
3: PHYSIOGRAPHY, TOPOGRAPHY AND GEOLOGY

A. Physiography

New Jersey can be divided into four regions, known as *physiographic provinces*, which are areas with similar sequences of rock types, geologic structures and a common geologic history (see **Figure 3a**). The northwestern section of New Jersey is part of the *Valley and Ridge Province*, which is characterized by long, parallel ridges and valleys formed by folded and faulted limestones, shales and sandstones of early and middle Paleozoic age. Erosion-resistant sandstone and siltstone bedrock lie beneath the ridges of the Appalachian Mountains while shale and limestone underlie the valleys.

Bordering the Valley and Ridge Province to the southeast, the *Highlands Province* consists of metamorphic rocks of Precambrian age. The granites and gneisses are resistant to erosion and create a hilly upland with deep, steep-sided valleys carved by streams. These features are seen in the northern half of Holland Township (see **Figures 3a** and **3e**).

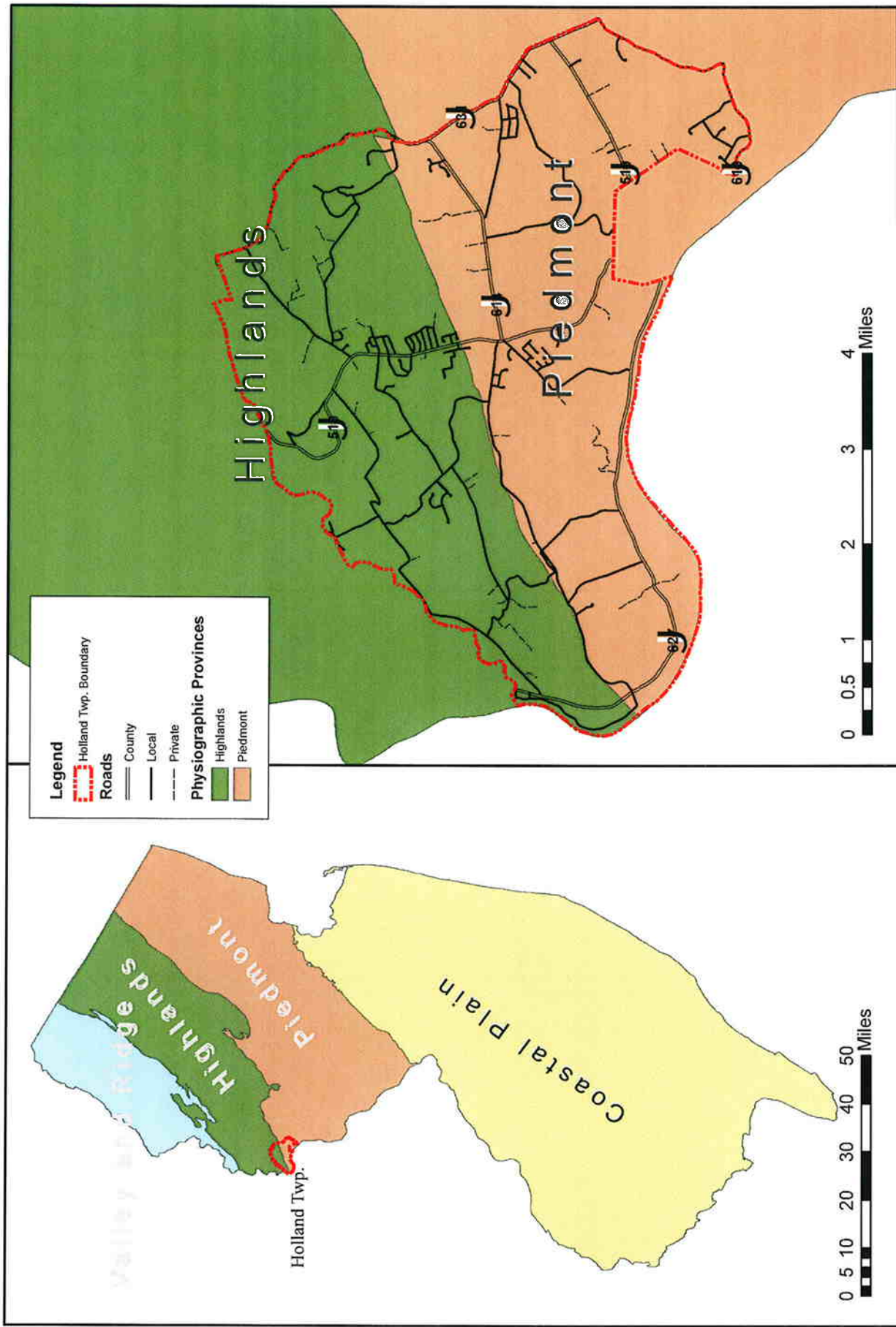
The Highlands Province is separated from the *Piedmont Province* by a series of major faults which cross Holland Township and reach the Delaware River near Church Road (see **Figure 3a** and **3e**). The Piedmont Province is characterized by gently rolling hills. The rocks of the Piedmont are of Late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

B. Topography

Topography depicts the relief features of an area. Holland Township's topography consists of gently rolling hills and steep-sided hills with deep valleys carved by streams and rivers. The elevation in the township ranges from about 100 feet above mean sea level (adjacent to the Delaware River) to over 900 feet. In **Figure 3b**, each line represents 200 feet of elevation, and is drawn to follow the contour of the land. **Figure 3c** displays elevation with the hills shaded (called "hillshade") to present a three dimensional effect.

