U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

# Upper Delaware Scenic and Recreational River

*GRI Ancillary Map Information Document*

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Upper Delaware Scenic and Recreational River

upde_geology.pdf

Version: 9/16/2019

# Geologic Resources Inventory Map Document for Upper Delaware Scenic and Recreational River

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## Geologic Resources Inventory Map Document

# Upper Delaware Scenic and Recreational River, New York and Pennsylvania

## Document to Accompany Digital Geologic-GIS Data

upde_geology.pdf

Version: 9/16/2019

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Upper Delaware Scenic and Recreational River, New York and Pennsylvania (UPDE).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2) **GRI Digital Maps and Source Map Citations** – A listing of all GRI digital geologic-GIS maps produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided.

3) **Map Unit List** – A listing of all geologic map units present on maps for this project, generally listed from youngest to oldest.

4) **Map Unit Descriptions** – Descriptions for all geologic map units. If a unit is present on multiple source maps the unit is listed with its source geologic unit symbol, unit name and unit age followed by the unit's description for each source map.

5) **Geologic Cross Sections** – Geologic cross section graphics with source geologic cross section abbreviations.

6) **Ancillary Source Map Information** – Additional source map information presented by source map. For each source map this may include a stratigraphic column, index map, map legend and/or map notes.

7) **GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

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# About the NPS Geologic Resources Inventory Program

## Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

## Products

**Scoping Meetings:** These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

**Digital Geologic Maps:** Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm

**Geologic Reports:** Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage: http://go.nps.gov/gri_products

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park

(s), enter “GRI” as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: https://www.nps.gov/subjects/geology/gri.htm, or contact:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

# GRI Digital Maps and Source Map Citations

The GRI digital geologic-GIS maps for Upper Delaware Scenic and Recreational River, New York and Pennsylvania (UPDE):

**Digital Surficial Geologic-GIS Map of Upper Delaware Scenic and Recreational River, New York and Pennsylvania (*GRI MapCode UPDE*)**

*-Compilation of all sources list below.*

**Digital Surficial Geologic-GIS Map of the New York Portion of Upper Delaware Scenic and Recreational River, New York (*GRI MapCode UDNY*)**

*-Digital geologic-GIS dataset data of the New York portion of the Upper Delaware Scenic and Recreational River.*

**Digital Geologic-GIS Map of Portions of Pike County, Pennsylvania (*GRI MapCode PICO*)**

*-Stand-alone digital geologic-GIS dataset of showing both bedrock and surficial geologic data for the north half of Pike County.*

The following map and data sources were used in the production of the above maps:

Pennsylvania Geologic Survey 7.5 Minute Surficial Geology Data and Maps - These datasets were used in their entirety for the compiled Upper Delaware GIS dataset. The extent of these maps is shown as magenta cross-hatch pattern on the Index and Location Map page below.

Braun, D. D., 2008, Surficial Geology of the Aldenville 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–09.0, 15 p., 1 map, scale 1:24,000 (Aldenville Quadrangle). (*GRI Source Map ID 74569*).

Braun, D. D., 2008, Surficial Geology of the Damascus 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–15.0, 14 p., 1 map, scale 1:24,000 (Damascus Quadrangle). (*GRI Source Map ID 74567*).

Braun, D. D., 2008, Surficial Geology of the Galilee 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–10.0, 15 p., 1 map, scale 1:24,000 (Galilee Quadrangle). (*GRI Source Map ID 74568*).

Braun, D. D., 2011, Surficial Geology of the Hancock 7.5-Minute Quadrangle, Wayne County, Pennsylvania, and Broome County, New York: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 11–02.0, 13 p., 1 map, scale 1:24,000 (Hancock Quadrangle). (*GRI Source Map ID 74563*).

Braun, D. D., 2011, Surficial Geology of the Hawley 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, Open-File Report OFSM 06-13.0, scale 1:24,000 ( Hawley Quadrangle). (*GRI Source Map ID 74575*).

Braun, D. D., 2008, Surficial Geology of the Honesdale 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–04.0, 15 p., 1 map, scale 1:24,000 (Honesdale Quadrangle). (*GRI Source Map ID 74573*).

Braun, D. D., 2010, Surficial Geology of the Lake Como 7.5-Minute Quadrangle, Wayne County,

Pennsylvania, and Delaware County, New York: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 10–07.0, 13 p., 1 map, scale 1:24,000 (Lake Como Quadrangle). (*GRI Source Map ID 74566*).

Braun, D. D., 2011, Surficial Geology of the Long Eddy and Callicoon 7.5-Minute Quadrangles, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 11–01.0, 13 p., 1 map, scale 1:24,000 (Long Eddy and Callicoon Quadrangles). (*GRI Source Map ID 74564*).

Braun, D. D., 2008, Surficial Geology of the Wayne County portion of the Narrowsburg 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–06.0, 14 p., 1 map, scale 1:24,000 (Narrowsburg Quadrangle). (*GRI Source Map ID 74571*).

Braun, D. D., 2010, Surficial Geology of the Orson 7.5-Minute Quadrangle, Susquehanna and Wayne Counties, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 10–06.0, 12 p., 1 map, scale 1:24,000 (Orson Quadrangle). (*GRI Source Map ID 75682*).

Braun, D. D., 2006, Surficial Geology of the Starrucca 7.5-Minute Quadrangle, Wayne and Susquehanna Counties, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 06–05.0, 15 p., 1 map, scale 1:24,000 (Starrucca Quadrangle). (*GRI Source Map ID 74429*).

Braun, D. D., 2008, Surficial Geology of the Wayne County portion of the White Mills 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–05.0, 15 p., 1 map, scale 1:24,000 (White Mills Quadrangle). (*GRI Source Map ID 74572*).

Pennsylvania Geological Survey County Geologic Maps - Only a portion of these maps were used (roughly the northern half) -- the extent used is shown in green hatch pattern on the Index and Location Map page below. Only the surficial maps below were used in the compiled Upper Delaware GIS data. The stand-alone Pike County GIS data contains both bedrock and surficial data from the maps below. Only well location points were captured from the water resource report listed below.

Sevon, W.D., Berg, Thomas M., and Schultz, Lane D., 1989, Geology and Mineral Resources of Pike County, Pennsylvania: Pennsylvania Geological Survey, County Report 52, 141p., plate 1 (Bedrock Geologic Map), scale 1:50,000 (Pike County Geology and Mineral Resources, Bedrock Geologic Map). (*GRI Source Map ID 4459*).

Sevon, W.D., Berg, Thomas M., Schultz, Lane D., and Crowl, George H., 1989, Geology and Mineral Resources of Pike County, Pennsylvania; Pennsylvania Geological Survey, County Report C 52, 141p., plate 2 (Surficial Geologic Map), scale 1:50,000 (Pike County Geology and Mineral Resources, Surficial Geologic Map). (*GRI Source Map ID 4794*).

Davis, Drew K., 1989, Groundwater Resources of Pike County, Pennsylvania: Pennsylvania Geological Survey, Water Resource Report 65, 63 p., plate 1 (Bedrock Geologic Map), scale 1:50,000 (Pike County Groundwater Resources, Bedrock Geologic Map). (*GRI Source Map ID 4456* ).

Davis, Drew K., 1989, Groundwater Resources of Pike County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Water Resource Report 65, 63 p., plate 2 (Surficial Geologic Map), scale 1:50,000 (Pike County Groundwater Resources, Surficial Geologic Map). (*GRI Source Map ID 5779*).

New York State Geological Survey 1:24,000 Scale Digital Data - The New York State Geologic Survey was contracted by the GRI to produce surficial geologic map data for the 7.5 minute quadrangles in New York bordering Upper Delaware Scenic and Recreational River. The extent of these maps, delivered in two phases, is shown as red cross-hatch and blue hatch patterns on the Index and Location Map page below.

> Kowzlowski, A. L., 2017, Surficial Geology of the New York Portion of Upper Delaware Scenic and Recreational River and Vicinity, New York (Northern 7.5' quadrangles): New York State Geological Survey, unpublished data and map, scale 1:24,000 (New York Upper Delaware River). (*GRI Source Map ID 76117*).
>
> Leone, James et al., 2019, Surficial Geology of the New York Portion of Upper Delaware Scenic and Recreational River and Vicinity, New York (Southern 7.5' quadrangles): New York State Geological Survey, unpublished data and map, scale 1:24,000 (New York Upper Delaware River). (*GRI Source Map ID 76289*).

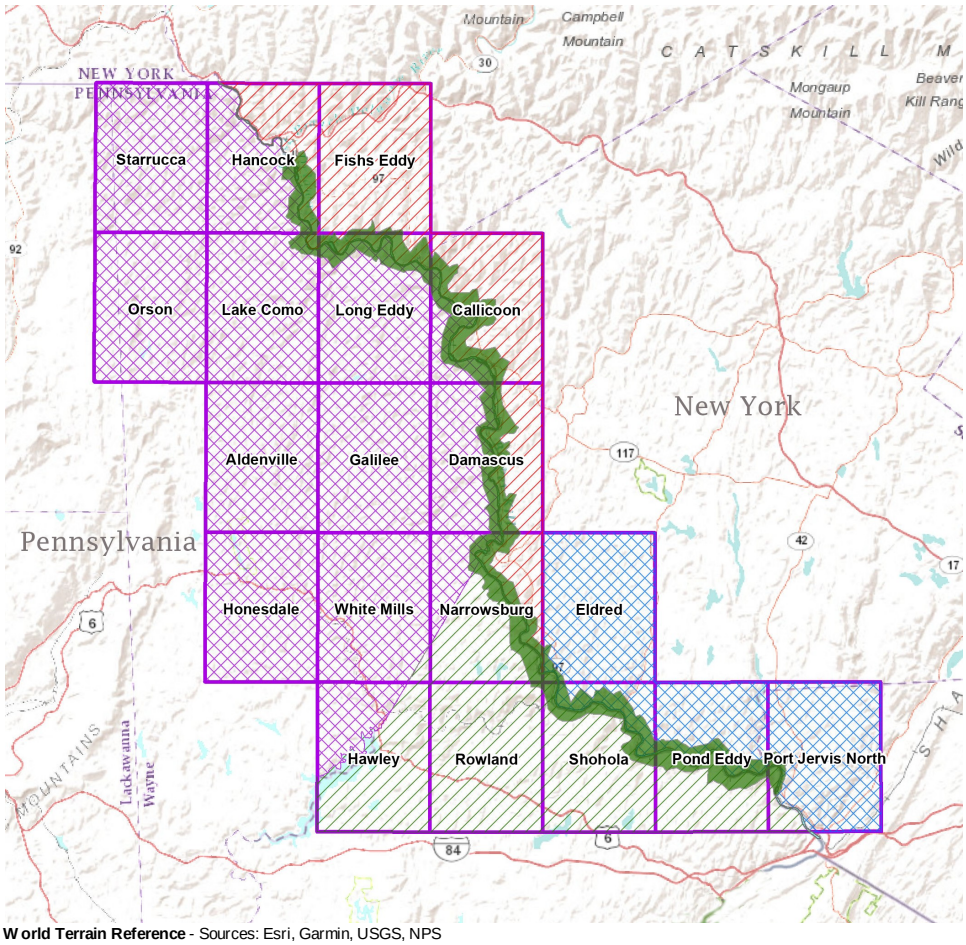
USGS National Hydrography Dataset - The Delaware River was extracted from this dataset and merged with digital geologic-GIS data used for this project.

> U.S. Geological Survey, 2018, USGS National Hydrography Dataset Best Resolution (NHD) for Hydrologic Unit (HU) 8: U.S. Geological Survey, scale 1:24,000 (National Hydrography Dataset). ( *GRI Source Map ID 76278*).

Additional information pertaining to each source map is also presented in the GRI Source Map Information (UPDEMAP) table included with the GRI geologic-GIS data.

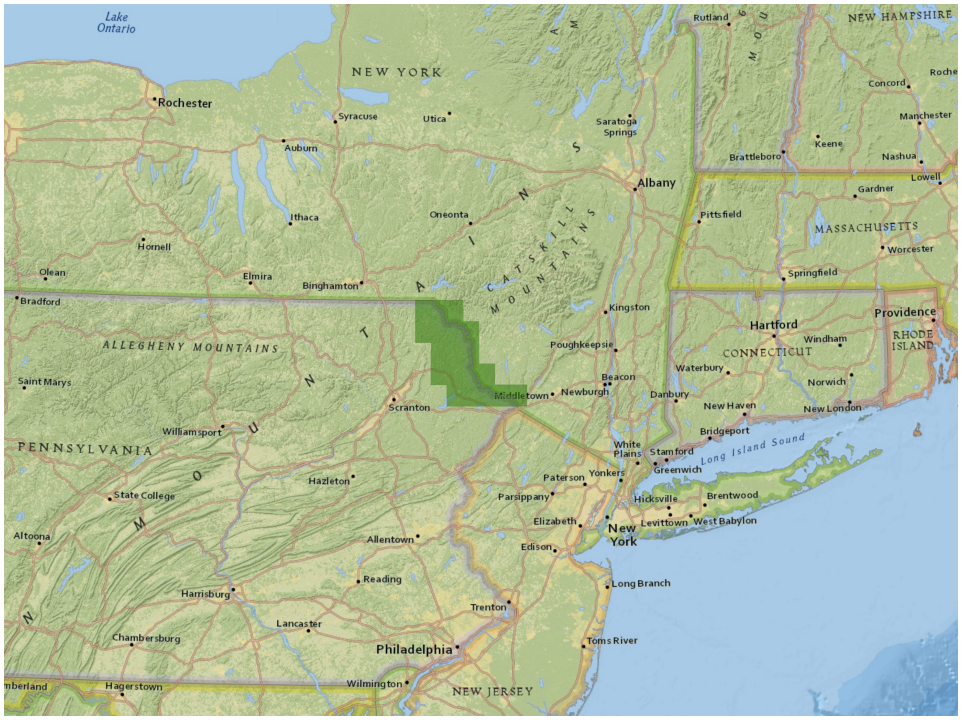
## Index and Location Map

The follow index map displays the extent of the GRI digital geologic-GIS datasets produced for Upper Delaware Scenic and Recreational River. The park's extent (as of September, 2019) is displayed in green. Source maps used for the project are shown in varying cross-hatch colors as follows: the extent of the Pennsylvania Geologic Survey 7.5 Minute Surficial Geology source maps are shown in magenta, the extent of Pennsylvania Geologic Survey county geologic source maps are shown in green, and the extent of New York 1:24,000 scale source maps are shown in red (Kowzlowski, 2017) and blue (Leone, 2019). The GRI digital geologic-GIS map extents cover the following 7.5 minute quadrangles in Pennsylvania and New York: Starrucca, Hancock, Fishs Eddy, Orson, Lake Como, Long Eddy, Callicoon, Aldenville, Galilee, Damascus, Honesdale, While Mills, Narrowsburg, Eldred, Hawley, Rowland, Shohola, Pond Eddy and Port Jervis North.




**World Terrain Reference** - Sources: Esri, Garmin, USGS, NPS
**World Terrain Base** - Sources: Esri, USGS, NOAA

The following location map displays the extent of the GRI digital geologic-GIS data (shown in green).




**National Geographic World Map** - National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Graphics by James Chappell (Colorado State University).

# Map Unit List

The surficial and bedrock geologic units present in the digital geologic-GIS data produced for Upper Delaware Scenic and Recreational River, New York and Pennsylvania (UPDE) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qd - Mine Dump). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (UPDEUNIT) table included with the GRI geologic-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI the unit's source map symbol, name and/or age appears with the unit's source map description.

## Cenozoic Era

### Quaternary Period

Qd - Mine Dump
Qcf - Cut and fill
Qf - Fill
Qrg - Rock and/or gravel pit
Qa - Alluvium
Qat - Alluvial terrace
Qaf - Alluvial fan
Qp - Peat bog
Qdc - Diamict colluvium
Qw - Wetland
Qs - Stratified sand
Qwo - Wisconsinan outwash
Qbc - Boulder colluvium
Qwic - Wisconsinan ice-contact stratified drift
Qokt - Olean kame terrace
Qdcs - Diamicton (clast supported)
Qwt - Wisconsinan till
Qwtb - Wisconsinan bouldery till

## Paleozoic Era

PZbr - Sandstone and shale bedrock

### Devonian Period

Dcl - Catskill Formation, Lackawaxen Member
Dcdr - Catskill Formation, Delaware River Member
Dct - Catskill Formation, Towamensing Member
Dtm - Trimmers Rock Formation, Millrift Member
Dtsb - Trimmers Rock Formation, Sloat Brook Member
Dmn - Mahantango Formation

# Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. In order to reduce repetitive text, units descriptions, from the 7.5 minute Pennsylvania Geologic Survey maps by Braun, D. D., where similar on multiple maps, have been condensed into one description. Slight differences between unit descriptions were ignored when deciding which descriptions should be combined.

## Qd - Mine dump (Quaternary)

**d - Mine Dump (Quaternary)**
Waste material from a surface mine containing a mixture of broken rock and soil debris; associated with aggregate or building stone pits; typically tens of feet (meters) thick. Description from source map: White Mills Quadrangle

## Qcf - Cut and fill (Quaternary)

**cf - Cut and Fill (Quaternary)**
Disturbed area of excavation and fill around the General Edgar Jadwin Dam. Description from source map: Honesdale Quadrangle

## Qf - Fill (Quaternary)

**f - Fill (Quaternary)**
Rock fragments and/or soil material; typically in road, railroad, or dam embankments; up to several tens of feet (meters) thick. Description from source maps: Aldenville Quadrangle, Galilee Quadrangle, Hancock Quadrangle, Hawley Quadrangle, Honesdale Quadrangle, Lake Como Quadrangle, Orson Quadrangle, Starrucca Quadrangle, and White Mills Quadrangle

**Haf - Artificial Fill (Holocene)**
Surficial sediment composed of coarse/fine and or crushed rock anthropogenically transported and used for construction purposes. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

**af - Artificial Fill (Holocene)**
Unconsolidated, compacted mixture of rock fragments, sand, silt, and clay, or concrete that is used for roadway fill or earth dams. Generally several feet thick.

> Groundwater Characteristics: No aquifer potential.
>
> Engineering Characteristics: Moderately easy to excavate. Generally good slope stability; susceptible to erosion. Good foundation for heavy structures where specifically designed.
>
> Mineral Resources: No mineral resources.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

## Qrg - Rock and/or gravel pit (Quaternary)

**gp - Sand and Gravel Pit (Quaternary)**
Sand and gravel pits typically have steep sides and are tens of feet (meters) deep. Description from source maps: Aldenville Quadrangle and Honesdale Quadrangle

**gp - Sand and Gravel Pit (Quaternary)**
Sand and gravel pits typically have steep sides and are meters to tens of meters deep. Description from source map: Hawley Quadrangle

**rp - Sandstone and/or Shale Pit (Quaternary)**
Pits typically have steep sides and are tens of feet deep. Active pits are used to produce aggregate and dimension stone. Description from source map: Lake Como Quadrangle

**rp - Rock Quarry Pit (Quaternary)**
Pits typically have steep sides and are tens of feet deep; active pits are used to produce aggregate and dimension stone. Description from source map: Long Eddy and Callicoon Quadrangles

**Rp - Rock Pit (Quaternary)**
Bedrock pits typically have steep sides and are tens of feet (meters) deep. Description from source map: White Mills Quadrangle

**Rp - Bedrock Aggregate Pit (Quaternary)**
Bedrock aggregate pits typically have steep sides and are tens of feet (meters) deep. Description from source maps: Damascus Quadrangle and Galilee Quadrangle

## Qa - Alluvium (Quaternary)

**Qa - Alluvium (Quaternary)**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; usually is underlain by other unconsolidated material (glacial deposits); 6 feet (2 meters) thick in headward tributary valleys, as much as 20 feet (6.5 meters) thick in the valley of the Delaware River. Description from source maps: Aldenville Quadrangle, Damascus Quadrangle, Galilee Quadrangle, Honesdale Quadrangle, Lake Como Quadrangle, Narrowsburg Quadrangle, Starrucca Quadrangle, and White Mills Quadrangle

**Qa - Alluvium (Quaternary)**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; more bouldery in upstream reaches; usually underlain by glacial deposits; 6 feet thick in headward tributary valleys; 20 feet or more thick in the Delaware River valley. Description from source map: Hancock Quadrangle

**Qa - Alluvium (Quaternary)**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; yellowish brown color; 6 feet (2 meters) thick in headward tributary valleys, as much as 10 feet (3 meters) thick in the valley of the West Branch - Wallenpaupack Creek. Description from source map: Hawley Quadrangle

**Qa - Alluvium (Quaternary)**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; usually underlain by glacial deposits; 6 feet thick in headward tributary valleys; as much as 20 feet thick in the valley of the Delaware River. Description from source map: Long Eddy and Callicoon Quadrangles

**Qa - Alluvium (Quaternary)**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; usually underlain by other unconsolidated material (glacial deposits); 6 feet thick in headward tributary valleys. Description from source map: Orson Quadrangle

**Qal - Alluvium (Holocene)**
Unconsolidated, poorly stratified, poorly to moderately well sorted mixture of clay, silt, sand, gravel, cobbles, and some boulders. Clasts are angular and platy to well rounded; composition reflects the underlying bedrock. Alluvium has flat and smooth to very rough surfaces and occupies valley bottoms. Alluvium is a fluvial deposit in valley bottoms. Thickness is generally unknown, but most deposits are thought to be not more than several feet thick.

> Groundwater Characteristics: Locally may yield large quantities of water to wells.
>
> Engineering Characteristics: Easy to excavate; generally shallow depth to bedrock. Unsuitable for septic systems and construction because of the potential for flooding.
>
> Mineral Resources: No known mineral resources.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

**Ha- Holocene Alluvium (Holocene)**
Sorted and stratified silt, sand, and gravel, deposited by rivers and streams. May include cobbles and boulders. Inferred as post-glaical alluvium and includes modern channel, over-bank and fan deposits. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

## Qat - Alluvial terrace (Quaternary)

**Qat - Alluvial Terrace (Quaternary)**
Stratified silt, sand, and gravel with some boulders; subrounded to rounded clasts; the deposits form benches running parallel to and a few feet (meters) above the present floodplain; usually is underlain by other unconsolidated material (glacial deposits); generally 6 to 20 feet (2 to 6.5 meters) thick. Description from source maps: Galilee Quadrangle, Hawley Quadrangle, Lake Como Quadrangle, Long Eddy and Callicoon Quadrangles and Starrucca Quadrangle

## Qaf - Alluvial fan (Quaternary)

**Qaf - Alluvial Fan (Quaternary)**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; having a fan shaped landform; usually is underlain by other unconsolidated material (glacial deposits); 6 feet (2 meters) or

more thick. Description from source maps: Aldenville Quadrangle, Damascus Quadrangle, Galilee Quadrangle, Honesdale Quadrangle, Lake Como Quadrangle, Long Eddy and Callicoon Quadrangles, Orson Quadrangle, Starrucca Quadrangle, and White Mills Quadrangle

**Qaf - Alluvial Fan (Quaternary)**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; has a fan-shaped landform; usually is underlain by glacial deposits; 6 feet or more thick. Some fans have a series of levels with younger, lower, less steeply sloped segments inset in older, higher, steeper segments. Some fans have matrix-supported material, suggesting that they are partly composed of debris-flow deposits. Description from source map: Hancock Quadrangle

**Qaf - Alluvial Fan (Pleistocene)**
Unconsolidated, poorly stratified, poorly to moderately well sorted mixture of clay, silt, sand, gravel, cobbles, and some boulders. Clasts are angular and platy to well rounded; composition reflects the underlying bedrock. Alluvial fans have relatively smooth, fan-shaped surfaces and low to steep gradients, and occur at the mouths of tributaries. Alluvial fans are fluvial deposits at tributary mouths. Thickness is generally unknown, but most deposits are thought to be not more than several feet thick.

