

Geologic Resource Evaluation Scoping Summary

Morristown National Historical Park

Geologic Resources Division
National Park Service
US Department of the Interior



The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park Service (NPS) units with a geologic scoping meeting, a digital geologic map, and a geologic resource evaluation report. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity for discussion of park-specific geologic management issues and, if possible, include a site visit with local geologic experts. The purpose of these meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and potential monitoring and research needs. Outcomes of this scoping process are a scoping summary (this report), a digital geologic map, and a geologic resource evaluation report.

The National Park Service held a GRE scoping meeting for Morristown National Historical Park (MORR) on July 10, 2007 at the University of Massachusetts, Amherst. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Bruce Heise (NPS-GRD) led the discussion regarding geologic processes and features at the national historical park. Participants at the meeting included NPS staff from the park, Northeast Temperate Network, and Geologic Resources Division, geologists from the New Jersey Geological Survey, Andover Geologic Consulting company, and University of Massachusetts, Amherst as well as cooperators from Colorado State University (see table 1). This scoping summary highlights the GRE scoping meeting for Morristown including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Morristown National Historical Park covers 1,710 acres over four separate units (Jocky Hollow, New Jersey Brigade, Washington's Headquarters, and Ft. Nonsense) commemorating the quarters for the Continental army during the 1777 and 1779-80 winters of the Revolutionary War. Congress authorized this unit on March 2, 1933. Morristown sits along the junction between the New Jersey Highlands (Trowbridge Range of the Reading Prong) and Piedmont physiographic provinces in New Jersey some 50 km (30 miles) from New York City. The national historical park sits within 3 7.5-minute quadrangles of interest along the eastern edge of the Appalachian Mountains.

Hilly terrain, rounded knobs, broad vistas, and narrow ravines characterize the landscape at Morristown National Historical Park. The park sits within the Great Swamp watershed and protects the headwaters of several local streams including Primrose Brook and portions of Indian Grove Brook and the Passaic River. Regional foliation of metamorphic rock units, geologic structures such as folds, faults, and joints as well as differential erosion controlled the formation of the current topography in the area. Ridges and hills such as Kemble Mountain (Ft. Nonsense unit), Mount Kemble, Tea Hill, Sugar Loaf, and Blachleys Hill contrast sharply with the gently undulating landscape to the southeast of Morristown. Kemble Mountain (a long, narrow ridge) and Mount Kemble rise to over 220 m (700 ft).

Exposed in the park and immediate surrounding areas are at least six bedrock units primarily Proterozoic in age or approximately 1 billion-years-old. These units are granites, gneisses, schists, and phyllites of the Highlands province. These were uplifted, metamorphosed and deformed during the intermittent formation of the Appalachian Mountains throughout the Paleozoic Era. Trending northeast-southwest along the southeastern edge of the national historical park is the Ramapo Fault. This major regional normal fault (with some strike-slip components) separates the mountainous Highlands from a Mesozoic-age extensional basin containing sandstones, conglomerates, diabase, and shales. An escarpment - 60 to 250 m (200-800 ft) high along its length - marks this boundary.

Though the glacial ice of the last major ice age did not extend as far south as Morristown, some of the earlier Pleistocene glaciations did and periglacial processes affected the local landscape less than 10,000 years ago. These glacial events left a mantle of unconsolidated sediments that almost completely eroded from the landscape. Glacial Lake Passaic (associated with the last Wisconsin glaciation) left lake bottom deposits in the area. Today, unconsolidated alluvium and colluvium, as well as weathered conglomerates, shales, and gneisses dominate the surficial geology of the area.

Geologic Mapping for Morristown National Historical Park

During the scoping meeting Tim Connors (NPS-GRD) showed some of the main features of the GRE Program's digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of GIS compatibility. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation set for the GRE Program. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcMap software. Final digital geologic map products include data in geodatabase, shapefile, and coverage format, layer files, FGDC-compliant metadata, and a Windows HelpFile that captures ancillary map data. Completed digital maps are available from the NPS Data Store at <http://science.nature.nps.gov/nrdata/>.

When possible, the GRE program provides large-scale (1:24,000) digital geologic map coverage for each park's area of interest, usually composed of the 7.5-minute quadrangles that contain park lands (figure 1). Maps of this scale (and larger) are useful to resource management because they capture most geologic features of interest and are positionally accurate within 40 feet. The process of selecting maps for park management begins with the identification of existing geologic maps and mapping needs in vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data to be derived by GRE staff as well as determine areas in need of further mapping or refinement. Table 2 (at the end of this document) lists the source maps chosen for Morristown National Historical Park as well as any further action required to make these maps appropriate for inclusion in the final geologic map for the site.

