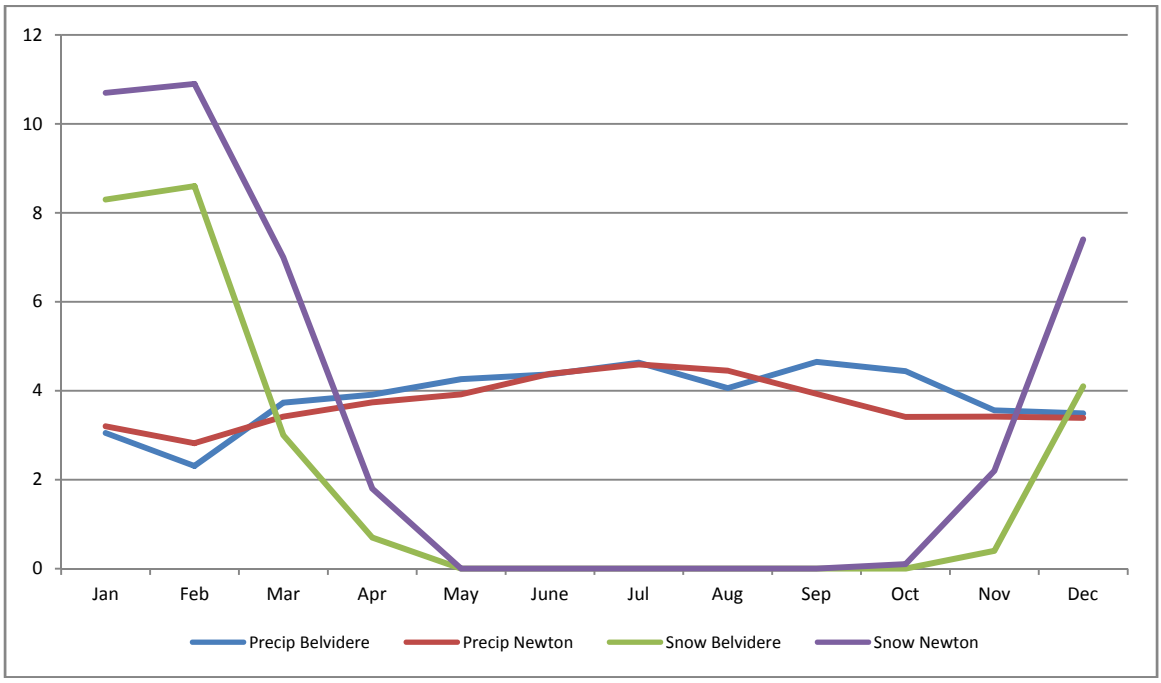

Figure 5. Precipitation and Snowfall (Inches)

Clean Energy Initiatives

In 2010, the Township of Frelinghuysen adopted an ordinance to amend the Land Development Ordinance (1987) to allow solar energy systems as a conditional accessory use in all zones for the primary purpose of providing power for the property on which it is situated. The above ordinance was amended in 2011 to include an abandonment provision. (Ordinance No. 2010-06 and Ordinance No. 2011-07).

In 2011, the Township adopted an ordinance establishing regulations regarding the erection and location of wind energy systems as accessory uses, on the basis that wind energy is an abundant, renewable and nonpolluting energy resource, the use of which, in place of conventional energy sources, can decrease air and water pollution. Wind Energy systems are permitted on a minimum of 10 acres as a conditional accessory use on the same lot as the principal use and "shall not be for the generation of power for commercial purposes." (Ordinance No. 2011-06)

KNOWN CONTAMINATED SITES

The Known Contaminated Sites List (KCSL) for New Jersey are those sites and properties within the state where contamination of soil or groundwater has been confirmed at levels equal to or greater than applicable standards.

Known Contaminated Sites may include:

- Active sites with known contamination, these sites can have one or more active case with any number of pending and closed cases
- Pending sites with confirmed contamination which are those sites having one or more pending cases, no active cases, and any number of closed cases, and
- Closed sites with remediated contamination, which are those sites having only closed cases. Sites in this category have no active or pending cases.

These lists are produced by the NJDEP in response to *N.J.S.A. 58:10-23.16-17*, which requires the preparation of a list of sites affected by hazardous substances. It also satisfies Program's obligations under the New Jersey New Residential Construction Off-Site Conditions Disclosure Act (*N.J.S.A. 46:3C1 et seq.*). Sites included in the KCSL report can undergo a wide variety of remedial activities, ranging from relatively simple "cut and scrape" cleanups to highly complex cleanups. The sites with complex contamination issues can have several sources of contamination, which can affect both soil and groundwater at the same time.

Tables 17 and 18 (page 41) present Active Sites with Confirmed Contamination and Pending Sites with Confirmed Contamination, respectively, in Frelinghuysen as of July 1, 2011. These tables present the Site ID, the Project Interest (PI) Number and Name, the address, and whether or not the site is a home. There are currently 4 active sites with known contamination and 2 pending sites with confirmed contamination in Frelinghuysen.

The Community Right to Know (CRTK) program is responsible for collecting and disseminating data on hazardous substances produced, stored or used at companies in New Jersey. In 2011, there were no active or non-active CRTK facilities in Frelinghuysen Township. (NJDEP)

Table 17. Active Sites With Confirmed Contamination in Frelinghuysen				
Site ID	*PI Number*	*PI Name*	*Address*	*Homeowner*
29921	020931	Westbrook Realty (*Now owned by RTC Farms, LLC*) Block 1301, Lot 9	1090 Dark Moon Road	No
440	007083	Andy's Exxon (*Now owned by Johnsonburg Properties*) Block 1003, Lot 5	Main Street	No
66274	G000004502	Green Acres Landfill (*Now owned by DVI-Data Ventures, Inc.*) Block 1401, Lot 17	170 Greendell Road	No
196741	258284	285 Main Street (*Owned by Patricia Fleno*) Block 1602, Lot 2	285 Main Street	Yes
Source: NJDEP				

Table 18. Pending Sites With Confirmed Contamination in Frelinghuysen				
Site ID	*PI Number*	*PI Name*	*Address*	*Home Owner*
G000042046	75028	Kerrs Corner Rd and Silver Lake Road (*Owned by Andrew Williams*) Block 502, Lot 27	126 Silver Lake Road	No
012718	441	State of NJ DOT Maintenance Yard Block 201, Lot 17.01	874 Route 94	No
Source: NJDEP				

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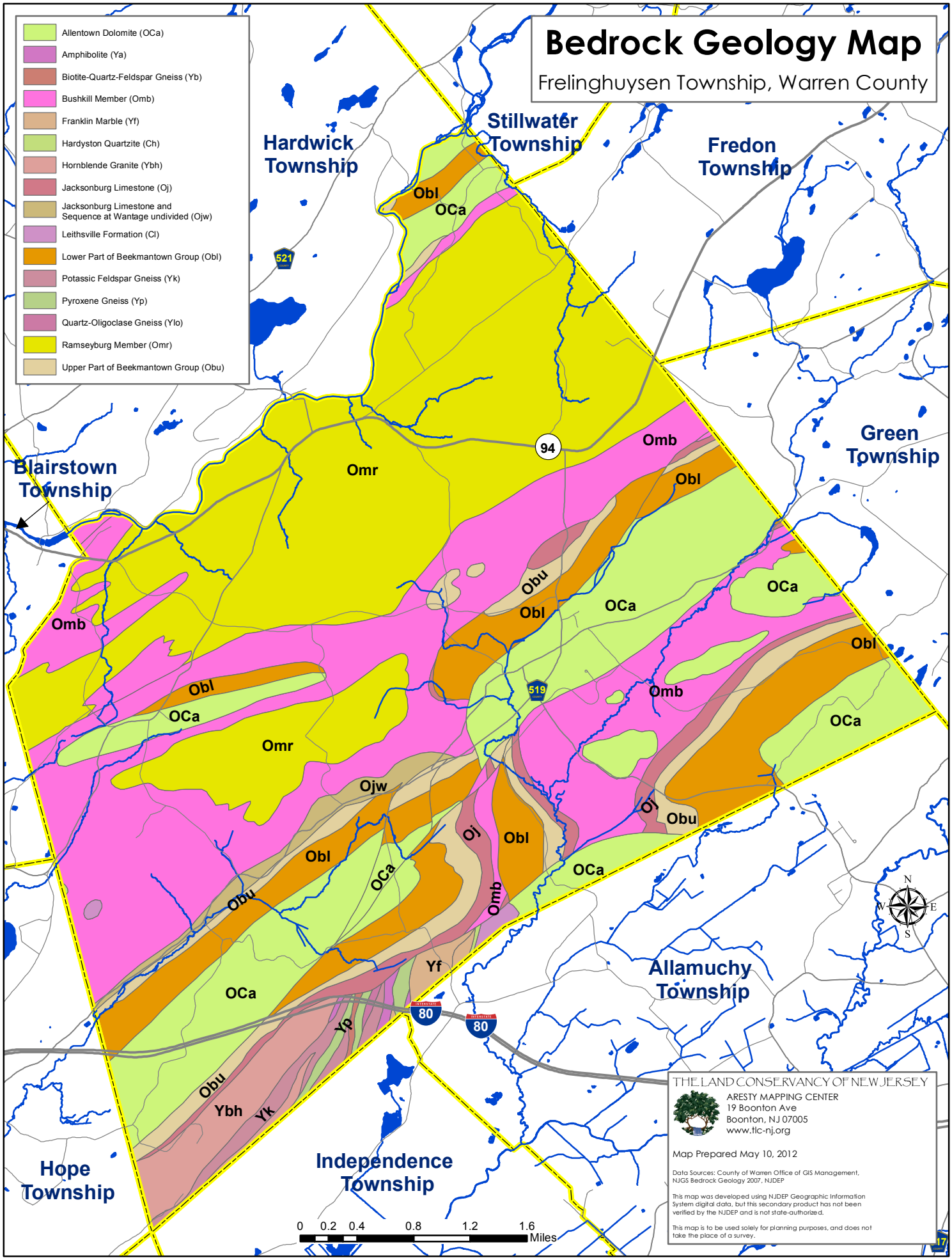
MAPS