Groundwater Characteristics: Locally may yield large quantities of water to wells.

Engineering Characteristics: Easy to excavate; generally shallow depth to bedrock. Unsuitable for septic systems and construction because of the potential for flooding.

Mineral Resources: No known mineral resources.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

## Qp - Peat bog (Quaternary)

**Qp - Peat (Quaternary)**
Wetland underlain by peat, thickness variable, usually less than 6 feet (2 meters) thick in localized upland sites and up to 30 feet (10 meters) thick in valley floor settings; usually is underlain by other unconsolidated material (glacial deposits). Description from source maps: Aldenville Quadrangle, Damascus Quadrangle, Galilee Quadrangle, Honesdale Quadrangle, Lake Como Quadrangle, Narrowsburg Quadrangle, Orson Quadrangle, Starrucca Quadrangle, and White Mills Quadrangle

**Qp - Peat (Quaternary)**
Wetland underlain by peat or variable thickness, usually less than 6 feet (2 meters) thick in localized upland sites and up to 30 feet (10 meters) thick in valley floor settings; usually is underlain by other unconsolidated material (glacial deposits). Description from source map: Starrucca Quadrangle

**Qp - Peat (Quaternary)**
Wetland underlain by peat, beneath which are glacial deposits; thickness variable; usually less than 6 feet thick in localized upland sites, and up to 30 feet thick in valley floor settings. Description from source maps: Hancock Quadrangle, Hawley Quadrangle and Long Eddy and Callicoon Quadrangles

**Qp - Peat (Holocene)**
Decayed vegetation, commonly water saturated. Occurs in undrained or poorly drained natural depressions; thickly vegetated; water table is at or near the surface. Product of accumulation and partial decay of vegetation below water level. Large deposits are 10 feet thick or more.

Groundwater Characteristics: No aquifer potential.

Engineering Characteristics: Easy to excavate. Unsuitable for foundations, septic systems, and sanitary-landfill sites because the water table is at or near the surface.

Mineral Resources: Abundant potential as soil conditioner.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

## Qdc - Diamict colluvium (Quaternary)

**Hdc - Holocene Diamict Colluvium (Holocene)**
Unsorted and unstratified deposit of gravel, sand, silt, clay, with boulders/cobbles possible. Described as a mass-wasting deposit at the base of steep hillslopes and cliffs as part of a slump or hillslope failure. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

## Qw - Wetland (Quaternary)

**Qw - Wetland (Quaternary)**
Area with standing water for part of each year; usually underlain by peat, clay, silt, sand, or some combination of those materials beneath which is other unconsolidated material (glacial deposits); thickness of peat usually less than 1.5 feet (0.5 meter), overall thickness of unconsolidated material is usually greater than 6 feet (2 meters). Description from source maps: Aldenville Quadrangle, Damascus Quadrangle, Galilee Quadrangle, Honesdale Quadrangle, Narrowsburg Quadrangle, Orson Quadrangle, Starrucca Quadrangle, and White Mills Quadrangle

**Qw - Wetland (Quaternary)**
Area with standing water for part of each year; usually underlain by peat, clay, silt, sand, or some combination of those materials, beneath which are glacial deposits; thickness of peat is usually less than 1.5 feet; overall thickness of sediments usually greater than 6 feet. Description from source maps: Hancock Quadrangle, Lake Como Quadrangle, Long Eddy and Callicoon Quadrangles

**Qw - Wetland (Quaternary)**
Area with standing water for part of each year; underlain by peat, clay, silt, sand, or some combination of those materials; thickness of peat usually less than 1.5 feet (0.5 meter), overall thickness of the sediments is often greater than 6 feet (2 meters). Description from source map: Hawley Quadrangle

**Qs - Swamp Deposits (Holocene)**
Unconsolidated clay, silt, and sand mixed with partly decomposed organic material; may contain cobbles and boulders. Occurs in shallow, undrained areas that commonly have standing water and a thick overstory of trees. Most deposits are thought to be less than 6 feet thick.

Groundwater Characteristics: No aquifer potential.

Engineering Characteristics: Easily excavated. Unsuitable for foundations, septic systems, and sanitary-landfill sites because of the high water table.

Mineral Resources: No known mineral resources.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

**Hw - Wetlands (Holocene)**
Peat, muck, marl, silt, clay or sand deposited in association with wetland environments. Various sediments can be present at transitional boundaries from one facies to another. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

## Qs - Stratified sand (Pleistocene)

**Qs - Stratified sand (Pleistocene)**
Well sorted and stratified sand, deposited by fluvial, lacustrine or eolian processes. Inferred as deposits associated with distal glacial environments. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

## Qwo - Wisconsinan outwash (Quaternary)

**Qwo - Wisconsinan Outwash (Quaternary)**
Stratified sand and gravel forming terraces beside the floodplains of the larger streams. The overall stratification is horizontal with individual strata showing crossbeds, ripples, clast-imbrication, or cut-fill features. Thicknesses are usually less than 20 feet (6 meters). Description from source map: Galilee Quadrangle

**Qwo - Wisconsinan Outwash (Quaternary)**
Stratified sand and gravel deposits that form terrace remnants along the flanks of the Delaware River valley; overall stratification is horizontal with individual strata showing crossbeds, ripples, clast-imbrication, or cut-fill features; thickness may exceed 100 feet in a few places along the Delaware River. Description from source map: Hancock Quadrangle

**Qwo - Wisconsinan Outwash (Quaternary)**
Stratified sand and gravel typically forming terraces along the flank of the Delaware River valley; overall stratification is horizontal with individual strata showing crossbeds, ripples, clast-imbrication, or cut-fill features; thickness may exceed 100 feet in a few places along the Delaware River. Description from source map: Long Eddy and Callicoon Quadrangles

**Qwo - Wisconsinan Outwash (Quaternary)**
Stratified sand and gravel deposits that form terraces along the flanks of valleys; overall stratification is horizontal with individual strata showing crossbeds, ripples, clast imbrication, or cut-fill features; mapped only along the flank of the East Branch Lackawanna River; thickness less than 30 feet. Description from source map: Orson Quadrangle

**Qwo - Wisconsinan Outwash (Quaternary)**
Stratified sand and gravel typically forming terraces along the flanks of valleys. The overall stratification is horizontal with individual strata showing cross-beds, ripples, clast-imbrication, or cut-fill features. Thickness is 6 feet (2 meters) to more than 30 feet (10 meters) in places. Description from source map: White Mills Quadrangle

**Qaoo - Alluvium and Olean Outwash Undifferentiated (Pleistocene)**
Outwash consists of unconsolidated, stratified sand and gravel, and some boulders. Outwash has planar bedding and crossbedding; a large variation in clast size may occur from bed to bed; composition is dominated by Catskill Formation lithologies; occurs as valley fill in larger valleys. Alluvium consists of clay, silt, and very fine grained sand on flood-plain surfaces and coarser material in stream channels. Outwash was deposited by glacial meltwater streams. Alluvium was deposited by streams not of glacial origin. Combined thickness ranges from several feet to 501 feet at Matamoras.

> Groundwater Characteristics: High infiltration capacity. Median yield of domestic wells is 22 gal/min. Water has good quality.
>
> Engineering Characteristics: Easy to excavate. Maintains moderate to gentle cut slopes; has potential for slumping. Generally unsuitable for septic systems because of potential for contamination of groundwater. Moderate to poor foundation for heavy structures; flooding is a potential hazard in many places.
>
> Mineral Resources: Source of coarse and fine aggregate; screening and washing are generally required, and crushing may be required; groundwater may be encountered at shallow depths in some valley bottoms.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

**Psd - Pleistocene Sand and Gravel (Pleistocene)**
Well-sorted and stratified sand and gravel. May include cobbles and boulders. Inferred to be delta, fan or lag deposits in glacial channels or near ice margins. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

## Qbc - Boulder colluvium (Quaternary)

**Qbc - Boulder Colluvium (Quaternary)**
Sandstone or conglomerate boulders and cobbles cover more than 75 percent of the ground surface down-slope of bedrock ledges; boulders are concentrated at the surface of the deposit; clasts are generally from 1 foot (25 cm) to 6 feet (2 meters) in diameter; the subangular to subrounded clasts are tabular to equidimensional; tabular clasts exhibit a strong down-slope orientation (near parallel to slope fabric); form crudely layered lenses oriented down-slope; clasts are typically sandy silt matrix-supported (texturally a diamict - a nonsorted or poorly sorted, unconsolidated deposit that contains a wide range of particle sizes, commonly from clay to cobble- or boulder-size, and rounded and/or angular fragments.) with lenses of clast-supported material with or without matrix; thickness typically 6 to 15 feet (2 to 3.5 meters); usually is underlain by other unconsolidated material (glacial deposits) along the toe-slopes of the hillsides. Description from source maps: Aldenville Quadrangle, Damascus Quadrangle, Galilee Quadrangle, Honesdale Quadrangle, and White Mills Quadrangle

**Qbc - Boulder Colluvium (Quaternary)**
Quartz sandstone or conglomerate boulders and cobbles cover more than 75 percent of the ground surface down slope of the bedrock ledge source; clasts are generally from 1 foot (25 cm) to 6 feet (2 meters) in diameter; the subangular to subrounded clasts are tabular to equidimensional; tabular clasts exhibit a strong downslope orientation (near parallel to slope fabric) or form crudely layered lenses oriented downslope; boulders are concentrated at the surface of the deposit; clast-supported diamict, (a nonsorted or poorly sorted, unconsolidated deposit that contains a wide range of particle sizes,

commonly from clay to cobble- or boulder-size), and rounded and/or angular fragments, or matrixless clasts with lenses or pockets of sandy silt matrix-supported diamict underlies the boulders; surface relief of less than 6 feet (2 meters) over tens of meters horizontally; thickness typically 6 to 12 feet (2 to 4 meters); variable thicknesses of glacial deposits are buried under the boulder colluvium along the toeslopes of the hillsides. Description from source map: Hawley Quadrangle

**Qbc - Boulder Colluvium (Quaternary)**
Sandstone or conglomerate boulders and cobbles cover more than 75 percent of the ground surface downslope of bedrock ledges; boulders are concentrated at the surface of the deposit; clasts are generally from 1 foot to 6 feet in diameter; the subangular to subrounded clasts are tabular to equidimensional; tabular clasts exhibit a strong downslope orientation (near parallel to slope fabric); form crudely layered lenses oriented downslope; sandy silt matrix between boulders; texturally a diamict (nonsorted or poorly sorted, unconsolidated deposit that contains a wide range of particle sizes, commonly from clay to cobble or boulder size, and rounded and/or angular fragments) with lenses of clast-supported material with or without matrix; thickness typically 6 to 15 feet; usually underlain by other unconsolidated material (glacial deposits) along the toe slopes of the hillsides. Description from source maps: Lake Como Quadrangle, Long Eddy and Callicoon, Quadrangles, and Orson Quadrangle

**Qba - Boulder Accumulations (Pleistocene)**
Unsorted, unconsolidated mixture of angular to rounded boulders up to 6 feet or more in diameter, but generally less than 3 feet. Mainly sandstone having relatively flat to very rough surfaces. Occurs in open flats, below ledges, in small drainages, around the margins of peat deposits, and on swamp surfaces. Deposits result from glaciation and/or colluviation. Thickness is unknown, but appears to range from 1 foot to several feet.

Groundwater Characteristics: No aquifer potential.

Engineering Characteristics: Moderately difficult to excavate. Generally unsuitable for foundations. Unsuitable for septic systems and sanitary-landfill sites.

Mineral Resources: Potential source of riprap.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

## Qwic - Wisconsinan ice-contact stratified drift (Quaternary)

**Qwic - Wisconsinan Ice-Contact Stratified Drift (Quaternary)**
Stratified sand and gravel with some boulders; often chaotic stratification; some internal slump structures; gently sloping upper surfaces with a few closed depressions; generally not more than 30 feet (10 meters) thick; in buried valley may exceed 100 feet (30 meters) in thickness; typically deposited in valley side kames. Description from source maps: Aldenville Quadrangle, Galilee Quadrangle and Honesdale Quadrangle

**Qwic - Wisconsinan Ice-Contact Stratified Drift (Quaternary)**
Stratified sand and gravel with some boulders; often chaotic stratification; some internal slump structures; gently sloping upper surfaces with a few closed depressions; generally not more than 30 feet (10 meters) thick; in buried valley areas and along the flanks of the Delaware River valley may exceed 100 feet (30 meters) in thickness; typically deposited in valley side kames. Description from source

maps: Damascus Quadrangle, Hancock Quadrangle, Lake Como Quadrangle, Long Eddy and Callicoon Quadrangles, Narrowsburg Quadrangle, Starrucca Quadrangle, and White Mills Quadrangle

**Qwic - Wisconsinan Ice-Contact Stratified Drift (Quaternary)**
Stratified sand and gravel with some boulders; often chaotic stratification; some internal slump structures; gently sloping upper surfaces with few closed depressions; generally not more than 30 feet (10 meters) thick; in buried valley areas may exceed 100 feet (30 meters) in thickness; also deposited in eskers, valley side and floor kames; some as sublacustrine fans. Description from source map: Hawley Quadrangle

**Qwic - Wisconsinan Ice-Contact Stratified Drift (Quaternary)**
Stratified sand and gravel with some boulders; often chaotic stratification; some internal slump structures; gently sloping upper surfaces with a few closed depressions; generally not more than 30 feet thick. Description from source map: Orson Quadrangle

**Qoic - Olean Ice-contact stratified sand and gravel (Pleistocene)**
Unconsolidated, stratified sand and gravel, commonly containing large boulders. Abrupt textural changes between beds and lenses; composition reflects underlying bedrock of the region; includes valley-bottom and valley-side kames and kame terraces, and some upland kames. Forms hummocky surface topography; kames have undrained depressions. Deposited by fluvial action in close proximity to stagnant ice. Thickness is variable and generally unknown, ranging from several feet to more than 200 feet.

> Groundwater Characteristics: High infiltration capacity. Median yield of domestic wells is 20 gal/min. Water has good quality.
>
> Engineering Characteristics: Generally easy to excavate; large boulders may be encountered. Maintains only moderate to gentle cut slopes; potential for slumping. Generally unsuitable for septic systems and sanitary landfills because sand and gravel afford little or no attenuation of chemical and bacterial contaminants. Poor to unsuitable foundation for heavy structures.
>
> Mineral Resources: Source of coarse and fine aggregate; crushing, screening, and washing are generally required; groundwater may be encountered in valley bottoms.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

**Pd - Diamicton (Pleistocene)**
An admixture of unsorted sediment ranging from clay to boulders. Generally matrix supported, massive and clast-rich. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

## Qokt - Olean kame terrace (Quaternary)

**Qokt - Olean Kame Terrace (Pleistocene)**
Unconsolidated, stratified sand and gravel, commonly containing large boulders. Abrupt textural changes between beds and lenses; composition reflects underlying bedrock of the region; includes valley-bottom and valley-side kames and kame terraces, and some upland kames. Forms hummocky surface topography; kames have undrained depressions; kame terraces have undulating sloping surfaces. Deposited by fluvial action in close proximity to stagnant ice. Thickness is variable and generally unknown, ranging from several feet to more than 200 feet.

Groundwater Characteristics: High infiltration capacity. Median yield of domestic wells is 20 gal/min. Water has good quality.

Engineering Characteristics: Generally easy to excavate; large boulders may be encountered. Maintains only moderate to gentle cut slopes; potential for slumping. Generally unsuitable for septic systems and sanitary landfills because sand and gravel afford little or no attenuation of chemical and bacterial contaminants. Poor to unsuitable foundation for heavy structures.

Mineral Resources: Source of coarse and fine aggregate; crushing, screening, and washing are generally required; groundwater may be encountered in valley bottoms.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

## Qdcs - Diamicton (clast supported) (Pleistocene)

**Pdcs - Pleistocene Diamicton (Clast Supported) (Pleistocene)**
An admixture of unsorted sediment ranging from clay to boulders. Generally clast supported, massive and clast-rich. Generally found along a former ice margin or moraine. Description from source map: New York Upper Delaware River South

## Qwt - Wisconsinan till (Quaternary)

**Qwt - Wisconsinan Till (Quaternary)**
Glacial or resedimented till; texturally a diamict with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far traveled crystalline erratics; typically occurs as a fairly smooth landform with a bouldery surface and little distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet (1 meter) is often colluviated, displaying a downslope-oriented fabric; thickness is greater than 6 feet (2 meters), is typically 15 feet (5 meters), and can be greater than 150 feet (50 meters) in buried to partly in-filled valleys. Description from source maps: Aldenville Quadrangle, Damascus Quadrangle, Galilee Quadrangle, Honesdale Quadrangle, and White Mills Quadrangle

**Qwt - Wisconsinan Till (Quaternary)**
Glacial or resedimented till; texturally a diamict (nonsorted or poorly sorted, unconsolidated deposit that contains a wide range of particle sizes, commonly from clay to cobble or boulder size, and rounded and/or angular fragments) with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far-traveled crystalline erratics; typically occurs as a fairly smooth landform or with a subtle (indistinct) constructional (knob and kettle) topography on hillslopes; upper 3 feet is often colluviated, displaying a downslope-oriented fabric; in more than 90 percent of the area mapped as till, thickness is greater than 6 feet, typically 15 feet, and can be greater than 200 feet in buried to partly infilled valleys; locally, on hilltops and along the edge of cliffs and hillside benches, thickness is less than 6 feet. Description from source map: Hancock Quadrangle

**Qwt - Wisconsinan Till (Quaternary)**
Till; poorly sorted, unstratified diamict with a clayey, silty, or sandy matrix depending on the local source

bedrock; common cobble and boulder clasts; typically occurs as a fairly smooth landform with a bouldery surface and no clear constructional (knob and kettle) topography on hillslopes; upper 3 feet (1 meter) is often colluviated, displaying a downslope-oriented fabric; thickness is greater than 6 feet (2 meters), is typically 10 to 15 feet (3 to 5 meters), and can be greater than 100 feet (30 meters) in some buried valley segments. Description from source map: Hawley Quadrangle

**Qwt - Wisconsinan Till (Quaternary)**
Glacial or resedimented till; texturally a diamict with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far-traveled crystalline erratics; typically occurs as a fairly smooth landform with a bouldery surface and little distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet is often colluviated, displaying a downslope-oriented fabric; thickness typically 6 to 15 feet and can be greater than 150 feet in buried to partly infilled valleys. Description from source map: Long Eddy and Callicoon Quadrangles

**Qwt - Wisconsinan Till (Quaternary)**
Glacial or resedimented till; texturally a diamict (a nonsorted or poorly sorted, unconsolidated deposit that contains a wide range of particle sizes, commonly from clay to cobble- or boulder-size, and rounded and/or angular fragments) with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far traveled crystalline erratics; typically occurs as a fairly smooth landform with a bouldery surface and little distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet (1 meter) is often colluviated, displaying a downslope-oriented fabric; thickness is greater than 6 feet (2 meters), is typically 15 feet (5 meters), and can be greater than 150 feet (50 meters) in buried to partly in-filled valleys. Description from source maps: Narrowsburg Quadrangle and Lake Como Quadrangle

**Qwt - Wisconsinan Till (Quaternary)**
Glacial or resedimented till; texturally a diamict with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far-traveled crystalline erratics; typically occurs as a fairly smooth landform with a bouldery surface and little distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet is often colluviated, displaying a downslope-oriented fabric; thickness is greater than 6 feet, is typically 15 feet, and can be greater than 150 feet in buried to partly infilled valleys. Description from source map: Orson Quadrangle

**Qwt - Wisconsinan Till (Quaternary)**
Glacial or resedimented till; texturally a diamict, a nonsorted or poorly sorted, unconsolidated deposit that contains a wide range of particle sizes, commonly from clay to cobble- or boulder-size, and rounded and/or angular fragments with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far traveled crystalline erratics; typically occurs as a fairly smooth landform with a bouldery surface and little distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet (1 m) is often colluviated, displaying a downslope-oriented fabric; thickness is greater than 6 feet (2 m), is typically 15 feet (5 m), and can be greater than 200 feet (60 m) in buried to partly in-filled valleys. Description from source map: Starrucca Quadrangle

**Qot - Olean till (Pleistocene)**
Unsorted and nonstratified mixture of clay, silt, sand, pebbles, cobbles, and boulders. Reddish brow in most of the county; brown to gray where it overlies the Trimmers Rock and Mahantango Formation;

moderately cohesive; composition reflects underlying bedrock; shallow soil profiles; occurs mainly on lower slopes or in valley bottoms. Deposited as lodgment till at the base of ice or as ablation till by melting ice. Thickness ranges from 6 feet to over 200 feet.

Groundwater Characteristics: Moderate to high infiltration capacity. Four domestic wells have a median yield of 28 gal/min. Water has good quality.

Engineering Characteristics: Moderately easy to excavate; some problems due to large boulders. Generally fast drilling rates. Generally maintains gentle to moderate cut slopes; susceptible to landslide failure where water saturated. Poor to good foundation for heavy structures. Not suitable for septic systems. Suitable in some places for sanitary-landfill sites.