Morristown National Historical Park expressed interest in bedrock and surficial geologic map coverage for four 7.5' quadrangles of interest: Morristown, Mendham, Chatham, and Bernardsville New Jersey. At present, there is at least 1:100,000-scale published digital bedrock and surficial geologic map coverage, completed by both the U.S. Geological Survey and the New Jersey Geological Survey (NJGS) for the quadrangles of interest (figure 2). It is likely much of this may have been derived from larger-scale data. At the time of scoping in July 2007, large-scale (1:24,000) map coverage needs existed in the Bernardsville 7.5' quadrangle for both bedrock and surficial

geology, and in the Mendham 7.5' quadrangle for surficial geology. NJGS staff may have unpublished map coverage of these quadrangles (contact: Rich Volkert and Ron Pristas).

In the early 1990's, Rutgers (The State University of New Jersey) did geologic mapping for the park; this mapping is unpublished and exists in digital "GRAS" format. GRE staff would like to acquire this map to further evaluate its utility.

Table 2 lists the source maps chosen for Morristown National Historical Park and mapping needs in certain quadrangles, in addition to a unique "GMAP ID" number assigned to each map by GRE staff for data management purposes, map scale, and action items.

Where 1:24,000 scale data is available, GRE staff will compare and contrast with the following 1:100,000 scale New Jersey state digital bedrock and surficial maps to determine the best maps to use.

- (7285) Drake, Avery A. Jr., Volkert, Richard, A., Monteverde, Donald H., Herman, Gregory C., Houghton, Hugh F., Parker, Ronald A., and Dalton, Richard F., 1999, Digital Bedrock Geology for New Jersey 1:100,000 Scale, New Jersey Geological Survey, DGS04-6, <http://www.state.nj.us/dep/njgs/geodata/dgs04-6.htm>
- (74858) Pristas, R. P., 2007, Surficial geology of New Jersey, New Jersey Geological Survey, Digital Geodata Series DGS 07-2, 1:100,000 scale, <http://www.state.nj.us/dep/njgs/geodata/dgs07-2.htm>

Larger-scale maps to be compared and contrasted with are listed below:

For the **Morristown, NJ** 7.5' quadrangle, GRE staff will use the following maps:

- (2801) Volkert, Richard A., 1988, Provisional Geologic Map of the Proterozoic Rocks of the Morristown Quadrangle, New Jersey, New Jersey Geological Survey, Geologic Map Series GMS 88-4, 1:24000 scale
- (74754) Stanford, S. D., 2006, Surficial geology of the Morristown quadrangle, Essex and Morris counties, New Jersey, New Jersey Geological Survey, Open-file Map OFM 67, 1:24000 scale, <http://www.state.nj.us/dep/njgs/pricelst/ofmap/ofm67.pdf>

For the **Mendham** 7.5' quadrangle, GRE staff will use the following maps:

- (2800) Volkert, Richard A., 1988, Geologic Map of the Mendham Quadrangle, Morris County, New Jersey, New Jersey Geological Survey, Geologic Map Series GMS 88-3, 1:24000 scale, <http://www.state.nj.us/dep/njgs/pricelst/gmseries/gms88-3.pdf>

For the **Chatham, NJ** 7.5' quadrangle, GRE staff will use the following maps:

- (73985) Monteverde, D.H. and Volkert, R.A., 2005, Bedrock geologic map of the Chatham quadrangle, Morris, Somerset, and Union counties, New Jersey, New Jersey Geological Survey, Geologic Map Series 04-2, 1:24000 scale, <http://www.state.nj.us/dep/njgs/pricelst/gmseries/gms04-2.pdf>

- (74986) Stanford, S. D., 2007, Surficial geology of the Chatham quadrangle, Morris, Union, and Somerset counties, New Jersey, New Jersey Geological Survey, Open-file Map OFM 69, 1:24000 scale, <http://www.nj.gov/dep/njgs/pricelst/ofmap/ofm69.pdf>

