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SURFICIAL GEOLOGIC MAP OF THE FLEMINGTON QUADRANGLE
HUNTERDON AND SOMERSET COUNTIES, NEW JERSEY
OPEN-FILE MAP SERIES OFM 138
pamphlet containing table 1 accompanies map

INTRODUCTION

Surficial materials in the Flemington quadrangle include 1) weathered bedrock of Quaternary and possibly Neogene age derived from Jurassic diabase, Triassic-Jurassic shale, sandstone, and mudstone, Cambrian and Ordovician dolomite and quartzite, and Middle Proterozoic gneiss and granite; 2) glacial till and outwash of early Pleistocene (older than 788,000 years or 788 ka) age; 3) stony colluvium of Quaternary age chiefly derived from weathered diabase and gneiss; 4) fluvial deposits in the South Branch of the Raritan River valley of middle and late Pleistocene age; 5) loess of late Pleistocene age; and 6) alluvium of late Pleistocene and Holocene age. The extent of these surficial deposits is shown on the map and is based on their physical characteristics, readily distinguishable boundaries, and location on the landscape.

The quadrangle's physiography reflects a composite landscape shaped largely by fluvial erosion caused by lowering of global sea level due to the growth of the Antarctic ice sheet during the middle and late Miocene and by growth of ice sheets in the northern hemisphere in the early Pleistocene. Later, during the middle and late Pleistocene, the land was further shaped by multiple periods of periglacial weathering and erosion linked to episodic cold climate and the growth and decay of North American ice sheets. Based on the marine isotope record, Braun (1989) estimated that there might have been as many as ten Pleistocene glaciations of a magnitude sufficient to introduce a periglacial climate to the New Jersey region. During these periods, cold temperatures and frozen ground enhanced the break-up and fragmentation of rock and the downslope transport of surficial sediment. Additionally, the rate of movement of slope materials by mass wasting also increased due to a change to a shallow-rooted vegetative cover. Colluvium, the main product of periglacial mass wasting, was shed off uplands onto the lower areas of hillslopes, the floors of narrow valleys, and into the heads of first-order drainage basins. In contrast, during warm interglacials, the relative rate of chemical weathering increased and an extensive cover of deeper-rooted vegetation helped reduce the rate of mass wasting. During these periods, bedrock was weathered to form saprolite and decomposition residuum and colluvial valley-fills were eroded by fluvial action.

The topographic position, degree of preservation, and difference in weathering characteristics of glacial drift in New Jersey show that continental ice sheets reached the state at least three times (Salisbury, 1902; Stone and others, 2002). Only the oldest of these, the pre-Illinoian glaciation, reached the Flemington quadrangle (fig. 1). The limit of this glaciation trends northwestward from Whitehouse Station to Cushetunk Mountain where it wraps around the mountain's northern side. From here, it continues southwestward and exits the quadrangle about one mile north of Stanton Station. Near Whitehouse Station, the limit is represented by a low ridge of pre-Illinoian till, possibly the remnant of the pre-Illinoian terminal moraine. Elsewhere, the limit is defined by the most southerly occurrence of quartzite, conglomerate, gneiss, diabase, and chert erratics. Most evidence of pre-Illinoian glaciation has been removed by weathering and erosion. A few patches of pre-Illinoian till (Qpt) and outwash (Qps), and scattered erratics, are all that remain from this glaciation.

PHYSIOGRAPHY AND BEDROCK GEOLOGY

The Flemington quadrangle is in north-central New Jersey (fig. 1) and includes a mix of suburban and rural lands. Patchwork wood lots and cultivated fields cover large areas with larger forested areas covering Round and Cushetunk Mountains. The highest point is on Cushetunk Mountain at 834 feet above sea level and the lowest point lies on the South Branch of the Raritan River (hereafter, SBRR) where it flows out of the quadrangle in the southeast corner near Woodfern, at approximately 75 feet above sea level.

The SBRR is the largest stream in the quadrangle. It and its many tributaries, including Prescott Brook, Pleasant Run, and Holland Brook, drain more than 95 percent of the quadrangle. In the far northeastern corner near Whitehouse, the South Branch of Rockaway Creek flows eastward to the Lamington River. All these streams lie in the Raritan River drainage basin.