Mineral Resources: Useful as artificial fill.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

**Pics - Pleistocene Ice-Contact Cobbles and Sand (Pleistocene)**
Stratified ice contacted deposits, variable coarse-grained sediment consisting of boulders to sand size particles. Inferred to be deposited along an ice-margin. May include, interbedded coarse lenses of gravel and clast supported diamictons (flow tills). Description from source map: New York Upper Delaware River South

## Qwtb - Wisconsinan bouldery till (Quaternary)

**Qwtb - Wisconsinan Bouldery Till (Quaternary)**
Glacial or resedimented till with a boulder-mantled surface (more than 50 per cent of ground surface boulder covered); texturally a diamict with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far traveled crystalline erratics; typically occurs as a fairly smooth landform but sometimes shows a distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet (1 meter) is often colluviated, displaying a downslope oriented fabric; thickness is greater than 6 feet (2 meters), is typically 15 feet (5 meters), and can be greater than 150 feet (50 meters) in buried to partly in-filled valleys. Description from source maps: Aldenville Quadrangle, Honesdale Quadrangle, Starrucca Quadrangle and White Mills Quadrangle

**Qwtb - Wisconsinan Bouldery Till (Quaternary)**
Glacial or resedimented till with a boulder-mantled surface (more than 50 percent of ground surface is boulder covered); texturally a diamict with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far-traveled crystalline erratics; typically occurs as a fairly smooth landform but sometimes shows a distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet is often colluviated, displaying a downslope-oriented fabric; thickness is typically 6 to 15 feet and can be greater than 150 feet in buried to partly in-filled valleys. Description from source maps: Damascus Quadrangle, Hancock Quadrangle and Lake Como Quadrangle

**Qwtb - Wisconsinan Bouldery Till (Quaternary)**
Glacial or resedimented till with a boulder-mantled surface (more than 50 per cent of ground surface boulder covered); texturally a diamict; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; typically occurs in the lee of bedrock knobs

as a fairly smooth landform but sometimes shows a distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet (1 meter) is often colluviated, displaying a downslope-oriented fabric; thickness is greater than 6 feet (2 meters), is typically 15 feet (5 meters), and can be greater than 100 feet (30 meters) in buried to partly in-filled valleys. Description from source map: Hawley Quadrangle

## PZbr - Sandstone and shale bedrock (Paleozoic and younger)

**R - Sandstone and Shale Bedrock (Paleozoic and younger?)**
Bedrock outcrops or clast-rich diamict of residual and colluvial material derived from the directly underlying bedrock of interbedded red and gray sandstone, and shale; reddish brown to yellowish brown, clayey silt to sandy silt matrix; clasts are typically matrix-supported with lenses of clast-supported material with or without matrix; tabular clasts generally exhibit a down slope directed orientation within the upper 1.5 feet (0.5 meter) of the material; less than 6 feet (2 meters) to bedrock; on greater than 25 percent slopes, typically less than 3 feet (1 meter) thick. Description from source maps: Aldenville Quadrangle, Damascus Quadrangle, Galilee Quadrangle, Honesdale Quadrangle, Narrowsburg Quadrangle, Starrucca Quadrangle, and White Mills Quadrangle

**br - Sandstone and Shale Bedrock (Paleozoic and younger?)**
Bedrock outcrops or clast-rich diamict of residual and colluvial material overlying bedrock of interbedded red and gray sandstone and shale. Residual and colluvial material have a reddish-brown to yellowish-brown, clayey silt to sandy silt matrix; clasts are typically matrix supported, but there are some lenses of clast-supported material with or without matrix; tabular clasts generally exhibit a downslope-directed orientation within the upper 1.5 feet of the material. In areas of residual and colluvial material, there is less than 6 feet to bedrock, and on greater than 25 percent slopes, there is typically less than 3 feet to bedrock. Description from source map: Hancock Quadrangle

**R - Sandstone, Conglomeratic Sandstone, and Shale Bedrock (Paleozoic and younger?)**
Bedrock outcrops or clast-rich diamict of residual and colluvial material derived from the directly underlying bedrock of interbedded red and gray sandstone, conglomeratic sandstone, and shale; reddish brown to yellowish brown, clayey silt to sandy silt matrix; clasts are typically matrix-supported with lenses of clast-supported material with or without matrix; sandstone clasts are 0.5 to 1 foot (10 to 25 cm) across; many sandstone clasts are a meter or more in diameter; tabular clasts generally exhibit a down slope directed orientation within the upper 1.5 feet (0.5 meter) of the material; less than 6 feet (2 meters) to bedrock; on greater than 15 percent slopes, typically less than 3 feet (1 meter) thick. Description from source map: Hawley Quadrangle

**br - Sandstone and Shale Bedrock (Paleozoic and younger?)**
Bedrock outcrops or clast-rich diamict of residual and colluvial material derived from the directly underlying bedrock of interbedded red and gray sandstone and shale; reddish-brown to yellowish-brown, clayey silt to sandy silt matrix; clasts are typically matrix supported with lenses of clast-supported material with or without matrix; tabular clasts generally exhibit a downslope-directed orientation within the upper 1.5 feet of the material; less than 6 feet to bedrock; on greater than 25 percent slopes, typically less than 3 feet to bedrock. Description from source maps: Lake Como Quadrangle and Orson Quadrangle

**br - Sandstone and Shale Bedrock (Paleozoic and younger?)**
Bedrock outcrops or areas of thin clast-rich diamict of residual and colluvial material derived from the directly underlying bedrock of interbedded red and gray sandstone and shale. Residual and colluvial material have reddish-brown to yellowish-brown; clayey silt to sandy silt matrix; clasts are typically matrix supported, but there are some lenses of clast-supported material with or without matrix; tabular clasts generally exhibit a downslope-directed orientation within the upper 1.5 feet of the material. In areas of residual and colluvial material, there is less than 6 feet to bedrock, and on greater than 25 percent slopes, there is typically less than 3 feet to bedrock. Description from source map: Long Eddy and Callicoon Quadrangles

**br - Bedrock and Thin Olean Till, Undivided (Paleozoic and younger)**
Rock exposures and till less than 6 feet thick. Includes rock ledges having steep faces up to several feet high; broken rock is common at the base of the ledges. Unvegetated, gently dipping rock surfaces adjacent to ledges may have scattered large boulders and glacially striated surfaces. See Olean Till for description of till.

Groundwater Characteristics: Till has no aquifer potential because of inadequate thickness.

Engineering Characteristics: Thin till is easily excavated. Till thickness is inadequate for septic systems and sanitary-landfill sites.

Mineral Resources: Till may be used for artificial fill.

Description from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

**Br - Bedrock (Middle to Late Devonian)**
Non-glacially derived, hard rock, pre-pleistocene in age. May be covered up to a meter in diamicton, sand and gravel, or sand and clay in areas marked as Br. Generally a shale, sandstone or pebble conglomerate. Description from source maps: New York Upper Delaware River North and New York Upper Delaware River South

## Dcl - Catskill Formation, Lackawaxen Member (Upper Devonian)

**Dcl - Lackawaxen Member (Upper Devonian)**
Dominantly gray sandstone, some gray conglomeratic sandstone, and a few thin red siltstones and claystones; moderate quantity of detrital feldspar. Base is marked by persistent conglomeratic sandstone up to 20 feet thick and containing up to 75 percent pebbles, which average from 0.25 to 0.5 inch in diameter. Discontinuous conglomeratic sandstone (blue line) occurs at higher stratigraphic interval. Sandstone is mainly trough crossbedded and fine to medium grained; intervals of planar-bedded sandstone occur mainly in the eastern part of the county. Sandstone and claystone rarely crop out. Deposited by braided streams. Maximum thickness is estimated to be between 400 and 500 feet in the northern third of the county and is about 200 feet in the western part.

Groundwater Characteristics: Moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 10 and 30 gal/min, respectively. Water is soft to moderately hard and low in dissolved solids.

Engineering Characteristics: Moderately difficult to difficult to excavate; sandstone and conglomeratic sandstone may require blasting. Slow to variable drilling rates. Generally maintains steep to vertical cut slopes; some rockfall may be anticipated after prolonged

exposure. Excellent to good foundation for heavy structures. Slight to moderate percolation difficulty for septic systems developed in well-broken, weathered bedrock having soil cover. Sanitary-landfill siting requires careful evaluation, but the unit is generally poorly suited.

Mineral Resources: Planar-bedded sandstone has good potential for flagstone in the northeastern third of the county and some potential for dimension stone; waste piles at former flagstone quarries have potential for crushed rock. Claystone has marginal potential as material for building brick and floor brick.

Description from source map: Pike County Geology and Mineral Resources, Bedrock Geologic Map

## Dcdr - Catskill Formation, Delaware River Member (Upper Devonian)

**Dcdr - Delaware River Member (Upper Devonian)**
Cyclic sequences of gray, trough-crossbedded and planar-bedded, fine- to medium-grained sandstone and some red siltstone and claystone. Sandstone is in part feldspathic, forms small ledges, has blocky to flaggy fragmentation, and contains local calcareous, intraformational conglomerate. Discontinuous conglomeratic sandstone (red line and black circles) occurs near the top of the member in the northeastern and southwestern portions of the county. Thin siltstone and claystone in the northeast become thicker and more persistent to the southwest. Deposited by braided streams. Maximum thickness where overlain by the Lackawaxen Member is 2,600 feet; maximum thickness where the Lackawaxen is absent is 2,800 feet.

Groundwater Characteristics: Moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and non-domestic wells are 16 and 100 gal/min, respectively. Water is soft to moderately hard and low in dissolved solids.

Engineering Characteristics: Moderately difficult to difficult to excavate; sandstone and conglomeratic sandstone may require blasting. Slow to variable drilling rates. Generally maintains steep to vertical cut slopes; some rockfall may be anticipated after prolonged exposure. Excellent to good foundation for heavy structures. Slight to moderate percolation difficulty for septic systems developed in well-broken, weathered bedrock having good soil cover. Sanitary-landfill siting requires careful evaluation, but the unit is generally poorly suited.

Mineral Resources: Planar-bedded sandstone has good potential for flagstone, particularly in the northeastern third of the county, and some potential for dimension stone; waste piles at former flagstone quarries have potential for crushed rock. Claystone has marginal potential as material for building brick and floor brick.

Description from source map: Pike County Geology and Mineral Resources, Bedrock Geologic Map

## Dct - Catskill Formation, Towamensing Member (Upper Devonian)

**Dct - Towamensing Member (Upper Devonian)**
Dominantly gray, fine- to medium-grained, trough-crossbedded sandstone; some planar-bedded sandstone; some lensoidal, intraformational conglomerate containing calcite cement, shale clasts, and carbonaceous material; and some thin, interbedded, dark-gray (lower part) and olive-gray (upper part) siltstone and claystone. Sandstone has blocky to flaggy fragmentation. Member contains freshwater plant fossils and trace fossils (bivalve burrows). Deposited in fluvial environment of lower delta plain, including river mouth bars. Thickness ranges from 247 feet in the west to 1,625 feet in the northeast.

Groundwater Characteristics: Moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 30 and 98 gal/min, respectively. Water is soft and low in dissolved solids.

Engineering Characteristics: Difficult to excavate; sandstone may require blasting. Slow drilling rate in sandstone; moderate drilling rate in siltstone. Generally maintains steep to vertical cut slopes; interbedded siltstone may contribute to rockfall. Excellent to good foundation for heavy structures. Generally suitable for septic systems developed in well-broken, weathered bedrock having a good soil cover. Sanitary-landfill siting requires careful evaluation, but the unit is generally poorly suited.

Mineral Resources: Planar-bedded sandstone has potential for flagstone. Sandstone has good potential for crushed rock. Claystone has marginal potential as material for building brick, floor brick, and lightweight aggregate, but presence of carbonate could cause problems.

Description from source map: Pike County Geology and Mineral Resources, Bedrock Geologic Map

## Dtm - Trimmers Rock Formation, Millrift Member (Upper Devonian)

**Dtm - Millrift Member (Upper Devonian)**
Dominantly dark-gray to medium-dark-gray siltstone, shale, and sandstone; Millrift Member contains approximately 60 percent very fine grained sandstone, whereas Sloat Brook Member is dominantly siltstone and silt shale. Generally thin to medium bedded, although some sandstone in the Millrift Member is thick bedded; well-developed joints; poorly developed cleavage; forms low, subparallel ledges; marine fossils are common (especially brachiopods). Siltstone and shale disintegrate to hackly, platy, and chippy fragments; sandstone disintegrates to rubbly and slabby fragments. Deposited mostly by density currents in marine prodelta. Formation thickness ranges from 720 to 1,825 feet; Millrift Member has a maximum thickness of 1,000 feet; Sloat Brook Member has a maximum thickness of 950 feet.

Groundwater Characteristics: Low to moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 20 and 60 gal/min, respectively. Water is soft to moderately hard and in some places contains excessive manganese.

Engineering Characteristics: Moderately easy to difficult to excavate using heavy equipment; sandstone and some siltstone beds may require blasting. Fast to moderate drilling rates. Generally maintains very steep to vertical cut slopes; has potential for large rockfalls from curved joint surfaces. Good to excellent foundation for heavy structures. Sloat Brook Member is suitable for impoundments, but Millrift Member has well-developed joints that may present problems. Slight to moderate percolation difficulty is a problem for septic systems. Relatively narrow outcrop belt and presence of hard, fractured sandstone and siltstone beds are limiting factors for siting of sanitary landfills.

Mineral Resources: Shale has limited potential as material for building brick or facing brick. Sloat Brook Member has marginal potential for lightweight aggregate. Sloat Brook Member and lower part of Millrift Member have good potential for road metal and random fill. Upper part of Millrift Member has material suitable for riprap and embankment facing, and may have some potential for building stone or concrete aggregate.

Description from source map: Pike County Geology and Mineral Resources, Bedrock Geologic Map

## Dtsb - Trimmers Rock Formation, Sloat Brook Member (Upper Devonian)

**Dtm - Sloat Brook Member (Upper Devonian)**
Dominantly dark-gray to medium-dark-gray siltstone, shale, and sandstone; Millrift Member contains approximately 60 percent very fine grained sandstone, whereas Sloat Brook Member is dominantly siltstone and silt shale. Generally thin to medium bedded, although some sandstone in the Millrift Member is thick bedded; well-developed joints; poorly developed cleavage; forms low, subparallel ledges; marine fossils are common (especially brachiopods). Siltstone and shale disintegrate to hackly, platy, and chippy fragments; sandstone disintegrates to rubbly and slabby fragments. Deposited mostly by density currents in marine prodelta. Formation thickness ranges from 720 to 1,825 feet; Millrift Member has a maximum thickness of 1,000 feet; Sloat Brook Member has a maximum thickness of 950 feet.

> Groundwater Characteristics: Low to moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 20 and 60 gal/min, respectively. Water is soft to moderately hard and in some places contains excessive manganese.
>
> Engineering Characteristics: Moderately easy to difficult to excavate using heavy equipment; sandstone and some siltstone beds may require blasting. Fast to moderate drilling rates. Generally maintains very steep to vertical cut slopes; has potential for large rockfalls from curved joint surfaces. Good to excellent foundation for heavy structures. Sloat Brook Member is suitable for impoundments, but Millrift Member has well-developed joints that may present problems. Slight to moderate percolation difficulty is a problem for septic systems. Relatively narrow outcrop belt and presence of hard, fractured sandstone and siltstone beds are limiting factors for siting of sanitary landfills.
>
> Mineral Resources: Shale has limited potential as material for building brick or facing brick. Sloat Brook Member has marginal potential for lightweight aggregate. Sloat Brook Member and lower part of Millrift Member have good potential for road metal and random fill. Upper part of Millrift Member has material suitable for riprap and embankment facing, and may have some potential for building stone or concrete aggregate.

Description from source map: Pike County Geology and Mineral Resources, Bedrock Geologic Map

## Dmn - Mahantango Formation (Middle Devonian)

**Dmh - Mahantango Formation (Middle Devonian)**
Interbedded, dark-gray siltstone, shale, and claystone. Shale is thickly laminated to thin bedded and fissile to subfissile. Siltstone is medium to thick bedded and subfissile to non-fissile. Formation has moderate to good cleavage development; hackly and splintery fragmentation; zones of nodules parallel to bedding; forms cliffs along Delaware River valley and low, strike ridges on uplands; locally fossiliferous. Deposited in open-shelf to gentle-slope marine environment. Thickness ranges from 1,300 feet in the north to 2,450 feet in the east.

> Groundwater Characteristics: Low to moderate infiltration capacity along fractures. The median yields of domestic wells and nondomestic wells are 16 and 34 gal/min, respectively. Water is soft to moderately hard.
>
> Engineering Characteristics: Easy to moderately difficult to excavate. Moderate drilling rate.

Maintains steep cut slopes. Good foundation for heavy structures. Generally unsuitable for septic systems because of poor percolation. Potentially suitable for sanitary-landfill sites.

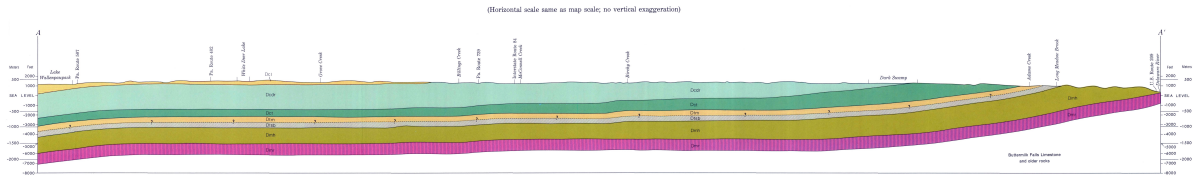
Mineral Resources: Limited potential for lightweight aggregate. Shale has potential as material for building brick and floor brick, but may have to be pelletized. Derived colluvium is used for surfacing secondary roads and for random fill (locally called sharpstone).

Description from source map: Pike County Geology and Mineral Resources, Bedrock Geologic Map

# Geologic Cross Section

The geologic cross section present in the GRI digital geologic-GIS data produced for Upper Delaware Scenic and Recreational River, New York and Pennsylvania (UPDE) is presented below. The cross section graphics was scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

## Cross Section A-A'




Of note, portions of the cross section line extend outside the extent of the GRI digital geologic-GIS data.

Graphic from source map: Pike County Geology and Mineral Resources

# GRI Ancillary Source Map Information

The following sections present ancillary source map information associated with sources used for this project.

## Aldenville Quadrangle

The formal citation for this source.

Braun, D. D., 2008, Surficial Geology of the Aldenville 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–09.0, 15 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74569*).

Prominent graphics and text associated with this source.

## Map Legend

**BEDROCK LEDGE OUTCROP**

2

**STRIATION:**
Site number is above the arrow. Locations and orientations are given in Table 2. Point of the head of the arrow marks the location of the striation site.

**QUARRY:**
Sandstone (bluestone) quarry or shale aggregate pit; most are abandoned.

200
150
100
30

**ISOCHORES AT 30, 100, 150, AND 200 FEET:**
An isochore is the thickness of a deposit measured in a vertical borehole or in an excavation with a vertical face. The isochores drawn on the map pass from one surficial deposit to another, like from till to ice-contact-stratified-drift. This indicates that a 30 foot thickness of till is next to a 30 foot thickness of ice-contact-stratified-drift or ice-contact-stratified-drift with underlying till, together being 30 feet thick.

Graphic from source map: Aldenville Quadrangle

## Table 1: Classification of Soil Series

| Table 1. Classification of soil series by surficial geology map unit. | |
|---|---|
| **Surficial geology unit** | **Wayne County Soil Series** |
| FILL (f) | |
| GRAVEL PIT (gp) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx), Volusia (Vo, Vx) |
| PEAT (Qp) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba), Basher (Bh), Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| BOULDER COLLUVIUM (Qb) | Lordstown (Lx), Oquaga (Ox, Oy), Wellsboro and Mardin (Wx)<br>Norwich and Chippewa (Nx), Volusia (Vx) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Mardin (Ma, Md), Morris (Mo, Mx), Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx), Volusia (Vo, Vx), Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Arnot (Ar), Lordstown (Ld, Lx), Mardin (Md), Morris (Mx)<br>Oquaga (Oa, Ox, Oy), Rock outcrop-Arnot (Ro), Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Aldenville Quadrangle

## Table 2: Glacial Striations

| Table 2. Locations of glacial striation sites on the Aldenville quadrangle. | | | | |
|---|---|---|---|---|
| **Map Site** | **Location** | | **Direction** | **Topographic Position** |
| | **Latitude** | **Longitude** | | |
| 1 | 41° 42’ 50” | -75° 17’ 14” | S 31°W | South slope* |
| 2 | 41° 42’ 03” | -75° 19’ 12” | S 23°W | Hill top |
| 3 | 41° 41’ 47” | -75° 21’ 45” | S 35°W | Northeast slope* |
| 4 | 41° 40’ 52” | -75° 18’ 02” | S 25°W | Hill top |
| 5 | 41° 40’ 35” | -75° 22’ 28” | S 23°W | Hill top |
| 6 | 41° 40’ 38” | -75° 19’ 10” | S 35°W | Northeast slope* |
| 7 | 41° 39’ 50” | -75° 19’ 12” | S 07°W | Steep east slope* |
| 8 | 41° 38’ 55” | -75° 19’ 05” | S 23°W | Hill top |
| 9 | 41° 38’ 56” | -75° 18’ 06” | S 20°W | Hill top |
| 10 | 41° 38’ 33” | -75° 21’ 39” | S 25°W | Hill top |

* Direction slope faces

Graphic from source map: Aldenville Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Aldenville 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil mapping (Martin, 1985), bedrock mapping (White, 1881), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of field work by Eugene Szymanski and Ruth Braun (geologist assistants) and Duane Braun (surficial geologist). In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto three mylar overlays, and had the text added by Duane Braun. In the fourth phase, the mylar overlays were scanned, digitized, and produced in an ArcGIS format and Adobe PDF (Portable Document Format) by Pennsylvania Geological Survey personnel.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 25 to 50 feet on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 feet to as much as 200 feet on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

### Mapping Technique - Thickness of Deposits

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 meters) overlying the bedrock (the contact of the bedrock (R) unit with all other surficial units), 30 feet (10 meters), 100 feet (30 meters), 150 feet (50 meters), and 200 feet (70 meters). The 30, 100, 150, and 200 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

### Quaternary History

During the Quaternary, the Aldenville 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial

conditions. About ten such alternations have affected northeastern Pennsylvania during the last one million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Aldenville area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre- Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Aldenville area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S 20°W – N 20°E direction (Braun, 1997). Within the quadrangle, glacial striations (Table 2) indicate that ice flow was about S 20°-35°W. A series of subglacial and/or ice marginal meltwater channels (sluiceways) were incised across saddles in the ridges.

Only late Wisconsinan-aged deposits and landforms have been observed in the Aldenville quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 - 18 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 to 2 meters) thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Aldenville area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (10 meters) (Edgerton, 1969).

Text from source map: Aldenville Quadrangle

## References

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Martin, G.D., 1985, Soil survey of Wayne County, Pennsylvania: U.S. Department of Agriculture, 119 p. and 52 maps.

White, I.C., 1881, The geology of Susquehanna County and Wayne County, Pennsylvania Geological Survey, 2nd, ser., Report G5, 243 p. and one map.

Text from source map: Aldenville Quadrangle

## Damascus Quadrangle

The formal citation for this source.

Braun, D. D., 2008, Surficial Geology of the Damascus 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–15.0, 14 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74567*).

Prominent graphics and text associated with this source.

## Map Legend

**BEDROCK LEDGE OUTCROP**

2

**STRIATION:**
Site number is above the arrow. Locations and orientations are given in Table 2. Point of the head of the arrow marks the location of the striation site.

150
100
30

**ISOCHORES AT 30, 100, AND 150 FEET:**
An isochore is the thickness of a deposit measured in a vertical borehole or in an excavation with a vertical face. The isochores drawn on the map pass from one surficial deposit to another, like from till to ice-contact-stratified-drift. This indicates that a 30 foot thickness of till is next to a 30 foot thickness of ice-contact-stratified-drift or ice-contact-stratified-drift with underlying till, together being 30 feet thick.