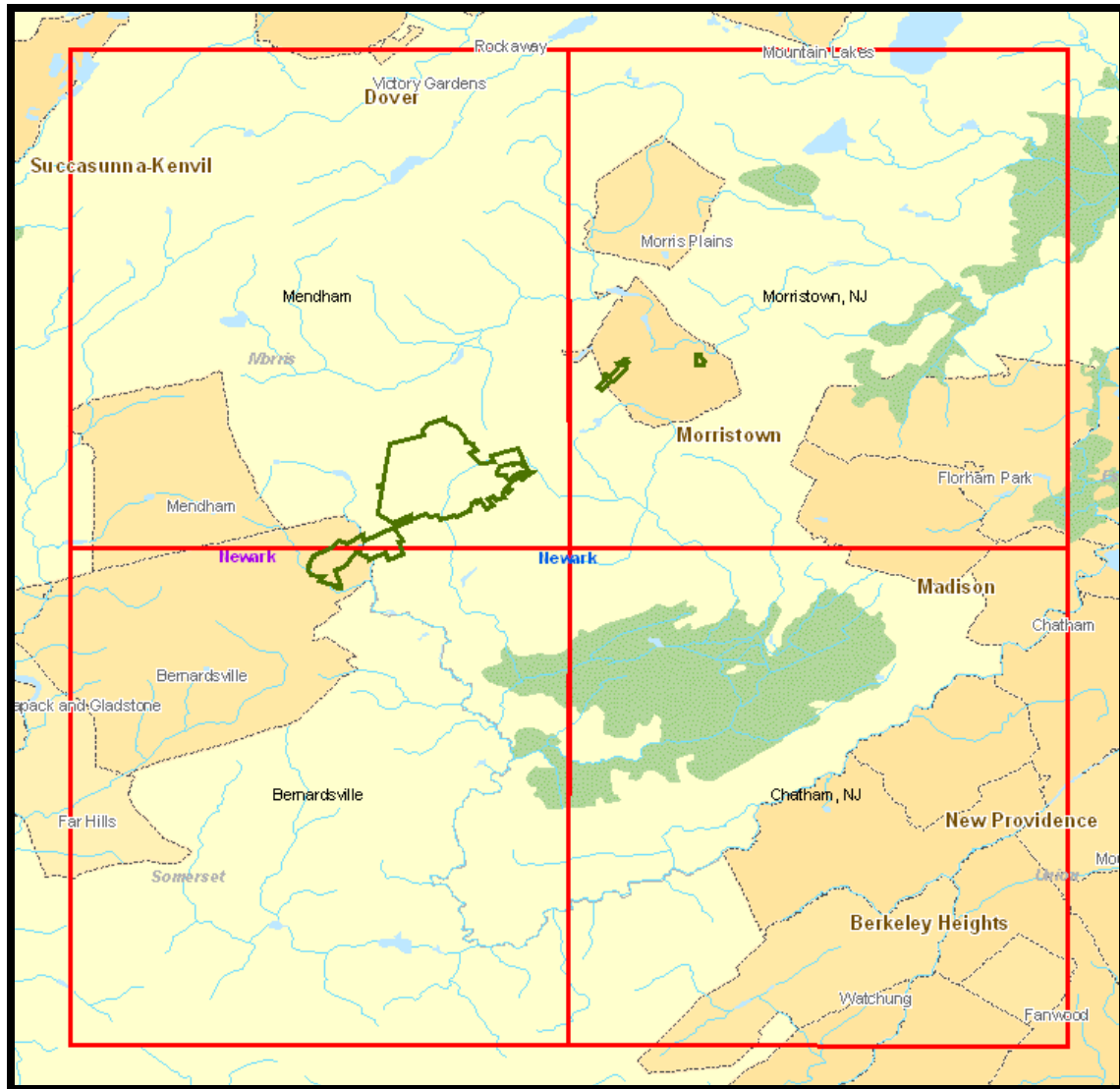


Figure 1. Quadrangles of interest for Morristown National Historical Park. The figure shows USGS 7.5' quadrangles (red outline), 30' x 60' sheet (blue outline, blue font labels), and 1° x 2° sheets (purple outline, purple font labels). The green outlines represent park boundaries.

Additional items of interest pertaining to geologic mapping from the scoping

The national historical park has some interest in groundwater flow maps, historic mine feature maps, interpretive maps connecting geology and history, and drill hole information for the Mesozoic basin southeast of the park. Landslide area maps would be helpful for park resource management.

Geologic Resource Management Issues

The scoping session for Morristown National Historical Park provided the opportunity to develop a list of geologic features and processes, which will be further discussed in the final GRE report.