A low plateau covers most of the quadrangle (fig. 2). It is a somewhat undulate, highly dissected plain, underlain by faulted and slightly folded sedimentary rocks of the Passaic Formation. The surface of the plain is at an elevation of 200 to 220 feet above sea level. The plain grades southeastward to the Pensauken Formation, a Pliocene fluvial deposit laid down along New Jersey's inner coastal plain (Stanford and others, 2001), suggesting that it was formed in the Pliocene. This low area is bounded to the west by a topographic escarpment that marks the change to a higher plateau, located mostly in the Pittstown quadrangle (fig. 2), that rises in elevation to 500 to 600 feet. This plateau, known as the Hunterdon Plateau, is underlain by conglomeratic sandstone, sandstone, shale, and siltstone of the Stockton and Passaic Formations and argillite of the Lockatong Formation (Herman and others, 1992). The elevation change across the scarp is about 200 to 300 feet, forming a pronounced rise in the land. In part, the scarp is formed along the contact between the easily eroded mudstones of the Passaic Formation and the tough argillites of the Lockatong Formation. The scarp is also in proximity to the Flemington Fault and its many splays (Herman and others, 1992), where the down thrown side of the fault block underlies areas of lower elevation. The Hunterdon Plateau is a low relief erosional surface that may be the product of a long period of erosion between the Oligocene and the middle Miocene. During this time, the long-term trend of relative sea level along the eastern seaboard of North America was slightly rising to stable, inhibiting river incision and favoring planation (Stanford and others, 2001).

Cushetunk Mountain and Round Mountain, both underlain by diabase of Jurassic age, form pronounced uplands in the northern part of the quadrangle. The upland on the west side of Round Valley is underlain by Proterozoic gneiss, which is bordered to the west by a belt of Paleozoic quartzite and carbonate rock. These uplands are the result of deep erosion of the weak shale bedrock within Round Valley and surrounding Cushetunk and Round mountains. Rock outcrops are few on the uplands because in many places the rock surface is covered by thick saprolite, fragmentation rubble, and colluvium. Uplands west of the SBRR underlain by sandstone are similar but have slightly lower relief. The lowlands east and south of these uplands are underlain by Mesozoic mudstone and shale. Low elongate ridges (shown as dashed red lines on the map) mark slightly more resistant beds. Ridge orientation reflects the overall northeast-southwest strike and westward dip of the strata, modified by gentle folds in places.

PREVIOUS INVESTIGATIONS

Cook (1880) discussed the geology of New Jersey's glacial deposits in an Annual Report of the State Geologist. He included detailed observations on the terminal moraine, recessional moraines, distribution and kinds of drift, and evidence of glacial lakes. Deposits of "older" weathered drift were discussed by Cook (1880) who noted the distribution of quartzose boulders and scattered patches of thin gravely drift in western New Jersey. Most of this material was thought to be "modified glacial drift", possibly deposited by meltwater and reworked later by weathering and fluvial erosion. On greater inspection (Salisbury, 1894) this "modified glacial drift" was determined to be of glacial origin and called extra-morainic drift because of its distribution south of the terminal moraine.

Salisbury (1902) detailed the glacial geology of New Jersey region by region. The terminal moraine and all surficial deposits north of it were interpreted to be products of a single glaciation of Wisconsinan age. South of the terminal moraine Salisbury (1902, Plate XXVIII) shows two deposits of extra-morainic glacial drift. The first, forming a narrow belt just outside the terminal moraine, consisted of glacial drift of late glacial age mixed with material that was older than the terminal moraine. Salisbury indicated that the drift was deposited during a temporary advance of ice beyond the terminal moraine or was carried out by running water. The second body of extra-morainic drift is much older than the terminal moraine based on its deep weathering and patchy distribution. It lies as much as twenty miles beyond the terminal moraine. Salisbury (1902) assigned a Kansan age to the older drift because its deeply weathered appearance suggested it was the product of a much older glaciation than the Wisconsinan. Chamberlin and Salisbury (1906) correlated the oldest drift with the sub-Aftonian glacial stage of Iowa, using the term "Jerseyan" as an equivalent stage for the older glacial deposits in Pennsylvania and New Jersey. Bayley and others (1914) divided the extra-morainic drift into "early glacial drift" that was largely till deposited during the Jerseyan stage and "extra-morainic drift" that consisted of a mix of Wisconsinan and early drift.

Salisbury (1902) also discussed the character and development of terraces in the SBRR valley. The most notable are remnants of an extensive terrace that lies about 35 feet above the modern river. The "clayey gravel" is moderately weathered, largely consisting of gneiss clasts with secondary quartzite, sandstone, and shale.