Graphic from source map: Damascus Quadrangle

## Table 1: Classification of Soil Series

| Table 1. Classification of soil series by surficial geology map unit. | |
|---|---|
| **Surficial geology unit** | **Wayne County Soil Series** |
| FILL (f) | |
| GRAVEL PIT (gp) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx), Volusia (Vo, Vx) |
| PEAT (Qp) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba), Basher (Bh), Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| BOULDER COLLUVIUM (Qb) | Lordstown (Lx), Oquaga (Ox, Oy), Wellsboro and Mardin (Wx)<br>Norwich and Chippewa (Nx), Volusia (Vx) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Mardin (Ma, Md), Morris (Mo, Mx), Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx), Volusia (Vo, Vx), Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Arnot (Ar), Lordstown (Ld, Lx), Mardin (Md), Morris (Mx)<br>Oquaga (Oa, Ox, Oy), Rock outcrop-Arnot (Ro), Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Damascus Quadrangle

## Table 2: Glacial Striations

| Table 2. Locations of glacial striation sites on the Damascus quadrangle. | | | | |
|---|---|---|---|---|
| Map Site | Location | | Direction | Topographic Position |
| | Latitude | Longitude | | |
| 1 | 41° 44' 37" | -75° 04' 12" | S 35°W | Hill top |
| 2 | 41° 42' 35" | -75° 04' 28" | S 36°W | Hill top |
| 3 | 41° 42' 29" | -75° 06' 01" | S 36°W | Hill top |
| 4 | 41° 42' 05" | -75° 06' 29" | S 36°W | East slope* |
| 5 | 41° 38' 37" | -75° 04' 58" | S 34°W | North slope |

* Direction slope faces

Graphic from source map: Damascus Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Damascus 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil mapping (Martin, 1985), bedrock mapping (White, 1881), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of fieldwork by Eugene Szymanski (geologist assistant) and Duane Braun (surficial geologist). In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto mylar overlays, and had the text added by Duane Braun. In the fourth phase, the mylar overlays were scanned, digitized, and produced in an ArcGIS format and Adobe PDF (Portable Document Format) by Pennsylvania Geological Survey personnel.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet (15 to 30 meters) on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 feet (30 meters) to as much as 200 feet (60 meters) on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

### Mapping Technique - Thickness of Deposits

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 meters) overlying the bedrock (the contact of the bedrock (R) unit with all other surficial units), 30 feet (10 meters), 100 feet (30 meters), and 150 feet (50 meters). The 30, 100, and 150 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that several of the preglacial tributaries to the Delaware River have segments partly to entirely filled with glacial deposits.

### Quaternary History

During the Quaternary, the Damascus 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Damascus area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-

Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre- Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Damascus area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S 30°W to N 30°E direction. Within the quadrangle, glacial striations (Table 2) indicate that ice flow was about S 36°W. A series of subglacial and/or ice marginal meltwater channels (sluiceways) were incised across saddles in the ridges.

Only late Wisconsin-aged deposits and landforms have been observed in the Damascus quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 - 18 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 to 2 meters) thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Damascus area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock.

Text from source map: Damascus Quadrangle

## References

Braun, D. D., 1997, Physiography and Quaternary of the Scranton/Wilkes-Barre Region: *in* Inners, J. D., editor, Geology of the Wyoming-Lackawanna Valley: Guidebook, 62nd Annual Field Conference of Pennsylvania Geologists, Scranton, PA p. 1-15.

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Braun, D. D., 1989, Glacial and periglacial erosion of the Appalachians: *in* Gardner, T. W. and Sevon, W. D., editors, Appalachian geomorphology, Geomorphology, v. 2, no. 1-3, p. 233-258.

Cameron, C.C., 1970, Peat deposits of Northeastern Pennsylvania: U.S. Geological Survey, Bulletin 1317-A, 90 p.

Dalton, T. S., Carson, B., and Meltzer, A. S., 1997, Holocene stratigraphy of Lake Lacawac: Establishment of a framework for paleoecological and paleoclimatic studies: Geological Society of America Abstracts with Program, v. 29, no. 1 p. 39.

Martin, G. D., 1985,Soil Survey of Wayne County, Pennsylvania: U. S. Department of Agriculture, 119p. and 52 maps.

White, I. C., 1881, The geology of Susquehanna County and Wayne County, Pennsylvania Geological Survey, 2nd ser., Report G5, 243 p. and one map.

References from source map: Damascus Quadrangle

## Galilee Quadrangle

The formal citation for this source.

Braun, D. D., 2008, Surficial Geology of the Galilee 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–10.0, 15 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74568*).

Prominent graphics and text associated with this source.

## Map Legend

**BEDROCK LEDGE OUTCROP**

2

**STRIATION:**
Site number is above the arrow. Locations and orientations are given in Table 2. Point of the head of the arrow marks the location of the striation site.

**QUARRY:**
Sandstone (bluestone) quarry or shale aggregate pit; most are abandoned.

Sand and gravel quarry.

150
100
30

**ISOCHORES AT 30, 100, AND 150 FEET:**
An isochore is the thickness of a deposit measured in a vertical borehole or in an excavation with a vertical face. The isochores drawn on the map pass from one surficial deposit to another, like from till to ice-contact-stratified-drift. This indicates that a 30 foot thickness of till is next to a 30 foot thickness of ice-contact-stratified-drift or ice-contact-stratified-drift with underlying till, together being 30 feet thick.

Graphic from source map: Galilee Quadrangle

## Table 1: Classification of Soil Series

| Table 1. Classification of soil series by surficial geology map unit. | |
|---|---|
| **Surficial geology unit** | **Wayne County Soil Series** |
| FILL (f) | |
| GRAVEL PIT (gp) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx), Volusia (Vo, Vx) |
| PEAT (Qp) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba), Basher (Bh), Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| BOULDER COLLUVIUM (Qb) | Lordstown (Lx), Oquaga (Ox, Oy), Wellsboro and Mardin (Wx)<br>Norwich and Chippewa (Nx), Volusia (Vx) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Mardin (Ma, Md), Morris (Mo, Mx), Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx), Volusia (Vo, Vx), Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Arnot (Ar), Lordstown (Ld, Lx), Mardin (Md), Morris (Mx)<br>Oquaga (Oa, Ox, Oy), Rock outcrop-Arnot (Ro), Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Galilee Quadrangle

## Table 2: Glacial Striations

| Table 2. Locations of glacial striation sites on the Galilee quadrangle. | | | | |
|---|---|---|---|---|
| Map Site | Location | | Direction | Topographic Position |
| | Latitude | Longitude | | |
| 1 | 41° 40' 47" | -75° 10' 33" | S 26°W | Hill top |
| 2 | 41° 41' 39" | -75° 08' 02" | S 30°W | Hill top |
| 3 | 41° 42' 13" | -75° 08' 05" | S 18°W | Hill top |
| 4 | 41° 42' 22" | -75° 11' 05" | S 20°W | South slope* |
| 5 | 41° 39' 13" | -75° 13' 56" | S 16°W | Hill top |

* Direction slope faces

Graphic from source map: Galilee Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Galilee 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil mapping (Martin, 1985), bedrock mapping (White, 1881), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of fieldwork by Eugene Szymanski and Ruth Braun (geologist assistants) and Duane Braun (surficial geologist). In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto mylar overlays, and had the text added by Duane Braun. In the fourth phase, the mylar overlays were scanned, digitized, and produced in an ArcGIS format and Adobe PDF (Portable Document Format) by Pennsylvania Geological Survey personnel.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 25 to 50 feet (8 to 15 meters) on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 feet (30 meters) to as much as 200 feet (60 meters) on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

### Mapping Technique - Thickness of Deposits

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 meters) overlying the bedrock (the contact of the bedrock (R) unit with all other surficial units), 30 feet (10 metes), 100 feet (30 meters), and 150 feet (50 meters). The 30, 100, and 150 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

### Quaternary History

During the Quaternary, the Galilee 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one

million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Galilee area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre-Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Galilee area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S 20°W – N 20°E direction (Braun, 1997). Within the quadrangle, glacial striations (Table 2) indicate that ice flow was about S 20°-30°W. A series of subglacial and/or ice marginal meltwater channels (sluiceways) were incised across saddles in the ridges.

Only late Wisconsin-aged deposits and landforms have been observed in the Galilee quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 - 18 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 to 2 meters) thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Galilee area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (10 meters) (Edgerton, 1969).

Text from source map: Galilee Quadrangle

## References

Braun, D. D., 1997, Physiography and Quaternary of the Scranton/Wilkes-Barre Region: *in* Inners, J. D., editor, Geology of the Wyoming-Lackawanna Valley: Guidebook, 62nd Annual Field Conference of Pennsylvania Geologists, Scranton, PA p. 1-15.

Braun, D. D., 1994, Late Wisconsinan to pre-Illinoian (G?) glacial events in eastern Pennsylvania: *in* Braun, D. D., editor, Late Wisconsinan to Pre-Illinoian (G?) glacial and periglacial events in eastern Pennsylvania: Guidebook, 57th Field Conference of the Friends of the Pleistocene (Northeastern Section), U.S. Geological Survey Open-File Report 94-434. p. 1-21.

Braun, D. D., 1989, Glacial and periglacial erosion of the Appalachians: *in* Gardner, T. W. and Sevon, W. D., editors, Appalachian geomorphology, Geomorphology, v. 2, no. 1-3, p. 233-258.

Cameron, C. C., 1970, Peat deposits of Northeastern Pennsylvania: U.S. Geological Survey, Bulletin 1317-A, 90 p.

Dalton, T. S., Carson, B., and Meltzer, A. S., 1997, Holocene stratigraphy of Lake Lacawac: Establishment of a framework for paleoecological and paleoclimatic studies: Geological Society of America Abstracts with Program, v. 29, no. 1 p. 39.

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Martin, G. D., 1985, Soil Survey of Wayne County, Pennsylvania: U. S. Department of Agriculture, 119p. and 52 maps.

White, I. C., 1881, The geology of Susquehanna County and Wayne County, Pennsylvania Geological Survey, 2nd ser., Report G5, 243 p. and one map.

References from source map: Galilee Quadrangle

## Hancock Quadrangle

The formal citation for this source.

Braun, D. D., 2011, Surficial Geology of the Hancock 7.5-Minute Quadrangle, Wayne County, Pennsylvania, and Broome County, New York: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 11–02.0, 13 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74563*).

Prominent graphics and text associated with this source.

## Map Legend

### Isochore

Thickness of surficial deposits in feet, as measured in vertical boreholes or in excavations with vertical faces. Where deposits overlap, contours represent the combined thickness of the stacked surficial units. Shown for thicknesses of 30, 100, 150, and 200 feet.



### Bedrock Ledge Outcrop

TK

### Till Knob

Rounded knob of till on the side of a valley. Typically a few tens of feet high. A wetland is often present up valley of the knob. The stream valley beside the knob has a markedly narrower form than elsewhere in the valley, and often the stream has cut into bedrock on the side of the valley opposite the knob.

### Open Water

Area of open water where the underlying surficial unit is uncertain.

### Glacial Striation

Arrow shows inferred direction of glacial flow. Site number is above the arrow (see Table 2). Point at the head of the arrow marks the location of the striation site.

### Glacial Meltwater Sluiceway

Abandoned glacial meltwater channel cut into bedrock and/or glacial deposits. Barbs show direction of meltwater flow.



### Geologic Contact

Location approximate

Graphic from source map: Hancock Quadrangle

## Table 1: Classification of Soil Series

Table 1. *Classification of Soil Series by Surficial Geologic Map Unit*

| Surficial geology unit | Wayne County soil series[1] | |
|---|---|---|
| Fill (f) | Not defined | |
| Alluvium (Qa)<br>Alluvial fan (Qaf) | Barbour (Ba)<br>Basher (Bh) | Fluvents and Fluvaquents (FF) |
| Peat (Qp) | Medihemists and Medifibrists (ME) | |
| Wetland (Qw) | Norwich and Chippewa (Nc, Nx)<br>Volusia (Vo, Vx) | |
| Wisconsinan outwash (Qwo)<br>Wisconsinan ice-contact stratified drift (Qwic) | Rexford (Re)<br>Wyoming (Wy) | |
| Wisconsinan till (Qwt)<br>Wisconsinan bouldery till (Qwtb) | Mardin (Ma, Md)<br>Morris (Mo, Mx)<br>Norwich and Chippewa (Nc, Nx) | Swartswood (Sw, Sx)<br>Volusia (Vo, Vx)<br>Wellsboro (We, Wo, Wx) |
| Sandstone and shale bedrock (br) | Arnot (Ar)<br>Lordstown (Ld, Lx)<br>Mardin (Md)<br>Morris (Mx)<br>Oquaga (Oa, Ox, Oy) | Rock outcrop-Arnot (Ro)<br>Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Hancock Quadrangle

## Table 2: Glacial Striations

Table 2. *Locations of Glacial Striation Sites on the Hancock Quadrangle*

| Site no. | Location[1] latitude | Location[1] longitude | Orientation | Topographic position |
|---|---|---|---|---|
| 1 | 41°56'03" | 75°18'29" | S73°W | North-facing slope of hollow |
| 2 | 41°55'45" | 75°17'05" | S52°W | South-facing slope |
| 3 | 41°55'05" | 75°16'50" | S53°W | South-facing slope |
| [2]4 | 41°54'54" | 75°16'38" | S46°W<br>S30°W | Hilltop |
| 5 | 41°54'19" | 75°17'15" | S48°W | Hilltop |
| 6 | 41°54'17" | 75°16'40" | S10°W | East-facing slope |
| 7 | 41°53'07" | 75°18'32" | S32°W | North-facing slope |

[1]North American Datum 1927.
[2]Station 4 has two striations.

Graphic from source map: Hancock Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Hancock 1:24,000-scale detailed reconnaissance surficial geologic map (map of unconsolidated materials overlying bedrock) was produced in six phases. The first three phases occurred in 2000, the fourth in 2001, the fifth in 2003, and the sixth in 2010 and 2011. These phases were as follows: (1) a preliminary surficial deposit map was made by Duane Braun based on soil maps (Martin, 1985), a bedrock geologic map (White, 1881), and landform analysis that utilized the 1:24,000-scale topographic map and aerial photographs; (2) the preliminary surficial deposit map was verified and/or corrected during 10 to 20 person days of fieldwork by Larry Prizblick and Ryan Steigerwalt (geologist assistants) and Braun; (3) Braun finalized the surficial geology map, drafted the data onto mylar overlays, and added the explanation; (4) the mylars were scanned, and the information was digitized and saved as shapefiles by Jerry T. Mitchell (GIS consultant, Bloomsburg University); (5) the shapefiles were converted into ArcInfo coverages and corrected by Pennsylvania Geological Survey personnel; (6) Pennsylvania Geological Survey personnel upgraded the ArcInfo coverages to geodatabase feature classes, which were used to prepare the surficial geologic map (page 12). As part of this final step, the map was reviewed and revised by Braun.

The distribution and type of units on the surficial geologic map is primarily a combined parent material and topographic-position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in Table 1 (page 10). Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which of the surficial deposit types related to the mapped soil series is most likely to occur at that site. The soil series boundaries were manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines were estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet on the ground where there are distinct features to locate the boundaries. Where boundaries cross large featureless areas of forest, line placement error is near 100 feet and occasionally as much as 200 feet. During the field verification and correction phase, many contacts were moved to reflect conditions directly observed in the field.

### Mapping Technique - Thickness of Deposits

The thickness of surficial deposits is divided into five categories: 6 feet (the contact of the bedrock (br) unit with all other surficial units), 30 feet, 100 feet, 150 feet, and 200 feet. The individual thickness contours (isochores) are drawn to be a conservative estimate of thickness (minimum thickness). The thickness was determined from sparse water-well data and outcrops of the surficial deposits. In most areas, the thickness was interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly filled with glacial deposits. In a few places, streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997, 2002).

### Quaternary History

During the Quaternary, the Hancock 7.5-minute quadrangle area has been affected by a climate that has alternated between cold, glacial-periglacial conditions and warm, humid-temperate, interglacial conditions. About 10 such alternations have affected northeastern Pennsylvania during the last million years (Braun, 1989, 1994, 2004). There is evidence for at least three different glacial advances across the Hancock area resulting in three glacial limits of distinctly different ages to the southwest of the area (Braun, 1994). The oldest and farthest glacial limit to the southwest is considered to be of pre-Illinoian G

age (850 ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 ka) or pre-Illinoian B (450 Ka) age and is only about 10 miles beyond the most recent, late Wisconsinan (20 Ka) glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994, 2004).

The earlier glacial advances across the Hancock area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice, and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly backfilled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997, 2002). The late Wisconsinan glacier advanced and retreated across the region in a general S30°W-N30ºE direction (White, 1881; Braun, 1997). Within the Hancock quadrangle, glacial striations (Table 2 and the map) indicate that ice flow was strongly affected by topography and was quite variable. The general flow was about S46°W to S53°W, but flow around knobs produced directions from S10°W to S73°W. One subglacial and/or ice-marginal meltwater channel (sluiceway) was incised across saddles in ridges in the south-central part of the quadrangle.

Only late-Wisconsinan-age deposits and landforms have been observed in the Hancock quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession, probably centered around 17 to18 ka (radiocarbon years) for this area. The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock, indicating considerable erosion of the bedrock during the last glaciation.

In the Hancock quadrangle, the overall deposit pattern is one of bedrock ridges separated by valleys partly filled with 30 to more than 200 feet of glacial till (as delineated by the thickness contours on the map). The original dendritic drainage pattern has been little modified by glacial erosion but has been markedly modified by glacial deposition. Masses of till, often in excess of 100 feet in thickness, form knobs that partly to entirely block individual valleys. Coates and King (1973) and Coates (1981) described such knobs in adjacent areas of New York State and noted from well data and limited surface exposures that the knobs are composed of till. In the map area, a few outcrops also showed the knobs to be composed of till. A series of such knobs form “beaded valleys” that have a series of narrower and wider segments (Braun, 2002, 2006). Today the wider segments are often wetlands or human-dammed lakes. A good example of such a beaded valley is Falls Creek valley in the center of the map. It has a string of three wide spots, a wetland and two lakes, separated by till masses. During and immediately after deglaciation, there were short-lived proglacial and paraglacial (immediately postglacial) lakes in essentially all such wide spots dammed by glacial till. Such dams were rapidly breached by water flow, probably in tens to hundreds of years, until only wetlands remained. Up to the present time, beavers have repeatedly dammed such sites.

The southwest-moving glacier deposited thick “till shadows” (Coates, 1966) on the sides of south-, southwest-, and west-facing slopes (north, northeast, and east sides of individual valleys). Stockport Creek, in the southeast corner of the map, is a good example of such a till-shadow situation. In its lower reaches, the creek has a “one-sided” bedrock gorge with bedrock on the floor and south side of the channel and thick glacial till, exposed in cuts almost 100 feet high, on the north side (till-shadow side) of the channel.

Exceptionally thick masses of till, in excess of 200 feet, were deposited in the mouths of tributaries to Shehawken Creek. Those till masses are the dams for Hempstead Lake, Starlight Lake, Perch Pond, Mud Pond, and several other unnamed ponds and wetlands. As the glacier retreated northeasterly across the region, the southwest-northeast-trending Shehawken Valley would have contained an ice

tongue (similar to a valley glacier) that protruded from the glacier in the adjacent uplands. This ice tongue would have deposited thick lateral moraines across the mouths of the tributary valleys that had just been deglaciated by the upland ice front.

The only significant sand and gravel deposits in the Hancock quadrangle are located in the Delaware River valley. Just west of the town of Hancock on the south side of the West Branch Delaware River is an abandoned incised meander loop containing an ice-contact stratified drift (Qwic) deposit near the river and till (Qwt) farther from the river. These deposits are 100 to 150 feet thick, as shown by water-well records and surface outcrop, and the Qwic extends from 500 to 1,000 feet back from the river. Other sand and gravel deposits are located where tributary streams have built large fans tens of feet thick out onto the floor of the Delaware Valley, like at Balls Eddy and Stockport. Gravel outwash deposits nearly 100 feet thick form a high terrace covered by houses just west of the Pa. Route 191 bridge to Hancock. Narrow outwash terrace remnants underlain by a few tens of feet of sand and gravel occur north and south of Balls Eddy and just west of the junction of the West and East Branches of the Delaware River.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years (Coates and King, 1973; Coates, 1981; Braun, 1989, 1997). At that time, exposed sandstone ledges were frost shattered, and the blocks were transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been “mobilized” on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet of material is a till-derived colluvium. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes, the till-derived colluvium often reaches 3 to 6 feet or greater in thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997), vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Hancock area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock.

Text from source map: Hancock Quadrangle

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Braun, D. D. 1989, Glacial and periglacial erosion of the Appalachians, *in* Gardner, T. W., and Sevon, W. D., eds., Appalachian geomorphology: Geomorphology, v. 2, no. 1–3, p. 233–258.

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References from source map: Hancock Quadrangle

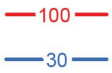
## Hawley Quadrangle

The formal citation for this source.

Braun, D. D., 2011, Surficial Geology of the Hawley 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, Open-File Report OFSM 06-13.0, scale 1:24,000 (*GRI Source Map ID 74575*).

Prominent graphics and text associated with this source.

## Map Legend




**Contours of Total Thickness of Surficial Deposits in Feet**
Isochore lines sometimes pass over more than one surficial deposit, indicating total thickness of all deposits encountered.

**Striations**
Site number above arrow. Location and striation orientation in Table 2, listed by site number. Arrow point marks site location.



**Bedrock Ledge Outcrops**

**Glacial Meltwater Sluiceway**



**Moraine Dam**



**Preglacial Valley**
Valleys partly to completely buried by glacial deposits.

**Rock Quarries**
Mostly abandoned.

Graphic from source map: Hawley Quadrangle

## Table 1: Classification of Soil Series

| Table 1. Classification of Soil Series by Surficial Geology Map Unit | |
|---|---|
| **Surficial geology unit** | **Wayne County Soil Series** |
| FILL (f) | |
| GRAVEL PIT (gp) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx)<br>Volusia (Vo, Vx) |
| PEAT (Qp) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba)<br>Basher (Bh)<br>Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| BOULDER COLLUVIUM (Qbc) | Lordstown (Lx)<br>Oquaga (Ox, Oy)<br>Swartswood (Sx)<br>Wellsboro and Mardin (Wx)<br>Norwich and Chippewa (Nx)<br>Volusia (Vx) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Mardin (Ma, Md)<br>Morris (Mo, Mx)<br>Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx)<br>Volusia (Vo, Vx)<br>Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Arnot (Ar)<br>Lordstown (Ld, Lx)<br>Mardin (Md)<br>Morris (Mx)<br>Oquaga (Oa, Ox, Oy)<br>Rock outcrop-Arnot (Ro)<br>Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Hawley Quadrangle

## Table 2: Glacial Striations

| Table 2. Hawley quadrangle glacial striations | | | | |
|---|---|---|---|---|
| **Site** | **Location** | | **Dominant Direction** | **Topographic Position** |
| | **Latitude** | **Longitude** | | |
| 1 | 41° 29' 47" N | 75° 10' 21" W | S 20° W | Hilltop |
| 2 | 41° 29' 09" N | 75° 11' 53" W | S 20° W | Hillside - upper NE facing |
| 3 | 41° 28' 50" N | 75° 13' 30" W | S 27° W | NW facing hillside |
| 4 | 41° 28' 40" N | 75° 14' 20" W | S 22° W | Hilltop |
| 5 | 41° 28' 08" N | 75° 11' 05" W | S 20° W | Hilltop |
| 6 | 41° 28' 05" N | 75° 11' 10" W | S 20° W | Hilltop |
| 7 | 41° 27' 59" N | 75° 13' 05" W | S 15° W | Hilltop |

Graphic from source map: Hawley Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Hawley 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil mapping (Martin, 1985), bedrock mapping (Sevon, 1976), comments on the glacial geology (White, 1884), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of fieldwork by Duane Braun (surficial geologist), and Ruth Braun (geologist assistant). In the third phase, the field verified/corrected preliminary surficial geology map was finalized and had the text added by Duane Braun, and was drafted onto mylar by Ruth and Duane Braun. In the fourth phase, Steven J. Thomas, student intern, and Thomas G. Whitfield of the Bureau of Topographic and Geologic Survey digitized the mylars and completed the digital map and produced these final digital files; geologic contacts, surficial deposit isochors, striations, bedrock ledge outcrops, pre-glacial valleys, mines, sluiceways, and a moraine dam.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 to as much as 200 feet on the ground.