During the meeting, participants prioritized the most significant geologic issues as follows:

- (1) Fluvial issues
- (2) Mass wasting
- (3) Impoundments and pond features
- (4) Seismicity

Fluvial Issues

Morristown National Historical Park sits on large floodplain areas of the Passaic River (a wild trout stream). Seasonal flooding along this waterway poses a minor threat to park infrastructure including trails and walkways, roads, and other visitor use areas. High water events have washed away sections of an unofficial social trail to a popular swimming and fishing area near a large rock. This area was once a water quality monitoring station, but the station was relocated and now the publicly used trail is unsafe. When flood surges undermine large trees by washing away stabilizing regolith from their roots, ensuing collapse of the tree poses visitor safety concerns.

Morristown National Historical Park contains the headwaters of several local streams that are part of the Great Swamp watershed. The most pristine among these streams is Primrose Brook. Park resource management is concerned about increased erosion and channel morphology changes along this brook particularly how increased sedimentation may affect water quality downstream.

Overpopulations in herbivorous species such as deer have stripped the understory vegetation from the landscape at Morristown; this in turn increases surface runoff and erosion causing increased sedimentation in the area's waterways.

Mass Wasting

The steep landscape characteristic of Morristown National Historical Park is prone to mass wasting events such as landslides, slumps, minor rockfall, and slope creep. Gravity, frost heave, root wedging, and undercutting erosion are primary causes of natural slope instability. Features such as dipping geologic units, undercut bedrock, and natural groundwater seeps create unstable settings on steep slopes. Human activities such as landscaping, road construction, and facilities development may lead to new mass wasting and reactivation of old landslide features. Developers may cut into the toe of a slope or load the top of a slope. Diverting water into certain areas may lubricate slopes.

In the surrounding vicinity, old slide scars on slopes suggest major slope failure is possible within park boundaries. At present, slope creep is the dominant mass wasting process at Morristown. Active erosion at the toe of some colluvial apron slopes at the park may be due to water flowing from local springs. Park resource management is interested in determining the vulnerability of a given slope to failure. Information about the depth of unconsolidated regolith and weathered bedrock (thick, weathered saprolite develops on gneissic bedrock locally) is critical to this goal. Cores from mid-1990s drilling in the area for monitoring wells may contain information on the depth of unconsolidated material on park slopes.

Erosion and slope processes may expose and wash away cultural resources such as Revolutionary War artifacts. Geologic weathering is muting subtle features such as depressions cut into slopes for soldier huts. High-resolution LIDAR surveys may help park management determine subtle depressions on park slopes to target for archaeological excavation efforts.

Impoundments and Pond Features

Proterozoic gneisses and granites underlying the Highlands area are generally not productive aquifers unless they are highly fractured or weathered. For this reason, groundwater is relatively scarce. In the early 1900s, an aqueduct was constructed in the park area to move water to nearby communities. Two impounded small ponds (approximately 0.5 acres in size) were within park boundaries on small streams. The park removed one and the remaining pond (Catswamp Pond) is less than 2 to 3 m (7-9 ft) deep behind a 1.5 m (5 ft) high mud and soil berm. Other water-control features include pipes along the east branch of Primrose Brook. This pipe frequently clogs and park resource management is concerned over tree roots and erosion compromising the pipe and berm structures.

Seismicity

Large earthquakes are not widely associated with the Morristown area, but small earthquake events are occurring along local faults including a small cross fault in the park area. The large, regional Ramapo Fault (bordering the Mesozoic basin to the southeast) has the potential to be seismically active in a normal or strike-slip sense. Reactivation of such border faults is a concern along the east coast of the United States. Earthquakes take up tectonic stresses on basement structures deep beneath the earth's surface. The U.S. Geological Survey maintains an earthquake monitoring website: <http://earthquake.usgs.gov/eqcenter/recenteqsus/>. Lamont Dougherty (Columbia University, contact: Nick Radcliff) has the nearest seismic station.

Features and Processes

Geology and History Connections

The geology of Morristown has direct connections with its historical significance. During the Revolutionary War, the strategic importance of Morristown was obvious to George Washington. Ten thousand of his soldiers camped here in 1,200 huts. Streams and springs provided ample, clean drinking water. The nearby Watchung Mountains protected Morristown from invasion. Fort Nonsense sits atop the high ridge, Kemble Mountain. The vantage point of this fort was vital to observe any potential British threat. The British had headquarters on Staten Island.