PREGLACIAL DRAINAGE

The Delaware and Raritan Rivers were probably well established in their current courses before the Pleistocene. Transverse gaps in the New Jersey Highlands are possibly relicts of an earlier Raritan River drainage system that flowed in a southeasterly direction during the early to middle Miocene (Stanford, 1997; Witte, 1997). In the Flemington quadrangle, the Raritan River and its tributaries incised and eroded in the middle to late Miocene, forming the general outlines of the present valleys and lowlands (Stanford and others, 2001). To the north and west of the Flemington quadrangle during this period, the Delaware River, through headward erosion, had greatly enlarged its drainage area by extending its tributaries upvalley along belts of weak bedrock, and capturing parts of the Raritan River drainage (Witte, 1997).

In response to the overall lowering of sea level during the early Pleistocene, drainage has further evolved by additional incision, which along the Raritan River and its larger tributaries has resulted in the formation of a narrow, inset valley between 60 to 100 feet lower than the general level of the older 200-foot erosional surface of the shale lowland. Extensive headward erosion by first and second-order streams has resulted in the dissection of this older surface. The location of Illinoian glaciofluvial deposits within the incised inner valley along the Delaware River (Stone and others, 2002) and periglacial fluvial deposits of likely Illinoian age (unit Qtu) within the inner SBRR valley in the Flemington quadrangle shows that the river valleys in the study area had been lowered or nearly lowered to their present levels by the time of the Illinoian glaciation.

PRE-ILLINOIAN GLACIATION

New Jersey's oldest glaciation is represented by the Port Murray Formation (Stone and others, 2002). The formation consists of till, till-stone lag, and meltwater deposits. The deposits are deeply weathered, thin and patchy, and lie on weathered bedrock. In lowlands, they are generally preserved only on flat interfluves above the incised inner valleys described above. On uplands they occur only on a few saddles and flats where they are protected from erosion. In places, these older deposits occur beneath colluvium on footslopes. The till and meltwater deposits are typically less than 15 feet thick. Constructional topography is not preserved, although it is possible that the till ridge near Dreahook is in part from original deposition. In the Flemington quadrangle, the till (unit Qpt) occurs on interfluves between 60 and 80 feet above adjacent valley floors. Possible meltwater deposits along the SBRR near Woodfern (unit Qps) are on rock-cut benches between 30 and 40 feet above the valley floor. Similar deposits upstream in the Pittstown quadrangle are 60 to 80 feet above the valley floor (Witte and Stanford, 2018), and it is possible that the Woodfern deposits are somewhat younger nonglacial gravels. Intense weathering has made original characteristics of the till and meltwater sediments difficult to discern. However, the presence of erratics from outside the drainage basin and the presence of both matrix-supported diamictons, which contain clasts up to boulder size, and separate deposits of clast-supported gravels, are strong evidence of glacial origin, and of both till and meltwater facies.

The southern limit of the glaciation is based on the most southerly occurrence of thin, deeply weathered patchy till, till-stone lag, and erratics. In most places it is poorly defined because erratics are sparse.

The age of this glaciation is uncertain. Silty clay within a pre-Illinoian fluvial deposit in the Pohatcong Creek valley near Kennedys (fig. 1) is magnetically reversed, indicating an early Pleistocene age (>788 ka) (Ridge, 2004). The Port Murray Formation is correlative with the oldest glacial deposits in eastern Pennsylvania, which are older than 788 ka based on the reversed magnetic polarity of lake-bottom deposits (Braun, 2004). Braun (2004) favors a pre-Illinoian G (850 ka; Richmond and Fullerton, 1986) age for these deposits whereas Stanford (1997) favors a pre-Illinoian K (2.1 Ma; Richmond and Fullerton, 1986) age based on pollen taxa associated with the pre-Illinoian deposits, and the depth of fluvial incision into bedrock after the pre-Illinoian glaciation.

The position of the pre-Illinoian margin around the north side of Cushetunk Mountain, and high-standing weathered gravels near Lebanon, just north of the map area in the Califon quadrangle, indicate that a small glacial lake in the headwaters of the South Branch of Rockaway Creek was controlled by a spillway southward into the Prescott Brook valley in the Flemington quadrangle, beneath what is now Round Valley Reservoir (Stanford, 2016). However, no glacial deposits have been observed in the Prescott Brook valley.