**Mapping Technique - Thickness of Deposits**

The thickness of surficial deposits is divided into three thickness categories: less than 6 feet (2 meters) overlying the bedrock (R contact), 30 feet (10 meters), and 100 feet (30 meters). The30 and 100 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are directly determined in a few areas from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil/landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that a number of preglacial stream valleys have segments partly to entirely filled with glacial deposits.

**Quaternary History**

During the Quaternary, the Hawley 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Hawley area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka). The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre-Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Hawley area should have accomplished some erosional work and initiated some of the drainage derangements observed today. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and the most backfilled, sometimes becoming completely buried. The late Wisconsinan glacier advanced and retreated across the region in a general S 20°W - N20°E direction (Table 2).

Only late Wisconsinan-aged deposits and landforms have been observed in the Hawley quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 - 18 Ka for this quadrangle; Braun, 1997). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation. Older deposits may still exist under the late Wisconsinan deposits in the Wallenpaupack valley.

On the Hawley quadrangle, Wallenpaupack Creek turns east and then northeastward to join the Lackawanna River. The glacier would have blocked the northeast trending part of Wallenpaupack valley and impounded a series of proglacial lakes (different stages of Glacial Lake Wallenpaupack) as the ice both advanced and receded across the region. As receding ice entered the southern edge of the Hawley quadrangle, Glacial Lake Wallenpaupack flooded the area in front of the ice to an elevation of 1585 feet. This level was controlled by a bedrock sluiceway sill in the southwestern part of the Lake Ariel quadrangle. The lake discharged southwesterly across that sill and went down Roaring Creek to the

North Branch Susquehanna Valley. As the ice receded northward across the Hawley quadrangle, a series of sluiceways developed in saddles to the east of the Wallenpaupack valley permitting drainage to the Delaware valley by several different routes. When the ice temporarily stabilized, it built the Amoraine dam across the Wallenpaupack valley at the site of the human made earthen dam of present Lake Wallenpaupack, the glacial lake was discharging eastward at about an elevation of 1330 feet. This several hundred foot deep glacial lake would have tended to minimize the down valley lobation of the ice due to iceberg calving at the ice front.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction. These processes resulted in a boulder colluvium mantle often extending 500 feet and, in places as much as a 1000 feet, down slope of individual bedrock ledges. A few exposures showed late Wisconsinan till or ice-contact sand and gravel under the boulder colluvium.

The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till derived colluvium material. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hill slopes the till derived colluvium often reaches a 3 to 6 feet (1 to 2 meters) thickness.

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted regionally by Cameron (1970) and confirmed locally in the Hawley area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (Edgerton, 1969).

Text from source map: Hawley Quadrangle

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References from source map: Hawley Quadrangle

## Honesdale Quadrangle

The formal citation for this source.

Braun, D. D., 2008, Surficial Geology of the Honesdale 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–04.0, 15 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74573*).

Prominent graphics and text associated with this source.

## Map Legend

**BEDROCK LEDGE OUTCROP**

2

**STRIATION:**
Site number is above the arrow. Locations and orientations are given in Table 2. Point of the head of the arrow marks the location of the striation site.

**QUARRY:**
Sandstone (bluestone) quarry or shale aggregate pit; most are abandoned.

150
100
30

**ISOCHORES AT 30, 100, AND 150 FEET:**
An isochore is the thickness of a deposit measured in a vertical borehole or in an excavation with a vertical face. The isochores drawn on the map pass from one surficial deposit to another, like from till to ice-contact-stratified-drift. This indicates that a 30 foot thickness of till is next to a 30 foot thickness of ice-contact-stratified-drift or ice-contact-stratified-drift with underlying till, together being 30 feet thick.

Graphic from source map: Honesdale Quadrangle

## Table 1: Classification of Soil Series

| Table 1. Classification of soil series by surficial geology map unit | |
|---|---|
| **Surficial geology unit** | **Wayne County Soil Series** |
| FILL (f) | |
| GRAVEL PIT (gp) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx), Volusia (Vo, Vx) |
| PEAT (Qp) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba), Basher (Bh), Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| BOULDER COLLUVIUM (Qb) | Lordstown (Lx), Oquaga (Ox, Oy), Wellsboro and Mardin (Wx)<br>Norwich and Chippewa (Nx), Volusia (Vx) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Mardin (Ma, Md), Morris (Mo, Mx), Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx), Volusia (Vo, Vx), Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Arnot (Ar), Lordstown (Ld, Lx), Mardin (Md), Morris (Mx)<br>Oquaga (Oa, Ox, Oy), Rock outcrop-Arnot (Ro), Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Honesdale Quadrangle

## Table 2: Glacial Striations

| Table 2. Locations of glacial striation sites on the Honesdale quadrangle. | | | | |
|---|---|---|---|---|
| **Map Site** | **Location** | | **Direction** | **Topographic Position** |
| | **Latitude** | **Longitude** | | |
| 1 | 41° 36’ 50” | -75° 21’ 16” | S 25°W | Hill top |
| 2 | 41° 35’ 03” | -75° 17’ 55” | S 45°W | Valley |
| 3 | 41° 34’ 11” | -75° 20’ 55” | S 34°W | Hill top |
| 4 | 41° 33’ 40” | -75° 17’ 57” | S 20°W | West slope* |
| 5 | 41° 32’ 43” | -75° 19’ 55” | S 24°W | Hill top |
| 6 | 41° 32’ 02” | -75° 21’ 57” | S 28°W | Hill top |
| 7 | 41° 31’ 53” | -75° 17’ 35” | S 01°W | Hill top |
| 8 | 41° 31’ 48” | -75° 17’ 18” | S 25°W | East slope* |
| 9 | 41° 31’ 48” | -75° 17’ 29” | S 12°W | Hill top |

* Direction slope faces

Graphic from source map: Honesdale Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) of the Honesdale 7.5-minute quadrangle was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil mapping (Martin, 1985), bedrock mapping (Sevon, 1976), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of fieldwork by Darrick Kreischer and Ruth Braun (geologist assistants) and Duane Braun (surficial geologist). In the third phase, the field verified/ corrected preliminary surficial geology map was finalized, drafted onto three mylar overlays, and had the text added by Duane Braun. In the fourth phase, the mylar overlays were scanned, digitized, and produced in an ArcGIS format and Adobe PDF (Portable Document Format) by Pennsylvania Geological Survey personnel.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 25 to 50 feet on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 feet to as much as 200 feet on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

### Mapping Technique - Thickness of Deposits

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 meters) overlying the bedrock (the contact of the bedrock (R) unit with all other surficial units), 30 feet (10 meters), 100 feet (30 meters), and 150 feet (50 meters). The 30, 100, and 150 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

### Quaternary History

During the Quaternary, the Honesdale 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one

million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Honesdale area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre- Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Honesdale area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S20°W - N20°E direction (Braun, 1997). Within the quadrangle, glacial striations (Table 2) indicate that ice flow direction was quite variable, with a range of S01°W to S45°W. A series of subglacial and/or ice marginal meltwater channels (sluiceways) were incised across saddles in the ridges.

Only late Wisconsin-aged deposits and landforms have been observed in the Honesdale quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 - 18 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 to 2 meters) thickness (Braun, 1994). In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Honesdale area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (10 meters) (Edgerton, 1969).

Text from source map: Honesdale Quadrangle

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References from source map: Honesdale Quadrangle

## Lake Como Quadrangle

The formal citation for this source.

Braun, D. D., 2010, Surficial Geology of the Lake Como 7.5-Minute Quadrangle, Wayne County, Pennsylvania, and Delaware County, New York: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 10–07.0, 13 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74566*).

Prominent graphics and text associated with this source.

## Map Legend

**Bedrock Ledge Outcrop**

**Geologic Contact:**
Location approximate.

2

**Glacial Striation:**
Arrow shows inferred direction of glacial flow. Site number is above the arrow (see Table 2). Point at the head of the arrow marks the location of the striation site.

30

**Isochore:**
Thickness of surficial deposits in feet, as measured in vertical boreholes or in excavations with vertical faces. Where deposits overlap, contours represent the combined thickness of the stacked surficial units. Shown for thicknesses of 30, 100, and 150 feet.

**Glacial Meltwater Sluiceway:**
Abandoned glacial meltwater channel cut into bedrock and/or glacial deposits. Barbs show direction of meltwater flow.

**Open Water:**
Area of open water where the underlying surficial unit is uncertain.

Graphic from source map: Lake Como Quadrangle

## Table 1: Classification of Soil Series

Table 1. *Classification of Soil Series by Surficial Geologic Map Unit*

| Surficial geology unit | Wayne County soil series[1] | |
|---|---|---|
| Fill (f) | None defined | |
| Sandstone and/or shale pit (rp) | Quarries (Qu) | |
| Alluvium (Qa)<br>Alluvial fan (Qaf) | Barbour (Ba)<br>Basher (Bh) | Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| Alluvial terrace (Qat) | Barbour (Ba) | |
| Peat (Qp) | Medihemists and Medifibrists (ME) | |
| Wetland (Qw) | Norwich and Chippewa (Nc, Nx)<br>Volusia (Vo, Vx) | |
| Boulder colluvium (Qbc) | Lordstown (Lx)<br>Norwich and Chippewa (Nx) | Oquaga (Ox, Oy)<br>Volusia (Vx)<br>Wellsboro and Mardin (Wx) |
| Wisconsinan till (Qwt) | Mardin (Ma, Md)<br>Morris (Mo, Mx)<br>Norwich and Chippewa (Nc, Nx) | Swartswood (Sw, Sx)<br>Volusia (Vo, Vx)<br>Wellsboro (We, Wo, Wx) |
| Wisconsinan bouldery till (Qwtb) | Mardin (Md)<br>Morris (Mx)<br>Norwich and Chippewa (Nx) | Swartswood (Sx)<br>Volusia (Vx)<br>Wellsboro (Wx) |
| Wisconsinan ice-contact stratified drift (Qwic) | Rexford (Re)<br>Wyoming (Wy) | |
| Sandstone and shale bedrock (br) | Arnot (Ar)<br>Lordstown (Ld, Lx)<br>Mardin (Md)<br>Morris (Mx)<br>Oquaga (Oa, Ox, Oy) | Rock outcrop-Arnot (Ro)<br>Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

[1]From Martin (1985).

Graphic from source map: Lake Como Quadrangle

## Table 2: Glacial Striations

Table 2. *Locations of Glacial Striation Sites on the Lake Como Quadrangle*

| Site no. | Location[1] | | Orientation | Topographic position |
|---|---|---|---|---|
| | latitude | longitude | | |
| 1 | 41°52'22" | –75°22'05" | S10°W | Hilltop |
| 2 | 41°51'09" | –75°16'47" | S34°W | North-facing slope |
| 3 | 41°48'17" | –75°17'10" | S38°W | East-facing slope |
| 4 | 41°47'37" | –75°21'50" | S35°W | Saddle in east-west ridge |
| 5 | 41°46'44" | –75°20'44" | S28°W | Hilltop |
| 6 | 41°47'00" | –75°18'05" | S32°W | Northeast-facing slope |
| 7 | 41°47'04" | –75°16'36" | S38°W | West-facing slope |
| 8 | 41°47'00" | –75°16'02" | S36°W | Hilltop |

[1]North American Datum 1927.

Graphic from source map: Lake Como Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Lake Como 1:24,000-scale, detailed reconnaissance surficial geologic map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun in the spring of 2000 using existing soil maps (Martin, 1985) and bedrock geologic map (White, 1881), and through landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during 10 to 20 person days of fieldwork by Eugene Szymanski and Ruth Braun (geologist assistants) and Braun in the summer of 2000. In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto three mylar overlays, and had the text added by Braun in the fall of 2000. In the fourth phase, the mylar overlays were scanned and the information digitized as shapefiles by Karen Trifonoff (Professor, Bloomsburg University). The shapefiles were converted to ArcInfo coverages and corrected by Pennsylvania Geological Survey personnel. The data were later upgraded to geodatabase feature classes, which were used to prepare the final surficial geologic map (page 12).

The distribution and type of units on the preliminary surficial geology map are primarily a combined parent-material and topographic-position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in Table 1 (page 10). Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which of the surficial deposit types related to the mapped soil series is most likely to occur at that site. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet on the ground where there are distinct features to help locate the boundaries. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 to as much as 200 feet on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

**Thickness of Deposits**

The thickness of surficial deposits is divided into four categories: 6 feet (the contact of the bedrock (br) unit with all other surficial units), 30 feet, 100 feet, and 150 feet. The individual thickness contours (isochores) were drawn to be a conservative estimate of thickness (minimum thickness). The thickness was determined from sparse water-well data and outcrops of the surficial deposits. In most areas, the thickness was interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places, streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

**Quaternary History**

During the Quaternary, the Lake Como 7.5-minute quadrangle area has been affected by a climate that has alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About 10 such alternations have affected northeastern Pennsylvania during the last million years (Braun, 1989, 1994, 2004). There is evidence for at least three different glacial advances across the Lake Como area in that there are three glacial limits of distinctly different ages to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian G age (850 ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 ka) or pre-Illinoian B (450 ka) age and is only about 10 miles beyond the most recent, late Wisconsinan (20 ka) glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Lake Como area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice, and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly backfilled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S30°W-N30ºE direction (White, 1881; Braun, 1997). Within the quadrangle, glacial striations (Table 2 and the map) indicate that ice flow was quite variable, from S10°W to S38°W. A series of subglacial and/or ice-marginal meltwater channels (sluiceways) were incised in saddles across the ridges that trend transverse to ice flow.

Only late-Wisconsinan-aged deposits and landforms have been observed in the Lake Como quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession, probably centered around 17 to18 ka (radiocarbon years) for this quadrangle. The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock, indicating considerable erosion of the bedrock during the last glaciation.

In the Lake Como quadrangle, valleys transverse to ice flow tend to have an asymmetric form from side to side with the north or northeast side having a gentler slope than the south or southwest side. The gentler north or northeast side is underlain by a thick mass of till, a “till shadow” (Coates, 1966), deposited in the lee of the ridge transverse to ice flow. In the central to northeastern part of the Lake Como quadrangle, the transverse-to-ice-flow portions of Crooked, Equinunk, and Kinneyville Creek valleys have well-developed till shadows, often exceeding 150 feet in thickness.

Other interesting glacial depositional features are the masses of till, often in excess of 100 feet in thickness, that form knobs partly to entirely blocking individual valleys (Coates and King, 1973, Coates, 1981). A series of such knobs form “beaded valleys” that have a series of narrower and wider segments (Braun, 2006). Today the wider segments are often wetlands or human-dammed lakes. The best examples of such “beaded” valleys are the headwater parts of Crooked, Equinunk, and Kinneyville Creek valleys in the west-central to northwestern part of the quadrangle. During and immediately after deglaciation there were short-lived proglacial and paraglacial (immediately postglacial) lakes in essentially all such wide spots dammed by glacial till. Such dams were rapidly breached by water flow, probably in tens to hundreds of years, until only wetlands remained. Up to the present time beavers have repeatedly re-dammed such sites.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years (Coates and King, 1973; Coates, 1981; Braun, 1997). At that time, exposed sandstone ledges were frost shattered, and the blocks were transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been “mobilized” on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet of material is a till-derived colluvium. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes, the till-derived colluvium often reaches 3 to 6 feet or greater in thickness (Braun, 1994). In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997), vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Lake Como area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (Edgerton, 1969).

Text from source map: Lake Como Quadrangle

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_____ 1994, Late Wisconsinan to pre-Illinoian (G?) glacial events in eastern Pennsylvania, *in* Braun, D. D., ed., Late Wisconsinan to pre-Illinoian (G?) glacial and periglacial events in eastern Pennsylvania: U.S. Geological Survey Open-File Report 94–434, p. 1–21. [Field Conference of the Friends of the Pleistocene (Northeastern Section), 57th, Guidebook.]

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References from source map: Lake Como Quadrangle

## Long Eddy and Callicoon Quadrangles

The formal citation for this source.

Braun, D. D., 2011, Surficial Geology of the Long Eddy and Callicoon 7.5-Minute Quadrangles, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 11–01.0, 13 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74564*).

Prominent graphics and text associated with this source.

## Map Legend

30

**Isochore**

Thickness of surficial deposits in feet, as measured in vertical boreholes or in excavations with vertical faces. Where deposits overlap, contours represent the combined thickness of the stacked surficial units. Shown for thicknesses of 30, 100, and 150 feet.

**Bedrock Ledge Outcrop**

**Geologic Contact**

Location approximate

2

**Glacial Striation**

Arrow shows inferred direction of glacial flow. Site number is above the arrow (see Table 2). Point at the head of the arrow marks the location of the striation site.

**Open Water**

Area of open water where the underlying surficial unit is uncertain.

TK

**Till Knob**

Rounded knob of till on the side of a valley. Typically a few tens of feet high. A wetland is often present up valley of the knob. The stream valley beside the knob has a markedly narrower form than elsewhere in the valley, and often the stream has cut into bedrock on the side of the valley opposite the knob.

Graphic from source map: Long Eddy and Callicoon Quadrangles

## Table 1: Classification of Soil Series

Table 1. *Classification of Soil Series by Surficial Geologic Map Unit*

| Surficial geology unit | Wayne County soil series[1] | |
|---|---|---|
| Rock quarry pit (rp) | Quarries (Qu) | |
| Alluvium (Qa)<br>Alluvial fan (Qaf) | Barbour (Ba)<br>Basher (Bh) | Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| Alluvial terrace (Qat) | Barbour (Ba) | |
| Peat (Qp) | Medihemists and Medifibrists (ME) | |
| Wetland (Qw) | Norwich and Chippewa (Nc, Nx)<br>Volusia (Vo, Vx) | |
| Boulder colluvium (Qbc) | Lordstown (Lx)<br>Norwich and Chippewa (Nx) | Oquaga (Ox, Oy)<br>Volusia (Vx)<br>Wellsboro and Mardin (Wx) |
| Wisconsinan outwash (Qwo)<br>Wisconsinan ice-contact stratified drift (Qwic) | Rexford (Re)<br>Wyoming (Wy) | |
| Wisconsinan till (Qwt) | Mardin (Ma, Md)<br>Morris (Mo, Mx)<br>Norwich and Chippewa (Nc, Nx) | Swartswood (Sw, Sx)<br>Volusia (Vo, Vx)<br>Wellsboro (We, Wo, Wx) |
| Sandstone and shale bedrock (br) | Arnot (Ar)<br>Lordstown (Ld, Lx)<br>Mardin (Md)<br>Morris (Mx)<br>Oquaga (Oa, Ox, Oy) | Rock outcrop-Arnot (Ro)<br>Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

[1]From Martin (1985).

Graphic from source map: Long Eddy and Callicoon Quadrangles

## Table 2: Glacial Striations

Table 2. *Locations of Glacial Striation Sites on the Long Eddy and Callicoon Quadrangles*

| Site no. | Location[1] latitude | Location[1] longitude | Orientation | Topographic position |
|---|---|---|---|---|
| 1 | 41°51'40" | –75°14'38" | S32°W | Hilltop |
| 2 | 41°49'55" | –75°12'42" | S20°W | Hilltop |
| 3 | 41°48'43" | –75°10'32" | S22°W | Upper southeast-facing slope |
| 4 | 41°47'47" | –75°13'15" | S27°W | Saddle |
| 5 | 41°45'38" | –75°14'52" | S37°W | Saddle |
| 6 | 41°45'09" | –75°14'33" | S52°W | Hilltop |
| [2]7 | 41°47'53" | –75°05'30" | S35°W<br>S38°W | Southeast-facing slope of the Delaware River valley |

[1]North American Datum 1927.
[2]Site 7 has two striations.

Graphic from source map: Long Eddy and Callicoon Quadrangles

## Discussion

### Mapping Technique – Surface Distribution of Deposits

The Long Eddy and Callicoon 1:24,000-scale, detailed reconnaissance surficial geologic map (map of unconsolidated materials overlying bedrock) was produced in six phases over a period of years. The first three phases occurred in 2000, the fourth in 2001, the fifth in 2003, and the sixth in 2010 and 2011. These phases were as follows: (1) a preliminary surficial deposit map was made for each quadrangle by Duane Braun based on soil maps (Martin, 1985), a bedrock geologic map (White, 1881), and landform analysis that utilized the 1:24,000-scale topographic map of each quadrangle and aerial photographs; (2) the preliminary surficial deposit maps were verified and/or corrected during 10 to 20 person days of fieldwork by Eugene Szymanski and Ruth Braun (geologist assistants) and Braun; (3) Braun finalized the surficial geology maps, drafted the data onto mylar overlays, and added the explanation; (4) the mylar overlays were scanned, and the information was digitized and saved as shapefiles by Karen Trifonoff (Professor, Bloomsburg University); (5) the shapefiles were converted into ArcInfo coverages and corrected by Pennsylvania Geological Survey personnel; and (6) Pennsylvania Geological Survey personnel upgraded the ArcInfo coverages for the two quadrangles to geodatabase feature classes, which were used to prepare the surficial geologic map of the combined quadrangles (page 12). As part of the final step, the map was reviewed and revised by Braun.

The distribution and type of units on the surficial geologic map are primarily a combined parent material and topographic-position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in Table 1 (page 10). Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which of the surficial deposit types related to the mapped soil series is most likely to occur at that site. The soil series boundaries were manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic maps. Positions of the boundary lines were estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic maps. Expectable line location error is on the order of 50 to 100 feet on the ground where there are distinct features to help locate the boundaries. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 to as much as 200 feet on the ground. During the field verification and correction

phase, many contacts were moved to reflect conditions directly observed in the field.