Today's topography of the Highlands section of Holland Township resulted from millions of years of erosion of mountains that were 4,000 feet high at one time (Gallagher, 1997). The highest point in Holland Township is 918 feet at the top of Musconetcong Mountain. The topography in the Piedmont section resulted from relatively recent erosion from a nearly flat plain. The composite rocks in the south central area of the township, known as Gravel Hill, are more resistant to erosion, resulting in a high elevation of 787 feet. Most of the steep slopes are located along the rivers and streams

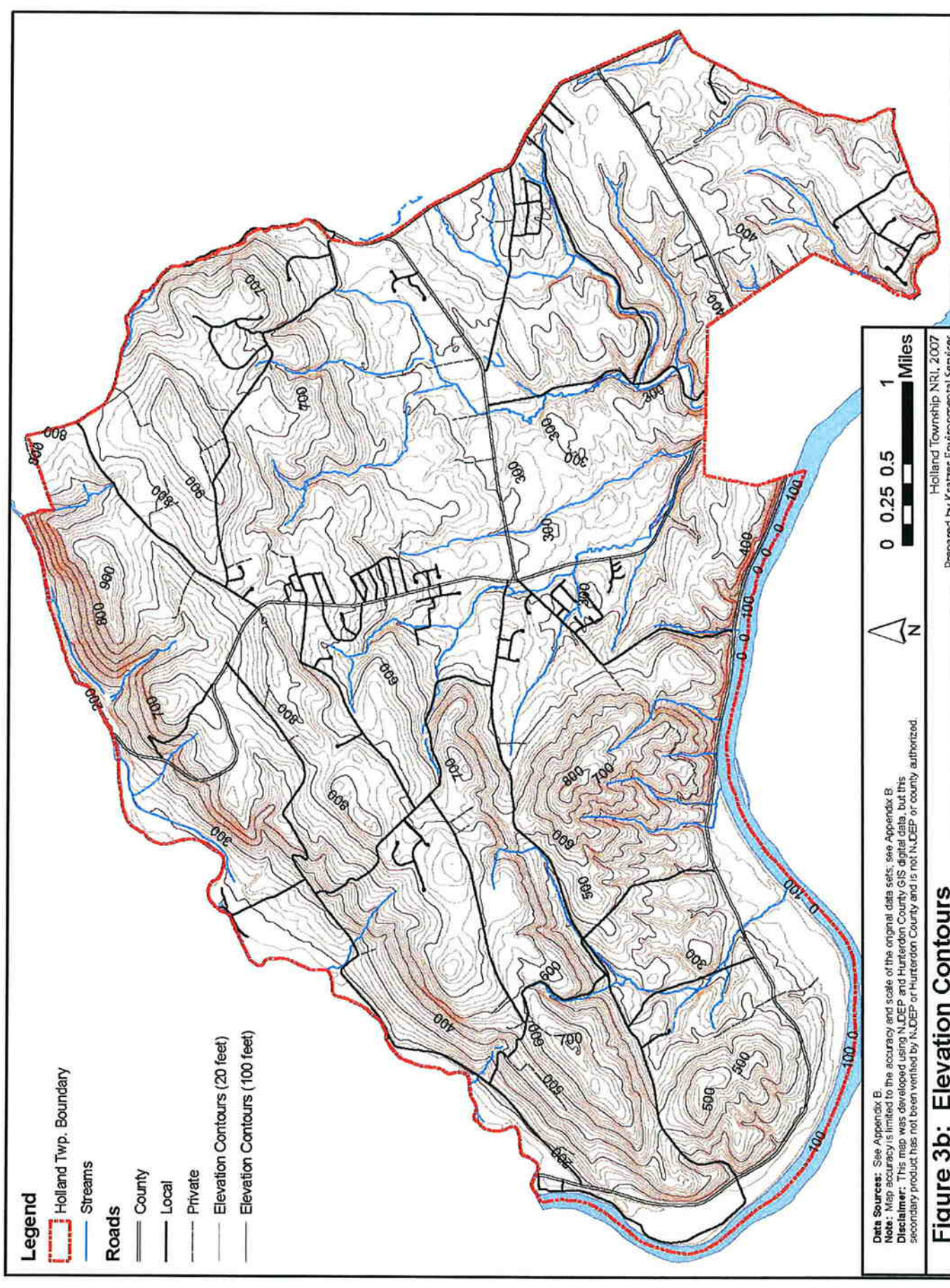
The closer the contour lines are spaced to each other, the steeper the topography is. Slopes greater than 15% are generally considered "steep slopes" (see **Figure 3d**). Steep slopes