Bedrock Geology Map
Frelinghuysen Township, Warren County
Allentown Dolomite (OCa)
Amphibolite (Ya)
Biotite-Quartz-Feldspar Gneiss (Yb)
Bushkill Member (Omb)
Franklin Marble (Yf)
Hardyston Quartzite (Ch)
Hornblende Granite (Ybh)
Jacksonburg Limestone (Oj)
Jacksonburg Limestone and Sequence at Wantage undivided (Ojw)
Leithsville Formation (Cl)
Lower Part of Beekmantown Group (Obl)
Potassic Feldspar Gneiss (Yk)
Pyroxene Gneiss (Yp)
Quartz-Oligoclase Gneiss (Ylo)
Ramseyburg Member (Omr)
Upper Part of Beekmantown Group (Obu)
Hardwick Township
Stillwater Township
Fredon Township
Green Township
Blairstown Township
Allamuchy Township
Hope Township
Independence Township
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OCa
Omr
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Miles
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Map Prepared May 10, 2012
Data Sources: County of Warren Office of GIS Management, NJGS Bedrock Geology 2007, NJDEP
This map was developed using NJDEP Geographic Information System digital data, but this secondary product has not been verified by the NJDEP and is not state-authorized.
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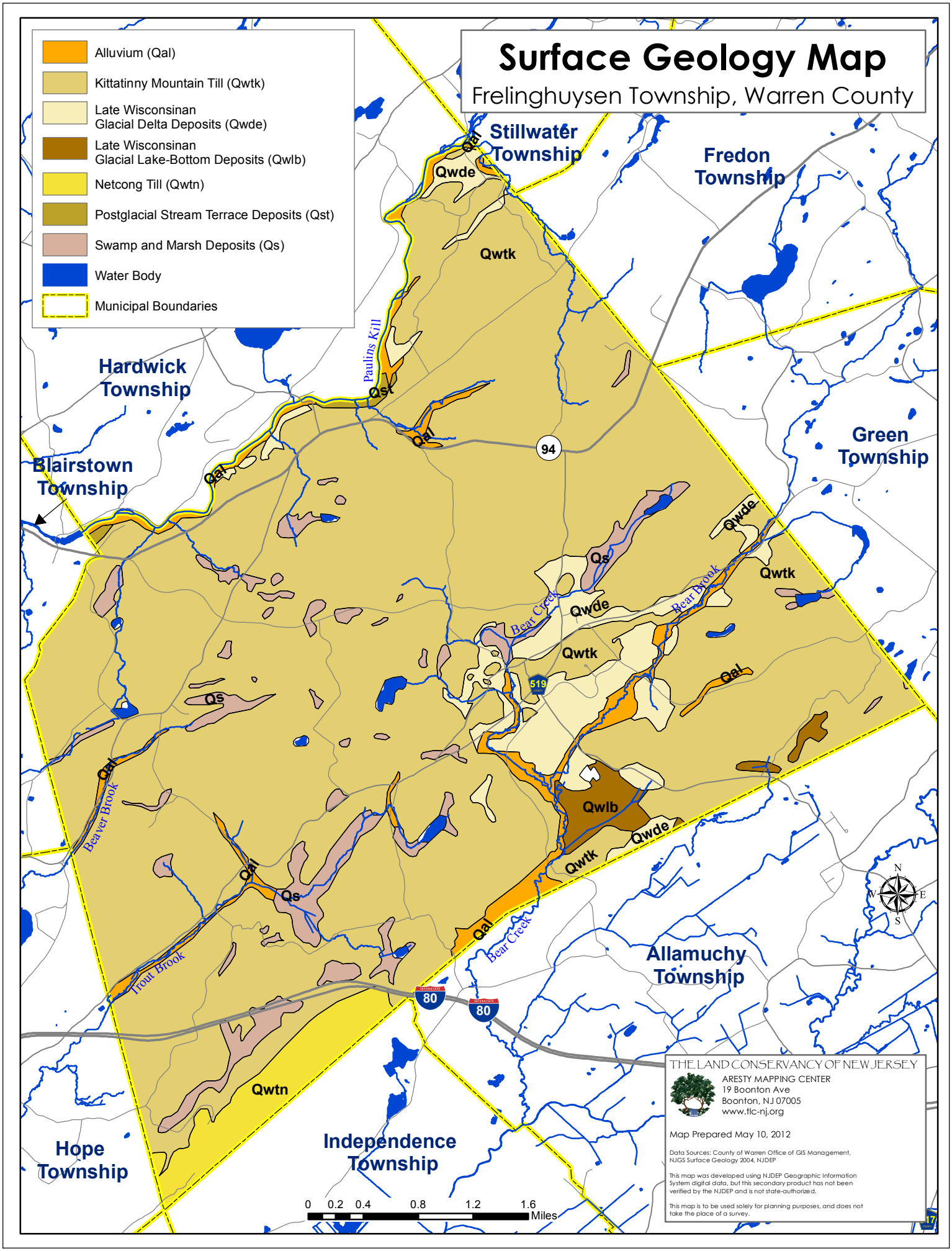
Surface Geology Map
Frelinghuysen Township, Warren County
Alluvium (Qal)
Kittatinny Mountain Till (Qwtk)
Late Wisconsinan Glacial Delta Deposits (Qwde)
Late Wisconsinan Glacial Lake-Bottom Deposits (Qwlb)
Netcong Till (Qwtn)
Postglacial Stream Terrace Deposits (Qst)
Swamp and Marsh Deposits (Qs)
Water Body
Municipal Boundaries
Stillwater Township
Fredon Township
Hardwick Township
Blairstown Township
Green Township
Allamuchy Township
Hope Township
Independence Township
Paulins Kill
Bear Creek
Bear Brook
Beaver Brook
Trout Brook
Qal
Qwde
Qwtk
Qst
Qs
Qwlb
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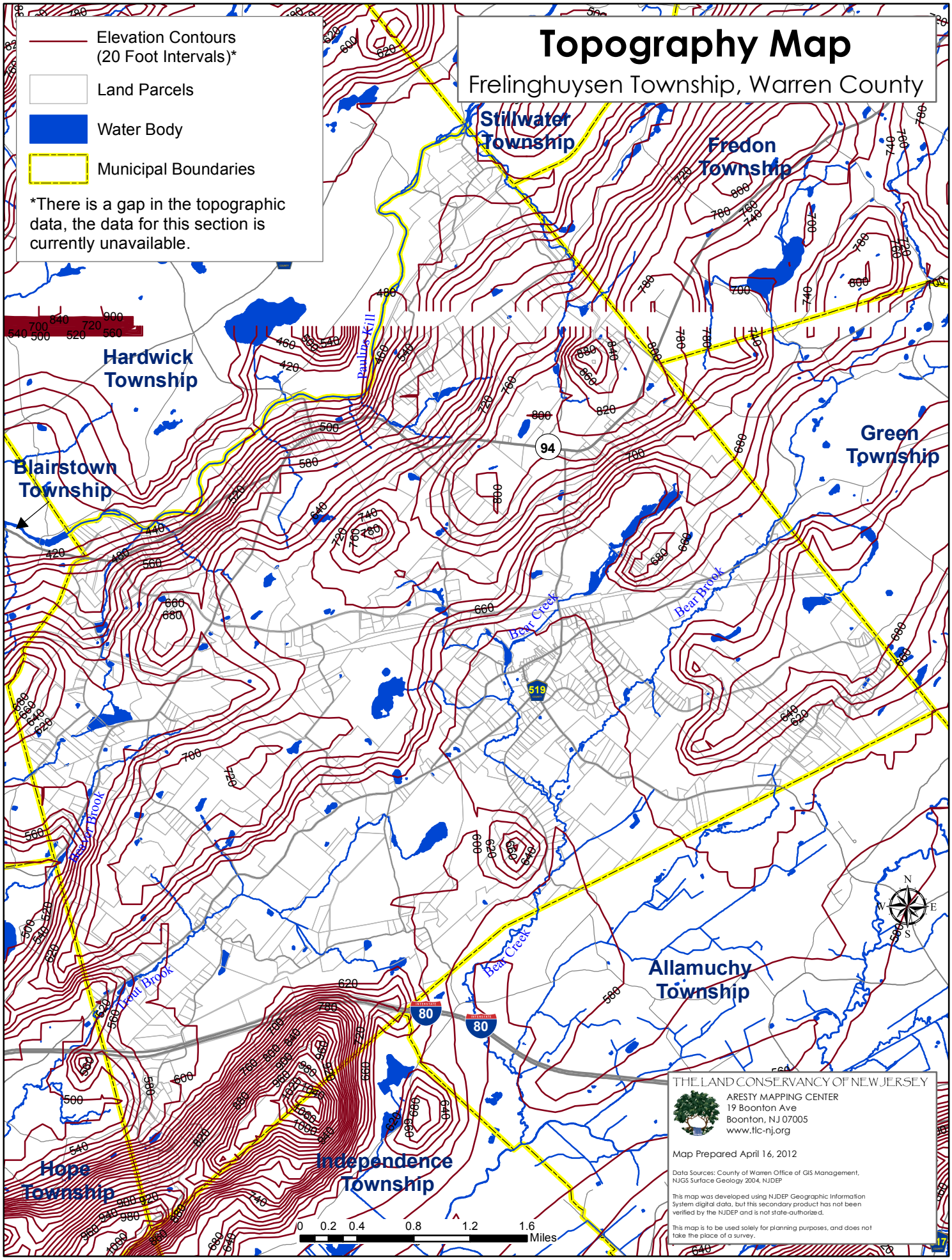
Topography Map
Frelinghuysen Township, Warren County
Elevation Contours
(20 Foot Intervals)*
Land Parcels
Water Body
Municipal Boundaries
*There is a gap in the topographic data, the data for this section is currently unavailable.
Stillwater Township
Fredon Township
Hardwick Township
Blairstown Township
Green Township
Allamuchy Township
Hope Township
Independence Township
Paulins Kill
Bear Creek
Bear Brook
Trout Brook
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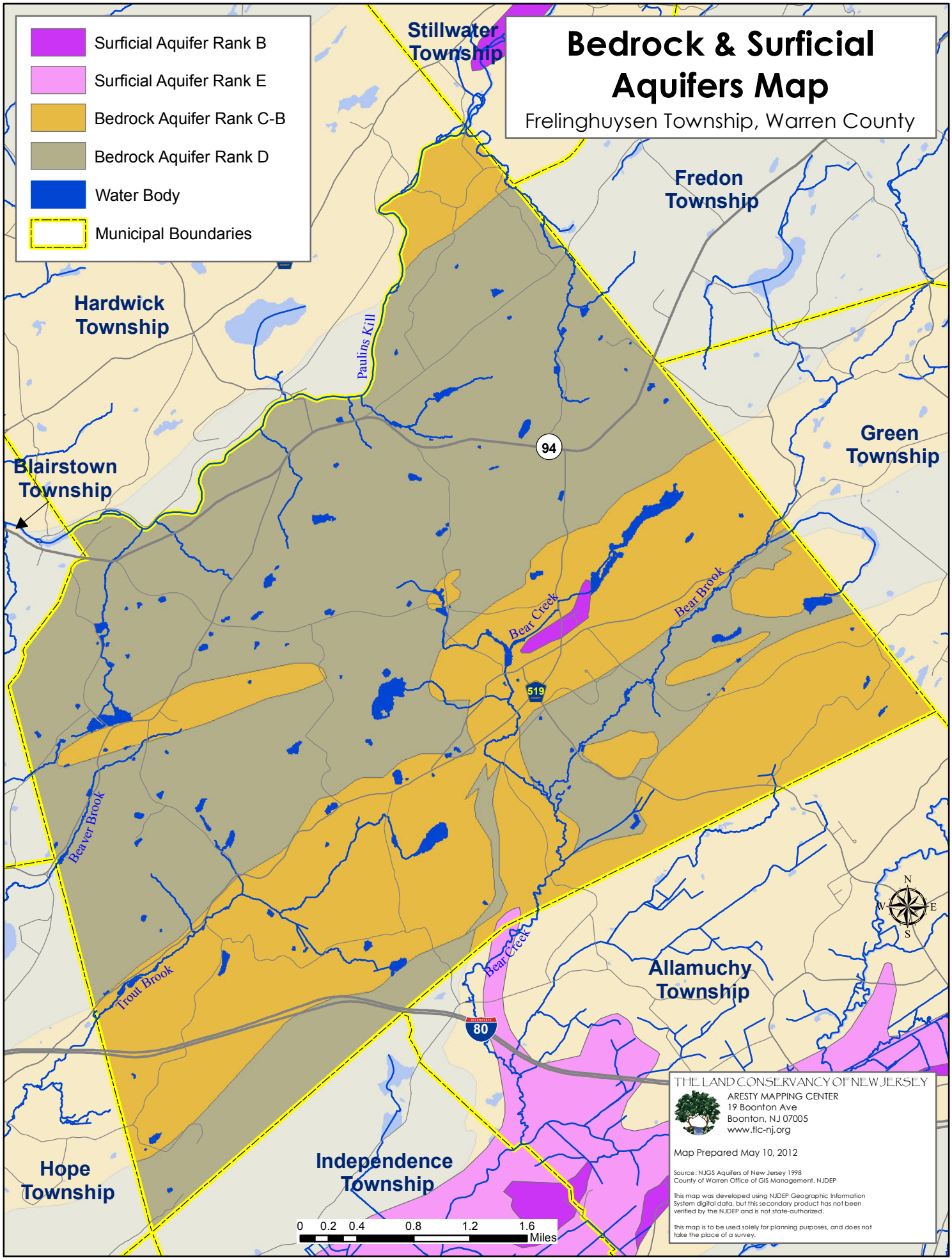
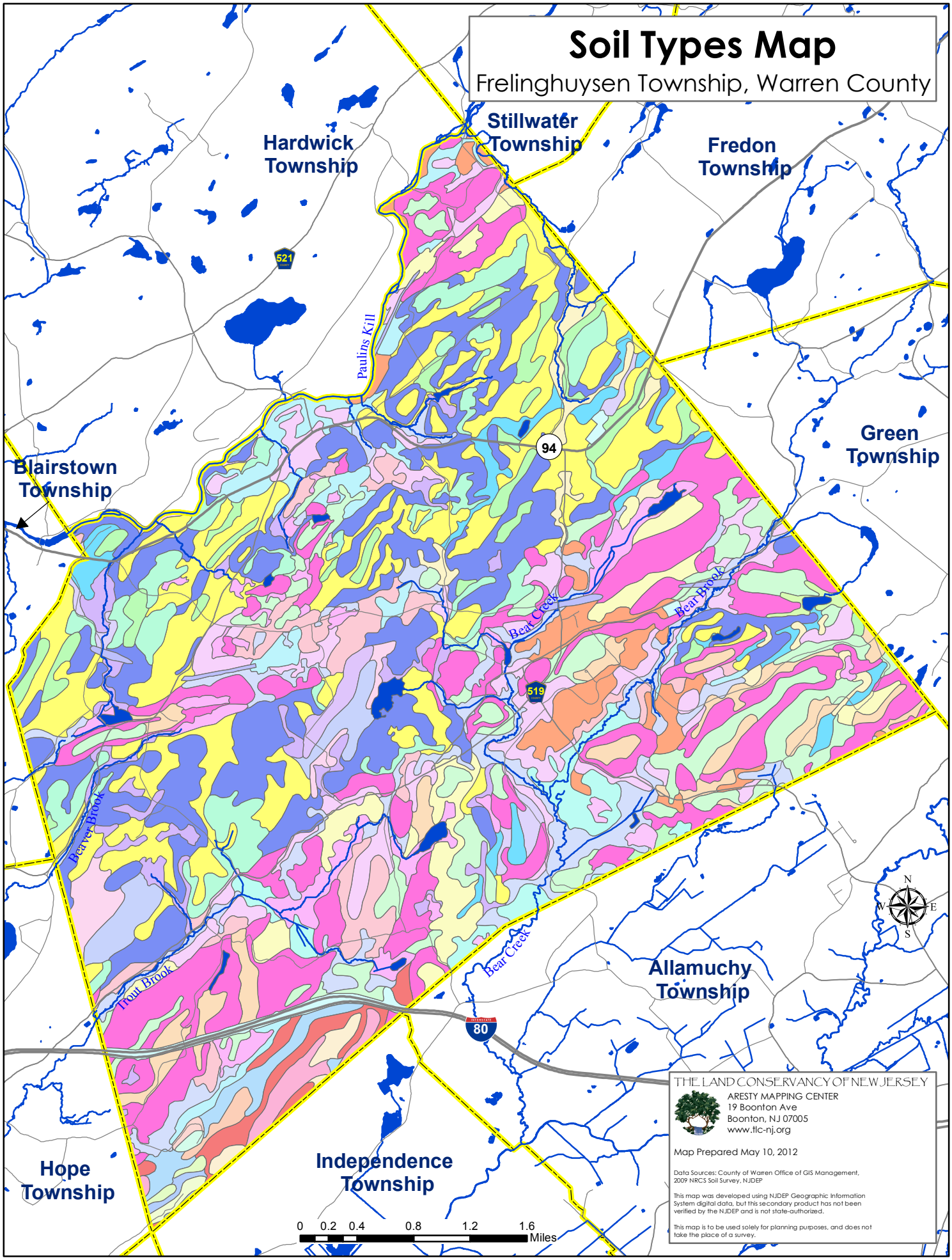
Map 4. Bedrock and Surficial Aquifers




Soil Types Map
Frelinghuysen Township, Warren County
Hardwick Township
Stillwater Township
Fredon Township
Green Township
Blairstown Township
Allamuchy Township
Hope Township
Independence Township
Paulins Kill
Beaver Brook
Trout Brook
Bear Creek
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Miles
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Boonton, NJ 07005
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Map Prepared May 10, 2012
Data Sources: County of Warren Office of GIS Management, 2009 NRCS Soil Survey, NJDEP
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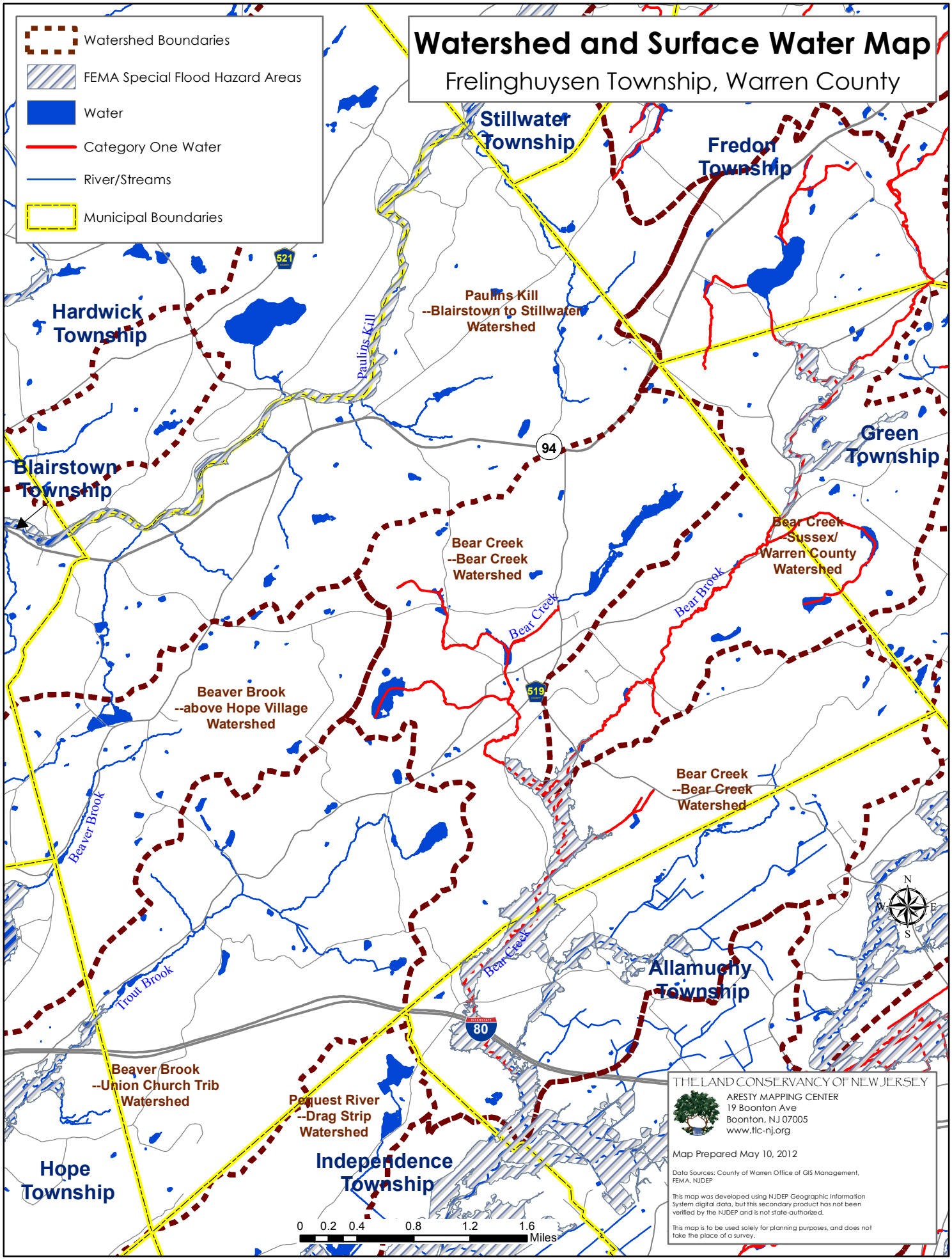
Soil Types Map--Legends

Frelinghuysen Township, Warren County

- Alden Silt loam, 0 to 8 percent slopes, extremely stony (AhbBc)
- Alden mucky silt loam, gneiss till substratum, 0 to 8 percent slopes, extremely stony (AhcBc)
- Catden mucky peat, 0 to 2 percent slopes (CatbA)
- Chatfield-Hollis-Rock outcrop complex, 35 to 60 percent slopes (ChkE)
- Chippewa silt loam, 0 to 8 percent slopes, extremely stony (ChwBc)
- Farmington-Rock outcrop complex, 0 to 15 percent slopes (FaxC)
- Farmington-Wassaic-Rock outcrop complex, 0 to 8 percent slopes (FdwB)
- Fredon-Halsey complex, 0 to 3 percent slopes, very stony (FrdAb)
- Gladstone loam, 8 to 15 percent slopes, extremely stony (GkanCc)
- Gladstone loam, 15 to 25 percent slopes, extremely stony (GkanDc)
- Halsey silt loam, 0 to 3 percent slopes, occasionally flooded (HazAs)
- Hazen-Hoosic complex, 0 to 3 percent slopes, very stony (HdxAb)
- Hazen-Hoosic complex, 3 to 8 percent slopes, very stony (HdxBb)
- Hollis-Rock outcrop-Chatfield complex, 15 to 35 percent slopes (HncD)
- Hoosic-Hazen complex, 8 to 15 percent slopes, very stony (HonCb)
- Hoosic-Otisville complex, 25 to 60 percent slopes, very stony (HopEb)
- Nassau-Manlius complex, 0 to 8 percent slopes, very rocky (NauBh)
- Nassau-Manlius complex, 8 to 15 percent slopes, very rocky (NauCh)
- Nassau-Manlius complex, 15 to 35 percent slopes, very rocky (NauDh)
- Nassau-Rock outcrop complex, 35 to 60 percent slopes (NavE)
- Netcong loam, 8 to 15 percent slopes, very stony (NetCb)
- Pits, sand and gravel (PHG)
- Parker gravelly sandy loam, 3 to 15 percent slopes (PaoC)
- Parker gravelly sandy loam, 15 to 25 percent slopes (PaoD)
- Rock outcrop-Farmington-Galway complex, 8 to 15 percent slopes (RnfC)
- Rock outcrop-Farmington-Galway complex, 15 to 35 percent slopes (RnfD)
- Rockaway-Chatfield-Rock outcrop complex, 0 to 8 percent slopes (RokB)
- Rockaway-Chatfield-Rock outcrop complex, 8 to 15 percent slopes (RokC)
- Rockaway-Chatfield-Rock outcrop complex, 15 to 35 percent slopes (RokD)
- Timakwa muck, 0 to 2 percent slopes, frequently flooded (TheaAt)
- Udorthents, 0 to 8 percent slopes, smoothed (UdaB)
- Udorthents-Urban land complex, 0 to 8 percent slopes (UdauB)
- Venango silt loam, 0 to 8 percent slopes, extremely stony (VepBc)
- Venango silt loam, 8 to 15 percent slopes, extremely stony (VepCc)
- Wurtsboro-Swartswood complex, 0 to 8 percent slopes, extremely stony (WusBc)
- Wurtsboro-Swartswood complex, 8 to 15 percent slopes, extremely stony (WusCc)
- Wurtsboro-Swartswood complex, 15 to 35 percent slopes, extremely stony (WusDc)
- Water Body
- Municipal Boundaries