ILLINOIAN GLACIATION

When Illinoian ice was at its terminal position about 25 miles upstream of Flemington near Flanders, New Jersey (fig. 1), meltwater deposited a small outwash plain in the headwaters of the SBRR well north of the Flemington quadrangle (Drakes Brook outwash of Stone and others, 2002). Some of this outwash may have been carried into the Flemington quadrangle and laid down in the upper terrace deposit (unit Qtu). However, the Drakes Brook outwash extends only a short distance (about one mile) south of the terminal position, and no outwash plain or gravel terrace is present along the Raritan downstream to the High Bridge area, 15 miles from the outwash plain. This lack of continuity suggests that the upper terrace deposits are mostly nonglacial. Weathering of gneiss clasts in the upper terrace deposits is like that in Illinoian glacial deposits, suggesting that they are of similar age. This age similarity suggests that the upper terrace may be of periglacial origin, when increased erosion of hillslopes delivered more gravel to the main SBRR valley. Today, erosional remnants form a discontinuous terrace that lies about 25 to 30 feet above the modern river. The deposit consists of moderately weathered gravel with a strong local lithologic component. Because the age of the terrace is not certain, it may include deposits of early and middle Wisconsinan age, when periglacial conditions may also have been present. It is older than the late Wisconsinan glacial maximum (25 ka) because downstream along the Raritan in the Manville area (fig. 1), the upper terrace is inset by outwash gravels of late Wisconsinan age (Millstone terrace deposit and Plainfield outwash of Stone and others, 2002).

LATE WISCONSINAN GLACIATION

The late Wisconsinan glacial terminus is north of the Raritan basin in western New Jersey (fig. 1), so the SBRR in the Flemington quadrangle did not receive any outwash during the late Wisconsinan glaciation. Only clean lake water outflow from glacial Budd Lake flowed into the SBRR valley during the late Wisconsinan maximum. A low terrace (Qtl, fig. 3) containing unweathered clasts that lies 10 to 15 feet above the modern river may represent alluvial aggradation during this time; the terrace largely built up by periglacial aggradation. Downstream, this terrace grades to the late Wisconsinan Plainfield outwash plain and the Millstone terrace in the Manville area (fig. 1), indicating a late Wisconsinan age (Stone and others, 2002).

SURFICIAL DEPOSITS

Surficial materials in the map area include alluvium, colluvium, wind-blown silt, pre-Illinoian glacial deposits, and weathered bedrock. They are defined by their lithic characteristics (composition, texture, color, and structure), and bounding discontinuities.

Non-Glacial Deposits

Stream Deposits (alluvium, stream-terrace deposits, and alluvial-fan deposits)

Alluvium (Qal) is chiefly of Holocene age and it includes both channel (sand and gravel) and overbank (sand and silt) sediment laid down by streams in sheet-like deposits on the floors of modern valleys. Stream-terrace deposits (Qst) are of late Pleistocene and Holocene age and include both channel and overbank sediment, and they form terraces that lie 5 to 10 feet above the modern flood plain along Walnut and Holland Brooks and Pleasant Run. Alluvial-fan deposits (Qaf) are scattered throughout the study area. They lie at the base of hill slopes where streams emerge from adjacent uplands, and their surfaces are entrenched by the modern drainage. These erosional channels show that the fans are not presently forming. In the SBRR and Rockaway Creek valleys, upper terrace deposits (Qtu) form terraces that lie 20 to 30 feet above the modern flood plain. They are predominantly periglacial deposits of Illinoian and early and middle Wisconsinan age. In the SBRR, lower terrace deposits (Qtl, fig. 3) form terraces that lie 10 to 15 feet above the modern flood plain. They are periglacial deposits of late Wisconsinan age.

Wind-blown Silt

Thin deposits of wind-blown silt (Qel, fig. 4) overlying weathered shale and siltstone in the southeastern part of the quadrangle were laid down by winds blowing from the west and northwest eroding silt from terraces in the SBRR valley. This material, based on its widespread distribution on both gentle slopes and flat uplands, and lightly weathered appearance, was deposited under periglacial conditions primarily during the late Wisconsinan and possibly during the early and middle Wisconsinan.