Holland Township NRI, 2007
 Prepared by Kratzer Environmental Services

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

Figure 3a: Physiographic Provinces



Legend

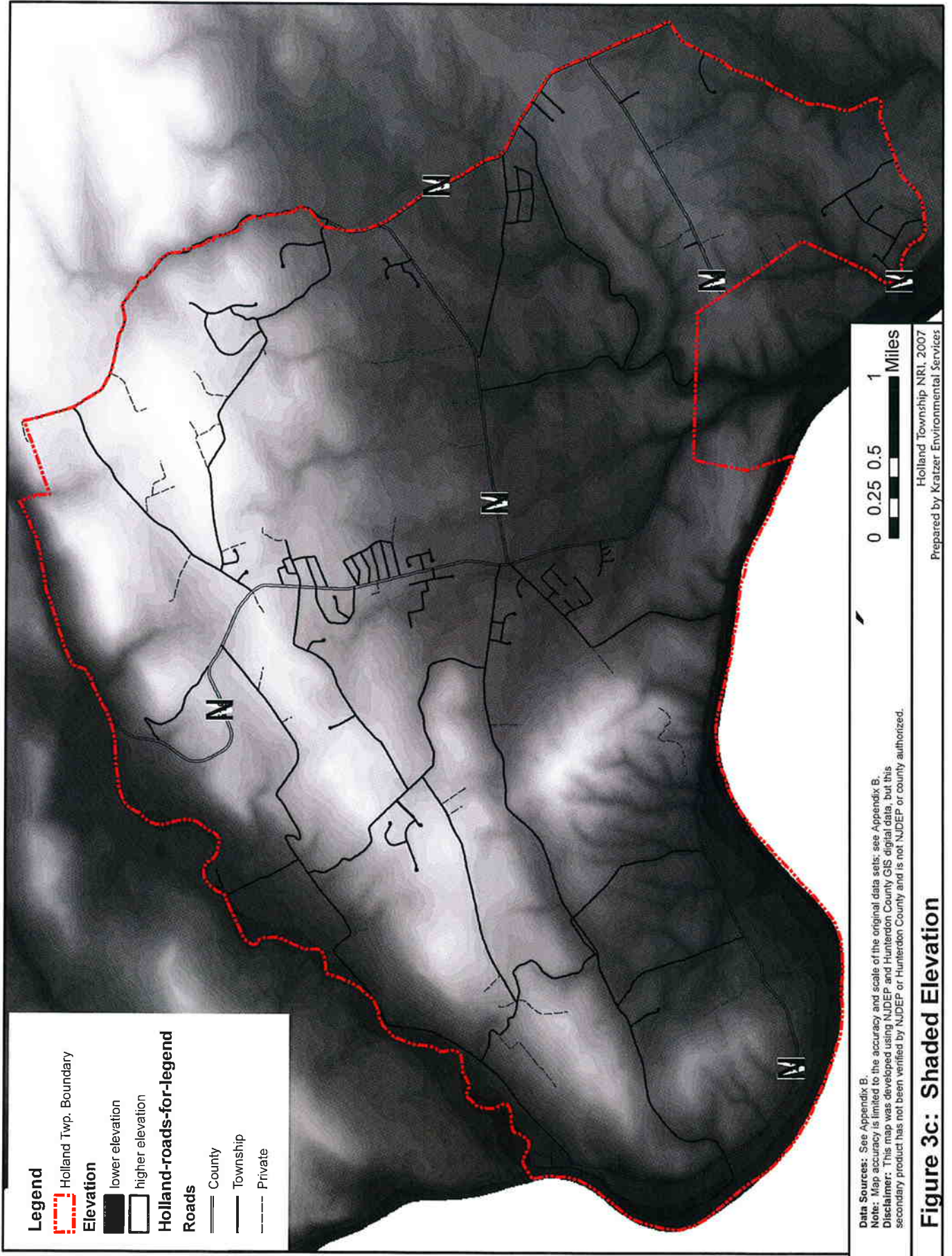
-  Holland Twp. Boundary
-  Streams
- Roads**
-  County
-  Local
-  Private
-  Elevation Contours (20 feet)
-  Elevation Contours (100 feet)

Data Sources: See Appendix B.
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
Figure 3b: Elevation Contours