Watershed and Surface Water Map
Frelinghuysen Township, Warren County
Watershed Boundaries
FEMA Special Flood Hazard Areas
Water
Category One Water
River/Streams
Municipal Boundaries
Stillwater Township
Fredon Township
Hardwick Township
Blairstown Township
Green Township
Allamuchy Township
Independence Township
Hope Township
Paulins Kill --Blairstown to Stillwater Watershed
Bear Creek --Bear Creek Watershed
Bear Creek --Sussex/ Warren County Watershed
Beaver Brook --above Hope Village Watershed
Bear Creek --Bear Creek Watershed
Beaver Brook --Union Church Trib Watershed
Pequest River --Drag Strip Watershed
Paulins Kill
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Beaver Brook
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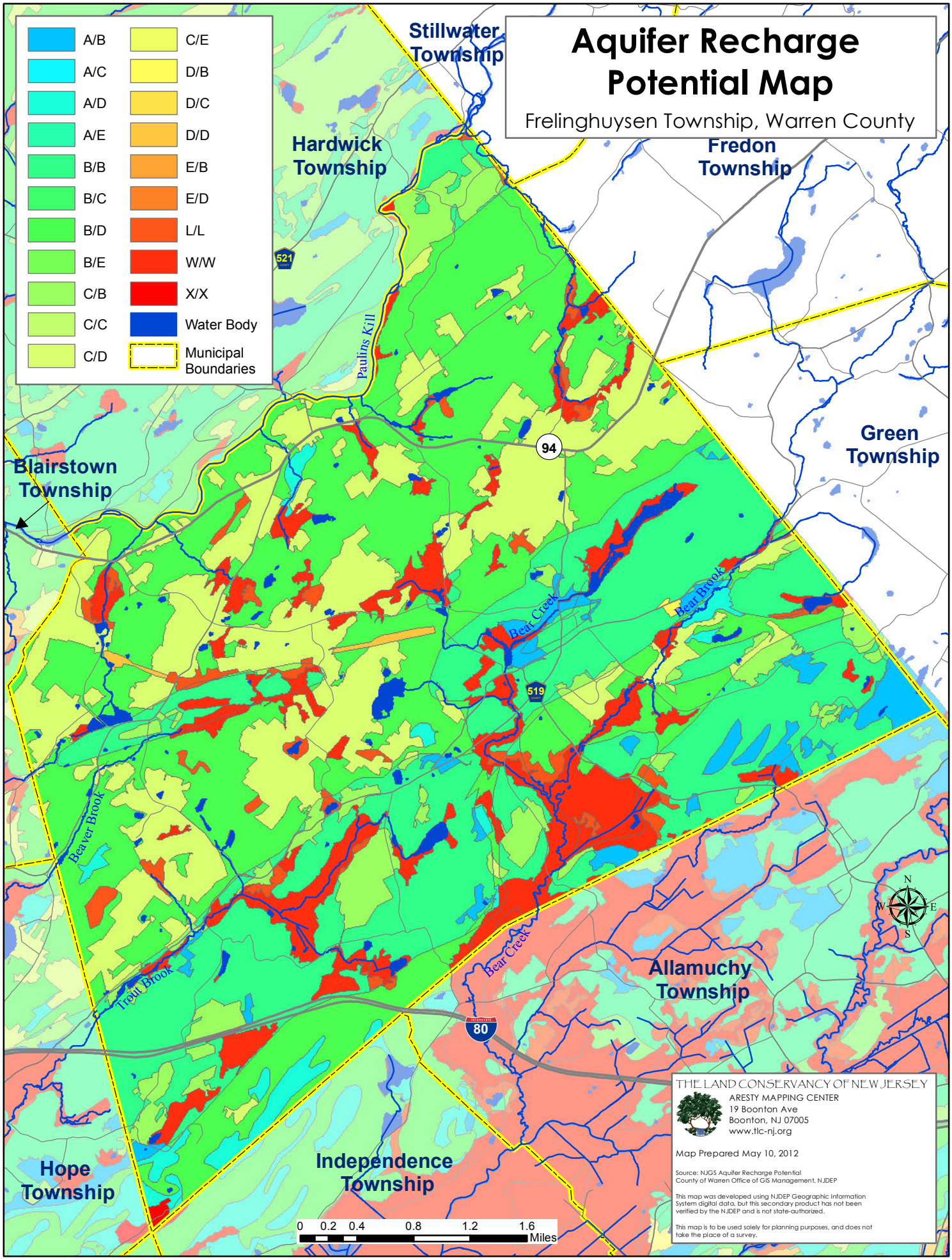
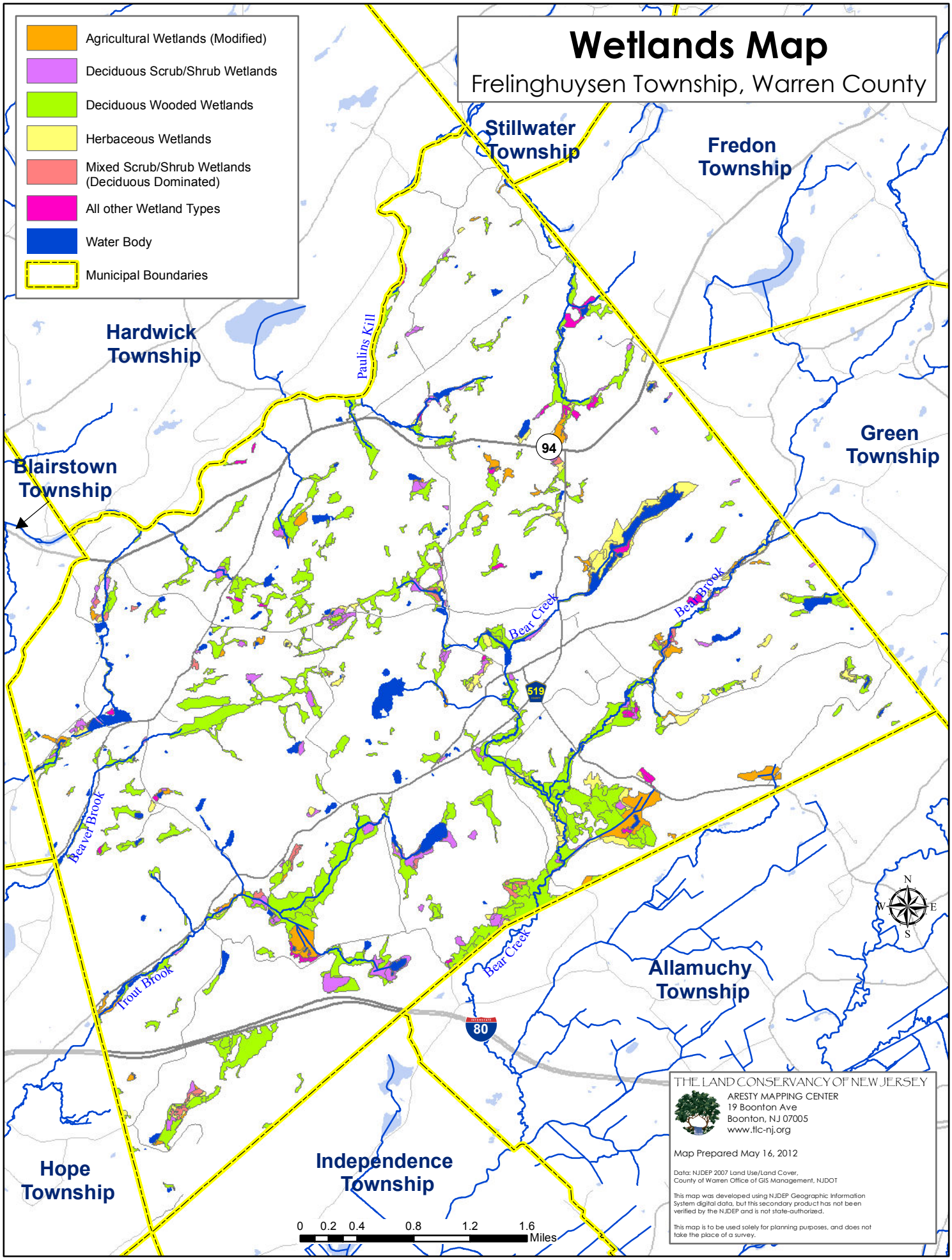
Map 7. Aquifer Recharge Potential




Wetlands Map
Frelinghuysen Township, Warren County
Agricultural Wetlands (Modified)
Deciduous Scrub/Shrub Wetlands
Deciduous Wooded Wetlands
Herbaceous Wetlands
Mixed Scrub/Shrub Wetlands (Deciduous Dominated)
All other Wetland Types
Water Body
Municipal Boundaries
Stillwater Township
Fredon Township
Hardwick Township
Blairstown Township
Green Township
Allamuchy Township
Hope Township
Independence Township
Paulins Kill
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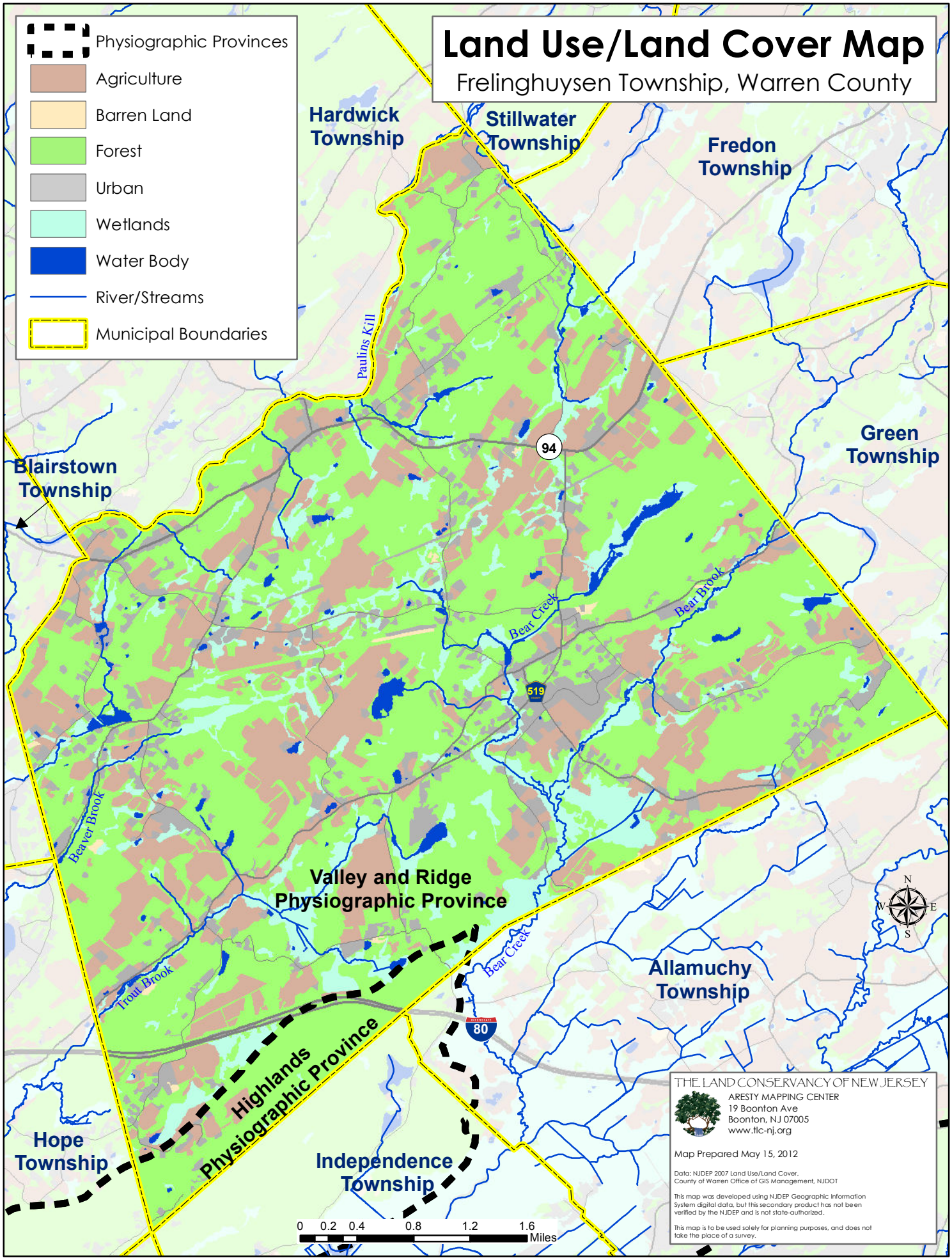
Land Use/Land Cover Map
Frelinghuysen Township, Warren County
Physiographic Provinces
Agriculture
Barren Land
Forest
Urban
Wetlands
Water Body
River/Streams
Municipal Boundaries
Hardwick Township
Stillwater Township
Fredon Township
Green Township
Blairstown Township
Allamuchy Township
Hope Township
Independence Township
Paulins Kill
Bear Creek
Bear Brook
Beaver Brook
Trout Brook
Valley and Ridge Physiographic Province
Highlands Physiographic Province
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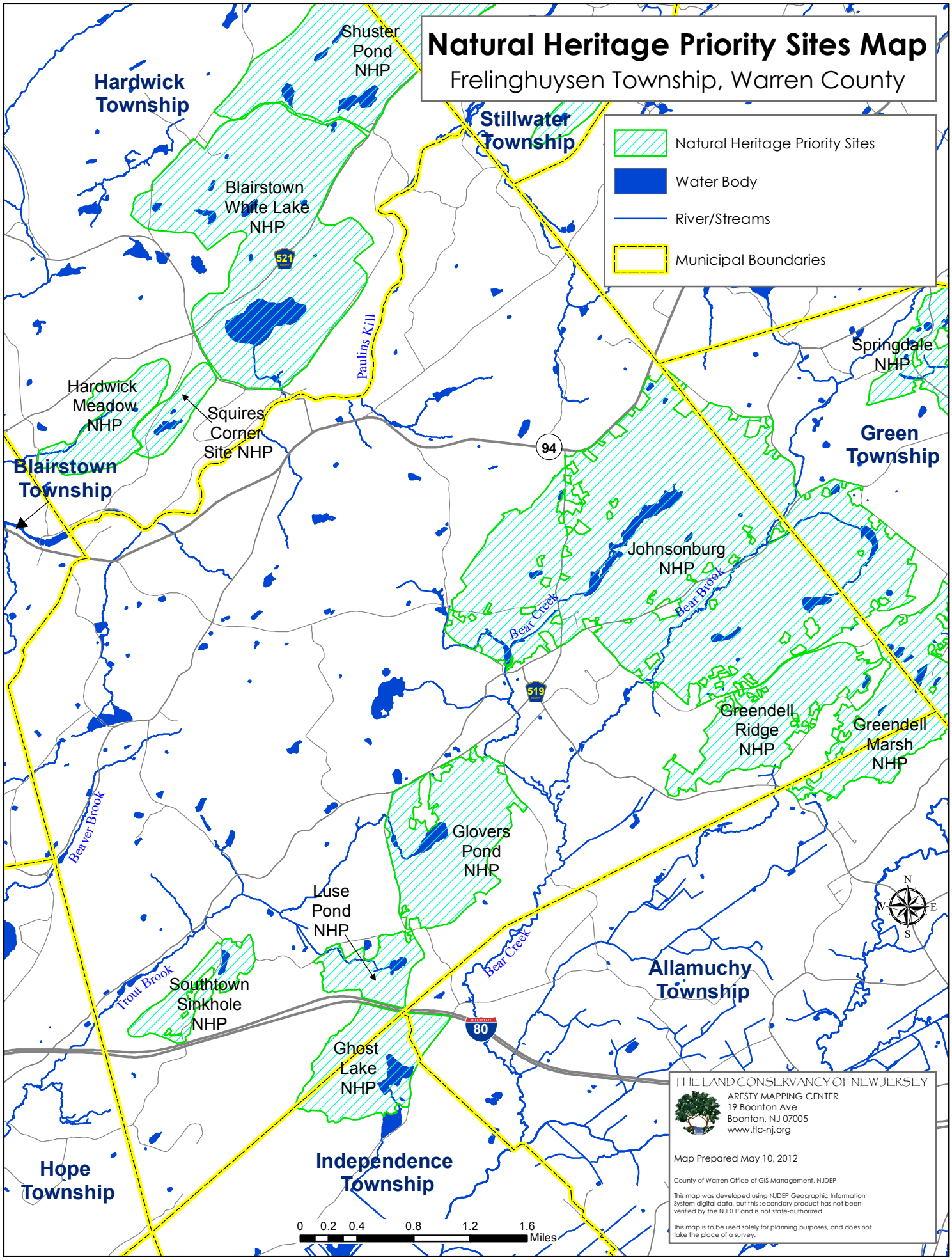
Map 10. Natural Heritage Priority Sites



APPENDIX

Excerpts from the *1989 Environmental Resource Inventory*: *Vegetation, Wildlife, Birds Sighted, and Plant Inventory at Genesis Farms*

VEGETATION

INTRODUCTION

Frelinghuysen Township is blessed with a large amount of open space and variety of habitats which support an abundance of vegetation. Some of this vegetation grows in so-called critical areas and has to be carefully protected to avoid undesirable effects such as flooding, soil erosion, and contamination of ground water.