Hillslope Sediment

Hillslope deposits include colluvium (Qcd, Qcg, and Qcs) and a mix of alluvium and colluvium (Qcal). These deposits are derived from underlying and upslope materials transported downslope by soil creep, solifluction, earth and debris flows, and rock falls. Colluvium typically forms a monolithic matrix-supported diamicton that mantles most slopes and forms thick aprons of material on their lower parts. It is mapped only where it is thick and continuous enough to form an apron-like deposit on footslopes. It also collects in small first-order drainage basins in upland areas. In places, colluvium includes thin beds and lenses of sorted, stratified sheet- and rill-wash sand and gravel. The most widespread and thickest deposits occur along the flanks of Cushetunk and Round Mountains where weathered diabase sheds thick stony aprons. Undifferentiated alluvium and colluvium (Qcal) consists of a mixture of diamict and sorted sand, gravel, and silt that has accumulated in thin sheets in narrow valleys (fig. 5) and the heads of first-order drainage basins. These deposits in places also include the toe slopes of small colluvial aprons.

Glacial Materials

Till

Till is a poorly sorted, deeply weathered, nonstratified to very poorly stratified mixture of clay- to boulder-sized material deposited directly by or from a glacier. Till in the study area is represented by the Port Murray Formation, till facies of Stone and others (2002). This till (Qpt) is highly weathered, has a clayey matrix, is oxidized and leached of carbonate material, lies on weathered bedrock, and is only found in topographic positions where it has been protected from erosion. Elsewhere, where erosion has occurred, glacial erratics may be found, the remnants of a once extensive till sheet. In the Flemington quadrangle, remnant deposits of Qpt and glacial erratics are found near Whitehouse Station, and in the far northwestern part of the quadrangle. North of the glacial limit (orange line on map), the pre-Illinoian till was formerly more extensive. Now in most places it has been eroded or is represented by sparse erratics that consist of gneiss, diabase, chert, and quartz-pebble conglomerate and quartzite. An exception is a low (40 feet) ridge of till in the Dreahook area that trends northwestward to the base of Cushetunk Mountain. Based on the absence of erratics south of the ridge and thickness of the till ridge (30 feet), it represents the terminal position of the pre-Illinoian ice sheet and may be its terminal moraine.

Deposits of Glacial Meltwater Streams

Possible meltwater deposits of pre-Illinoian age (Qps) are found in the downstream reach of the SBRR valley near Woodfern. These small remnants lie 30 to 40 feet above the modern river and consist of highly weathered fine cobble pebble gravel and pebbly sand. Their glacial origin is suggested by their proximity to the pre-Illinoian glacial border. However, as with other terrace deposits in the valley, a periglacial or nonglacial fluvial component cannot be ruled out.

Weathered Bedrock

Weathered bedrock consists of saprolite, decomposition and solution residuum, and rock rubble that formed on bedrock of Triassic-Jurassic, Cambro-Ordovician, and Proterozoic age. It was formed during the Pleistocene and perhaps through part of the Neogene during a long and complex history of weathering and erosion where the climate varied between cold conditions during glacial periods to temperate and subtropical conditions during preglacial and interglacial periods.

Weathered bedrock materials are divided into map units based on lithologic criteria. In many places, weathered bedrock is covered by thin deposits of colluvium. Bedrock outcrops sparsely in the quadrangle, mostly occurring along stream-cut banks, steam-channel beds, and along some steep slopes and ridge crests.

Weathered shale, mudstone, siltstone, and minor sandstone (Qws) consists chiefly of decomposition residuum (Richmond and others, 1991), and shale-chip or flagstone rubble. In places a dark reddish-brown clayey-silty nonstructured to structured saprolite may occur (fig. 5). Well records show that this material may be as much as 10 feet thick.

Weathered carbonate rock (Qwcb) occurs in the northwest corner of the quadrangle. It consists chiefly of solution residuum and karst-fill materials. Weathering extends deeply in the subsurface along fractures, joints and bedding planes. In many places, the weathered bedrock alternates in the subsurface with nonweathered bedrock. Bedrock outcrops are widely scattered, most are marked by subcrop consisting of irregularly shaped boulders along the crest of a ridge or on a hillslope. The bedrock surface is very irregular and deeply etched along joints and fractures. Solution basins (indicated by small red circular symbols on the map where observed on LiDAR imagery) occur in places and are the surface expression of solution cavities in the subsurface.

Weathered diabase (Qwd) consists chiefly of decomposition residuum. Bedrock outcrops are widely scattered, most are marked by subcrop consisting of irregularly shaped boulders along the crest of a ridge or on a hillslope (fig. 6). Two facies have been noted but were not mapped separately: 1) rubbly, clast-rich clayey silty sand diamict in areas of shallow diabase (ridge and hill tops, steep slopes) and 2) sandy clay-silt diamict in areas protected from erosion (topographic saddles, broad upland surfaces).