Legend




-  Holland Twp. Boundary

Elevation

-  lower elevation
-  higher elevation

Holland-roads-for-legend

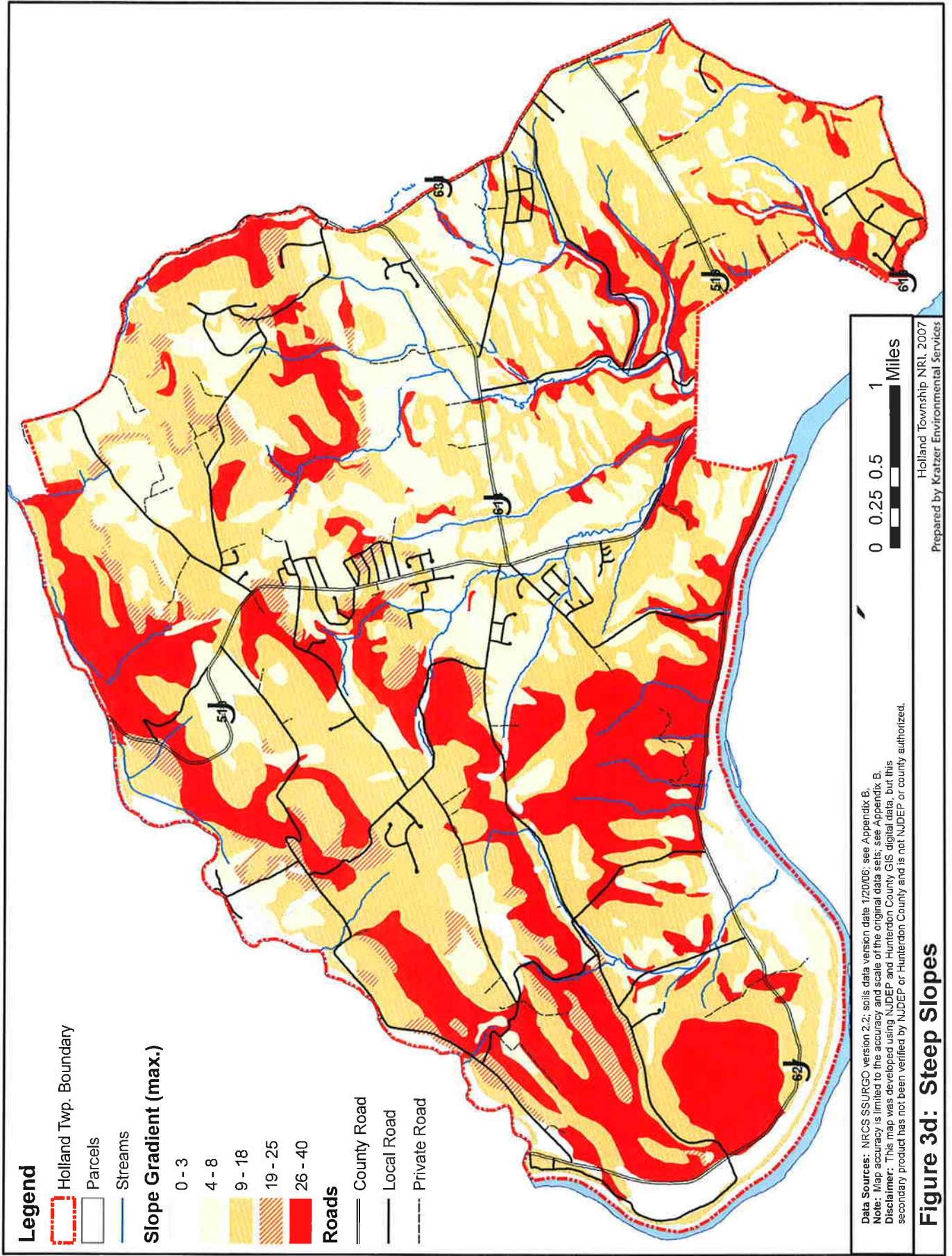
Roads

-  County
-  Township
-  Private

Data Sources: See Appendix B.
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Figure 3c: Shaded Elevation



are poor locations for septic systems, and present difficulties for driveway construction and for usable areas around a house. In addition, steeper slopes are more vulnerable to erosion. As the gradient or percent of slope increases, the velocity of runoff water increases, which increases its erosive power. A doubling of velocity of runoff water increases the erosive power fourfold and causes 32 times the amount of material of a given particle size that can be carried (Foth, 1978).

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

C. Geologic history

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

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

In the Mesozoic Era (the time when dinosaurs lived), New Jersey was part of the supercontinent Pangaea. Flashfloods eroded the mountains, dropping mud and silt in extensive floodplain deposits, gradually filling the valleys. This is known as the "Newark episode," which lasted between about 15 and 23 million years. The rate of deposition averaged between 215 and 325 millimeters per 1,000 years, keeping pace with the rate of basin sinking. Shallow lakes formed at the bottom of the desert basin (known as playa lakes). The sediments became rock under the pressure of each successive layer of mud, silt or sand. Dinosaurs walked on these mudflats, leaving footprints that occasionally became fossilized. Fossils of coelacanths and other fish have also been found in these rock formations (Gallagher, 1997) (although not in Holland Township).

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

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

Table 3.1: Summary of New Jersey's Geologic History

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

Table 3.1: Summary of New Jersey's Geologic History

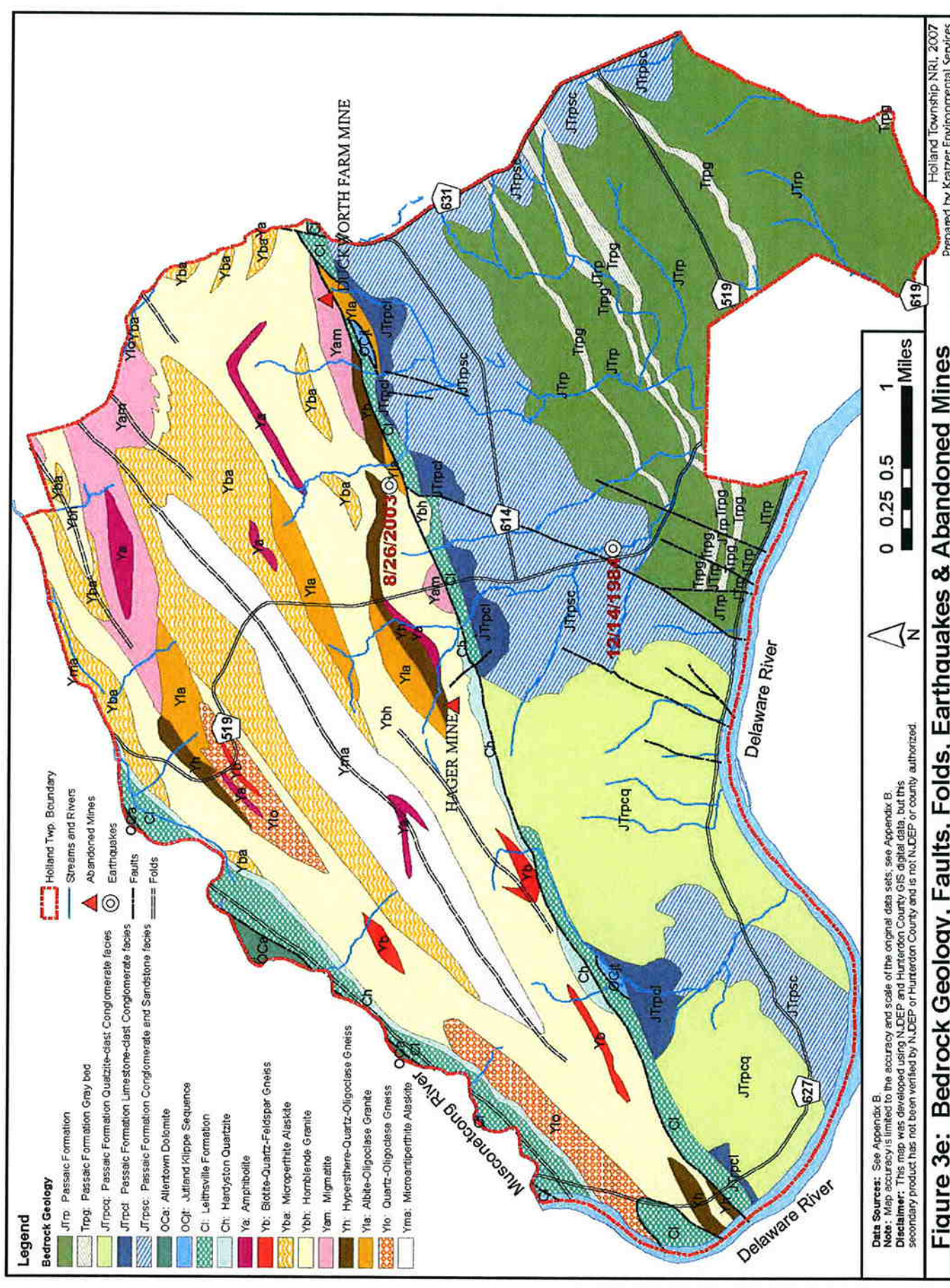
| Period | Million Years Ago | Description of Climate and Fossils Found in Corresponding Bedrock |
|--|-------------------|--|
| Cenozoic Era | | |
| Tertiary Period | 65 – 1.8 | <p>Climate: The climate was warm, and the sea level was higher, covering the Outer Coastal Plain.</p> <p>Fossils: Fossils of land animals include birds, such as the diatryma (a giant flightless bird), tillodont (an extinct mammal the size of a bear, but with rodent-like teeth) and possibly others similar to those found in the South Dakota badlands, such as brontotherium, ancestral horses, entelodonts (resembled giant warthogs), diceratherium (semi-aquatic rhinoceros), peccary, prosynthetoceras (a camel), anchitherium (horse), and a primitive doglike carnivore. Fossils found in the Outer Coastal Plain include brachiopods, corals, sponges, clams, sharks, mollusks, crinoids, mammals (probably washed to the sea in floods), crocodiles, snakes, and early whales.</p> |
| Quaternary Period | 1.8 - present | <p>Climate: The climate alternated between cold and warm, resulting in four intervals of glaciation. The glaciers covered northern New Jersey, reaching as far south as Belvidere on the Delaware River. South of the glacial ice, treeless, frozen tundra existed. When water was frozen in glaciers, the sea level was lower, resulting in a shoreline over a hundred miles east of the present coast.</p> <p>Fossils: Fossils of many familiar and some extinct animals have been found in nearby areas. There were insects, turtles, and snakes. Herbivores included squirrels, groundhogs, porcupines, beaver, muskrats, voles, mice, eastern cottontail rabbits, white-tailed deer, peccaries, tapirs, giant ground sloth, the elk-moose, giant beaver, American mastodon, and mammoth. Carnivores included otters, skunks, bobcats, foxes, black bears, coyotes, jaguars, jaguarundi, short-faced bear and a saber-toothed cat.</p> |
| Sources: Gallagher, 1997 and The Paleontology Portal website, 2003. http://www.paleoportal.org/time_space/state.php?state_id=35 and http://tapestry.usgs.gov/ages/ages.html | | |