The accommodation of an ever larger population, together with the trend toward more commercial and residential use of land each year, means that, each year, less natural vegetation is left. An important action of man that has an impact on vegetation is lumbering. When trees are cut selectively, forests will show little change in species composition; clear cutting, on the other hand, may change the composition of a forest so that is becomes quite different from what it was before it was first cut. Other than glaciation and its accompanying climatic change, man has had the greatest impact on vegetation. For example, Indians for years routinely set fires to the forests so as to create habitats for game; they recognized that many types of game, such as deer, prefer open woods to the dense forests. They also used fire to drive game. Thus, contrary to popular belief, the first European settlers to come to New Jersey and to this area did not find a vast expanse of virgin forest. Although the Indians' use of indiscriminate fires had a marked impact on vegetation, the European settlers and their descendants truly disturbed the vegetation. With the increase in population pressure, especially in the last few years, land values have increased astronomically and, as a consequence, farmland has been sold to builders and developers. There are now only a handful of working farms; and many of the open fields that presently are not used as building sites or horse pastures, are reverting to their natural state though various stages of successive vegetation.

ECOLOGICAL SUCCESSION

When a field that had been cultivated is left abandoned, the first plants to grow successfully are those with short lives. Of these, ragweed is the most abundant. Also, common invaders in the first year are the wild radish and wintercress; the latter can be seen in May and June as a blanket of yellow blooms. By the second year, more dominant plants such as the perennial goldenrods and asters develop. Other herbs start to grow in the field. One of the most common is a high-growing wild grass known as Little bluestem. Less common, but conspicuous for their flowers, are Queen Anne's lace, common mullein, daisy and black-eyed Susan. This herbaceous cover may persist for several years and then the seeds of woody shrubs and trees successfully germinate in the field and grow taller than the herbs. The first woody plant to show up conspicuously is the red cedar (Juniperus virginiana). As these trees get well established, they are joined by seedlings of other trees such as red maple (Acer rubrum), wild black cherry (Prunus serotina), white ash (Fraxinus americana) and staghorn sumac (Rhus typhina). In addition, lower growing shrubs such as gray dogwood, autumn olive, blackberries, wineberries, and black haw are interspersed with young trees.

In twenty to thirty years, either the grasses crowd out the showy flowering herbs or the trees shade them out. In about fifty years, the once-abandoned field will have been transformed to an open woodland of fairly tall trees. The trees of the first stage of the succession will have been eliminated as they are not tolerant of shade, and the trees whose seedlings can tolerate some shade - such as oaks, maples, ash and hickories - will become dominant. Eventually, the trees block out so much light that only young trees of such species as hemlock, beech, and maple can survive. In the temperate zone this is known as the climax forest. In Frelinghuysen Township, this stage has been reached in a few isolated areas whereas, in most of the township, this may never occur due to activities of man such as lumbering and clearing for pasture and development. Areas of climax forest can be seen along Southtown Road, the Presbyterian Camp site, Jenny Jump State Park, and other spots in the Mud Pond vicinity. Because of their rarity and beauty, these forests deserve some protection.

BENEFITS OF VEGETATION

Without vegetation, humans would not have developed at all in their present form. Oxygen in the atmosphere developed only after the advent of plant life, as a product of photosynthesis. Plants are the first link in the food chain (fig. 21); they are able, via photosynthesis, to transform non-living materials into organic foods. Thus, man depends upon plants as the initial source for all his food as well as for much of the material used for his shelter and clothing. Man may eat plants directly or indirectly when he

eats meat from animals which, in turn, depend on plants as their initial source of food. While man is totally dependent on vegetation, his actions usually are destructive to vegetation. In addition to being physiologically and economically essential to humans, plants have great aesthetic value, improve man's environment and contribute to his

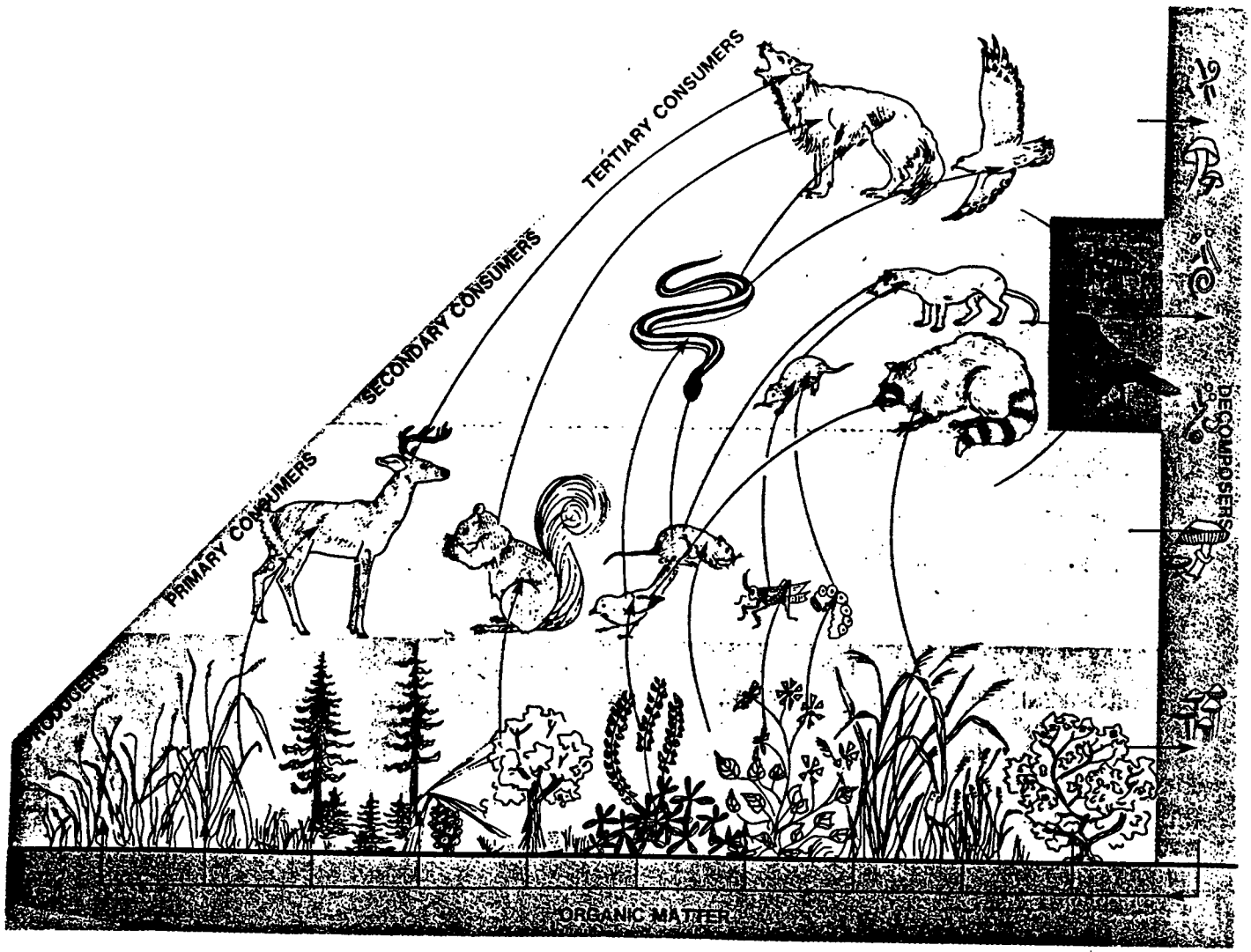


Fig 21 - Food Web (from *Ecological Planning for Farmlands Preservation.* See references)

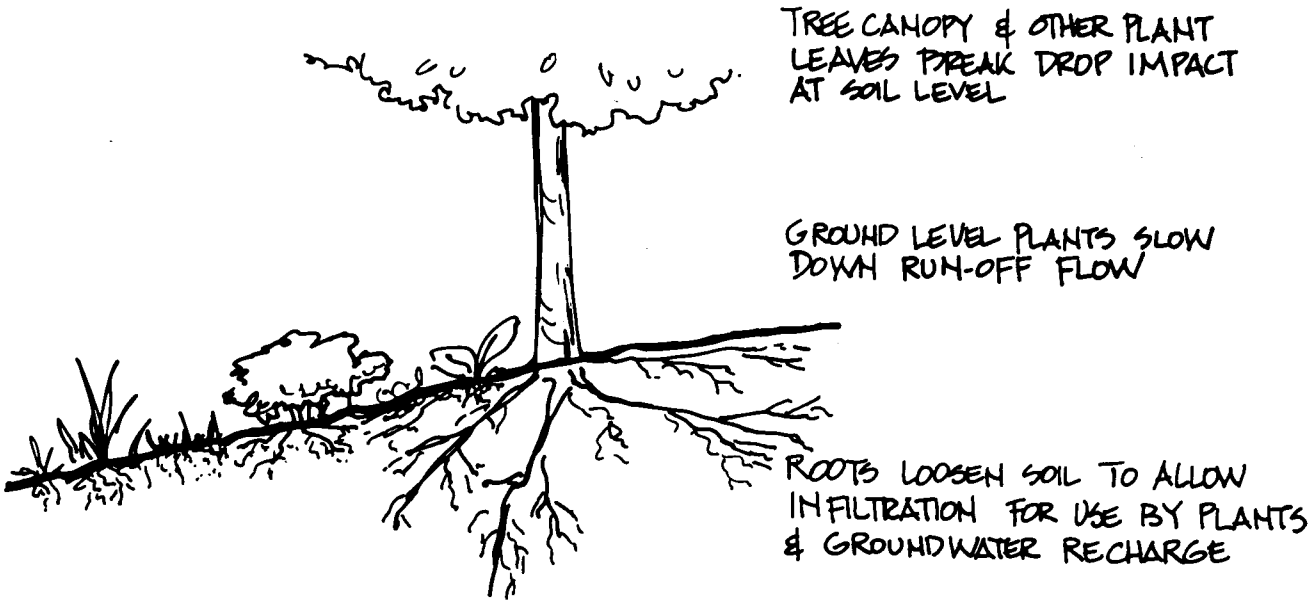


Fig 22A - Vegetation slows down run-off

mental health. People, to escape from the many stresses of life today, seek the change of pace that woodlands, lakes and gardens offer.

Forests and other plant cover on slopes prevent erosion and the loss of soil nutrients. Also, forest vegetation increases the rate at which water infiltrates into the soil and thus aids in the recharge of aquifers. As little as 5% of the rain falling on a forested area will run off into streams and rivers. Vegetation anchors the soil so that wind and water cannot carry it away. Flood plains adjacent to streams and rivers, with their typical vegetation, slow down flood waters and lessen the hazards of downstream flooding. (fig. 22A and 22B).

Woodlands, marshes, swamps and abandoned fields with their thickets and herbaceous ground cover provide diverse habitats for many species of animals, including many game animals. Birds and mammals can live, breed and find sufficient food such as berries, nuts and herbage in these habitats.

Plants also serve as traps for air-borne dust, and carbon and ash particles (fig. 23). Rain washes these trapped particles to the ground where they become part of the soil. By absorption, plants remove noxious gases, carbon dioxide, carbon monoxide, sulfur dioxide and odor from the air. Free oxygen and water vapor are added to the atmosphere as by-products of photosynthesis.

Vegetation ameliorates the extremes of temperature in summer and winter. A forest canopy can lower summer temperatures as much as 21° F. (fig. 24). Appropriate plantings of trees and shrubs lessen the impact of severe winds (fig. 25).

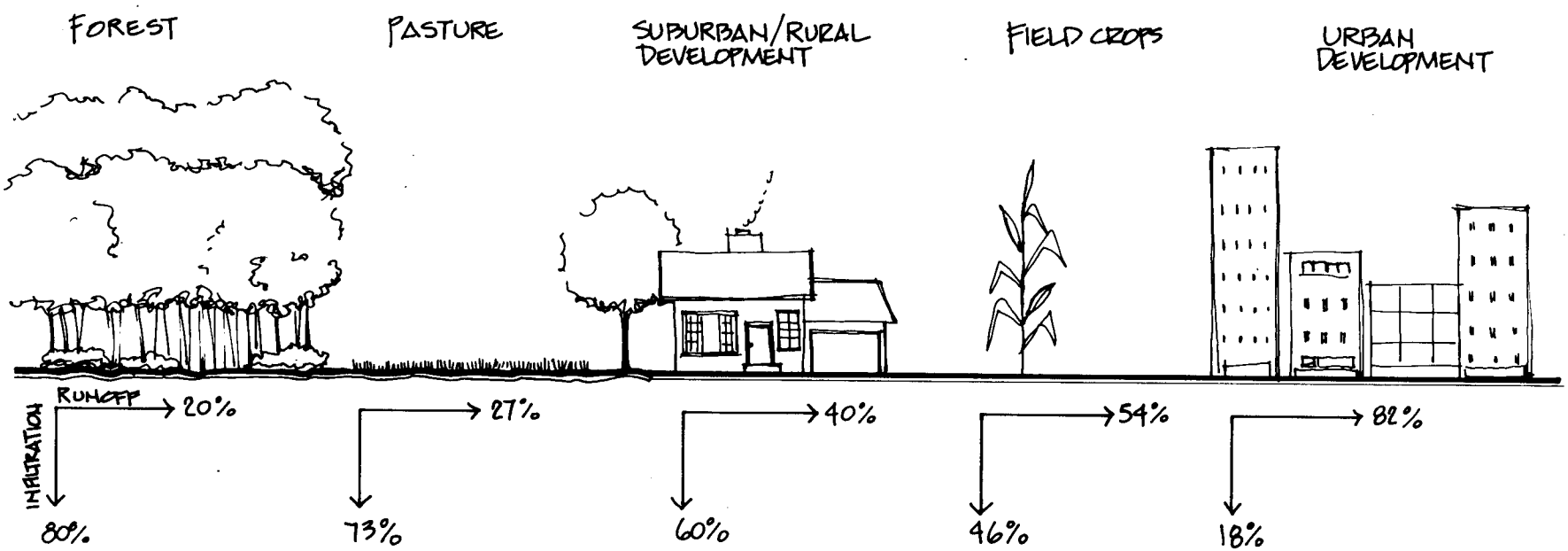


Fig 22B - Proportion of run-off and infiltration for various land uses. (all storm and soil conditions being equal).
(redrawn from *Getting It All Together*, see ref.)