**Thickness of Deposits**

The thickness of surficial deposits is divided into four categories: 6 feet (the contact of the bedrock (br) unit with all other surficial units), 30 feet, 100 feet, and 150 feet. The individual thickness contours (isochores) are drawn to be a conservative estimate of thickness (minimum thickness). The thickness was determined from sparse water-well data and outcrops of the surficial deposits. In most areas, the thickness was interpreted on the basis of soil-landform associations and a reconstruction of the pre-glacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places, streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997, 2002).

**Quaternary History**

During the Quaternary, the area of the Long Eddy and Callicoon 7.5-minute quadrangles has been affected by a climate that has alternated between cold, glacial-periglacial conditions and warm, humid-temperate, interglacial conditions. About 10 such alternations have affected northeastern Pennsylvania during the last million years (Braun, 1989, 1994, 2004). There is evidence for at least three different glacial advances across the Long Eddy-Callicoon area in that there are three glacial limits of distinctly different ages to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian G age (850 ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 ka) or pre-Illinoian B (450 ka) age and is only about 10 miles beyond the most recent, late Wisconsinan (20 ka) glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994, 2004).

The earlier glacial advances across the Long Eddy-Callicoon area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice, and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Pre-glacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly backfilled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997, 2002). The late Wisconsinan glacier advanced and retreated across the region in a S30°W-N30ºE direction (White, 1881; Braun, 1997). Within the Long Eddy and Callicoon quadrangles, glacial striations (Table 2 and the map) indicate that ice-flow direction varied as much as 19 degrees around a mean direction of S33°W. This variation is due to the basal ice flowing around topographic irregularities. For instance, in the southwest corner of the Long Eddy quadrangle, a steep-sided knob (Big Hickory) rises 300 feet above the surrounding landscape. Basal ice flowing around the southeast side of this hill turned to a much more westerly flow direction of S52°W.

Only late-Wisconsinan-age deposits and landforms have been observed in the Long Eddy and Callicoon quadrangles. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession, probably centered around 17 to18 ka (radiocarbon years) for this area. The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock, indicating considerable erosion of the bedrock during the last glaciation.

In the Long Eddy and Callicoon quadrangles, valleys transverse to ice flow tend to have an asymmetric form from side to side, with the north or northeast side having a gentler slope than the south or southwest side. The gentler north or northeast side is underlain by a thick mass of till, a “till

shadow" (Coates, 1966), deposited in the lee of the ridge transverse to ice flow. The best developed till shadows in the Long Eddy-Callicoon area occur in the transverse-to-ice-flow portions of unnamed valleys north of Little Equinunk Creek.

Other interesting glacial depositional features are the masses of till, often in excess of 100 feet in thickness, which form knobs partly to entirely blocking individual valleys (Coates and King, 1973; Coates, 1981). A series of such knobs form "beaded valleys" that have a series of narrower and wider segments (Braun, 2002, 2006). Today the wider segments are often wetlands or human dammed lakes. The best examples of such beaded valleys are in the central part of the Long Eddy quadrangle in the west-side tributary valleys to Little Equinunk Creek. During and immediately after deglaciation, there were short-lived proglacial and paraglacial (immediately postglacial) lakes in essentially all such wide spots dammed by glacial till. Such dams were rapidly breached by water flow, probably in tens to hundreds of years, until only wetlands remained. Up to the present time, beavers have repeatedly dammed such sites.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years (Coates and King, 1973; Coates, 1981; Braun, 1997). At that time, exposed sandstone ledges were frost shattered, and the blocks were transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet of material is a till-derived colluvium. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes, the till-derived colluvium often reaches 3 to 6 feet or greater in thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997), vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Long Eddy-Callicoon area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock.

Text from source map: Long Eddy and Callicoon Quadrangles

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References from source map: Long Eddy and Callicoon Quadrangles

## Narrowsburg Quadrangle

The formal citation for this source.

Braun, D. D., 2008, Surficial Geology of the Wayne County portion of the Narrowsburg 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–06.0, 14 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74571*).

Prominent graphics and text associated with this source.

## Map Legend

**BEDROCK LEDGE OUTCROP**

2

**STRIATION:**
Site number is above the arrow. Locations and orientations are given in Table 2. Point of the head of the arrow marks the location of the striation site.

150
100
30

**ISOCHORES AT 30, 100, AND 150 FEET:**
An isochore is the thickness of a deposit measured in a vertical borehole or in an excavation with a vertical face. The isochores drawn on the map sometimes pass from one surficial deposit to another, like from till to ice-contact-stratified-drift. This indicates that a 30 foot thickness of till is next to a 30 foot thickness of ice-contact-stratified-drift or ice-contact-stratified-drift with underlying till, together being 30 feet thick.

Graphic from source map: Narrowsburg Quadrangle

## Table 1: Classification of Soil Series

| Table 1. Classification of soil series by surficial geology map unit | |
|---|---|
| **Surficial geology unit** | **Wayne County Soil Series** |
| FILL (f) | |
| GRAVEL PIT (gp) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx), Volusia (Vo, Vx) |
| PEAT (Qp) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba), Basher (Bh), Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| BOULDER COLLUVIUM (Qb) | Lordstown (Lx), Oquaga (Ox, Oy), Wellsboro and Mardin (Wx)<br>Norwich and Chippewa (Nx), Volusia (Vx) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Mardin (Ma, Md), Morris (Mo, Mx), Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx), Volusia (Vo, Vx), Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Arnot (Ar), Lordstown (Ld, Lx), Mardin (Md), Morris (Mx)<br>Oquaga (Oa, Ox, Oy), Rock outcrop-Arnot (Ro), Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Narrowsburg Quadrangle

## Table 2: Glacial Striations

| Table 2. Locations of glacial striation sites on the Narrowsburg quadrangle. | | | | |
|---|---|---|---|---|
| **Map Site** | **Location** | | **Direction** | **Topographic Position** |
| | **Latitude** | **Longitude** | | |
| 1 | 41° 36’ 55” | -75° 05’ 42” | S 32° W | North slope* |
| 2 | 41° 36’ 51” | -75° 06’ 00” | S 35° W | North slope* |
| 3 | 41° 36’ 47” | -75° 06’ 02” | S 34° W | East slope* |
| 4 | 41° 35’ 54” | -75° 05’ 37” | S 35° W | Hill top |
| 5 | 41° 35’ 57” | -75° 05’ 03” | S 35° W | Hill top |
| 6 | 41° 33’ 27” | -75° 05’ 53” | S 36° W | Hill top |

* Direction slope faces

Graphic from source map: Narrowsburg Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Wayne County portion of the Narrowsburg 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil

mapping (Martin, 1985), bedrock mapping (White, 1881), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of field work by Eugene Szymanski (geologist assistant) and Duane Braun (surficial geologist). In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto mylar overlays, and had the text added by Duane Braun. In the fourth phase, the mylar overlays were scanned, digitized, and produced in an ArcGIS format and Adobe PDF (Portable Document Format) by Pennsylvania Geological Survey personnel.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet (15 to 30 meters) on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 (30) to as much as 200 feet (60 meters) on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

**Mapping Technique - Thickness of Deposits**

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 meters) overlying the bedrock (the contact of the bedrock (R) unit with all other surficial units), 30 feet (10 meters), 100 feet (30 meters), and 150 feet (50 meters). The 30, 100, and 150 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that several of the preglacial tributaries to the Delaware River have segments partly to entirely filled with glacial deposits.

**Quaternary History**

During the Quaternary, the Narrowsburg 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Narrowsburg area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre- Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Narrowsburg area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming

completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S 30°W – N 30°E direction. Within the quadrangle, glacial striations (Table 2) indicate that ice flow was about S 35°W. A series of subglacial and/or ice marginal meltwater channels (sluiceways) were incised across saddles in the ridges.

Only late Wisconsin-aged deposits and landforms have been observed in the Narrowsburg quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 to 18 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 to 2 meters) thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others , 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Narrowsburg area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock.

*Text from source map:* Narrowsburg Quadrangle

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Braun, D.D., 1997, Physiography and Quaternary of the Scranton/Wilkes-Barre Region: *in* Inners, J.D., editor, Geology of the Wyoming-Lackawanna Valley: Guidebook, 62nd Annual Field Conference of Pennsylvania Geologists, p. 1-15.

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References from source map*:* Narrowsburg Quadrangle

## Orson Quadrangle

The formal citation for this source.

Braun, D. D., 2010, Surficial Geology of the Orson 7.5-Minute Quadrangle, Susquehanna and Wayne Counties, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 10–06.0, 12 p., 1 map, scale 1:24,000 (*GRI Source Map ID 75682*).

Prominent graphics and text associated with this source.

## Map Legend

**Isochore**

Thickness of surficial deposits in feet, as measured in vertical boreholes or in excavations with vertical faces. Where deposits overlap, contours represent the combined thickness of the stacked surficial units. Shown for thicknesses of 30, 100, and 150 feet.

**Glacial Meltwater Sluiceway**

Abandoned glacial meltwater channel cut into bedrock and/or glacial deposits. Barbs show direction of meltwater flow.



**Bedrock Ledge Outcrop**

**Glacial Striation**

Arrow shows inferred direction of glacial flow. Site number is above the arrow (see Table 2). Point at the head of the arrow marks the location of the striation site.

**Open Water**

Area of open water where the underlying surficial unit is uncertain.



**Geologic Contact**

Location approximate

Graphic from source map: Orson Quadrangle

## Table 1: Classification of Soil Series

Table 1. *Classification of Soil Series by Surficial Geologic Map Unit*

| Surficial geology unit | Susquehanna County soil series[1] | Wayne County soil series[2] |
|---|---|---|
| Fill (f) | Cut and fill land (Cu) | None defined |
| Alluvium (Qa)<br>Alluvial fan (Qaf) | Barbour (Ba)<br>Basher (Bc)<br>Holly (Hw)<br>Mixed alluvial (Mn)<br>Unadilla (Us)<br>Wyalusing (Wy) | Barbour (Ba)<br>Basher (Bh)<br>Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| Peat (Qp) | Peat (Pt) | Medihemists and Medifibrists (ME) |
| Wetland (Qw) | Norwich and Chippewa (Nc, Ns)<br>Volusia (Vc, Vs) | Norwich and Chippewa (Nc, Nx)<br>Volusia (Vo, Vx) |
| Boulder colluvium (Qbc) | Lordstown and Oquaga (Ls)<br>Mardin (Mg)<br>Norwich and Chippewa (Ns)<br>Volusia (Vs) | Lordstown (Lx)<br>Norwich and Chippewa (Nx)<br>Oquaga (Ox, Oy)<br>Volusia (Vx)<br>Wellsboro and Mardin (Wx) |
| Wisconsinan outwash (Qwo) | Chenango (Cn) | None defined |
| Wisconsinan ice-contact stratified drift (Qwic) | Chenango (Cn) | Rexford (Re)<br>Wyoming (Wy) |
| **Surficial geology unit** | **Susquehanna County soil series[1]** | **Wayne County soil series[2]** |
| Wisconsinan till (Qwt) | Bath (Bc, Bf, Bs)<br>Lackawanna (La, Lf, Lg)<br>Mardin (Mc, Mf, Mg)<br>Morris (Mo, Mr, Ms)<br>Norwich and Chippewa (Nc, Ns)<br>Volusia (Vc, Vf, Vs)<br>Wellsboro (Wc, Wf, Ws) | Mardin (Ma, Md)<br>Morris (Mo, Mx)<br>Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx)<br>Volusia (Vo, Vx)<br>Wellsboro (Wc, Wo, Wx) |
| Sandstone and shale bedrock (br) | Lackawanna (Lf)<br>Lordstown and Oquaga (Lk, Lo, Ls)<br>Mardin (Mf)<br>Morris (Mr)<br>Volusia (Vf)<br>Wellsboro (Wf, Wc) | Arnot (Ar)<br>Lordstown (Ld, Lx)<br>Mardin (Md)<br>Morris (Mx)<br>Oquaga (Oa, Ox, Oy)<br>Rock outcrop-Arnot (Ro)<br>Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

[1]From Reber (1973).
[2]From Martin (1985).

Graphic from source map: Orson Quadrangle

## Table 2: Glacial Striations

Table 2. *Locations of Glacial Striation Sites on the Orson Quadrangle*

| Site no. | Location[1] latitude | Location[1] longitude | Orientation | Topographic position |
|---|---|---|---|---|
| 1 | 41°51'05" | –75°25'49" | S25°W | Hilltop |
| 2 | 41°49'49" | –75°23'25" | S18°W | Knob on valley floor |
| 3 | 41°49'34" | –75°27'24" | S01°W | North-facing slope |
| 4 | 41°49'19" | –75°27'35" | S20°W | West-facing slope |
| 5 | 41°49'17" | –75°27'25" | S04°W | Ridge crest |
| 6 | 41°49'06" | –75°23'31" | S21°W | Hilltop |
| 7 | 41°47'14" | –75°27'32" | S25°W | Ridge crest |
| 8 | 41°47'04" | –75°27'35" | S17°W | Ridge crest |
| 9 | 41°46'13" | –75°22'47" | S36°W | South-facing slope |
| 10 | 41°45'15" | –75°27'25" | S10°W | East-facing slope |

[1]North American Datum 1927.

Graphic from source map: Orson Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Orson 1:24,000-scale, detailed reconnaissance surficial geologic map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun in the spring of 2000 using existing soil maps (Martin, 1985; Reber, 1973) and bedrock geologic map (White, 1881), and through landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during 10 to 20 person days of fieldwork by Darrick Kreischer and Ruth Braun (geologist assistants) and Braun in the summer of 2000. In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto three mylar overlays, and had the text added by Braun in the fall of 2000. In the fourth phase, the mylar overlays were scanned and the information digitized as shapefiles by Karen Trifonoff (Professor, Bloomsburg University). The shapefiles were converted to ArcInfo coverages and corrected by Pennsylvania Geological Survey personnel. The data were later upgraded to geodatabase feature classes, which were used to prepare the final surficial geologic map (page 11).

The distribution and type of units on the preliminary surficial geology map are primarily a combined parent-material and topographic-position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in Table 1 (page 9). Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which of the surficial deposit types related to the mapped soil series is most likely to occur at that site. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet on the ground where there are distinct features to help locate the boundaries. Where boundaries cross large featureless areas of forest, line

placement error is in the range of 100 to as much as 200 feet on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

**Thickness of Deposits**

The thickness of surficial deposits is divided into four categories: 6 feet (the contact of the bedrock (br) unit with all other surficial units), 30 feet, 100 feet, and 150 feet. The individual thickness contours (isochores) were drawn to be a conservative estimate of thickness (minimum thickness). The thickness was determined from sparse water-well data and outcrops of the surficial deposits. In most areas, the thickness was interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places, streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

**Quaternary History**

During the Quaternary, the Orson 7.5-minute quadrangle area has been affected by a climate that has alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About 10 such alternations have affected northeastern Pennsylvania during the last million years (Braun, 1989, 1994, 2004). There is evidence for at least three different glacial advances across the Orson area in that there are three glacial limits of distinctly different ages to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian G age (850 ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 ka) or pre-Illinoian B (450 ka) age and is only about 10 miles beyond the most recent, late Wisconsinan (20 ka) glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Orson area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice, and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly backfilled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S30°W-N30ºE direction (White, 1881; Braun, 1997). Within the quadrangle, glacial striations (Table 2 and the map) indicate that ice flow was quite variable, from S01°W to S36°W. North-to-south meltwater flow cut a series of subglacial and/ or ice-marginal channels (sluiceways) across saddles in ridges transverse to ice flow. The best example of an incised saddle is at Spruce Lake in the northeastern part of the quadrangle. This saddle has been incised in the divide between the north-draining Shadigee Creek and the south-draining East Branch Lackawanna River.

Only late-Wisconsinan-aged deposits and landforms have been observed in the Orson quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession, probably centered around 17 to18 ka (radiocarbon years) for this quadrangle. The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock, indicating considerable erosion of the bedrock during the last glaciation.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years (Coates and King, 1973; Coates, 1981; Braun, 1997). At that time,

exposed sandstone ledges were frost shattered, and the blocks were transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been “mobilized” on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet of material is a till-derived colluvium. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes, the till-derived colluvium often reaches 3 to 6 feet or greater in thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997), vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Orson area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (Edgerton, 1969).

Text from source map: Orson Quadrangle

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Reber, E. J., 1973, Soil survey of Susquehanna County, Pennsylvania: U.S. Department of Agriculture, 89 p. White, I. C., 1881, The geology of Susquehanna County and Wayne County: Pennsylvania Geological Survey, 2nd ser., Report G5, 243 p.

References from source map: Orson Quadrangle

## Starrucca Quadrangle

The formal citation for this source.

Braun, D. D., 2006, Surficial Geology of the Starrucca 7.5-Minute Quadrangle, Wayne and Susquehanna Counties, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 06–05.0, 15 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74429*).

Prominent graphics and text associated with this source.

## Map Legend

30

100

150

**Contours of Total Thickness of Surficial Deposits in Feet**

Isochore lines sometimes pass over more than one surficial deposit, indicating total thickness of all deposits encountered.

2

**Striations**

Site number above arrow. Location and striation orientation in Table 2, listed by site number. Arrow point marks site location.

**Bedrock Ledge Outcrops**

Graphic from source map: Starrucca Quadrangle

## Table 1: Classification of Soil Series

| Table 1. Classification of soil series by surficial geology map unit | | |
|---|---|---|
| **Surficial geology unit** | **Susquehanna Co. Soil Series** | **Wayne County Soil Series** |
| FILL (f) | Cut and fill land (Cu) | |
| GRAVEL PIT (gp) | Pits, gravel (Pk) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx)<br>Volusia (Vc, Vs) | Norwich and Chippewa (Nc, Nx)<br>Volusia (Vo, Vx) |
| PEAT (Qp) | Peat (Pt) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba), Basher (Bc)<br>Holly (Hm, Ho), Mixed alluvial (Mn)<br>Unadilla (Us), Wyalusing (Wy) | Barbour (Ba), Basher (Bh)<br>Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Chenango (Cn) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Bath (Be, Bf, Bs)<br>Lackawanna (La, Lf,Lg)<br>Mardin (Mc, Mf, Mg)<br>Morris (Mo, Mr, Ms)<br>Norwich and Chippewa (Nc, Ns)<br>Volusia (Vc, Vf, Vs)<br>Wellsboro (We, Wl, Ws) | Mardin (Ma, Md)<br>Morris (Mo, Mx)<br>Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx)<br>Volusia (Vo, Vx)<br>Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Lackawanna (Lf)<br>Lordstown and Oquaga (Lk, Lo, Ls)<br>Mardin (Mf)<br>Morris (Mr)<br>Volusia (Vf)<br>Wellsboro (Wl) | Arnot (Ar), Lordstown (Ld, Lx)<br>Mardin (Md), Morris (Mx)<br>Oquaga (Oa, Ox, Oy)<br>Rock outcrop-Arnot (Ro)<br>Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: Starrucca Quadrangle

## Table 2: Glacial Striations

| Table 2. Starrucca quadrangle glacial striations | | | | |
|---|---|---|---|---|
| **Site** | **Location** | | **Direction** | **Topographic Position** |
| | **Latitude** | **Longitude** | | |
| 1 | 41° 57' 23" | 75° 29' 20" | S 31° W | North slope* |
| 2 | 41° 55' 18" | 75° 28' 56" | S 07° W* | Hill-top |
| 3 | 41° 52' 37" | 75° 23 28" | S 40° W | Upper east slope* |

* Direction slope faces

*Graphic from source map:* Starrucca Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Starrucca 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil mapping (Martin, 1985; Reber, 1973), bedrock mapping (White, 1881), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of field work by Ruth Braun, Larry Prizblick and Ryan Steigerwalt (geologist assistants) and Duane Braun (surficial geologist). In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto three mylar overlays, and had the text added by Duane Braun. In the fourth phase, Jerry T. Mitchell (GIS consultant, Bloomsburg University) did the preliminary digital work. Thomas G. Whitfield and student interns Jaclyn Giles and Edward Ptak (Bureau of Topographic and Geologic Survey) completed the digital map and produced three final digital files; geologic contacts, surficial deposit isochors, and bedrock outcrops.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 to as much as 200 feet on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

### Mapping Technique - Thickness of Deposits

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 m) overlying the bedrock [the contact of the bedrock (R) unit with all other surficial units], 30 feet (10 m), 100 feet (30 m), and 150 feet (45 m). The 30, 100, and 150 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thickness is determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

### Quaternary History

During the Quaternary, the Starrucca 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Starrucca area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre-Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late

Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Starrucca area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S20°W - N20°E direction (Braun, 1997). Within the quadrangle, glacial striations indicate that ice flow was from S 30 to 40°W with one hilltop having a S7°W trend (Table 2). A series of subglacial and/or ice marginal melt-water channels (sluice-ways) were incised across saddles in the ridges, especially the drainage divide between the Susquehanna and Delaware basins.

Only late Wisconsin-aged deposits and landforms have been observed in the Starrucca quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 15.5 - 16.5 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation In the Starrucca quadrangle the overall deposit pattern is one of bedrock ridges separated by valleys partly filled with 30 to more than 150 feet of glacial till (as delineated by the thickness contours on the map). The original dendritic drainage pattern has been little modified by glacial erosion but has been markedly modified by glacial deposition. Masses of till, often in excess of 100 feet in thickness, form knobs that partly to entirely block individual valleys. A series of such knobs form “beaded valleys” that have a series of narrower and wider segments. Today the wider segments are often wetlands or human dammed lakes. A good example of such a “beaded” valley is East Branch Hemlock Creek valley on the west-center part of the map. In its valley and the valley of one of its tributaries there is a complex of five wide spots, two wetlands and three lakes, separated by till masses. During and immediately after deglaciation there were short-lived proglacial and paraglacial (immediately post-glacial) lakes in essentially all such wide spots dammed by glacial till. Such dams were rapidly breached by water flow probably in tens to hundreds of years until only wetlands remained. Up to the present time beavers have repeatedly re-dammed such sites.

The southwest moving glacier deposited thick till “shadows” (Coates, 1966) on the sides of south, southwest, and west facing slopes (north, northeast, and east sides of individual valleys. A particularly interesting example of a valley with a till shadow is located the southwest corner of the map. It is a west trending unnamed tributary that enters the Starrucca valley by way of a waterfall, Bucks Falls. The stream flows along the south side of its valley with a steep south side on bedrock and a gentler north side on till, the “shadow”. As the stream has eroded down it has also migrated laterally down the bedrock side of the partly buried valley and has been cutting into the till “shadow”. Where the stream enters the larger and deeper Starrucca valley, it falls off the edge of the bedrock and has built a fan out onto the floor of the Starrucca valley. A waterfall knick-point cut back about a hundred feet before that channel was abandoned by the stream as it continued its down and sideways erosion along the bedrock - till contact. The second and current falls knick-point has also cutback about 100 feet and was just in the process of being abandoned until humans intervened. Water was just beginning to by-pass the present falls during high flows. A township road was built up the slope along that incipient channel, blocking the flow. Also an artificial channel was cut into bedrock above the falls to keep the channel on the north side of the road and prevent even high flow from coming down the roadway. The small dam at the lip of the falls and the ruins below the falls are the remains of the Buck family’s hydroelectric plant that operated in the early part of the 20th century.