D. Bedrock Geology of Holland Township

Bedrock is the solid rock beneath the soil and surficial rock. The geology of Holland Township is complex, with representative rocks from each era of geologic history evident at the surface, from Precambrian times a billion or more years ago, to Paleozoic, Mesozoic and the present day Cenozoic Era. (See **Table 3.2** and **Figure 3e**). The Triassic Border Fault bisects the township from the northeast to the southwest. North of this fault, the township lies within the Highlands Physiographic Province and is dominated by Precambrian rocks. The Piedmont Physiographic Province lies south of the fault and consists of the sedimentary rocks of the Triassic and Jurassic Periods of the Mesozoic Era.

Precambrian Era – gneiss, granite and amphibolite

The Precambrian rocks in the northern half of Holland Township are the oldest in the region. The oldest of these Precambrian rocks were sedimentary rocks such as limestone and dolomite. These rocks were metamorphosed by heat and pressure 1,150 million years ago and reheated when intruded by igneous rocks 840 million years ago; resulting in coarse grained gneiss. They did not originate here, however. About 450 million years ago, during the time of Taconic mountain-building, the influence of north-west stress uplifted and thrust a mile-thick and 38.5 mile long sheet of rock many miles east; depositing it on top of younger rocks in what is now the northern half of Holland Township. The Appalachian Mountain building caused folding approximately 3,000 feet high with a large fold to the north at least 4,000 feet high.



Legend

- Bedrock Geology**
- JTrp: Passaic Formation
 - Trpg: Passaic Formation Gray bed
 - JTrpqc: Passaic Formation Quartzite-clast Conglomerate facies
 - JTrpdc: Passaic Formation Limestone-clast Conglomerate facies
 - JTrpsc: Passaic Formation Conglomerate and Sandstone facies
 - OCa: Allentown Dolomite
 - OCJ: Juliard Klippe Sequence
 - Cl: Leithsville Formation
 - Ch: Hardyston Quartzite
 - Ya: Amphibolite
 - Yb: Biotite-Quartz-Feldspar Gneiss
 - Yba: Microperthite Alaskite
 - Ybh: Hornblende Granite
 - Yam: Migmatite
 - Yh: Hypersthene-Quartz-Oligoclase Gneiss
 - Yla: Albite-Oligoclase Granite
 - Ylo: Quartz-Oligoclase Gneiss
 - Yma: Microantiperthite Alaskite

- Holland Twp. Boundary
- Streams and Rivers
- Abandoned Mines
- Earthquakes
- Faults
- Folds

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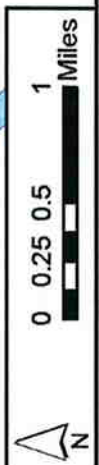


Figure 3e: Bedrock Geology, Faults, Folds, Earthquakes & Abandoned Mines

These Precambrian rocks then eroded, losing at least half their thickness. These sediments then helped fill the Newark Basin, discussed below.

Gneiss and granite are the major rocks from this era, forming the Musconetcong Mountain, a ridge with a maximum altitude of 940 feet (Lucey, 1970; SBWA, 1978).