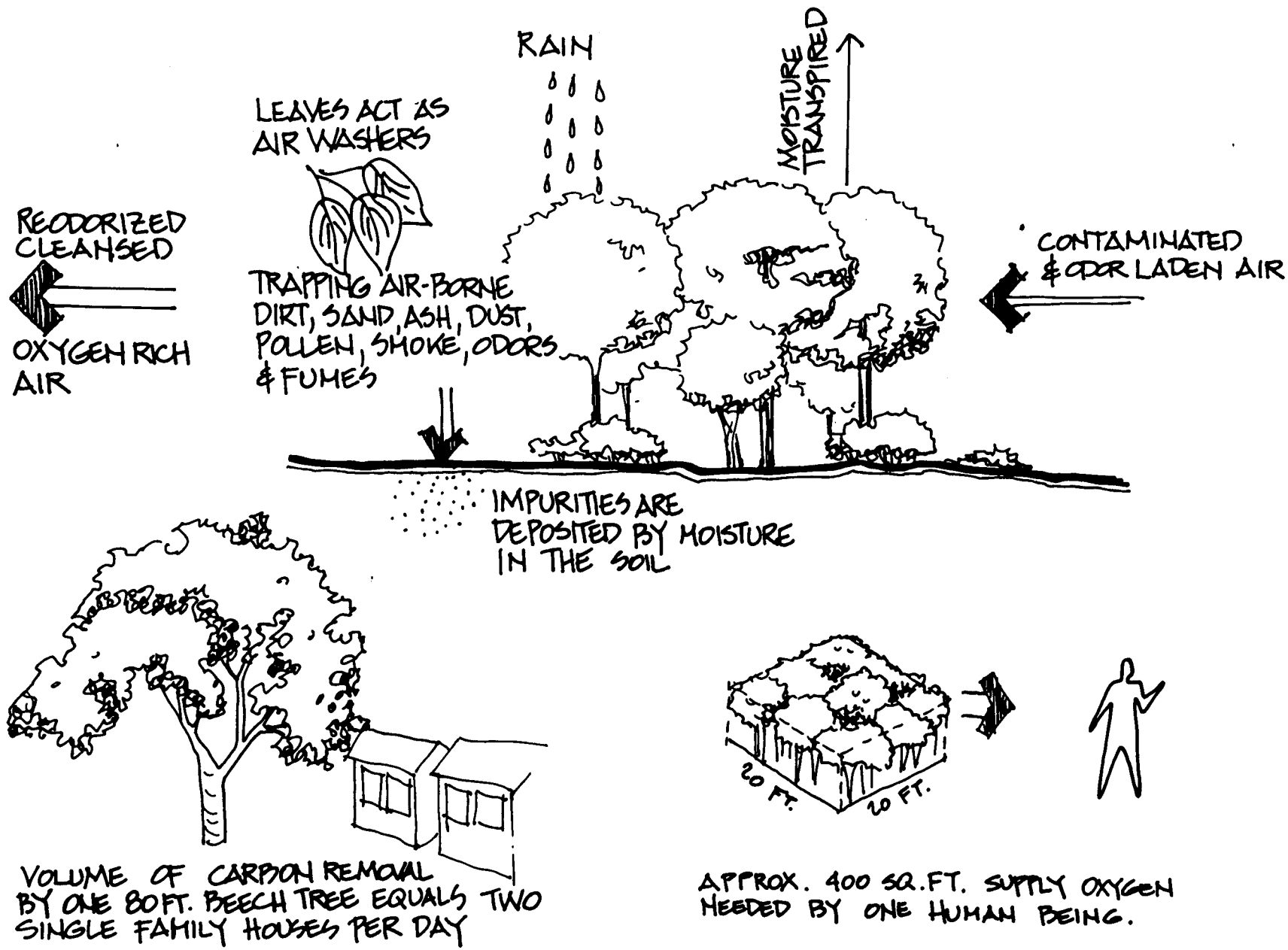


Fig 23 - Vegetation oxygenates, dilutes, filters, cleanses and reodorizes contaminated air.

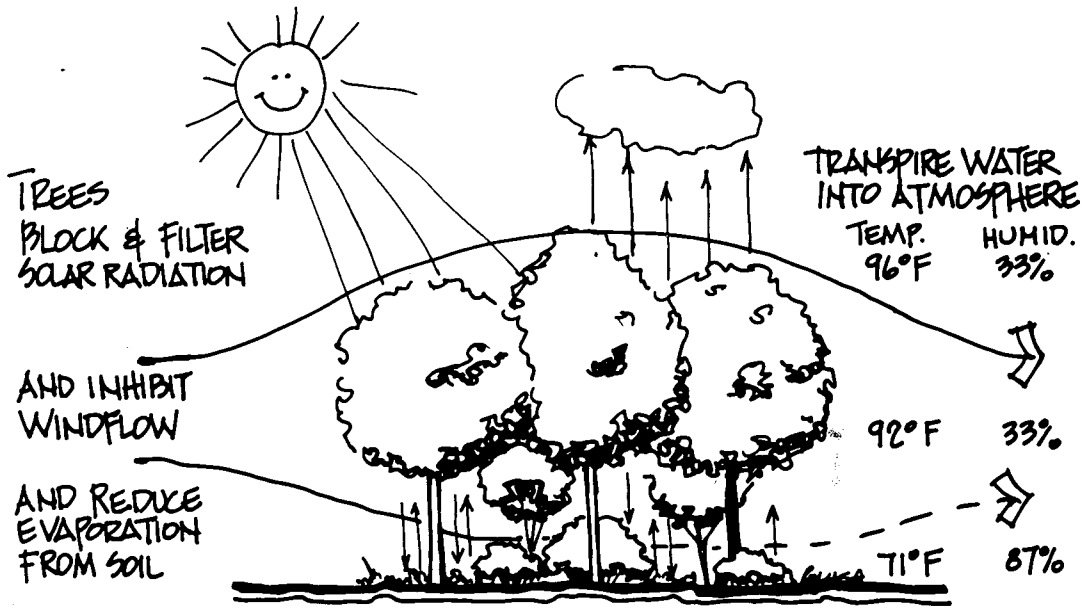
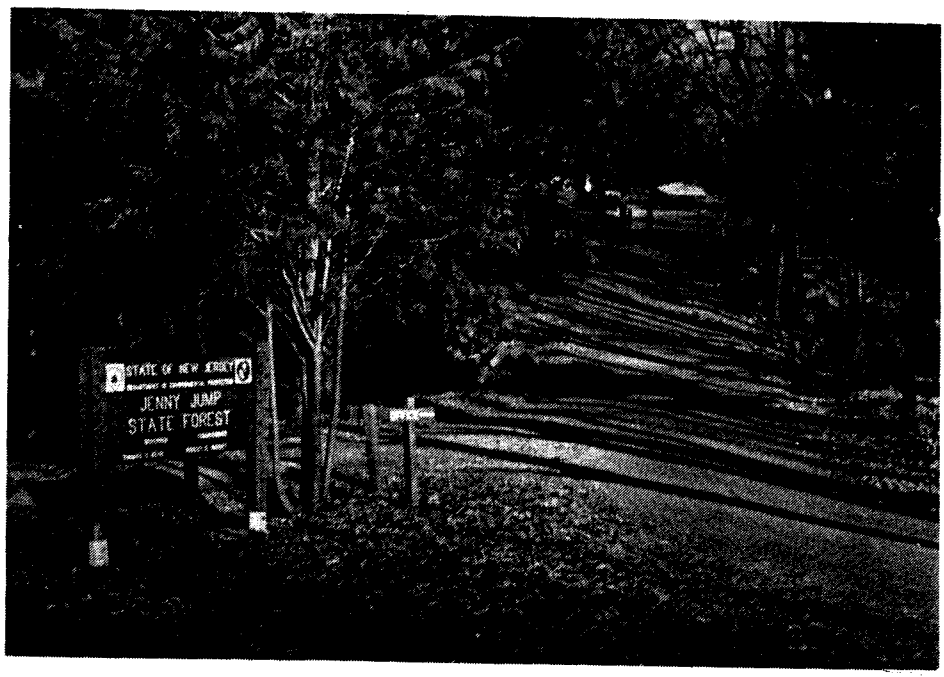


Fig 24 - Vegetation reduces temperature extremes. The relatively high humidity and low evaporation rate act to stabilize temperature, keeping it lower than surrounding air during the day and preventing it from dropping greatly at night. (redrawn based on G. Robinette, 1972).

Vegetation buffers (trees and hedges) reduce noise and provide barriers against unwanted sights and glare from lights. Traffic along a busy highway can generate as much as 72 decibels of sound and each 100 feet of woodland vegetation can absorb six to eight decibels of sound intensity.



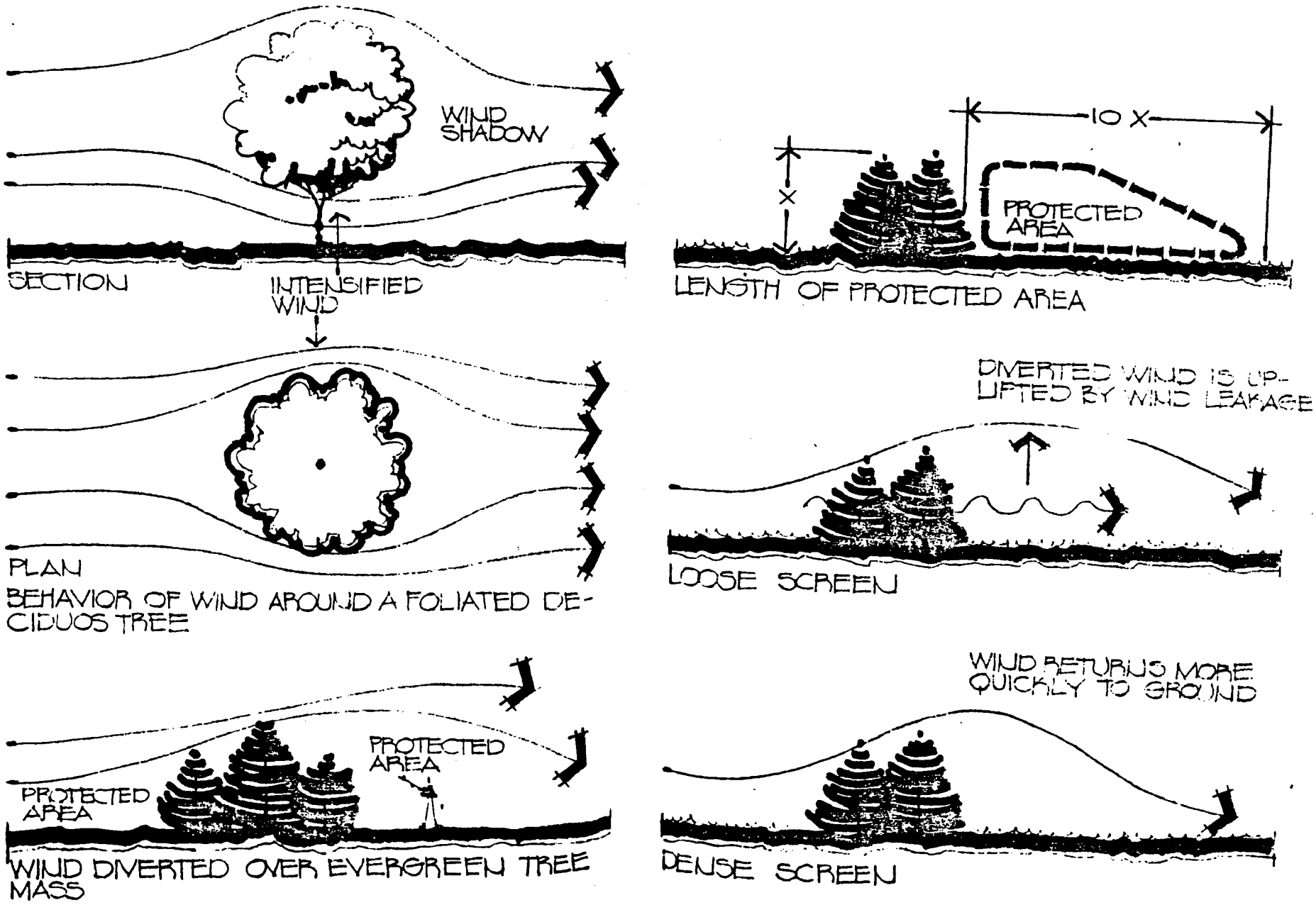


Fig 25 - Vegetation reduces wind impact. (from N.K. Booth, see references).

CHARACTERISTIC WOODLANDS

Frelinghuysen Township lies in the physiographic province known as the Ridge and Valley which occupies the northwestern corner of the state and is the region with the highest elevation in New Jersey. The Ridge and Valley terrain supports a distinct type of forest because of the bedrock underlying it. In general, the soil covering the ridges is poor, acid, often stony, and does not usually support abundant vegetation. The soil layer is thin on the ridges with bedrock exposed in many places. In contrast, the soils in the valleys, derived from limestone and shale that were covered by glacial till, are, for the most part, deeper, more fertile, and well drained.

The vegetation existing in any given area is dependent on terrestrial habitat with its characteristic soils. In Frelinghuysen Township, the habitats include freshwater marshes, flood plains, mesic uplands (ravines, valleys, flat slopes), steep slopes of higher elevations, and rock outcrops. Hazen-Hero-Fredon, Wassaic-Washington Rock Outcrop, and Annandale-Washington-Califon are good soils for woodlands. Bath-Nassau soils are only fair and Carlisle-Adrian soils are poor as they are found in wetlands.

In an area undisturbed by man diversity of vegetation is dependent solely on variety of plant habitats with each habitat having its characteristic or dominant species. For example, the characteristic appearance of upland vegetation is that of a forest because the most abundant or dominant species are trees. Forests may differ also in the growth that occurs under the tallest trees. They may, or may not, have a lower level of smaller growing trees (understory), and, in addition, they may, or may not, have a well-developed shrub layer. A shrub is a plant with multiple woody stems and is lower than the understory. Also, the herbs (non-woody plants) may form an abundant cover on a forest floor or may be conspicuously absent. Of the forest cover that now remains on the well-drained uplands in Frelinghuysen Township, the most common is the mixed oak forest (Table VII). Before the early 1900's, this forest was known as the Oak-Chestnut forest as chestnut trees were as abundant then as oaks.

Much of the fertile limestone valleys in Frelinghuysen have been cleared of natural vegetation. It is on such sites that the Sugar Maple-Mixed Hardwood and Mixed Oak forests flourish. (Table VIII).

Although the chestnut oak tree grows in the mixed oak upland forest, it is not one of the abundant trees in this type of forest. But on slopes at higher elevations, the chestnut oak becomes the most important tree in the plant community. It appears to be able to reproduce and develop better than other oaks under drier and poorer soil conditions at higher elevations.

The wetlands-marshes, bogs and swamps - each have a distinctive vegetation. (Table IX). Since no trees grow in marshes, they have the appearance of grassy fields. Swamps, on the other hand, do have a distinctive canopy.

Table VI lists typical mesic upland habitats found in Frelinghuysen Township and successional vegetation if stages of succession are undisturbed.

Appendix "C" provides plant inventories for specific areas within the Township.

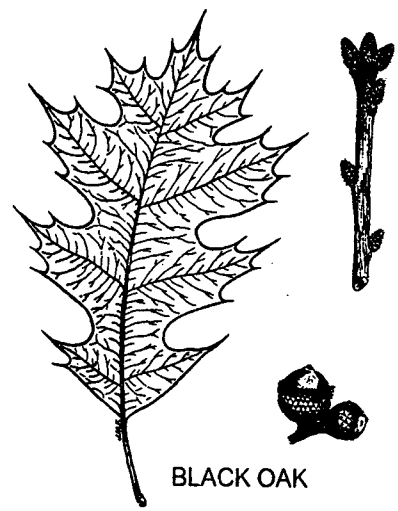
Characteristic Woodland

(Table VI)

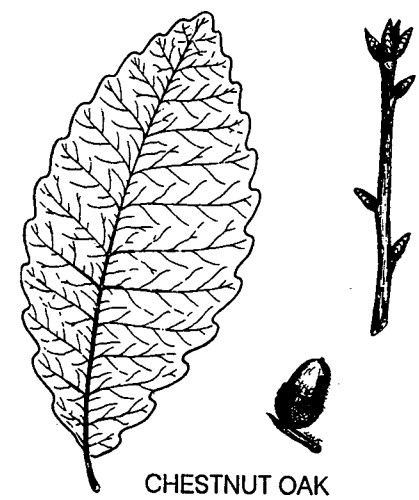
Successional vegetation Stages of succession	Community Structure	Forest types growing on undisturbed mesic upland (flats, slopes, hilltops, and ravines in Appalacian Ridge and Valley Provine)		
		Mixed oak	**Sugar Maple mixed hardwoods**	**Hemlock-Mixed hardwoods**
annual herbs ragweed wild radish yellow rocket ⇓	Tree dominants	red oak white oak black oak	sugar maple	hemlock and few others
perennial herbs aster golden rod ⇓ Initial woody invaders: ⇓ red cedar gray birch large-toothed aspen wild cherry red maple shrubs ⇓	Other typical trees	chestnut oak scarlet oak hickories red maple ash beech tulip tree white oak tulip tree other	sweet birch yellow birch basswood beech ash red maple red oak red maple	sweet birch yellow birch basswood beech ash red oak sugar maple
young woodland and mixed oak or tulip tree stand	tree understory (dominant)	dogwood dogwood ironwood sassafras hophornbeam iron weed	hophornbeam sassafras	few
	shrubs	viburnum spicebush others	viburnum spicebush others	few
	herbs	many spring and fall herbs	many spring and fall herbs	few partridge berry mosses