Historic mica mines are along the banks of the western branch of Primrose Brook. These 19th century mines dug into fissure veins for mica sheets used as windows in stoves and furnaces and in lanterns. Renewed interest in mica as a natural resource followed World War II when the electronics industry accelerated. Other economic resources in the area include graphite iron and limestone. None of these types of mines exist within the park. An enigmatic 30x30x1.5 m (100x100x5 ft) excavation may date to colonial prospecting efforts. Other smaller pits called "dog holes" are remnants of early prospecting in the park area.

The goal of Morristown National Historical Park is to preserve and protect the historic context of the area. Ideally, the landscape would represent the condition during the late 1770s when the

Continental Army wintered there. The park is considering reforesting some areas to reflect this landscape.

Glacial and Periglacial Features

During the Pleistocene Epoch, more than 10,000 years ago, glacial ice sheets intermittently descended from the north over the Morristown area, covering the landscape. The last glacial maximum, called the Wisconsinan advance, did not reach as far south as Morristown. Earlier glacial advances (as much as 1-2 million years ago) left visible remnant deposits and scars on the landscape at Morristown. Glaciers are effective agents of erosion, beveling hills and other topographic highs while transporting vast amounts of sediments picked up en route. When the glacial ice melts and retreats, these sediments remain and may cover the underlying landscape. If glacial retreat is rapid, the sediments once entrained in the glacial ice are relatively unsorted and contain fragments of various sizes ranging from the smallest clay to boulders. Outwash streams typically accompany glacial melting by draining downslope away from the melting ice front. These sediment choked streams leave sorted channel, delta, and floodplain deposits. Once the glacial ice is gone, the stark landscape is devoid of any stabilizing vegetation. Strong winds often collect dust and silt sized particles, transporting them on currents to create loess deposits.

Because of the long duration of time since the last glacial advance over the Morristown area, very little glacial till and outwash deposits remain on the landscape. Some rock rubble and colluvial boulder fields formed during periglacial (colder and drier) conditions throughout the Pleistocene ice ages. Frost wedging and solifluction (a type of mass wasting wherein water-saturated sediment slides downslope over impermeable frozen ground) during these periglacial conditions accelerated mechanical weathering on local slopes. Often accompanying glacial melt and retreat are large glacial lakes, forming at the front of the glacier and behind impoundments downstream. One such lake, Glacial Lake Passaic, collected thick lacustrine deposits which underlie the Great Swamp National Wildlife Refuge. This lake may have extended as far up as the Primrose Brook drainage.

Recommendations

- (1) Create an interpretive geologic map detailing how the geology controls the topography and impacts the availability of natural resources which were both significant factors in the history of the Morristown area.
- (2) Obtain core logs from groundwater quality monitoring wells to determine depth of unconsolidated regolith and weathered saprolite atop bedrock on park slopes. Use this information in conjunction with seismic potential to perform slope vulnerability assessments.
- (3) Attempt to obtain high-resolution LIDAR surveys of the park's slopes to locate target areas for archaeological investigations.
- (4) Develop an interpretive program highlighting the evolution of the landscape and local mining activity.

Action Items

- (1) GRD will obtain GRAS format digital geologic map coverage for the park from Rutgers.
- (2) GRE will produce digital geologic map for the national historical park (see above geologic mapping section).
- (3) GRE report author will locate mine and collapse/subsidence information for the park area.

- (4) GRE report author will investigate 15,000 ft of continuous core drilled in the Mesozoic basin (contact: Ken Miller at Rutgers).
- (5) GRE report author will consult NJGS website for ancillary geologic reports and regular informational circulars: <http://www.state.nj.us/dep/njgs/>.
- (6) GRE team will contact Deanna Greco (NPS-GRD) regarding a disturbed lands survey.
- (7) GRE report author will obtain geologic report and interpretive geologic map from NRBib.