Paleozoic Era – limestone, dolomite, and sandstone

During the Cambrian Period of the Paleozoic Era, the land slowly depressed, allowing a shallow sea to cover the surface from a southwesterly direction. Sediments eroded from the mountains to the east and southeast were continually deposited by streams, filling the trough.

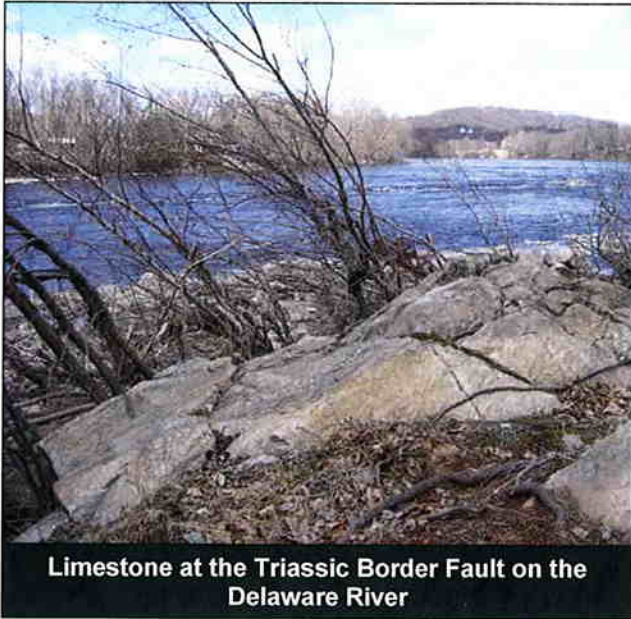
Table 3.2: Characteristics of Bedrock Types Found in Holland Township

| Bedrock formed during Era | Abbreviation | Geologic Formation Name | LITHOLOGY (physical character of the rocks) | THICKNESS in Holland Twp. (feet) |
|---|-----------------------------------|---|---|----------------------------------|
| Cenozoic (65 million years ago to the present) | See Figure 3f (Surficial Geology) | | Soil and glacial deposits | 0-40 |
| | JTrp | Passaic Formation | siltstone and shale | 0-3420 |
| | JTrpcl | Passaic Formation Limestone-clast Conglomerate facies | limestone conglomerate, sandstone | |
| | JTrpcq | Passaic Formation Quartzite-clast Conglomerate facies | quartzite conglomerate, sandstone | |
| | JTrpsc | Passaic Formation Conglomerate and Sandstone facies | conglomeratic sandstone | |
| Trpg | Passaic Formation Gray bed | sandstone, siltstone and shale | | |
| Paleozoic (544 to 248 million years ago) | OCjt | Jutland Klippe Sequence | shale, sandstone, limestone, and quartz-pebble conglomerate | |
| | OCa | Allentown Dolomite | dolomite, and less abundant quartzite and shale | |
| | Cl | Leithsville Formation (Kittatinny Formation) | dolomite, dolomitic sandstone, siltstone, and shale | 900 |
| | Ch | Hardyston Quartzite | conglomeratic sandstone, quartzite, and dolomitic sandstone | 100 |
| Precambrian (billions to 544 million years ago) | Ya | Amphibolite | amphibolite, fine- to medium-grained | 1,000-2,000 |
| | Yam | Migmatite | mixed amphibolite and gneiss | |
| | Yb | Biotite-Quartz-Feldspar Gneiss | gneiss, fine- to coarse-grained | |
| | Yba | Microperthite Alaskite | granite, medium- to coarse-grained | |
| | Ybh | Hornblende Granite | granite, medium- to coarse-grained | |
| | Yh | Hypersthene-Quartz-Oligoclase Gneiss | gneiss, medium-grained | |
| | Yla | Albite-Oligoclase Granite | granite, medium- to coarse-grained | |
| | Ylo | Quartz-Oligoclase Gneiss | gneiss, medium- to coarse-grained | |
| Yma | Microantiperthite Alaskite | granite, medium- to coarse-grained | | |

Sources: NJGS Bedrock Geology GIS data; Van Houten, 1969; South Branch Raritan Watershed Association, 1978; <http://tapestry.usgs.gov/ages/ages.html>

Currents and wave action of the sea further reduced the sediments to a uniform size, forming a well sorted sandstone composed of the minerals quartz and feldspar. At the base of the formation, a conglomerate containing Precambrian sands and gravels constitutes the Hardyston Quartzite.

During the late Cambrian and beginning of the Ordovician Periods, warm shallow seas covered most of the basin. Abundant lime organisms, such as corals, and the conditions of quiet seas resulted in the precipitation of calcium carbonate, which formed the Leithsville Dolomite, also known as the Kittatinny Limestone. Due to the dominance of limestone in these units, they are subject to solution weathering, and may exhibit karst features, including solution channels, sinkholes, soil piping sinks, and caverns.



Limestone at the Triassic Border Fault on the Delaware River

The Ordovician Period experienced a period of uplift, followed by another invasion of a warm sea, which deposited the Allentown Dolomite on top of the Leithsville. Gradually, as the basin deepened, more and more silt was deposited, cutting off the deposition of limestone. The Jutland Klippe Sequence, therefore, shows a gradual change from limestone to sandstone and shale.

At the end of this period, the Taconic mountain building occurred, mentioned above, which raised, moved, folded and faulted Precambrian formations eastward, eventually depositing them on top of these younger Paleozoic formations (Lucey, 1970; South Branch Watershed Association, 1978; DeMicco, 2004).