TABLE VI. MESIC UPLAND HABITATS IN NEW JERSEY

WHITE OAK



BLACK OAK



CHESTNUT OAK

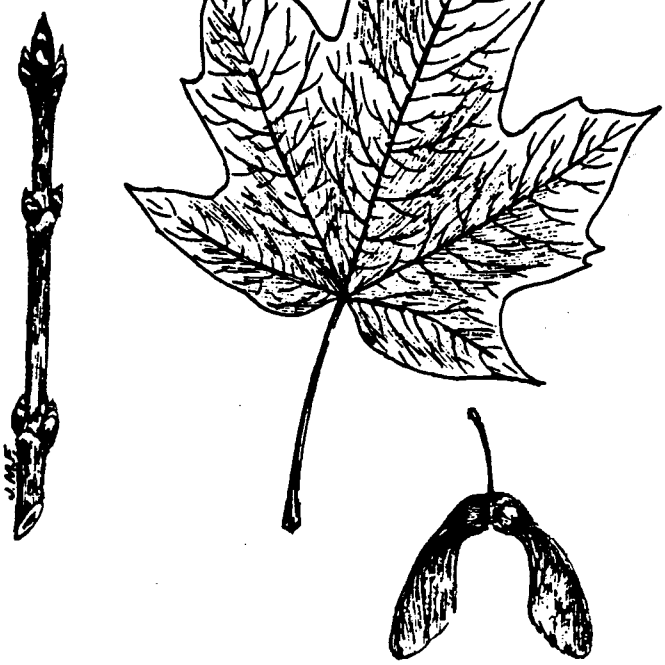
(Table VII)

Tree dominants

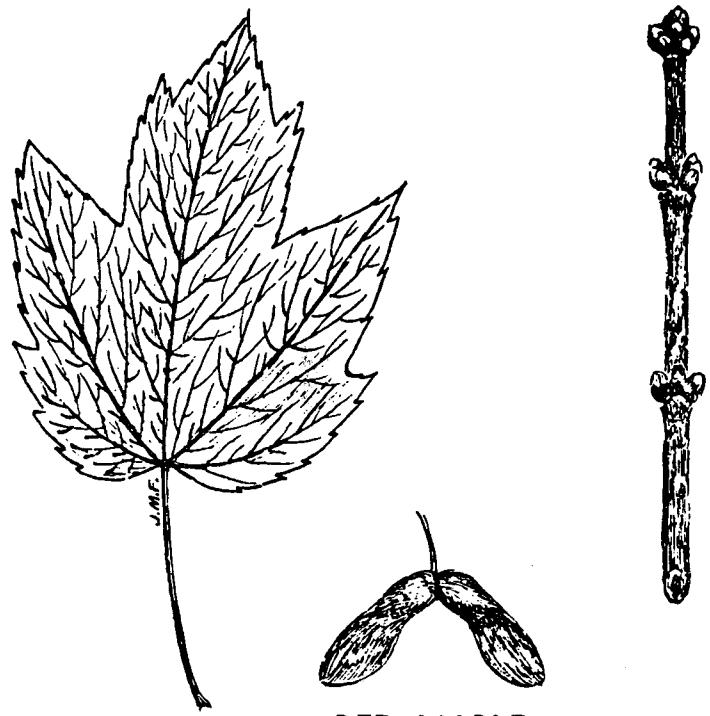
Quercus rubra	Red oak
Quercus alba	White oak
Carya ovata	Shagbark hickory
Fraxinus americana	White ash

Other typical trees

Acer saccharum	Sugar maple
Acer rubrum	Red maple
Carya glabra	Pignut hickory
Liriodendron tulipifera	Tulip poplar
Juglans nigra	Black walnut
Quercus coccinea	Scarlet oak
Sassafras albidum	Sassafras
Prunus serotina	Black cherry
Ulmus americana	American elm



SUGAR MAPLE
(Acer saccharum)



RED MAPLE
(Acer rubrum)

Tree understory

Cornus florida	Flowering dogwood
Ostrya virginiana	Eastern hophornbeam
Carpinus caroliniana	Ironwood
Viburnum prunifolium	Black haw

Shrubs

Cornus alternifolia	Alternate-leaved dogwood
Cornus racemosa	Gray dogwood
Lindera benzoin	Spicebush
Prunus virginiana	Chokecherry
Ribes (many species)	Brambles (raspberry, wineberry,etc.)
Sambucus canadensis	Elderberry

Vines

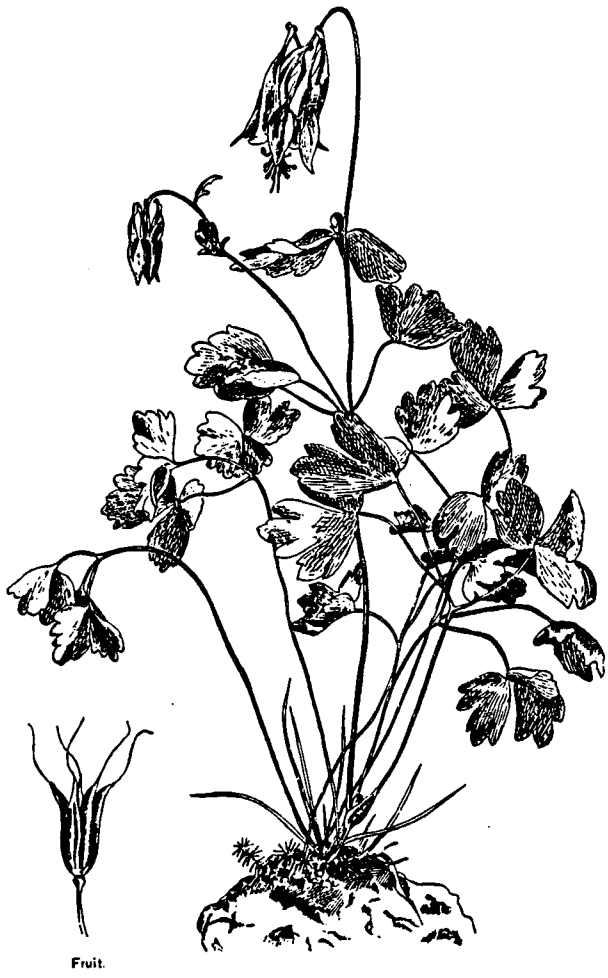
Rhus toxicodendron	Poison ivy
Parthenocissus cinquefolia	Virginia creeper

Herbs (occur where specific conditions exist, i.e. full shade, partial shade, moist depressions, dry rocky slopes, etc.)

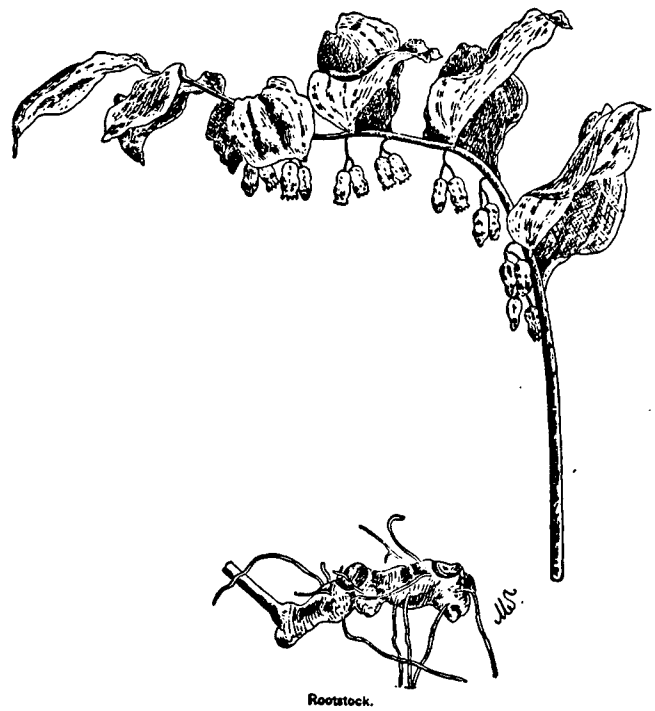
Adiantum pedatum	Maidenhair fern
Anemone thalictroides	Rue anemone
Aquilegia canadensis	Wild columbine
Asarum canadense	Wild ginger
Aster nova angliae	New England aster
Arisaema triphyllum	Jack-in-the-pulpit
Dryopteris marginalis	Marginal shield fern
Eupatorium fistulosum	Joe Pye weed

Table VII. PLANTS FOUND IN OAK-HICKORY FORESTS

Eupatorium perfoliatum	Boneset
Geranium maculatum	Wild geranium
Geranium robertianum	Herb-robert
Hepatica americana	Hepatica, liverwort
Heuchera americana	Alumroot
Lobelia siphilitica	Blue lobelia
Maianthemum canadense	Canada mayflower
Oxalis corniculata	Yellow wood sorrel
Pedicularis canadensis	Wood betony
Polygonatum biflorium	Solomon's seal
Podophyllum peltatum	Mayapple
Symplocarpus foetidus	Skunk cabbage
Impatiens pallida (wet)	Pale jewelweed
Impatiens capensis (moist)	Spotted jewelweed
Viola canadensis	Canada violet
Viola pubescens	Downy yellow violet
Geum aleppicum	Yellow avens
Hieracium venosum	Hawkweed
Linaria vulgaris	Butter-and-eggs
Phytolacca americana	Pokeweed
Smilacina racemosa	False Solomon's seal
Polystichum acrostichoides	Christmas fern
Thelypteris hexagonopter	Broad beech fern
Uvularia sessilifolia	Bellwort, wild oats



WILD COLUMBINE.—*Aquilegia canadensis.*



SOLOMON'S-SEAL.—*Polygonatum biflorum.*

(Table VIII)

Tree dominants

Acer saccharum	Sugar maple

Other typical trees

Acer rubrum	Red maple
Betula lenta	Black birch
Betula lutea	Yellow birch
Betula papyrifera	Gray birch
Fagus grandifolia	American beech
Fraxinus americana	White ash
Quercus alba	White oak
Quercus borealis	Northern red oak
Liriodendron tulipifera	Tulip poplar
Nyssa sylvatica	Black gum
Tilia americana	American basswood
Prunus serotina	Black cherry

TULIPTREE
(Liriodendron tulipifera)

Tree understory

Carpinus caroliniana	Ironwood (American hornbeam)
Ostrya virginiana	Hophornbeam
Cornus florida	Flowering dogwood
Alnus serrulata	Smooth alder

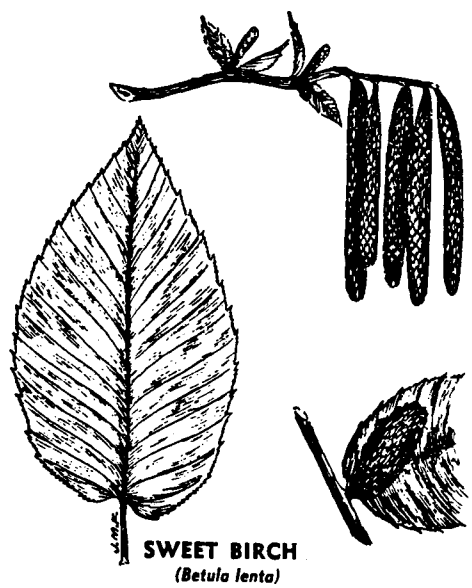
Shrubs

Cercis canadensis	Redbud (rare)
Cornus alterniflora	Alternate-leaved dogwood
Hamamelis virginiana	Witch hazel (rare)
Lindera benzoin	Spicebush
Lonicera varieties	Honeysuckle
Ptelea trifoliata	Hop-tree
Rubus, many	American red rasberry, black rasberry, wineberry (escaped)
Staphylla trifolia	American bladdernut
Ilex verticillata	Black alder (winterberry)
Viburnum acerifolium	Mapleleaf viburnum
Viburnum prunifolium	Black haw
Zanthoxylum americanum	Prickly ash

Vines

Parthenocissus quinquefolia	Virginia creeper
Lonicera japonica (foreign invader)	Hall's (Japanese) honeysuckle
Vitis, many	Grape
Rhus toxicodendron	Poison ivy
Celastrus scandens	American bittersweet
Rubus flagellaris	Common dewberry
Clematis virginiana	Virgin's bower

YELLOW BIRCH
(Betula lutea)



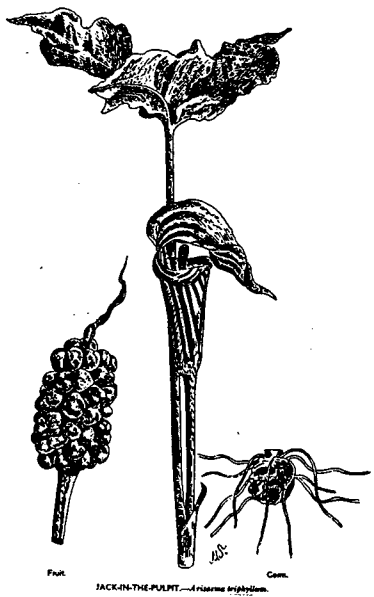
SWEET BIRCH
(Betula lenta)

(Table VIII – cont.)

Herbs (ground layer)

Common plants

Arisaema triphyllum	Jack-in-the-pulpit
Carex laxiflora	Sedge
Carex plantaginea	Plantain-leaved sedge
Claytonia virginica	Spring beauty
Dentaria laciniata	Cut-leaved toothwort

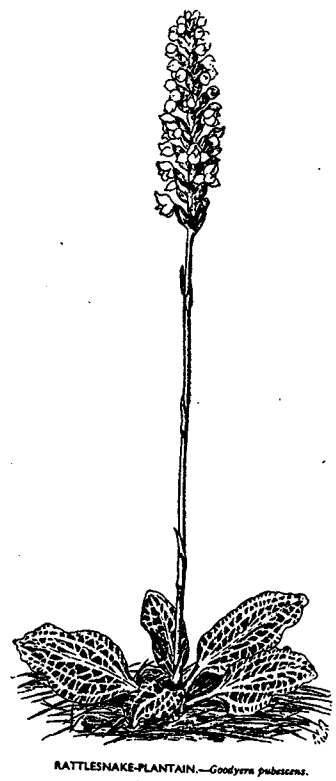


JACK-IN-THE-PULPIT.—*Arisaema triphyllum.*

Dryopoteris spinulosa	Spinulose wood fern
Erythronium americanum	Yellow trout lilly
Galium aparine	Shining bedstraw
Osmorhiza claytoni	Hairy sweet cicely
Podophyllum peltatum	Mayapple
Polygonatum pubescens	Solomon's seal
Smilacina racemosa	False Solomon's seal
Solidago flexicaulis	Broad-leaved goldenrod
Sanguinaria canadensis	Bloodroot
Viola pensylvanica	Smooth yellow violet
Viola pubescens	Downy yellow violet
Viola blanda	Sweet white violet
Viola rostrata	Long-spurred violet
Viola papilionacea	Common blue violet

Others

Actaea pachypoda	White baneberry ("doll's eyes")
Adiantum pedatum	Maidenhair fern
Allium tricoccum	Wild leek
Anemone quinquefolia	Wood anemone
Anemonella thalictroides	Rue anemone
Allium canadense	Wild garlic
Asarum canadense	Wild ginger
Athyrium filix-femina	Lady fern
Athyrium thelypteroides	Silvery spleenwort
Botrychium virginianum	Rattlesnake fern
Cardamine douglassii	Purple cress
Caulophyllum thalictroides	Blue cohosh
Cimicifuga racemosa	Black snakeroot
Chimaphila umbellata	Pipsissewa
Cypripedium acaule	Pink lady's slipper (rare)
Cypripedium reginae	Showy lady's slipper (very rare)
Cypripedium calceolus var. parviflorum	Small lady's slipper (rare)
Dicentra cucullaria	Dutchman's breeches
Dryopteris marginalis	Marginal shield fern
Disporum lanuginosum	Yellow mandarin (rare)
Epigaea repens	Trailing arbutus (rare)
Eupatorium purpureum	Sweet Joe-Pye-weed
Fragaria virginiana	Common strawberry
Galium triflorum	Fragrant bedstraw
Geranium maculatum	Wild geranium
Habenaria viridis	Bracted orchid (rare)
Goodyera pubescens	Downy rattlesnake plantain (rare)



RATTLESNAKE-PLANTAIN.—*Goodyera pubescens.*

TABLE IX. WETLANDS VEGETATION (BOGS, MARSHES, SWAMPS)

(Table VIII – cont.)