A few localized patches of sand and gravel deposits are located along three of the valleys on the map. Along Starrucca Creek there are three ice-contact-stratified-drift (Qwic) deposits and five alluvial fans deposited on the floor of the valley by tributary streams. The Qwic mass at the village of Starrucca, exposed in an excavation behind a large barn, is as much as 100 feet thick but has a limited extent and is partly occupied by two cemeteries. A potentially useable Qwic mass at least a few tens of feet thick occurs along Starrucca Creek just before it leaves the west edge of the map. A Qwic mass at the south-center edge of the map on a small tributary and hillside above the Shadigee Creek valley is fairly extensive but relatively thin (a few tens of feet thick). On the northeast edge of the map along the north side of the Sherman Creek valley are potentially useable Qwic deposits.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well-developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 - 2 m) thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Starrucca area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock.

Text from source map: Starrucca Quadrangle

## References

Braun, D. D., 1997, Physiography and Quaternary of the Scranton/Wilkes-Barre Region: *in* Inners, J. D., editor, Geology of the Wyoming-Lackawanna Valley: Guidebook, 62nd Annual Field Conference of Pennsylvania Geologists, Scranton, PA p. 1-15.

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and 52 maps.

Reber, E. J., 1973, Soil survey of Susquehanna County, Pennsylvania: U.S. Department of Agriculture, 89 p. and 69 maps.

White, I. C., 1881, The geology of Susquehanna County and Wayne County, Pennsylvania Geological Survey, 2nd ser.,, Report G5, 243 p. and one map.

References from source map: Starrucca Quadrangle

## White Mills Quadrangle

The formal citation for this source.

Braun, D. D., 2008, Surficial Geology of the Wayne County portion of the White Mills 7.5-Minute Quadrangle, Wayne County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFSM 08–05.0, 15 p., 1 map, scale 1:24,000 (*GRI Source Map ID 74572*).

Prominent graphics and text associated with this source.

## Map Legend

**BEDROCK LEDGE OUTCROP**

2

**STRIATION:**
Site number is above the arrow. Locations and orientations are given in Table 2. Point of the head of the arrow marks the location of the striation site.

150
100
30

**ISOCHORES AT 30, 100, AND 150 FEET:**
An isochore is the thickness of a deposit measured in a vertical borehole or in an excavation with a vertical face. The isochores drawn on the map pass from one surficial deposit to another, like from till to ice-contact-stratified-drift. This indicates that a 30 foot thickness of till is next to a 30 foot thickness of ice-contact-stratified-drift or ice-contact-stratified-drift with underlying till, together being 30 feet thick.

Graphic from source map: White Mills Quadrangle

## Table 1: Classification of Soil Series

| Table 1 Classification of soil series by Surficial geology map unit | |
|---|---|
| **Surficial geology unit** | **Wayne County Soil Series** |
| FILL (f) | |
| GRAVEL PIT (gp) | Pits, borrow (Pt) |
| BEDROCK PIT (Rp) | Quarries (Qu) |
| WETLAND (Qw) | Norwich and Chippewa (Nc, Nx), Volusia (Vo, Vx) |
| PEAT (Qp) | Medihemists and Medifibrists (ME) |
| ALLUVIUM (Qa) | Barbour (Ba), Basher (Bh), Fluvents and Fluvaquents (FF)<br>Holly (Ho) |
| BOULDER COLLUVIUM (Qb) | Lordstown (Lx), Oquaga (Ox, Oy), Wellsboro and Mardin (Wx)<br>Norwich and Chippewa (Nx), Volusia (Vx) |
| WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic) | Rexford (Re)<br>Wyoming (Wy) |
| WISCONSINAN TILL (Qwt) | Mardin (Ma, Md), Morris (Mo, Mx), Norwich and Chippewa (Nc, Nx)<br>Swartswood (Sw, Sx), Volusia (Vo, Vx), Wellsboro (We, Wo, Wx) |
| RED AND GRAY SANDSTONE AND SHALE BEDROCK (R) | Arnot (Ar), Lordstown (Ld, Lx), Mardin (Md), Morris (Mx)<br>Oquaga (Oa, Ox, Oy), Rock outcrop-Arnot (Ro), Swartswood (Sx)<br>Wellsboro and Mardin (Wx, Wo) |

Graphic from source map: White Mills Quadrangle

## Table 2: Glacial Striations

| Table 2 Locations of glacial striation sites on the White Mills quadrangle | | | | |
|---|---|---|---|---|
| **Map Site** | **Location** | | **Direction** | **Topographic Position** |
| | **Latitude** | **Longitude** | | |
| 1 | 41° 36’ 33” | -75° 13’ 20” | S 28° W | Hill Top |
| 2 | 41° 34’ 11” | -75° 14’ 56” | S 20° W | Hill top |
| 3 | 41° 30’ 38” | -75° 12’ 50” | S 25° W | Hill top |
| 4 | 41° 30’ 27” | -75° 11’ 45” | S 25° W | West slope* |
| 5 | 41° 30’ 33” | -75° 08’ 44” | S 37° W | East slope* |
| 6 | 41° 30’ 07” | -75° 08’ 50” | S 35° W | North-west slope |

* Direction slope faces

Graphic from source map: White Mills Quadrangle

## Discussion

### Mapping Technique - Surface Distribution of Deposits

The Wayne County portion of the White Mills 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil

mapping (Martin, 1985), bedrock mapping (White, 1881), and landform analysis using the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of field work by Eugene Szymanski and Ruth Braun (geologist assistants) and Duane Braun (surficial geologist). In the third phase, the field verified/ corrected preliminary surficial geology map was finalized, drafted onto mylar overlays, and had the text added by Duane Braun. In the fourth phase, the mylar overlays were scanned, digitized, and produced in an ArcGIS format and Adobe PDF (Portable Document Format) by Pennsylvania Geological Survey personnel.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet (15 to 30 meters) on the ground where there are distinct features to tie the boundaries to. Where boundaries cross large featureless areas of forest, line placement error is in the range of 100 (30 meters) to as much as 200 (60 meters) feet on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

**Mapping Technique - Thickness of Deposits**

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 meters) overlying the bedrock (the contact of the bedrock (R) unit with all other surficial units), 30 feet (10 meters), 100 feet (30 meters), and 150 feet ( 50 meters). The 30, 100, and 150 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

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During the Quaternary, the White Mills 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the White Mills area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre- Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the White Mills area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and

deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most backfilled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S 20°W – N 20°E direction. Within the quadrangle, glacial striations (Table 2) indicate that ice flow was about S 25 – 35°W. A series of subglacial and/or ice marginal meltwater channels (sluiceways) were incised across saddles in the ridges.

Only late Wisconsin-aged deposits and landforms have been observed in the White Mills quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 – 18 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Braun, 1997). The glacial till deposits themselves have been “mobilized” on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 to 2 meters) thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the White Mills area. A few of the smaller hilltop wetlands are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (10 meters) (Edgerton, 1969).

Text from source map: White Mills Quadrangle

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White, I.C., 1881, The geology of Susquehanna County and Wayne County, Pennsylvania Geological Survey, 2nd series, Report G5, 243 p. and one map.

References from source map: White Mills Quadrangle

## Pike County Geology and Mineral Resources

The formal citation for this source.

Sevon, W.D., Berg, Thomas M., Schultz, Lane D., and Crowl, George H., 1989, Geology and Mineral Resources of Pike County, Pennsylvania; Pennsylvania Geological Survey, County Report C 52, 141p., scale 1:50,000 (*GRI Source Map ID 4794*).

This publication contains two plates (surficial geology and bedrock geology) and a detailed report. Graphics associated with the surficial and bedrock plates are shown below. Visit here Pennsylvania Geologic Survey Pike County Geology and Mineral Resources to download and view the report.

## Location Map

Graphic from source map: Pike County Geology and Mineral Resources

## Surficial Geologic Map

The formal citation for this source.

Sevon, W.D., Berg, Thomas M., Schultz, Lane D., and Crowl, George H., 1989, Geology and Mineral Resources of Pike County, Pennsylvania; Pennsylvania Geological Survey, County Report C 52, 141p., plate 2 (Surficial Geologic Map), scale 1:50,000. (*GRI Source Map ID 4794*).

Prominent graphics associated with this source.

## Map Legend

Contact
Includes approximately located contacts.

Probable landslide scar
Sawteeth point in direction of sliding.

Glacial striation
Showing inferred direction of glacial flow. Point of observation is at tip of arrow.

Trend of debris-avalanche chute

Location of illustration shown in text
Number corresponds to figure number.

Graphic from source map: Pike County Geology and Mineral Resources, Surficial Geologic Map

## Correlation of Map Units

| | GEOLOGIC DESCRIPTION | UNIT | ENVIRONMENTAL CHARACTERISTICS[1] |
|---|---|---|---|
| HOLOCENE | Unconsolidated, compacted mixture of rock fragments, sand, silt, and clay, or concrete that is used for roadway fill or earth dams. Generally several feet thick. | ARTIFICIAL FILL af | No aquifer potential. Moderately easy to excavate. Generally good slope stability; susceptible to erosion. Good foundation for heavy structures where specifically designed. No mineral resources. |
| HOLOCENE | Decayed vegetation, commonly water saturated. Occurs in undrained or poorly drained natural depressions; thickly vegetated; water table is at or near the surface. Product of accumulation and partial decay of vegetation below water level. Large deposits are 10 feet thick or more. | PEAT Qp | No aquifer potential. Easy to excavate. Unsuitable for foundations, septic systems, and sanitary-landfill sites because the water table is at or near the surface. Abundant potential as soil conditioner. |
| HOLOCENE | Unconsolidated clay, silt, and sand mixed with partly decomposed organic material; may contain cobbles and boulders. Occurs in shallow, undrained areas that commonly have standing water and a thick overstory of trees. Most deposits are thought to be less than 6 feet thick. | SWAMP DEPOSITS Qs | No aquifer potential. Easily excavated. Unsuitable for foundations, septic systems, and sanitary-landfill sites because of the high water table. No known mineral resources. |
| HOLOCENE | Unconsolidated, poorly stratified, poorly to moderately well sorted mixture of clay, silt, sand, gravel, cobbles, and some boulders. Clasts are angular and platy to well rounded; composition reflects the underlying bedrock. Alluvium has flat and smooth to very rough surfaces and occupies valley bottoms. Alluvial fans have relatively smooth, fan-shaped surfaces and low to steep gradients, and occur at the mouths of tributaries. Alluvium is a fluvial deposit in valley bottoms. Alluvial fans are fluvial deposits at tributary mouths. Thickness is generally unknown, but most deposits are thought to be not more than several feet thick. | ALLUVIUM Qal / ALLUVIAL FAN Qal | Locally may yield large quantities of water to wells. Easy to excavate; generally shallow depth to bedrock. Unsuitable for septic systems and construction because of the potential for flooding. No known mineral resources. |
| PLEISTOCENE | Outwash consists of unconsolidated, stratified sand and gravel, and some boulders. Outwash has planar bedding and crossbedding; a large variation in clast size may occur from bed to bed; composition is dominated by Catskill Formation lithologies; occurs as valley fill in larger valleys. Alluvium consists of clay, silt, and very fine grained sand on floodplain surfaces and coarser material in stream channels. Outwash was deposited by glacial meltwater streams. Alluvium was deposited by streams not of glacial origin. Combined thickness ranges from several feet to 501 feet at Matamoras. | ALLUVIUM AND OLEAN OUTWASH, UNDIFFERENTIATED Qaoo | High infiltration capacity. Median yield of domestic wells is 22 gal/min. Water has good quality. Easy to excavate. Maintains moderate to gentle cut slopes; has potential for slumping. Generally unsuitable for septic systems because of potential for contamination of groundwater. Moderate to poor foundation for heavy structures; flooding is a potential hazard in many places. Source of coarse and fine aggregate; screening and washing are generally required, and crushing may be required; groundwater may be encountered at shallow depths in some valley bottoms. |

| | GEOLOGIC DESCRIPTION | UNIT | ENVIRONMENTAL CHARACTERISTICS[1] |
|---|---|---|---|
| PLEISTOCENE | Unsorted, unconsolidated mixture of angular to rounded boulders up to 6 feet or more in diameter, but generally less than 3 feet. Mainly sandstone having relatively flat to very rough surfaces. Occurs in open flats, below ledges, in small drainages, around the margins of peat deposits, and on swamp surfaces. Deposits result from glaciation and/or colluviation. Thickness is unknown, but appears to range from 1 foot to several feet. | BOULDER ACCUMULATIONS Qba | No aquifer potential. Moderately difficult to excavate. Generally unsuitable for foundations. Unsuitable for septic systems and sanitary-landfill sites. Potential source of riprap. |
| PLEISTOCENE | Unconsolidated, poorly to well-bedded, wedge-shaped deposits of angular, elongate to platy fragments of claystone and siltstone generally 1 to 2 inches long. Rubble has open interstices. Fragments have a thin clay coating; elongate fragments generally have their long axis parallel to the slope. Formed by accumulation of mass-wasted fragments (colluvium) at the base of steep cliffs. Thickness is variable; maximum is about 50 feet at the base of slopes. | SHALE CHIP RUBBLE Qsr | No aquifer potential. Easy to excavate. Moderate slopes; unstable where loaded or undercut. Unsuitable for foundations. May be unsuitable for septic systems and sanitary-landfill sites. Excellent source of material for random fill and surfacing for low-use secondary roads (locally called sharpstone). |
| PLEISTOCENE | Unconsolidated, stratified sand and gravel, commonly containing large boulders. Abrupt textural changes between beds and lenses; composition reflects underlying bedrock of the region; includes valley-bottom and valley-side kames and kame terraces, and some upland kames. Forms hummocky surface topography; kames have undrained depressions; kame terraces have undulating sloping surfaces. Deposited by fluvial action in close proximity to stagnant ice. Thickness is variable and generally unknown, ranging from several feet to more than 200 feet. | OLEAN ICE-CONTACT STRATIFIED SAND AND GRAVEL Qoic / OLEAN KAME TERRACE Qokt | High infiltration capacity. Median yield of domestic wells is 20 gal/min. Water has good quality. Generally easy to excavate; large boulders may be encountered. Maintains only moderate to gentle cut slopes; potential for slumping. Generally unsuitable for septic systems and sanitary landfills because sand and gravel afford little or no attenuation of chemical and bacterial contaminants. Poor to unsuitable foundation for heavy structures. Source of coarse and fine aggregate; crushing, screening, and washing are generally required; groundwater may be encountered in valley bottoms. |
| PLEISTOCENE | Unsorted and nonstratified mixture of clay, silt, sand, pebbles, cobbles, and boulders. Reddish brown in most of the county; brown to gray where it overlies the Trimmers Rock and Mahantango Formations; moderately cohesive; composition reflects underlying bedrock; shallow soil profiles; occurs mainly on lower slopes or in valley bottoms. Deposited as lodgment till at the base of ice or as ablation till by melting ice. Thickness ranges from 6 feet to over 200 feet. | OLEAN TILL Qot | Moderate to high infiltration capacity. Four domestic wells have a median yield of 28 gal/min. Water has good quality. Moderately easy to excavate; some problems due to large boulders. Generally fast drilling rates. Generally maintains gentle to moderate cut slopes; susceptible to landslide failure where water saturated. Poor to good foundation for heavy structures. Not suitable for septic systems. Suitable in some places for sanitary-landfill sites. Useful as artificial fill. |
| PALEOZOIC AND YOUNGER | Rock exposures and till less than 6 feet thick. Includes rock ledges having steep faces up to several feet high; broken rock is common at the base of ledges. Unvegetated, gently dipping rock surfaces adjacent to ledges may have scattered large boulders and glacially striated surfaces. See Olean Till for description of till. | BEDROCK[2] AND THIN OLEAN TILL, UNDIVIDED br | Till has no aquifer potential because of inadequate thickness. Thin till is easily excavated. Till thickness is inadequate for septic systems and sanitary-landfill sites. Till may be used for artificial fill. |

[1]Blue type refers to groundwater characteristics, red type to engineering characteristics, and black type to mineral resources. Groundwater data are from Davis (1989).
[2]See Plate 1 for geologic description and environmental characteristics of bedrock units.

Note: Not all geologic units shown on this correlation appear in the GRI GIS data.

Graphic from source map: [Pike County Geology and Mineral Resources, Surficial Geologic Map]

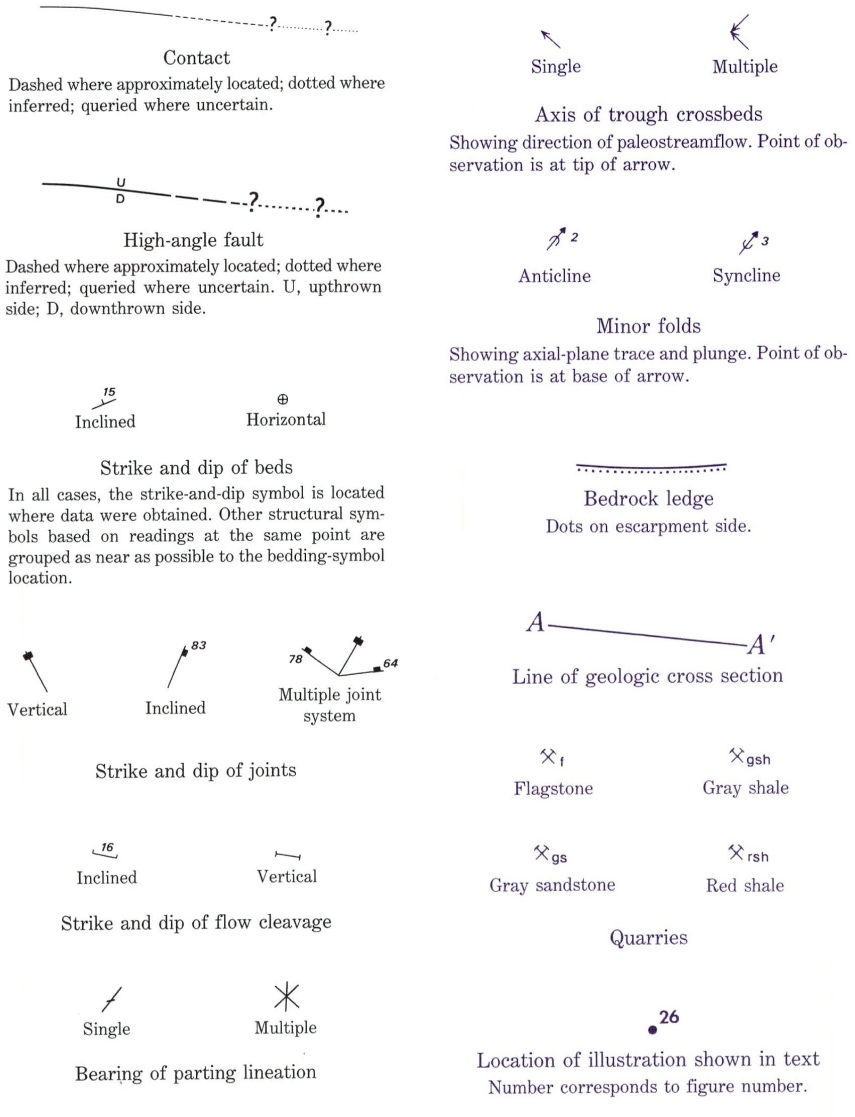
## Bedrock Geologic Map

The formal citation for this source.

Sevon, W.D., Berg, Thomas M., and Schultz, Lane D., 1989, Geology and Mineral Resources of Pike County, Pennsylvania: Pennsylvania Geological Survey, County Report 52, 141p., plate 1 (Bedrock Geologic Map), scale 1:50,000. (*GRI Source Map ID 4459*).

Prominent graphics associated with this source.