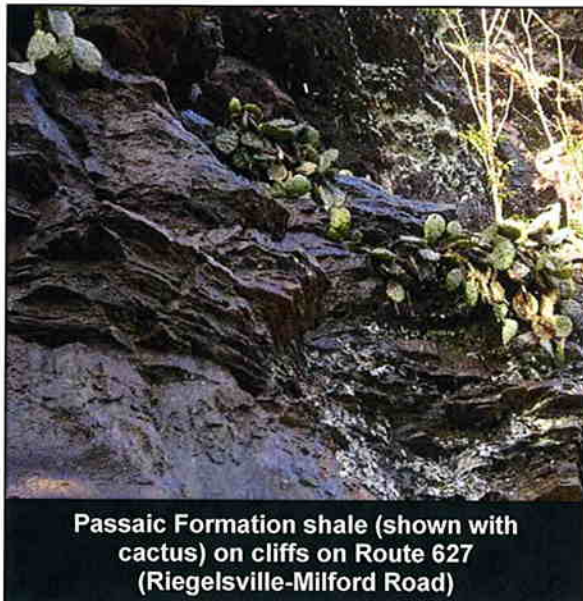
Mesozoic Era – conglomerate, siltstone and shale

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

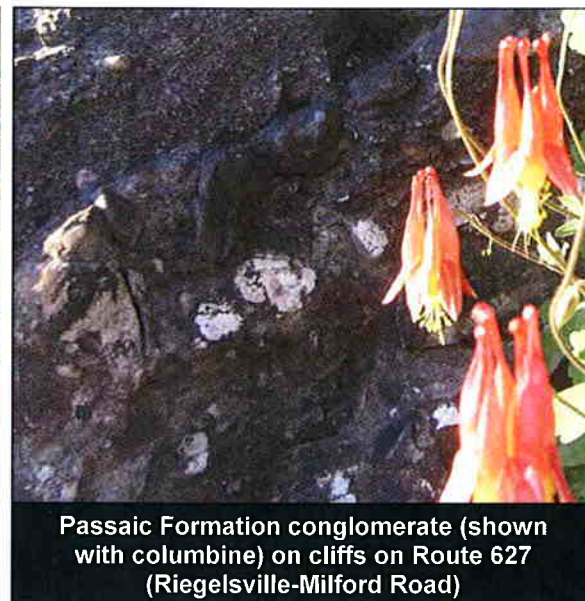
Erosion from the high mountains gradually filled the basins with sediments, forming the Late Triassic Newark Group. The Newark Group lies in a southwest-trending basin that extends from Rockland County, New York, to northeastern Lancaster County, Pennsylvania. This is the largest of the Triassic rift valleys that extend from Nova Scotia to North Carolina. The Newark Group consists of non-marine sedimentary rocks 16,000-20,000 feet thick, and associated intrusions of volcanic rocks. Older rocks, which lie beneath the Newark Group, are exposed to the north in the Highlands and Ridge and Valley Provinces. Younger strata overlap the Newark Group in the Coastal Plain Province to the southeast. The layers generally dip 10 – 20° northwest, and are locally broken by many small normal faults (Van Houten, 1969).

Near the Triassic Border Fault, fast flowing streams surged down the steep mountains, depositing alluvial fan sediments and quartzite and limestone boulders up to three feet in diameter on the valley floor. These resulting Triassic conglomerates are dominated by quartzite, which is more resistant to erosion, and is now seen as a band roughly through the middle of Holland Township, and forming the elevated area known as Gravel Hill.

As the streams flowed away from the mountains, the velocity slowed and, having already dropped the larger boulders and pebbles, carried and deposited the smaller particles farther from the mountains, which became sandstones, shale and mudstones. The rocks of the Passaic Formation furthest from the Highlands contain grey-bed sequences of thin-bedded to finely laminated shale and siltstone that include lake deposits (Lucey, 1970; DeMicco, 2004).



Passaic Formation shale (shown with cactus) on cliffs on Route 627 (Riegelsville-Milford Road)



Passaic Formation conglomerate (shown with columbine) on cliffs on Route 627 (Riegelsville-Milford Road)

Cenozoic Era – glacial till

During the beginning of the current era, erosion continued along the Triassic Border Fault, exposing the underlying Paleozoic rocks. During the last million years of geologic history, commonly known as the Ice Age, ice probably invaded New Jersey during all three glaciation events. The most recent, the Wisconsin, obliterated most evidence of earlier glaciation. The ice of the Wisconsin glacier did not enter Holland Township, but streams flowing away from the glacier deposited glacial till in several locations in the township (see **Figure 3f**). In addition, glacial sediments have accumulated in the two major river floodplains in Holland, the Delaware and the Musconetcong (shown on **Figure 3f**), which originate in areas that experienced glaciation (Lucey, 1970; SBWA, 1978).

Mining

Two abandoned mines exist in Holland Township, both of which mined magnetite (NJGS, 2003). Magnetite is a valuable source of iron ore and is the most magnetic mineral on Earth (Wikipedia, 2006). The Duckworth Farm Mine was in operation from 1776 to 1879 and the Hager Mine operated between 1879 and 1880 (see **Figure 3e**).

Earthquakes

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

Earthquakes occurring on December 14, 1984 (magnitude 1.7) and August 26, 2003 (magnitude 3.5) had epicenters in Holland Township (see **Figure 3e**).

The main shock of the August 2003 earthquake was felt intensely by residents in New Jersey and Pennsylvania along the Delaware River. The earthquake caused minor damage. The main- and about 40 after-shocks had very shallow depths, around 1.5 to 2 km. The areas where the shocks could be felt were much smaller than other earthquakes of similar size in the eastern United States. The earthquake occurred close to the boundary fault between the Precambrian Reading prong and Mesozoic Newark basin, but the aftershocks occurred on a line nearly perpendicular to the orientation of the Triassic Boundary Fault (Kim, 2003).