INTERRUPTED FERN

Hepatica acutiloba	Hepatica liverwort
Heuchera americana	Alumroot
Hypoxis hirsuta	Yellow star grass
Lobelia siphilitica	Great lobelia
Maianthemum canadense	Wild lily-of-the-valley
Mitchella repens	Partridgeberry
Monotropa uniflora	Indian pipe
Orchis spectabilis	Showy orchid (rare)
Osmunda claytoniana	Interrupted fern (rare)
Panax quinquefolium	Ginseng (very rare)
Panicum latifolium	Broad-leaf panic grass
Penstemon digitalis	Beardtongue
Poa sysvestris	Woodland bluegrass
Polygonatum biflorum	Solomon's seal
Polystichum acrostrichoides	Christmas fern
Polypodium vulgare	Common polypody
Saxifraga virginiensis	Early saxifraga
Sedum ternatum	Wild stone crop
Sisyrinchium angustifolium	Blue-eyed grass
Thalictrum dioicum	Early meadow-rue
Thalictrum polygamum	Tall meadow-rue
Trillium cernuum	Nodding trillium
Uvularia perfoliata	Bellwort
Lycopodium complanatum	Ground cedar
Lycopodium obscurum	Tree clubmoss

TABLE VIII. PLANTS FOUND IN SUGAR MAPLE/MIXED HARDWOODS (MESIC FOREST)

EVERGREEN WOOD FERN

HEPATICA.—*Hepatica americana.*

(Table IX)

A. Cattail Marsh

Dominant - Cattail
Other Herbs:

- Wild rice *(Zinzania aquatica)*
- Reed grass *(Phragmites sp.)*
- Bulrush *(Scirpus sp.)*
- Swamp loostrife *(Lythrum virgatum)*
- Arrowhead *(Sagittaria sp.)*
- Arrow-arum *(Peltandra virginica)*
- Blue flag *(Iris versicolor)*
- Spike rush *(Eleocharis sp.)*
- Bur reed *(Sparganium sp.)*
- Water dock *(Rumex sp.)*
- Sedges *(Carex sp.-many)*
- Marsh fern *(Thelypteris thelypteriodes)*
- Swamp milkweed *(Asclepias incarnata)*
- Jewelweed *(Impatiens pallida)*
- Sensitive fern *(Onoclea sensibilis)*
- Swamp thistle *(Cirsium sp.)*
- New York ironweed *(Vernonia nove-boracensis)*

B. Red maple swamp: (Palustrine forested wetland, characterized by woody vegetation taller than 20 feet)

Dominant tree - Red maple (Acer rubrum)
Other trees:

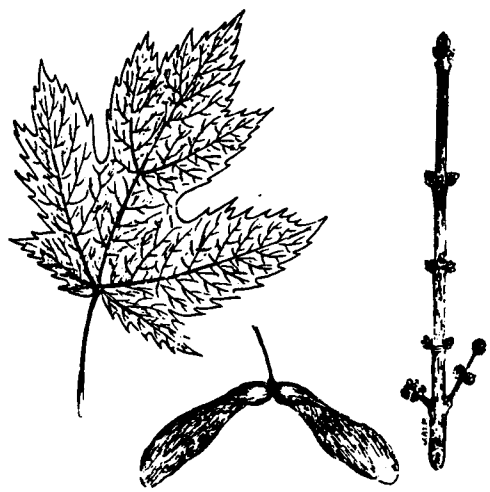
- White ash (Fraxinus americana)
- Silver maple (Acer saccharinum)
- Black willow (Salix nigra)
- Sycamore (Platanus occidentalis)
- American elm (Ulmus americana)
- Black cherry (Prunus serotina)
- Ironwood (Carpinus caroliniana)
- Yellow birch (Betula alleghaniensis)
- Basswood (Tilia americana)

Shrubs:

- Spicebush (Lindera benzoin)
- Dogwood (Cornus amomum & stolonifera)
- Alders (many)
- Winterberry (Ilex verticillata)
- Poison ivy (Rhus radicans)

Common herbs:

Skunk cabbage; jewelweed; marsh marigold tussock sedge and other sedges; asters, bugleweed; smartweeds; jack-in-the-pulpit, goldenrods (many); false nettle; cinnamon fern; royal fern; sensitive fern



SILVER MAPLE
(Acer saccharinum)

TABLE IX. WETLANDS VEGETATION (BOGS, MARSHES, SWAMPS)

Representative plant communities in Frelinghuysen Township may be found in the following areas:

I. Johnsburg Nature Area (Mud Pond) - Northern Hardwood forest

II. Between Lincoln Laurel Road and Route 94 - Upland Forest on shale

III. Bear Creek at Bear Creek Road - Typical swamp wetland with red maple dominating

IV. Jenny Jump State Park - Upland mixed forest/conifers and hardwoods, especially many varieties of oak, hemlock, arrowwood, and striped maple, with mountain laurel at the north-west facing summit.

V. Along the Paulins Kill- Examples of lowland forest may be found, with sycamore, red maple, tulip poplar and black birch as dominant species.

Major sources of information

Kittredge, Joseph, *Forest Influences - The Effects of Woody Vegetation on Climate, Water and Soil.* Dover Publications, Inc., New Edition, 1948, p. 253.

Robichaud and Buell, *Vegetation of New Jersey,* Rutgers University Press, 1973 p. 275.

Typical Habitat along the Paulinskill River.

WILDLIFE

Wildlife that occurs in Frelinghuysen Township is listed below, by class order, and sub-order. The habitat(s) with which each animal is associated follow the name of the animal. The status of several important organisms is listed as well, in parentheses. The following abbreviations are used:

Habitats:

(AG) Agricultural land

(CF) Coniferous forest (mainly hemlock, spruce, pine and juniper)

(DF) Deciduous forest (oak, hickory, maple, beach, elm, locust)

(FM) Freshwater marsh

(G) Grassland, meadow, cropland

(LPR) Lakes, ponds, rivers

(MM) Open woodland, residential and agricultural areas; man-made and disturbed areas

(OF) Open fields

(OP) Partly open country with scattered trees and shrubs (overlaps with deciduous forest)

(ROF) Rocky open fields and slopes

(WDF) Wet open fields; wet deciduous forest

(WG) Wet meadows

(WOP) Wet open country with scattered trees and shrubs.

Status (species without one of the following designations do occur in Township):

(P) Indicates that it is possible the animal can be found within 20 miles of Frelinghuysen Township.

(T) Indicates animals which may become endangered if conditions surrounding the animals begin or continue to deteriorate.

(E) Indicates endangered species whose prospects for survival in the State are in immediate danger due to loss or change of habit, over-exploitation, predation, competition or disease.

(* indicates that the animal has been seen or otherwise positively identified through its tracks by P. Armstrong, former ranger, Wildlife Preserves).

A. REPTILES (Class Reptilia)

(Reported Reptiles are referred to in Peterson's Field Guide, except Bog Turtles reported by Robert Cartica of New Jersey Department of Environmental Protection).

1. TURTLES (Order Chelonia)

a. Common Snapper *Chelydra serpentina.* LPR.Widespread; mud-bottomed waters.

b. Bog (reported*) (E) *Clemmys muhlenbergi.* WG, FM. Sunlit marsh meadows and springs.

c. Wood (T) *Clemmys insculpta.* AG, LPR, WG. Woodland streams, marshes and farmlands.

d. Spotted *Clemmys Cleguttata.* WDF, LPR. Floodplains, beaver ponds.

e. Common Musk *Sternotherus odoratus.* LPR. Ponds, canals, streams.

f. Eastern Painted *Chrysemys picta.* LPR, FM. Shallow, weedy freshwater areas.

g. Eastern Box *Terrapene carolina.* WDF, OF. Damp forests, old fields and floodplains.

2. LIZARDS (Sub-order Lacertilia)

a. Five-lined Skink (reported*) *Eumeces fasciatus.* DF. Damp woods with leaf litter.

b. Northern Fence Lizard *Sceloporus undulatus.* OP. Dry woodlands and brushlands.

3. SNAKES (Sub-order Ophidia)

a. Eastern Smooth Earth Snake *Haldea valeriae.* DF. Moist deciduous forest..

b. Red-bellied (reported*) *Storeria occipitomaculata.* DF, WG. Hilly woodlands and damp meadows.

c. Northern Brown *Storeria dekayi.* WDF, WG. Pond edges, grassed and wooded wetlands.

d. Northern Water *Natrix sipedon.* LPR. All freshwater.

e. Eastern Garter *Thamnophis sirtalis.* OF. Old fields, moist wetlands.

f. Eastern Ribbon *Thamnophis suritus.* WG. Damp meadows, edge of ponds and streams.

g. Eastern Hognose *Heterodon platyrhinos.* G, OP. Sandy areas, grassy woodland, edges.

h. Eastern Worm *Carphophis amoenus.* WOF. Hillside near streams, moist forests.

i. Northern Ringneck *Diadophis punctatus edwardsii.* ROF. Rocky wooded hillsides, old fields.

j. Northern Black Racer *Coluber constrictor.* ROF. Old fields, rocky slopes.

k. Eastern Smooth Green *Opheodrys aestivus.* WG, OF. Stream banks, marshes, old fields.

l. Eastern Rough Green *Opheodrys aestivus.* Southern species.

m. Black Rat *Elaphe obsoleta.* RAG. Rocky wooded hillsides, farmlands. (1) black, (2) yellow, (3) gray.

n. Eastern Milk *Lampropeltis doliata triangulum.* ROF. Various. Rocky wooded hillsides and old fields.

o. Northern Copperhead *Agkistrodon contortrix mokasen* RDF. Rock outcrops and ravines in forests, including edge of flood plains.

p. Timber Rattlesnake (E) *Crotalus horridus horridus.* Rocky, wooded slopes.

B. AMPHIBIANS (Class Amphibia)

1. NEWTS (Genus *Triturua*)

a. Eastern New (*Redeft*"). WDF, LPR. Shallow, weedy ponds and lakes, moist woodlands.

2. SALAMANDERS (Order *Urodeles*)

a. Spotted *Ambystoma maculatum.* LPR,OF. Woods, hillsides near water.

b. Jefferson *Ambystoma jeffersonianum.* WDF. Moist, deciduous woodlands.

c.Marbled *Ambystoma opacum.* WDF, LPR. Temperate ponds.

d. Red-backed or Lead-backed *Plethodon cinereus.* DF,CF. Deciduous to coniferous forests.

e. Slimy *Plethodon glutinosus.* WDF. Moist ravines, wooded floodplains, shale banks.

f. Northern Red *Pseudotriton ruber.* LPR,OF. Springs, cool mountain streams, see pages; adjacent woods and lowlands.

g. Long-tailed (T) (very common locally)*Surycea longicauda.* WDF. Cave entrances, springs, brooks and floodplains.

h. Northern Two-lined Toads

(1) Eastern Spade-foot *Scaphiopus holbrookii.* OP, AG, OF. Sandy gravelly or loamy soils, from farmland to forests.

(2) American Toad *Bufo americanus.* OP, MM. Diverse. From residential gardens to forests.

(3) Fowler's Toad *Bufo woodhous fowleri.* OP. Sandy areas near freshwater.

(4) Tiger Toad

3. FROGS (Order *Anura*)

a. Northern Spring Peepers *Hyla crucifer.* WOP, WDF. Shrubs near temporary.

b. Eastern Gray Treefrog *Hyla versicolor.* WDF. Trees (Shrubs) near woodlands and permanent water bodies.

c. Cricket Tree *Acris crepitans.* WOP. Mudflats, edges of shallow ponds, streams, floodplains.

d. New Jersey Chorus ? Interject ? *Pseudocris triseriata kalmi.*

e. Upland Chorus *Pseudocris triseriata feriarum*

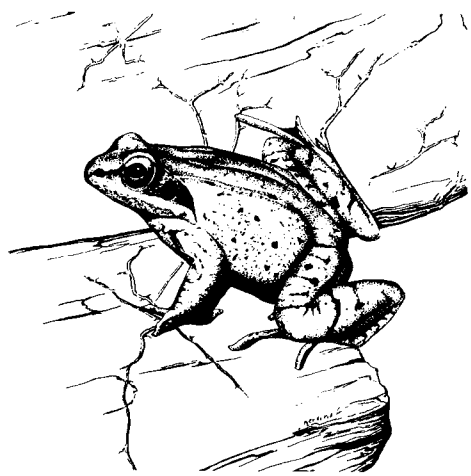
f. Pickerel Frog *Rana palustris.* LPR, WG, OF. Cool clear woodland streams, ponds adjacent to wet meadows.

g. Green Frog *Rana clamitans.* FM, LPR. Wetlands and streams.

h. Wood Frog *Rana palustris.* WDF. Damp shady woodlands.

i. Bull Frog *Rana catesbeiana.* LPR. Permanent body of water.

j. Leopard, Grass, or Meadow Frog *Rana pipiens.* Damp meadows, herb layer, edge of streams and ponds.



C. MAMMALS (Class *Mammalia*)

1. OPPOSUM *Didelphis marsupialis* (Order *Marsupiala*). AG, DF. Farmland, forests, usually near water.

2. INSECT EATERS (Order *Insectivora*). WOP, WG. Moist soil in grassland, shrub areas and forests.

a. Masked Shrew (P) *Sorex cinereus*

b. Smoky Shrew (P) *Sorex fumeus*

c. Long-tailed Shrew

d. Short-tailed Shrew. *Blarina brericauda.* Wide range of land habitats.

e. Least Shrew. *Cryptotis parva.* Open fields, freshwater marshes.

f. Hairy-tailed Mole (P) *Parascalops breweri*

g. Eastern Mole *Scalopus aquatious.* G. Moist sandy soil in grassy areas.

h. Star-nosed Mole *Condylura cristata.* G. Moist, low-lying soil.

3. BATS (Order *Chiroptera*)

a. Little Brown Bat *Myotis lucifugus.* AG. OF. Caves, hollow trees, barns, wooded areas and water.

b. Keen's Bat *Myotis keenii.* OF

c. Silver-haired Bat *Lasionycteris noctivagans.* hollow trees near water, forests.

d. Eastern Pipistcelli *Pipistrellus subflarus*

e. Big Brown Bat *Eptesious fuscus.* AG, OF. Caves, hollow trees, barns, (in summer), forests.

f. Red Bat *Lasiurus borealis*

g. Hoary Bat *Lasiurus cinereus*

4. RABBITS & HARES (Order *Lagomorpha*)

a. Eastern Cottontail* *Sylvilagus floridanus.* OP, FM. Edge old field, forests and swamps.

b. New England Cottontail *Sylvilagus transitionalis*

c. Snowshoe Hare (P) (reported in Green Township). DF, FM, OP. Northern forests, swamps, brush areas.

5. RODENTS (Order *Rodentia*)

a. Eastern Chipmunk* *Tamias striatus.* MM, OP. Gardens, shrubs, forested areas.

b. Woodchuck* *Marmota monax.* OP, AG. Forest edge, rocky edge, rocky areas, roadsides.

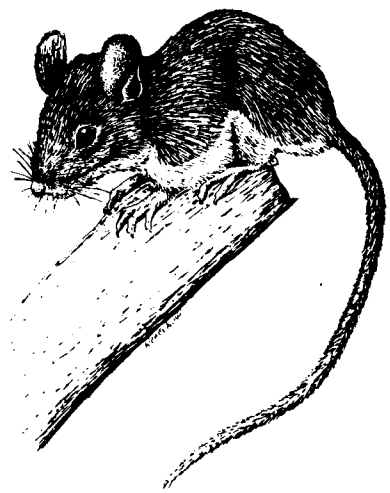
c. Gray Squirrel* *Sciurus carolinensis.* DF. Deciduous forest, suburbs, parks.

d. Red Squirrel *Tamiasciurushudsonicus.* CF. Mountain forests (Pines and Spruce).

e. Southern Flying Squirrel *Glaucomys volans.* DF, CF. Deciduous and mixed forests, snags.

f. Beaver* *Castor canadensis.* LPR. Streams bordered by poplars and birches.

g. Deer Mouse (P) White-Footed *Peromyscus leucopus.* OP. Diverse habitats, primarily uplands.



h. Eastern Wood Rat* *Neotoma magister.* WG. Open swamps and rocky areas.

i. Norway Rat (introduced) *Rattus norvegicus.* AG, MM. Barns, dumps.

j. Black Rat (") *Rattus rattus*

k. House Mouse (") *Mus musculus.* MM. Buildings.

l Gapper's Red-backed Mouse *Chlethrionomys gapperi.* WDF. Forests, usually moist.

m. Meadow Vole* *Microtus pennsylvanicus.* AG. Hay fields with dense vegetation, forst edge.

n. Pine Vole *Microtus pinetorum.* OF. Forests with thick humus layer and loose soil.

o. Muskrat *Ondatra zibethicus.* FM. LPR. Marshes, ponds, slow streams with cattails and reeds.

p. Southern Bog Lemming *Synaptomys cooperi.* FM, WG. Bogs and wet meadows with heavy vegetation.

q. Meadow Jumping Mouse *Zapushudson zapus hudsonius.* G. Meadows.

r. Woodland Jumping Mouse *Napaeozapus insignis*

6. CARNIVORES (Order *Carnivora*)

a. Coyote* *Canis latrans.* OP. Open fields, brush.

b. Red Fox *Vulpes fulva.* AG, OP. Farmlands, forests with open areas.

c.Gray Fox *Urocyon cinereoargenteus.* OP. Open woodlands.

d.Black Bear* *Euarctos americanus.* DF, WDF. Mountaqin forests, swamps.

e. Eastern Racoon* *Procyon lotor.* WDF. Bottom lands, forest edge of streams.

f. Short-tailed Weasel *Mustela erminea.* DF. Forests, near water.

g. Long-tailed Weasel *Mustela frenata.* G. OP. Open fields, forest edge near water.

h. Mink *Mustela vison.* OP. LPR. Along river, streams and lakes.

i. Striped Skunk* *Mephitis mephitis.* AG, OP. Farmlands, open forest and brush areas, usually near water.

j. River Otter* *Lutra canadensis.* LPR. Rivers, streams, lakes and associated.

k. Bobcat* *Lynx rufus.* DF, WDF. Forests, swamps.