Weathered gneiss and foliated granite (Qwg) consist chiefly of saprolite, grus (which is angular coarse sand and fine gravel formed by disintegration of the rock) and rock rubble. Structured saprolite extends deeply into bedrock along joints, fractures and foliations. Grus and rock rubble generally form a surface cover of varying thickness. Mounds of irregularly spaced joint-block boulders denote areas of subcrop. The surface of most block boulders is granular and deeply etched.

DESCRIPTION OF MAP UNITS

Map units denote unconsolidated materials generally more than 3 feet thick. Colors are based on Munsell Color Company (1975) and were determined from naturally moist samples.

HOLOCENE AND LATE WISCONSINAN

af **ARTIFICIAL FILL** – Rock waste, gravel, sand, silt, and manufactured materials emplaced by man. As much as 25 feet thick. Not shown beneath roads and railroads where it is less than 10 feet thick.

Qal **ALLUVIUM** – Stratified, moderately- to poorly sorted sand, gravel, silt, and minor clay. Color of the sand and finer sediment varies from gray to dark gray, reddish-brown to brown, and yellowish brown. Gravel is chiefly flagstones and chips of red and gray shale, mudstone, and sandstone. In the SBRR and valleys that drain glaciated terrain, gravel includes pebbles and cobbles of gneiss, diabase, chert, quartzite, and conglomerate. In places may contain wood and fine organic material. As much as 20 feet thick. Includes planar- to cross-bedded gravel and sand in channel deposits; and cross-bedded, laminated, and massive fine sand, very fine sand, and silt in overlying overbank deposits.

Qst **STREAM-TERRACE DEPOSITS** – Weakly stratified, well- to moderately sorted, reddish-brown, brown, yellowish-brown, massive to thinly planar-bedded, and minor cross-bedded, fine to very fine sand, silt, and minor coarse sand, pebbles, and rare cobbles. Gravel consists of red and gray shale, mudstone, and sandstone and minor gray basalt (along Walnut Brook). As much as 5 feet thick. Forms terrace remnants that lie 5 to 10 feet above the modern flood plain.

WISCONSINAN

Qaf **ALLUVIAL-FAN DEPOSITS** – Stratified, moderately-to poorly sorted, brown to yellowish-brown, reddish brown, sand, gravel, and silt in fan-shaped deposits; as much as 20 feet thick. Includes massive to planar-bedded sand and gravel and minor cross-bedded channel-fill sand. Bedding dips as much as 30 degrees toward the trunk valley. Locally interlayered with unstratified, poorly sorted, sandy-silty to sandy gravelly diamicton interpreted to be of colluvial or mass flow origins. Fans form at the mouths of upland valleys, gullies, and ravines. Clasts are local in origin and are eroded from upvalley weathered bedrock and colluvial source materials.

Qcal **ALLUVIUM AND COLLUVIUM, UNDIFFERENTIATED** – Stratified, poorly to moderately sorted, reddish-brown, brown, yellowish-brown, and gray sand, silt and minor gravel; as much as 20 feet thick. Interlayered with or overlying, massive to weakly layered, poorly sorted sand, silt, and minor gravel.

Qel **EOLIAN DEPOSITS** – Massive, well-sorted, yellowish brown, strong brown to reddish yellow, slightly compact, slightly clayey silt, silt, and very fine sandy silt (fig. 4). As much as 6 feet thick, but mostly less than 2 feet thick. Forms extensive sheet deposits overlying weathered mudstone and siltstone on upland surfaces near the SBRR. Typically eroded off steeper slopes. Thickness highly variable over short distances.

Qtl **LOWER TERRACE DEPOSITS** – Stratified, well- to moderately-sorted, yellowish brown, grayish brown, to light reddish-brown sand, silt, and cobble to pebble gravel in the SBRR valley (fig. 3). Gravel consists of subrounded to well-rounded pebbles and cobbles of gneiss, granite, diabase, quartzite, conglomerate, sandstone, and chert, and flagstones and chips of red and gray shale and mudstone. Clasts are unweathered. Consists of massive to horizontally-bedded and imbricated coarse gravel and sand, and planar to tabular and trough cross-bedded, fine gravel and sand in bars, and channel-lag deposits with minor cross-bedded sand in channel-fill deposits. In places covered by thin overbank deposits of yellowish-brown to reddish-brown massive to faintly laminated clayey silt and very fine sand. Forms terrace remnants that lie 10 to 15 feet above the modern flood plain. As much as 30 feet thick. Equivalent to the Raritan lower terrace deposit of Stone and others (2002).