E. The Surficial Geology of Holland Township

Surficial materials are the unconsolidated sediments that overlie bedrock formations, and that are the parent material for soils. In Hunterdon County they include stream, wetland, glacial, windblown, and hillslope sediments and weathered bedrock material. The weathered bedrock material may be as much as 200 feet thick, although most are generally less than 20 feet thick. The size of particles in the surficial materials ranges from coarse gravel to clay and peat. Surficial materials affect the movement of ground water from the surface into underlying bedrock aquifers, and some are aquifers themselves (See **Figure 3f** and **Table 3.3**).

Table 3.3: Types of Surficial Geology Found in Holland Township

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

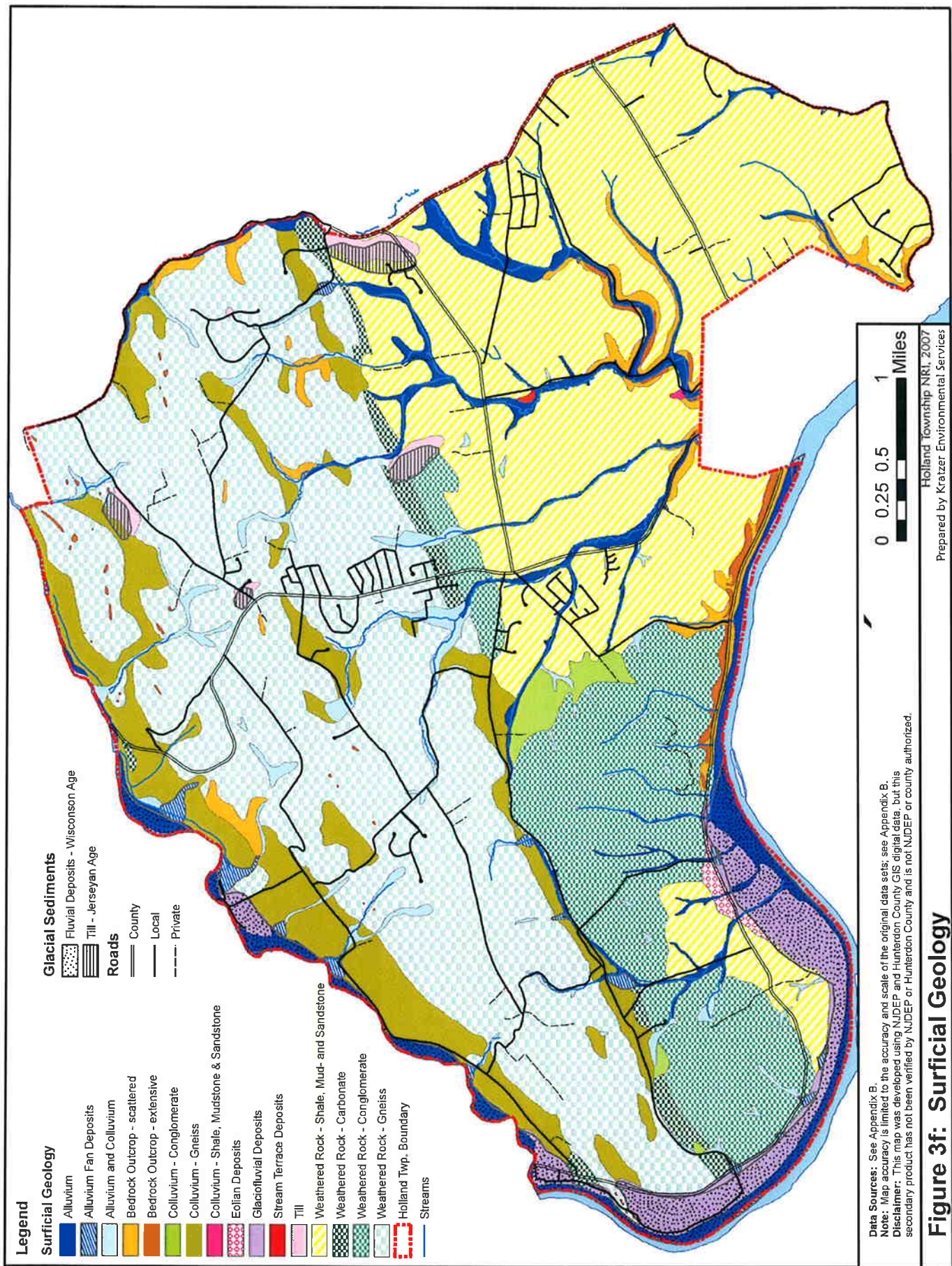
Source: NRCS Soils Online Study Guide: <http://www.nj.nrcs.usda.gov/partnerships/envirothon/soils/>

References: Physiography, Topography & Geology

DeMicco and Associates, Inc. 2004 Groundwater Resource Evaluation of Holland Township, Hunterdon County, New Jersey. Prepared for Holland Township Planning Board.

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Legend

Surficial Geology

- Alluvium
- Alluvium Fan Deposits
- Alluvium and Colluvium
- Bedrock Outcrop - scattered
- Bedrock Outcrop - extensive
- Colluvium - Conglomerate
- Colluvium - Gneiss
- Colluvium - Shale, Mudstone & Sandstone
- Eolian Deposits
- Glaciofluvial Deposits
- Stream Terrace Deposits
- Till
- Weathered Rock - Shale, Mud- and Sandstone
- Weathered Rock - Carbonate
- Weathered Rock - Conglomerate
- Weathered Rock - Gneiss
- Holland Twp. Boundary
- Streams

Glacial Sediments

- Fluvial Deposits - Wisconsin Age
- Till - Jerseyan Age

Roads

- County
- Local
- Private

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



Holland Township NRI, 2007
 Prepared by Kraizer Environmental Services

Figure 3f: Surficial Geology

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