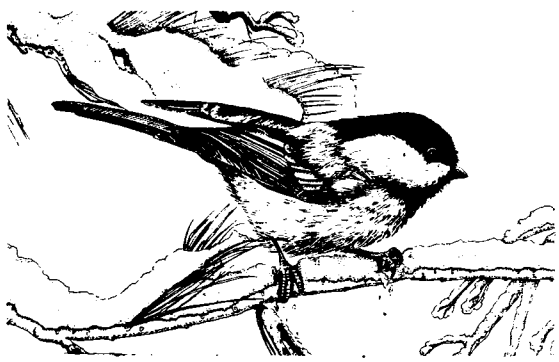
7. EVENTOED, HOOFED MAMMALS (Order *Artiodaetyla*)

a. White-tailed Deer *Odocoileus virginianus.* DF, FW, OF. Forests, swamps adjacent old fields.

BIRDS SIGHTED IN FRELINGHUYSEN TOWNSHIP

English (House) Sparrow *Passer domesticus*
Chipping Sparrow *Spizella passerina*
Ipswich Sparrow (migration) *Passerculus princeps*
Song Sparrow *Melospiza melodia*
Fox Sparrow *Passerella iliaca*
Field Sparrow *Spizella pusilla*
Vesper Sparrow *Pooecetes gramineus*
White-throated Sparrow *Zonotrichia albicollis*
White-crowned Sparrow *Zonotrichia leucophrys*
Tree Sparrow *Spizella arborea*
Golden-crowned Sparrow *Zonotrichia atricapilla*
(the third one to be reported in N.J.)

Common Crow *Corvus brachyrhynchos*
Turkey Vulture *Cathartes aura septentrionalis*

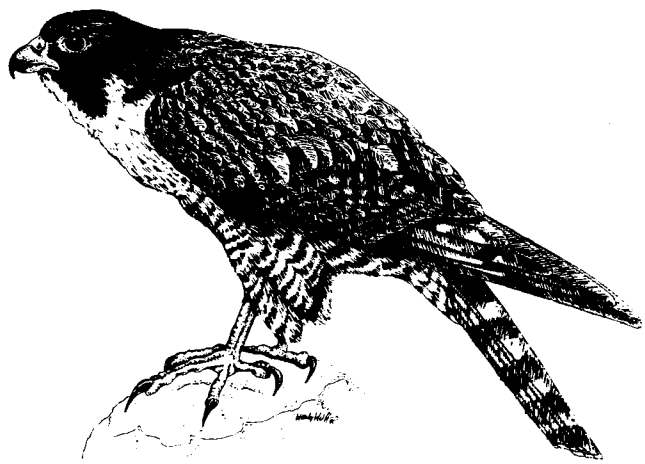


Starling *Sturnus vulgaris*
Evening Grosbeak *Hesperiphona vespertina*
Rose-breasted Grosbeak *Pheucticus ludovicianus*
Slate-colored Junco *Junco hyemalis*
Mockingbird *Mimus polyglottos*
Mourning Dove *Zenaida macroura*
White-winged Crossbill *Loxia leucoptera*
(Winter and only once)

Common Purple Grackle *Quiscalus quiscula*
Eastern Meadowlark *Sturnella magna*
Bobolink *Dolichonyx oryzivorus*
Robin *Turdus migratorius*
Eastern Bluebird *Sialia sialis*
House Wren *Troglodytes aedon*
Carolina Wren *Thryothorus ludovicianus*
Myrtle Warbler *Dendroica coronata*
(now listed as Yellow-rumped Warbler)

American Redstart *Setophaga ruticilla*
Yellow Warbler *Dendroica petechia*
Cape May Warbler (during migration) *Dedroica tigrina*
Yellow-breasted Chat *Icteria virens*
Ruby-crowned Kinglet (winter only) *Regulus calendula*
Golden-crowned Kinglet (winter only) *Rugulus satrapa*
Brown Creeper *Certhia familiaris*
Blue Jay *Cyanocitta cristata*

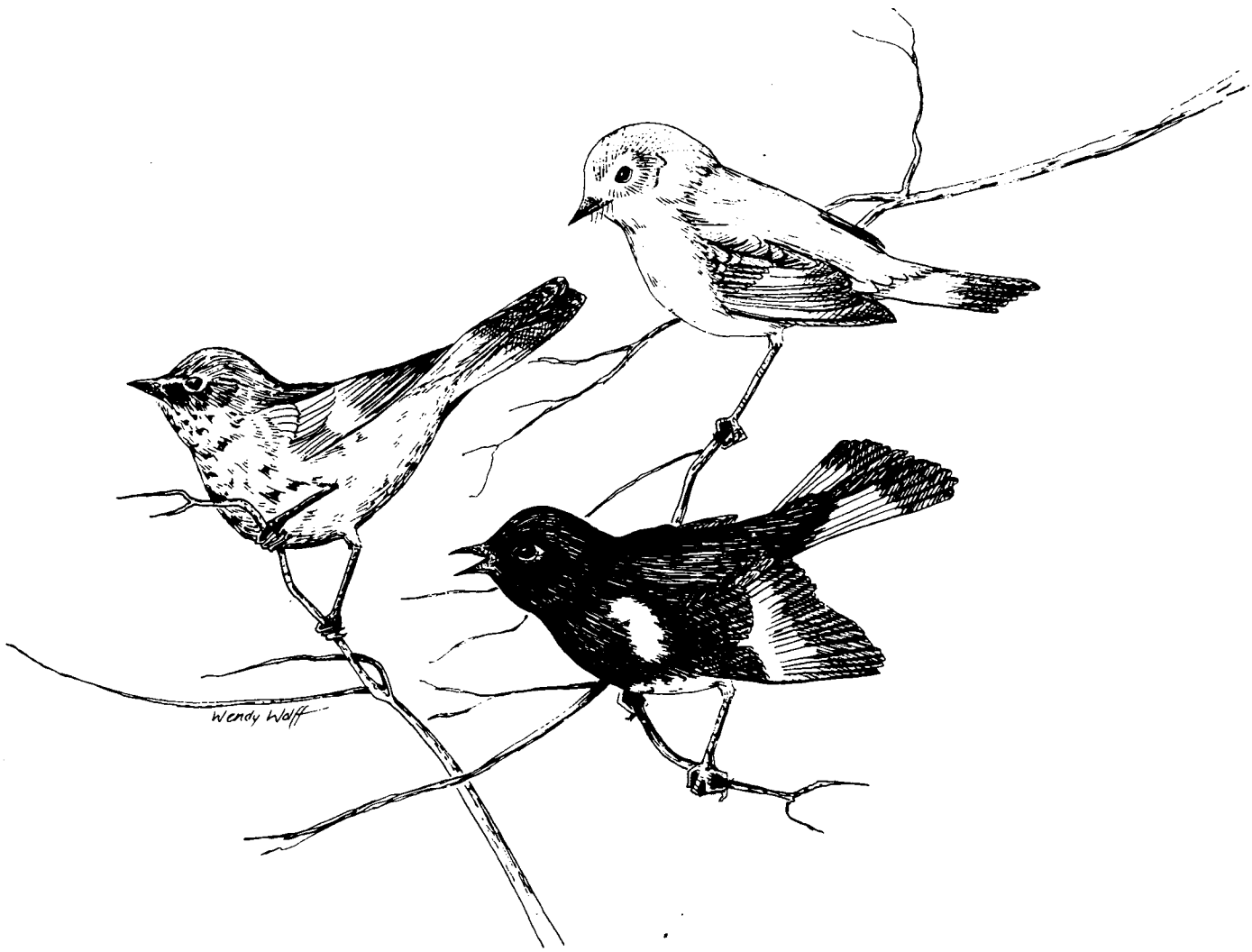
Cow Bird *Molothrus ater*
Red-winged Blackbird *Agelaius phoeniceus*
Kestrel *Falco sparverius*
Sharp-shinned Hawk *Accipiter striatus velox*
Red-shouldered Hawk *Buteo lineatus*
Red-tailed Hawk *Buteo jamaicensis borealis*
Northern Goshawk *Accipiter gentilis atricapillus*
Tufted Titmouse *Parus bicolor*
Black-capped Chickadee *Parus atricapillus*
White-breasted Nuthatch *Sitta carolinensis*
Red-breasted Nuthatch *Sitta canadensis*
Downy Woodpecker *Picoides pubescens*
Hairy Woodpecker *Picoides villosus*
Pileated Woodpecker *Dryocopus pileatus*
Red-bellied Woodpecker *Melanerpes carolinus*
Yellow-bellied Sapsucker *Sphyrapicus varius*
Flicker *Colaptes auratus*
Orchard Oriole *Icterus spurius*
Baltimore Oriole *Icterus galbula*
(now called Northern Oriole)
Scarlet Tanager *Piranga olivacea*
Dickcissel *Spiza americana*
Pine Grosbeak (winter) *Pinicola enucleator*
Pine Siskin *Carduelis pinus*
Indigo Bunting *Passerina cyanea*
Rufous-sided Towhee *Pipilo erythrophthamus*
Ruby-throated Hummingbird *Archilochus colubris*
Common Pigeon (family *Columbidae*)



Bobwhite *Colinus virginianus*
Cardinal *Richmondena cardinalis*
American Goldfinch *Carduelis tristis*
House Finch *Carpodacus mexicanus*
Purple Finch *Carpodacus purpureus*
Canada Goose *Branta canadensis*
Mallard Duck *Anas platyrhynchos*
Killdeer *Charadrius vociferus*
Ring-necked Pheasant *Phasianus colchicus*
Wild Turkey *Meleagris gallopavo*
Purple Martin *Progne subis*
Yellow-billed Cuckoo *Coccyzus americanus*
Great-crested Flycatcher *Myriarchus crinitus*
Least Flycatcher *Empidonax minimus*
Eastern Phoebe *Sayornis phoebe*
Eastern Kingbird *Tyrannus tyrannus*

Horned Lark (winter, rare) *Eremophila alpestris*
Barn Swallow *Hirundo rustica*
Chimney Swift *Chaetura pelagica*
Tree Swallow *Iridoprocne bicolor*
Rough-winged Swallow *Stelgidopteryx ruficollis*
Blue Gray Gnatcatcher *Polioptila caerulea*
Brown Thrasher *Toxostoma rufum*
Wood Thrush *Hylocichla mustelina*
Northern Shrike (winter) *Lanius excubitor*
Cedar Waxwing *Bombycilla cedrorum*
Warbling Vireo *Vireo gilvus*
Red-eyed Vireo *Vireo elivaceus*

*(*The above inventory was supplied by Mildred Read, an avid birder and resident of Frelinghuysen for over 40 years)*



APPENDIX B. PLANT INVENTORY AT GENESIS FARMS, TAKEN 1987
BY GENESIS FARMS (140 acres between Rt. 94, Silver Lake Road, and farm boundary, Marksboro)

Oak-hickory forest (wooded tract by Route 94)

Dominant tree species:

Quercus rubra	red oak
Quercus alba	white oak
Quercus velutina	black oak
Carya ovata	shagbark hickory
Fraxinus americana	white ash

Others:

Acer saccharum	sugar maple
Acer rubrum	red maple
Liriodendron tulipifera	tulip-poplar

Cattail marsh

Typha spp.	cattail
Decoden verticillatus	swamp loosestrife
Sagittaria latifolia	arrowhead
Eleocharis spp.	spike rush
Symplocarpus foetidus	skunk cabbage
Rumex verticillatus	water dock
Dryopteris thelypteris	marsh fern
Carex ?	sedge
Asclepias spp.	swamp milkweed
Impatiens capensis	jewelweed
Cypripedium pallida	lady's slipper
Onoclea sensibilis	sensitive fern
Iris versicolor	blue flag
Cirsium muticum	swamp thistle

Red maple swamp

Dominant tree species:

Acer rubrum	red maple

Herbaceous plants:

Onoclea struthiopteris	ostrich fern
Nasturtium officinale	watercress
Tussilago farfara	coltsfoot
Ranunculus septentrionalis	swamp buttercup
Caltha palustris	marsh marigold
Cicuta maculata	cow bane
Arisaema triphyllum	Jack-in-the-pulpit
Erythronium americana	trout lily

Sugar maple-mixed hardwoods

Dominants tree species:

Acer saccharum	sugar maple

Others:

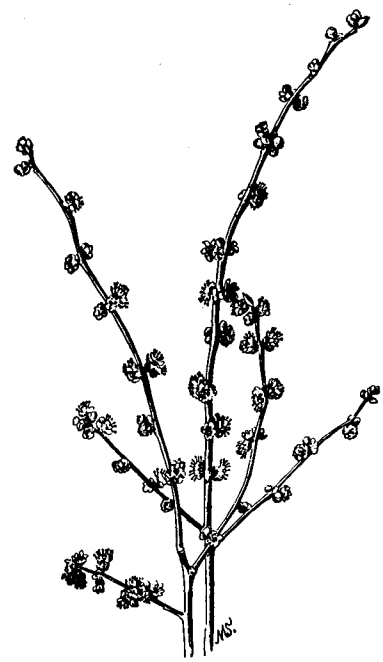
Acer rubrum	red maple
Betula lenta	black birch
Betula lutea	yellow birch
Betual papyrifera	white birch
Tilia americana	basswood
Fagus grandifolia	american beech
Fraxinus americana	white ash
Quercus alba	white oak
Ostrya virginiana	hop hornbeam
Carpinus caroliniana	ironwood
Prunus serotina	black cherry

Shrubs:

Lindera benzoin	spicebush
Viburnum	

Herbaceous plants:

Epigaea repens	trailing arbutus
Polygonatum pubescens	Solomon's seal
Smilacina racemosa	false Solomon's seal
Trientalis borealis	starflower
Hamamelis virginiana	witchhazel
Mitchella repens	partridgeberry
Polypodium vulgare	Common Polypody



Pteris aquilina	bracken fern
Oxalis acetosella	wood sorrel
Alliaria officinalis	garlic mustard
Monotropa uniflora	Indian pipe
Maianthemum canadense	Canada mayflower
Chimaphilia maculata	wintergreen
Allium canadensis	wild garlic
Asarum canadense	wild ginger
Polytrichum juniperinum	hair-cap moss
Amelanchier spp.	serviceberry
Cypripedium spp.	lady's slipper
Lycopodium obscurum	ground pine
Hepatica americana	hepatica
Coptis graenlandica	golden thread
Dicentra eximia	bleeding heart
Sanguinaria canadensis	bloodroot
Mitella diphylla	Miterwort
Viola palmata	violet

Open space (fields, streams, roadsides)

Dominant tree species:

Robinia pseudo-acacia	black locust
Catalpa speciosa	Indian bean
Rhus glabra	smooth sumac
R. typhina	staghorn sumac
Platanus occidentalis	sycamore
Juglans nigra	black walnut
Populus grandidentata	large-toothed aspen
Thuya occidentalis	American arborvitae
Juniperus virgininia	red cedar
Tsuga canadensis	hemlock
Pinus strobus	white pine

Herbaceous plants and shrubs:

Eupatorium perfoliatum	boneset
Plantago major	plantain
Asclepias syriaca	milkweed
Barbarea vulgaris	wintercress
Nepeta cataria (alien)	catnip
Hemerocallis fulva	day lily
Sambucus canadensis	elderberry
Galinsoga	ground ivy
Chenopodium album	lamb's quarters
Menta	mint
Conium maculatum	hemlock
Viola papilionacea	butterfly violet
V. sagittata	Arrow-Leaved violet
Daucus carota	Queen Anne's lace
Fragaria virginiana	wild strawberry
Potentilla canadensis	cinquefoil
Capsella bursapastoris	shepherd's purse
Phytolacca americana	poke weed
Lepidium	pepper grass
Rubus allegheniensis	wild blackberries
Portulaca oleracea	purslane
Thalictrum polygamum	meadow rue
Cichorium intybus	chickory
Trifolium spp.	clover
Symphytum officinale	comfrey
Malva neglecta	mallow
Taraxacum officinale	dandelion
Arctium	burdock
Stellaria media	chickweed
Rumex crispus	sourdock
R. acetosella	sheep sorrel
Vinca minor	myrtle
Ranunculus repens	creeping buttercup
Phlox	
Chrysanthemum leucanthemum	ox-eye daisy
Solidago spp.	goldenrod
Vitis novae-angliae	New England grape
Lonicera spp.	honeysuckle
Achillea millefolium	yarrow
Rosa multiflora	multiflora rose (introduced)
Cirsium arvense	Canada thistle

Rockledges

Polypodium virginianum	rock fern
Umbilicaria spp.	rock tripe
Cladonia cristatella	British soldier
Anemone quinquefolia	windflower
Aquilegia canadensis	columbine
Lycopodium spp.	club moss
Rinodina	custose lichens
Sedum	cushion moss
Polytrichum juniperinum	haircap moss
Potentilla spp.	three-toothed cinquefoil

WILD CARROT —*Daucus Carota.*