References

www.nps.gov/morr (accessed July 23, 2007)

www.topozone.com (accessed July 24, 2007)

<http://www.state.nj.us/dep/njgs/> (accessed July 26, 2007)

Table 1. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Connors, Tim	NPS – GRD	Geologist	303-969-2093	Tim_Connors@nps.gov
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Thornberry-Ehrlich, Trista	Colorado State University	Geologist-Report Writer	757-416-5928	tthorn@cnr.colostate.edu
Wall, Suzanne	Andover Geologic Consulting	Geologist	978-688-3654	andovergeologic@comcast.net
Wise, Don	University of Massachusetts, Amherst	Geologist	413-253-5342	dwise@geo.umass.edu
Witte, Ron	New Jersey Geological Survey	Geologist	609-292-2576	Ron.witte@dep.state.nj.us

Table 2. GRE Mapping Plan for Morristown National Historical Park

Covered Quadrangles	GMAP ¹ ID	Reference	GRE appraisal	GRE Action	Scale
Chatham NJ	74986	Stanford, S. D., 2007, Surficial geology of the Chatham quadrangle, Morris, Union, and Somerset counties, New Jersey, New Jersey Geological Survey, Open-file Map OFM 69, 1:24000 scale http://www.nj.gov/dep/njgs/pricelst/ofmap/ofm69.pdf	2008-0707: downloaded PDF; needs georeferenced. No GIS files on NJGS website; need to acquire them from NJGS if possible	Compare / contrast to digital statewide coverages; use best data	24000
Chatham, NJ	73985	Monteverde, D.H. and Volkert, R.A., 2005, Bedrock geologic map of the Chatham quadrangle, Morris, Somerset, and Union counties, New Jersey, New Jersey Geological Survey, Geologic Map Series 04-2 http://www.state.nj.us/dep/njgs/pricelst/gmseries/gms04-2.pdf	2008-0707: MORR non-intersecting QOI; not known to be digital-GIS based; have PDF; No GIS files on NJGS website; need to acquire them from NJGS if possible	Compare / contrast to digital statewide coverages; use best data	24000
Mendham	2800	Volkert, Richard A., 1988, Geologic Map of the Mendham Quadrangle, Morris County, New Jersey, New Jersey Geological Survey, Geologic Map Series GMS 88-3 http://www.state.nj.us/dep/njgs/pricelst/gmseries/gms88-3.pdf	2008-0707: MORR intersecting QOI; not known to be digital-GIS based; have PDF; is this the best available map? Ron Witte called it a "bedrock" map	Compare / contrast to digital statewide coverages; use best data	24000
Morristown, NJ	2801	Volkert, Richard A., 1988, Provisional Geologic Map of the Proterozoic Rocks of the Morristown Quadrangle, New Jersey, New Jersey Geological Survey, Geologic Map Series GMS 88-4 http://www.state.nj.us/dep/njgs/pricelst/gmseries/gms88-4.pdf	2007-0703: MORR intersecting QOI; not known to be digital-GIS based; have PDF; is this the best available map? Looks like GMAP 74754 should supercede it for surficial	Compare / contrast to digital statewide coverages; use best data	24000
Morristown, NJ	74754	Stanford, S. D., 2006, Surficial geology of the Morristown quadrangle, Essex and Morris counties, New Jersey, New Jersey Geological Survey, Open-file Map OFM 67 http://www.state.nj.us/dep/njgs/pricelst/ofmap/ofm67.pdf	2008-0707: MORR intersecting QOI; not known to be digital-GIS based; have PDF; is this the best available map? Looks like it supercedes surficial of GMAP 2801. No GIS files on NJGS website; need to acquire them from NJGS if possible	Compare / contrast to digital statewide coverages; use best data	24000
Morristown Mendham Chatham Bernardsville	7285	Drake, Avery A. Jr., Volkert, Richard, A., Monteverde, Donald H., Herman, Gregory C., Houghton, Hugh F., Parker, Ronald A., and Dalton, Richard F., 1999, Digital Bedrock Geology for New Jersey 1:100,000 Scale, New Jersey Geological Survey, DGS04-6 http://www.state.nj.us/dep/njgs/geodata/dgs04-6.htm	2006-0502: NJGS published digital compilation of NJ north bedrock (GMAP 1570) & NJ south-central bedrock (GMAP 2350); needs converted for NPS areas of interest (DEWA, UPDE) and then supercedes both GMAP 1570 & 2350	Convert if no superceding data at 24,000 scale	100000
Morristown	74858	Pristas, R. P., 2007, Surficial geology of New Jersey,	2008-0220: should supercede GMAP 7314 because this is	Convert if no	100000

Covered Quadrangles	GMAP ¹ ID	Reference	GRE appraisal	GRE Action	Scale
Mendham Chatham Bernardsville		New Jersey Geological Survey, Digital Geodata Series DGS 07-2, 1:100000 scale http://www.state.nj.us/dep/njgs/geodata/dgs07-2.htm	published and available on web	superceding data at 24,000 scale	

¹GMAP numbers are unique identification codes used in the GRE database.