## Map Legend




Graphic from source map: [Pike County Geology and Mineral Resources, Bedrock Geologic Map]

## Correlation of Map Units

| | GEOLOGIC DESCRIPTION | UNIT | ENVIRONMENTAL CHARACTERISTICS[1] |
|---|---|---|---|
| UPPER DEVONIAN | Dominantly gray sandstone, some gray conglomeratic sandstone, and a few red siltstones and claystones. Sandstone is medium to coarse grained and trough crossbedded. Conglomeratic sandstone contains up to 75 percent pebbles, which are up to 1.5 inches in diameter; a persistent basal conglomeratic sandstone forms prominent ledges at the front edge of the Pocono Plateau escarpment and smaller ledges elsewhere. Sandstone and conglomeratic sandstone have blocky to flaggy fragmentation. Siltstone and claystone rarely crop out and have platy to hackly fragmentation. Deposited by braided streams. Maximum thickness is 500 feet; member is less than 250 feet thick in most of the area. | POPLAR GAP AND PACKERTON MEMBERS, UNDIVIDED<br>Dcpp | Moderate infiltration capacity along fractures and some bedding planes. Domestic wells have a median yield of 19 gal/min; two nondomestic wells have a median yield of 90 gal/min. Water is soft to moderately hard and low in dissolved solids.<br>Siltstone and claystone are easily excavated using heavy equipment; sandstone and conglomeratic sandstone require blasting except near the surface where they have been loosened by weathering along various parting planes. Slow to variable drilling rates. Generally maintains very steep cut slopes; some rockfall may be anticipated after prolonged exposure. Excellent to good foundation for heavy structures. Slight to moderate percolation difficulty for septic systems developed in well-broken, weathered bedrock having a good soil cover. Sanitary-landfill siting requires careful evaluation, but the unit is generally poorly suited.<br>Sandstone and conglomeratic sandstone have potential for dimension stone and crushed aggregate. Claystone has marginal potential as material for building brick and floor brick, but the presence of carbonate could be a problem. Conglomeratic beds have possible use as heavy riprap and may serve as unusual decorative dimension stone. |
| UPPER DEVONIAN | Dominantly gray sandstone, some gray conglomeratic sandstone, and a few thin red siltstones and claystones; moderate quantity of detrital feldspar. Base is marked by persistent conglomeratic sandstone up to 20 feet thick and containing up to 75 percent pebbles, which average from 0.25 to 0.5 inch in diameter. Discontinuous conglomeratic sandstone (blue line) occurs at higher stratigraphic interval. Sandstone is mainly trough crossbedded and fine to medium grained; intervals of planar-bedded sandstone occur mainly in the eastern part of the county. Sandstone and conglomeratic sandstone have blocky to flaggy fragmentation and form numerous small ledges. Siltstone and claystone rarely crop out. Deposited by braided streams. Maximum thickness is estimated to be between 400 and 500 feet in the northern third of the county and is about 200 feet in the western part. | CATSKILL FORMATION<br>LACKAWAXEN MEMBER<br>Dcl | Moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 10 and 30 gal/min, respectively. Water is soft to moderately hard and low in dissolved solids.<br>Moderately difficult to difficult to excavate; sandstone and conglomeratic sandstone may require blasting. Slow to variable drilling rates. Generally maintains steep to vertical cut slopes; some rockfall may be anticipated after prolonged exposure. Excellent to good foundation for heavy structures. Slight to moderate percolation difficulty for septic systems developed in well-broken, weathered bedrock having soil cover. Sanitary-landfill siting requires careful evaluation, but the unit is generally poorly suited.<br>Planar-bedded sandstone has good potential for flagstone in the northeastern third of the county and some potential for dimension stone; waste piles at former flagstone quarries have potential for crushed rock. Claystone has marginal potential as material for building brick and floor brick. |
| UPPER DEVONIAN | Cyclic sequences of gray, trough-crossbedded and planar-bedded, fine- to medium-grained sandstone and some red siltstone and claystone. Sandstone is in part feldspathic, forms small ledges, has blocky to flaggy fragmentation, and contains local calcareous, intraformational conglomerate. Discontinuous conglomeratic sandstone (red line and black circles) occurs near the top of the member in the northeastern and southwestern portions of the county. Thin siltstone and claystone in the northeast become thicker and more persistent to the southwest. Deposited by braided streams. Maximum thickness where overlain by the Lackawaxen Member is 2,600 feet; maximum thickness where the Lackawaxen is absent is 2,800 feet. | DELAWARE RIVER MEMBER<br>Ddr | Moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 16 and 100 gal/min, respectively. Water is soft to moderately hard and low in dissolved solids.<br>Moderately difficult to difficult to excavate; sandstone and conglomeratic sandstone may require blasting. Slow to variable drilling rates. Generally maintains steep to vertical cut slopes; some rockfall may be anticipated after prolonged exposure. Excellent to good foundation for heavy structures. Slight to moderate percolation difficulty for septic systems developed in well-broken, weathered bedrock having good soil cover. Sanitary-landfill siting requires careful evaluation, but the unit is generally poorly suited.<br>Planar-bedded sandstone has good potential for flagstone, particularly in the northeastern third of the county, and some potential for dimension stone; waste piles at former flagstone quarries have potential for crushed rock. Claystone has marginal potential as material for building brick and floor brick. |

| | GEOLOGIC DESCRIPTION | UNIT | ENVIRONMENTAL CHARACTERISTICS[1] |
|---|---|---|---|
| UPPER DEVONIAN | Dominantly gray, fine- to medium-grained, trough-crossbedded sandstone; some planar-bedded sandstone; some lenseoidal, intraformational conglomerate containing calcite cement, shale clasts, and carbonaceous material; and some thin, interbedded, dark-gray (lower part) and olive-gray (upper part) siltstone and claystone. Sandstone has blocky to flaggy fragmentation. Member contains freshwater plant fossils and trace fossils (bivalve burrows). Deposited in fluvial environment of lower delta plain, including river mouth bars. Thickness ranges from 247 feet in the west to 1,625 feet in the northeast. | CATSKILL FORMATION<br>TOWAMENSING MEMBER<br>Dct | Moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 30 and 98 gal/min, respectively. Water is soft and low in dissolved solids.<br>Difficult to excavate; sandstone may require blasting. Slow drilling rate in sandstone; moderate drilling rate in siltstone. Generally maintains steep to vertical cut slopes; interbedded siltstone may contribute to rockfall. Excellent to good foundation for heavy structures. Generally suitable for septic systems developed in well-broken, weathered bedrock having a good soil cover. Sanitary-landfill siting requires careful evaluation, but the unit is generally poorly suited.<br>Planar-bedded sandstone has potential for flagstone. Sandstone has good potential for crushed rock. Claystone has marginal potential as material for building brick, floor brick, and lightweight aggregate, but presence of carbonate could cause problems. |
| UPPER DEVONIAN | Dominantly dark-gray to medium-dark-gray siltstone, shale, and sandstone; Millrift Member contains approximately 60 percent very fine grained sandstone, whereas Sloat Brook Member is dominantly siltstone and silt shale. Generally thin to medium bedded, although some sandstone in the Millrift Member is thick bedded; well-developed joints; poorly developed cleavage; forms low, subparallel ledges; marine fossils are common (especially brachiopods). Siltstone and shale disintegrate to hackly, platy, and chippy fragments; sandstone disintegrates to rubbly and slabby fragments. Deposited mostly by density currents in marine prodelta. Formation thickness ranges from 720 to 1,825 feet; Millrift Member has a maximum thickness of 1,000 feet; Sloat Brook Member has a maximum thickness of 950 feet. | TRIMMERS ROCK FORMATION<br>MILLRIFT MEMBER<br>Dtm<br>SLOAT BROOK MEMBER<br>Dtsb | Low to moderate infiltration capacity along fractures and some bedding planes. The median yields of domestic wells and nondomestic wells are 20 and 60 gal/min, respectively. Water is soft to moderately hard and in some places contains excessive manganese.<br>Moderately easy to difficult to excavate using heavy equipment; sandstone and some siltstone beds may require blasting. Fast to moderate drilling rates. Generally maintains very steep to vertical cut slopes; has potential for large rockfalls from curved joint surfaces. Good to excellent foundation for heavy structures. Sloat Brook Member is suitable for impoundments, but Millrift Member has well-developed joints that may present problems. Slight to moderate percolation difficulty is a problem for septic systems. Relatively narrow outcrop belt and presence of hard, fractured sandstone and siltstone beds are limiting factors for siting of sanitary landfills.<br>Shale has limited potential as material for building brick or facing brick. Sloat Brook Member has marginal potential for lightweight aggregate. Sloat Brook Member and lower part of Millrift Member have good potential for road metal and random fill. Upper part of Millrift Member has material suitable for riprap and embankment facing, and may have some potential for building stone or concrete aggregate. |
| MIDDLE DEVONIAN | Interbedded, dark-gray siltstone, shale, and claystone. Shale is thickly laminated to thin bedded and fissile to subfissile. Siltstone is medium to thick bedded and subfissile to nonfissile. Formation has moderate to good cleavage development; hackly and splintery fragmentation; zones of nodules parallel to bedding; forms cliffs along Delaware River valley and low, strike ridges on uplands; locally fossiliferous. Deposited in open-shelf to gentle-slope marine environment. Thickness ranges from 1,300 feet in the north to 2,450 feet in the east. | MAHANTANGO FORMATION<br>Dmh | Low to moderate infiltration capacity along fractures. The median yields of domestic wells and nondomestic wells are 16 and 34 gal/min, respectively. Water is soft to moderately hard.<br>Easy to moderately difficult to excavate. Moderate drilling rate. Maintains steep cut slopes. Good foundation for heavy structures. Generally unsuitable for septic systems because of poor percolation. Potentially suitable for sanitary-landfill sites.<br>Limited potential for lightweight aggregate. Shale has potential as material for building brick and floor brick, but may have to be pelletized. Derived colluvium is used for surfacing secondary roads and for random fill (locally called sharpstone). |
| MIDDLE DEVONIAN | Thin-bedded, slightly siliceous, dark-gray to grayish-black clay shale and silty clay shale, and some thin beds of argillaceous siltstone. Well-developed cleavage; disintegrates to chippy, flaky, and splintery fragments; forms steep bluffs above Bushkill; few marine fossils; intermittent zones of quartz-chlorite nodules parallel to bedding. Deposited in anoxic marine environment well below effective wave base. Maximum thickness is 950 feet. | MARCELLUS FORMATION<br>Dmr | Low infiltration capacity along fractures. Two domestic wells have a median yield of 3.75 gal/min. Water is soft.<br>Moderately easy to excavate using heavy equipment; blasting is not usually required. Fast drilling rates. Generally maintains steep cut slopes; disintegrates to small fragments after prolonged exposure. Fair to good foundation for heavy structures. Unsuitable for septic systems due to poor percolation. Not suitable for sanitary-landfill sites because of steep slopes.<br>Shale has some potential as material for building brick, limited potential for facing or floor brick, and marginal potential for lightweight aggregate; quartz-chlorite nodules and bands may be deleterious constituents. Formation is used for random fill; derived colluvium may be used for moderately impervious fill packing around foundations laid in unconsolidated surficial deposits. |

[1]Blue type refers to groundwater characteristics, red type to engi-

Note: Not all geologic units shown on this correlation appear in the GRI GIS data.

Graphic from source map: Pike County Geology and Mineral Resources, Bedrock Geologic Map

## Pike County Groundwater Resources

The formal citation for this source.

Davis, Drew K., 1989, Groundwater Resources of Pike County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Water Resource Report 65, 63 p., scale 1:50,000 (*GRI Source Map ID 5779*).

Note: Only well points were captured from this publication.

This publication contains two plates (surficial geology and bedrock geology) and a detailed report. Graphics associated with the surficial and bedrock plates are shown below. Visit here Pennsylvania Geologic Survey Pike County Groundwater Resources to download and view the report.

## Location Map

Graphic from source map: Pike County Groundwater Resources

## Surficial Geologic Map

The formal citation for this source.

Davis, Drew K., 1989, Groundwater Resources of Pike County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Water Resource Report 65, 63 p., plate 2 (Surficial Geologic Map), scale 1:50,000. ( *GRI Source Map ID 5779*).

Prominent graphics associated with this source.

## Map Legend

Contact
Includes approximately located contacts.

Well having main groundwater yield from surficial deposits, and county well number

Note: Only wells were captured in the GRI digital geologic-GIS data from this source map.

Graphic from source map: Pike County Groundwater Resources, Surficial Geologic Map

## Correlation of Map Units

| | GEOLOGIC DESCRIPTION | UNIT | WATER-BEARING PROPERTIES |
|---|---|---|---|
| HOLOCENE | Unconsolidated, generally packed mixture of rock fragments, sand, silt, and clay, or concrete that is used for roadway fill or earth dams. Generally several feet thick. | ARTIFICIAL FILL af | Lies mostly above the water table. Not an aquifer. |
| HOLOCENE | Decayed vegetation, commonly water saturated. Occurs in undrained or poorly drained natural depressions; thickly vegetated; water table is at or near the surface. Product of partial decay of vegetation below water level. Large deposits are 10 feet thick or more. | PEAT Qp | Not an aquifer. Water in underlying deposits may be discolored. |
| HOLOCENE | Unconsolidated clay, silt, and sand mixed with partly decomposed organic material; may contain cobbles and boulders. Occurs in shallow, undrained areas that commonly have standing water. Most deposits are thought to be less than 6 feet thick. | SWAMP DEPOSITS Qs | Not an aquifer. |
| HOLOCENE | Unconsolidated, poorly stratified mixture of clay, silt, sand, gravel, cobbles, and some boulders. Alluvium occurs in valley bottoms; alluvial fans occur at the mouths of tributaries. Deposits are commonly vegetated. Thickness is generally unknown, but most deposits are thought to be not more than several feet thick. | ALLUVIUM Qal; ALLUVIAL FAN Qaf | Of limited areal extent. Locally may yield large quantities of water to wells. |
| HOLOCENE / PLEISTOCENE | Outwash consists of unconsolidated, stratified sand and gravel, and some boulders. Alluvium consists of clay, silt, and very fine grained sand on floodplain surfaces and coarser material in stream channels. Occurs as valley fill in the Delaware River valley and other smaller valleys. Outwash constitutes the bulk of the deposits; alluvium forms a thin veneer on top of the outwash. Combined thickness ranges from several feet to 501 feet at Matamoras. | ALLUVIUM AND OLEAN OUTWASH, UNDIFFERENTIATED Qaoo | Probably the best aquifer in the county. Nondomestic wells have reported yields up to 350 gal/min. Median specific capacity is 20 (gal/min)/ft for nondomestic wells and 1.0 (gal/min)/ft for domestic wells. Water quality is good. |
| PLEISTOCENE | Unsorted, unconsolidated mixture of angular to rounded boulders up to 6 feet or more in diameter, but generally less than 3 feet. Mainly sandstone having relatively flat to very rough surfaces. Occurs in open flats, below ledges, in small drainages, around the margins of peat deposits, and on swamp surfaces. Deposits result from glaciation and/or colluviation. Thickness is unknown, but appears to range from 1 foot to several feet. | BOULDER ACCUMULATIONS Qba | Not an aquifer. |

| | GEOLOGIC DESCRIPTION | UNIT | WATER-BEARING PROPERTIES |
|---|---|---|---|
| PLEISTOCENE | Unconsolidated, poorly to well-bedded, wedge-shaped deposits of angular, elongate to platy fragments of claystone and siltstone generally 1 to 2 inches long. Rubble has open interstices. Fragments have a thin clay coating; elongate fragments generally have their long axis parallel to the slope. Formed by accumulation of mass-wasted fragments (colluvium) at the base of steep cliffs. Thickness is variable; maximum is about 50 feet at the base of slopes. | SHALE-CHIP RUBBLE Qsr | Not an aquifer. |
| PLEISTOCENE | Unconsolidated, stratified sand and gravel, commonly containing large boulders. Abrupt textural changes between beds and lenses; composition reflects underlying bedrock of the region; includes valley-bottom and valley-side kames and kame terraces, and some upland kames. Forms hummocky surface topography; kames have undrained depressions; kame terraces have undulating sloping surfaces. Deposited by fluvial action in close proximity to stagnant ice. Thickness is variable and generally unknown, ranging from several feet to more than 200 feet. | OLEAN ICE-CONTACT STRATIFIED SAND AND GRAVEL Qoic; OLEAN KAME TERRACE Qokt | An excellent aquifer. Nondomestic wells have reported yields up to 350 gal/min. Median specific capacity is 3.3 (gal/min)/ft for nondomestic wells and 0.59 (gal/min)/ft for domestic wells. Water is soft and of good quality. |
| PLEISTOCENE | Unsorted and nonstratified, moderately cohesive mixture of clay, silt, sand, pebbles, cobbles, and boulders. Reddish brown in most of the county; brown to gray where it overlies the Trimmers Rock and Mahantango Formations; composition reflects underlying bedrock; shallow soil profiles. Occurs mainly on lower slopes or in valley bottoms. Thickness ranges from 6 feet to over 200 feet. | OLEAN TILL Qot | Apparently a good aquifer; median yield is 28 gal/min for four domestic wells, and median specific capacity is 0.92 (gal/min)/ft for four domestic wells. No data are available for nondomestic wells. Water quality is good. |
| PALEOZOIC AND YOUNGER | Rock exposures and till less than 6 feet thick. Includes rock ledges having steep faces up to several feet high; broken rock is common at the base of ledges. Unvegetated, gently dipping rock surfaces adjacent to ledges may have scattered large boulders and glacially striated surfaces. See Olean Till for description of till. | BEDROCK[1] AND THIN OLEAN TILL, UNDIVIDED br | Till has no aquifer potential because of inadequate thickness. |

[1]See Plate 1 for geologic description and water-bearing properties of bedrock units.

Note: The geologic units present on this correlation and their respective symbols, ages and descriptions are the same as those shown on Pennsylvania Geologic Survey Pike County Geology and Mineral Resources. The major difference is this correlation describes the water-bearing properties of geologic unit shown in the GIS data. Not all geologic units shown on this correlation appear in the GRI GIS data.

Graphic from source map: Pike County Groundwater Resources, Surficial Geologic Map

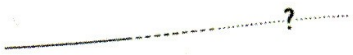
## Bedrock Geologic Map

The formal citation for this source.

Davis, Drew K., 1989, Groundwater Resources of Pike County, Pennsylvania: Pennsylvania Geological Survey, Water Resource Report 65, 63 p., plate 1 (Bedrock Geologic Map), scale 1:50,000 (*GRI Source Map ID 4456*).

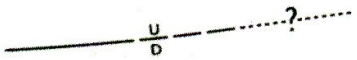
Prominent graphics associated with this source.

### Map Legend




Contact

Dashed where approximately located; dotted where inferred; queried where uncertain.




High-angle fault

Dashed where approximately located; dotted where inferred; queried where uncertain. U, upthrown side; D, downthrown side.

Water-level contour

Altitude in feet above mean sea level. Contour interval 100 feet.

Strike and dip of beds

Well having main groundwater yield from bedrock, and county well number

Note: Only wells were captured in the GRI digital geologic-GIS data from this source map.

Graphic from source map: Pike County Groundwater Resources, Bedrock Geologic Map

## Correlation of Map Units

| | GEOLOGIC DESCRIPTION | UNIT | | WATER-BEARING PROPERTIES |
|---|---|---|---|---|
| UPPER DEVONIAN | Dominantly gray, crossbedded, medium- to coarse-grained sandstone; some gray conglomeratic sandstone; minor red siltstone and claystone. Conglomeratic zone resistant to weathering occurs at the base of the member. Maximum thickness is 500 feet; member is less than 250 feet thick in most of the area. | | POPLAR GAP AND PACKERTON MEMBERS, UNDIVIDED Dcpp | Excellent aquifer for domestic wells; yields are up to 150 gal/min, and median specific capacity is 0.83 (gal/min)/ft. Two nondomestic wells have moderate yields. Water quality is good. |
| | Dominantly gray, crossbedded, fine- to medium-grained, feldspathic sandstone; intervals of planar-bedded sandstone; minor red siltstone and claystone. Two thin conglomeratic zones occur, one at the base and one (blue line) near the top of the member. Maximum thickness is estimated to be between 400 and 500 feet in the northern third of the county and is about 200 feet in the western part. | CATSKILL FORMATION | LACKAWAXEN MEMBER Dcl | Adequate supplies for domestic wells; yields range from 3 to 100 gal/min, and median specific capacity is 0.12 (gal/min)/ft. |
| | Cyclic sequences of gray, planar-bedded and crossbedded, fine- to medium-grained sandstone. Some thin red siltstone and claystone occur in the northeast and become thicker and more abundant to the southwest. Thin conglomeratic beds (red line and black circles) occur locally near the top of the member. Maximum thickness where overlain by the Lackawaxen Member is 2,600 feet; maximum thickness where the Lackawaxen is absent is 2,800 feet. | | DELAWARE RIVER MEMBER Dcdr | Adequate supplies for domestic wells; median yield is 16 gal/min. Capable of high yields. Median yield of nondomestic wells is 100 gal/min, and median specific capacity is 0.76 (gal/min)/ft. |

| | GEOLOGIC DESCRIPTION | UNIT | | WATER-BEARING PROPERTIES |
|---|---|---|---|---|
| UPPER DEVONIAN | Dominantly light- to medium-gray, crossbedded, fine- to medium-grained sandstone; some planar-bedded sandstone; some interbedded siltstone and claystone; some intraformational conglomerate. No coarse-grained sandstone or conglomeratic beds are known to occur. Siltstone and claystone beds are generally less than 2 feet thick. Thickness of the member ranges from 247 feet in the west to 1,625 feet in the northeast. | CATSKILL FORMATION | TOWAMENSING MEMBER Dct | Excellent supplies for domestic wells; median yield is 30 gal/min, and specific capacity is 0.36 (gal/min)/ft. Adequate supplies for nondomestic wells. Water is soft. |
| | Dominantly dark-gray to medium-dark-gray siltstone, shale, and sandstone; Millrift Member contains approximately 60 percent very fine grained sandstone, whereas Sloat Brook Member is dominantly siltstone and silt shale. Both members are generally thin to medium bedded, although a few sandstone beds in the Millrift are thick bedded. Formation thickness ranges from 720 to 1,825 feet; Millrift Member has a maximum thickness of 1,000 feet and Sloat Brook Member has a maximum thickness of 950 feet. | TRIMMERS ROCK FORMATION | MILLRIFT MEMBER Dtm<br>SLOAT BROOK MEMBER Dtsb | Supply is adequate for domestic wells. Median yield is 20 gal/min for domestic wells and 60 gal/min for nondomestic wells. Median specific capacity is 0.26 (gal/min)/ft for domestic wells and 1.0 (gal/min)/ft for nondomestic wells. Water contains excessive manganese in some places. |
| MIDDLE DEVONIAN | Interbedded, dark-gray siltstone, claystone, clay shale, and silt shale. Siltstone is medium to thick bedded, and shale is thickly laminated to thin bedded; however, bedding is commonly indistinct. Thickness ranges from 1,300 feet in the north to 2,450 feet in the east. | MAHANTANGO FORMATION Dmh | | Adequate supplies for domestic and nondomestic wells. Median specific capacity is 0.09 (gal/min)/ft for domestic wells and 0.16 (gal/min)/ft for nondomestic wells. Water is slightly basic and soft to moderately hard. |
| | Dark-gray to grayish-black, slightly siliceous clay shale and silty clay shale; minor argillaceous siltstone. Intermittent zones of quartz-chlorite nodules occur parallel to bedding. Some marine fossils are present. Maximum thickness is 950 feet. | MARCELLUS FORMATION Dmr | | Not an important aquifer in Pike County. |

Note: The geologic units present on this correlation and their respective symbols, ages and descriptions are the same as those shown on Pennsylvania Geologic Survey Pike County Geology and Mineral Resources. The major difference is this correlation describes the water-bearing properties of geologic unit shown in the GRI GIS data. Not all geologic units shown on this correlation appear in the GRI GIS data.

Graphic from source map: Pike County Groundwater Resources, Bedrock Geologic Map

## New York Upper Delaware River

The following datasets were part of a multi-year New York State Geological Survey mapping project contracted by the NPS GRI. The mapping was conducted in two phases and delivered as two separate collections of shapefiles. The New York State Geological Survey produced a report describing the surficial geology and geologic history of the area mapped. That report can be viewed by double-clicking the following link: NYSGS Upper Delaware Report.

## New York Upper Delaware River North

The formal citation for this source.

Kowzlowski, A. L., 2017, Surficial Geology of the New York Portion of Upper Delaware Scenic and Recreational River and Vicinity, New York (Northern 7.5' quadrangles): New York State Geological Survey, unpublished data and map, scale 1:24,000 (*GRI Source Map ID 76117*).

## New York Upper Delaware River South

The formal citation for this source.

Leone, James et al., 2019, Surficial Geology of the New York Portion of Upper Delaware Scenic and Recreational River and Vicinity, New York (Southern 7.5' quadrangles): New York State Geological Survey, unpublished data and map, scale 1:24,000 (*GRI Source Map ID 76289*).

## National Hydrography Dataset

The formal citation for this source.

U.S. Geological Survey, 2018, USGS National Hydrography Dataset Best Resolution (NHD) for Hydrologic Unit (HU) 8: U.S. Geological Survey, scale 1:24,000 (*GRI Source Map ID 76278*).

## GRI Digital Data Credits

This document was developed and completed by Jakob Suri and James Chappell (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory (GRI) Program. Quality control of this document by James Chappell and Stephanie O'Meara (Colorado State University).

The information in this document was compiled from GRI source maps, and is intended to accompany the digital geologic-GIS maps and other digital data for Upper Delaware Scenic and Recreational River, New York and Pennsylvania (UPDE) developed by James Chappell, Dylan Rolley and James Winter (Colorado State University). See the GRI Digital Maps and Source Map Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS maps.

GRI finalization by James Chappell (Colorado State University).

GRI program coordination and scoping provided by Jason Kenworthy and Tim Connors (NPS GRD, Lakewood, Colorado).