MIDDLE PLEISTOCENE TO HOLOCENE

Qcs **SHALE, SANDSTONE, AND MUDSTONE COLLUVIUM** – Silt, sandy silt, clayey silt, reddish-brown to yellowish-brown, with some to many subangular flagstones, chips, and pebbles of red and gray shale, mudstone, and minor sandstone. Poorly sorted, nonstratified to weakly stratified. The flat planes of flagstones and chips have strong slope-parallel alignment. As much as 20 feet thick.

Qcg **GNEISS COLLUVIUM** – Massive to crudely layered, slightly compact, poorly sorted yellowish-brown, dark yellowish-brown, brown, and strong brown silty sand and sandy silt, containing as much as 60 percent lightly to moderately weathered angular to subangular cobbles, pebbles, and boulders of gneiss and foliated granite; as much as 30 feet thick. Matrix consists of a varied mixture of quartz sand, weathered feldspar, mica, amphibole, heavy minerals, silt, and clay.

Qcd **DIABASE COLLUVIUM** – Clayey silt to clayey sandy silt, yellowish-brown to reddish-yellow, with some to many subrounded boulders and cobbles of diabase. Poorly sorted, nonstratified to weakly stratified. As much as 40 feet thick. Includes some areas of boulder lag formed by footslope groundwater seepage, with little or no accumulation of colluvium.

ILLINOIAN TO EARLY WISCONSINAN

Qtu **UPPER TERRACE DEPOSITS** – Stratified, well- to moderately-sorted, reddish-brown, brown, and gray sand, silt, and cobble and pebble gravel. Gravel consists of subrounded to well-rounded pebbles and cobbles of gneiss, granite, diabase, quartzite, conglomerate, sandstone, and chert, and flagstones and chips of red and gray shale and mudstone. Crystalline clasts have thin to thick weathering rinds, quartzite and sandstone clasts have thin weathering rinds and exhibit ferromanganese staining, and carbonate clasts are weathered to depths of at least 15 feet. Forms extensive terrace remnants in the SBRR and South Branch of Rockaway Creek valleys that lie 20 to 25 feet above the modern flood plain. In places underlies thin lower terrace deposits. Equivalent to the Raritan upper terrace deposit of Stone and others (2002).

PRE-ILLINOIAN

Qpt **TILL** – Deeply weathered, compact, massive to crudely layered reddish-yellow to strong-brown to yellowish-brown, or reddish-brown to weak-red sandy silt and clayey silt that typically contains 2 to 5 percent gravel; as much as 20 feet thick. Gravel consists of pebbles and cobbles of quartzite, gneiss, diabase, quartzose sandstone and siltstone, and chert, and a few boulders of quartzite, quartzite conglomerate, diabase, and gneiss. Gneiss and diabase clasts have thick weathering rinds or are completely decomposed; carbonate clasts are fully decomposed. Quartzite, sandstone, and chert pebbles and cobbles have pitted surfaces and thin weathering rinds. Matrix contains clay, quartz, weathered rock fragments, minor weathered mica, and few heavy minerals. Subvertical joints are poorly to moderately developed to depths exceeding 10 feet. Clasts and joints are commonly coated with red ferrous and black ferromanganese oxide. In many places, quartzite and quartzite conglomerate clasts and sparse chert clasts form a very thin stony lag on weathered rock. As much as 10 feet thick. Equivalent to the Port Murray Formation, till facies (Stone and others, 2002)

Qps **OUTWASH DEPOSITS** – Reddish yellow to strong brown sand and gravel. Clasts are subrounded to well-rounded quartzite, quartzose sandstone and siltstone, chert, conglomerate, and gneiss. Gneiss clasts are decomposed to depths exceeding 15 feet. Quartzite and chert clasts have thin (<0.1 inch) weathering rinds and are coated with a brown iron-manganese stain. Sandstone and quartzite clasts have pitted surfaces. Planar bedding with minor cross-stratification. Soils developed on these deposits form diamict sediments that may resemble pre-Illinoian till (Qpt). As much as 15 feet thick. Equivalent to the Port Murray Formation, stratified facies (Stone and others, 2002).

NEOGENE (?) TO QUATERNARY

Qwcb **WEATHERED BEDROCK DERIVED FROM DOLOMITE AND LIMESTONE** – Massive, compact light-red to red, reddish-yellow to strong-brown to yellowish-brown, or yellow, locally highly variegated, clay and silty-clay solution residuum of clay, quartz, and iron oxide; generally containing less than 5 percent chert, vein quartz and minor quartzite; thickness is highly variable, typically less than 15 feet, but locally as much as 100 feet. Locally includes thin colluvium as much as 5 feet thick on gentle hillslopes. Also may include sand, gravel, silt, and clay washed into sinkholes and solution cavities from overlying colluvial, alluvial, and glacial sediment. Weathered zone typically ends at an abrupt, very irregular contact with unweathered bedrock and extends deeply along joints and fractures.

Qws **WEATHERED BEDROCK DERIVED FROM SHALE, SILTSTONE AND SANDSTONE** – Massive to layered, noncompact to slightly compact reddish-brown silty clay or sandy silt decomposition residuum of clay, quartz, and rock fragments; and shale-chip gravel containing flat pebbles of slate, tabular pebbles of siltstone, and sandstone; as much as 30 feet thick but generally less than 10 feet thick. Locally includes thin shaly colluvium on hillslopes; as much as 10 feet thick. Weathered zone typically grades downward through a zone of fractured rock into underlying unweathered bedrock.

Qwg **WEATHERED BEDROCK DERIVED FROM GNEISS** – Massive to layered, noncompact to compact, brown, yellowish-brown, strong-brown, white, and red silty sand to clayey silt saprolite consisting of clay, quartz, minor mica and heavy minerals; and sandy, blocky rock rubble. As much as 100 feet thick. Includes thin stony and blocky colluvium on hillslopes, and bouldery to cobbly mantle of angular to subangular gneiss and granite on very gentle hillslopes; as much as 10 feet thick. Weathered zone grades downward through a bouldery zone of joint blocks into saprolite and then into underlying unweathered bedrock, and extends deeply along joints, fractures, and bedrock layers. Joint blocks typically have thick weathering rinds.

Qwd **WEATHERED BEDROCK DERIVED FROM DIABASE** – Massive, noncompact to compact brown to olive brown, yellowish brown sandy clayey silt to clayey sand decomposition residuum with some to many lightly to highly weathered, angular to subangular diabase pebbles, cobbles and boulders. As much as 20 feet thick. Includes thin stony and blocky colluvium on hillslopes, and bouldery to cobbly mantle of angular to subangular diabase clasts. In places, weathered zone grades downward through a bouldery zone of joint blocks into underlying unweathered bedrock, and extends deeply along joints, and fractures. Joint blocks typically have thick weathering rinds.

PRE-CENOZOIC

r **Bedrock** – Outcrop, subcrop, and minor regolith. In places includes extensive rock waste on steep slopes.

EXPLANATION OF MAP SYMBOLS

Contact - Contacts of Qal, Qtl, Qtu, Qaf, Qst, and Qcal are well-defined by landforms and are mapped from 1:12,000 stereo airphotos, LiDAR imagery, and field observations. Contacts of other units are gradational, feather-edged, or approximately located.

Bedrock ridge - Low ridge or scarp parallel to strike of bedrock. Mapped from 1:12,000 stereo airphotos and LiDAR imagery.

G Erratic - Letter denotes lithology, C = chert, Q = quartzite, and D = diabase.

80 Well with log in table 1.

figure 4 Location of photograph.

Limit of pre-Illinoian glaciation - Glacier margin on north side of line.

Solution basin - Line on rim, pattern in basin. Generally less than 5 feet deep. Mapped from LiDAR imagery.

REFERENCES CITED

Bayley, W. S., Salisbury, R. D., and Kummel, H. B., 1914, Description of the Raritan quadrangle, New Jersey: U. S. Geological Survey Geologic Atlas, Folio 191, 32 p., 4 map sheets, scale 1:62,250

Braun, D. D., 1989, Glacial and periglacial erosion of the Appalachians: Geomorphology, v. 2, p. 233-256.

Braun, D. D., 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: field conference of the Friends of the Pleistocene, northeastern section, 57th annual meeting, Hazleton, Pa., guidebook, U.S. Geological Survey Open-File Report 94–434, p. 1–21.

Braun, D. D., 2004, The glaciation of Pennsylvania, USA, *in* Ehlers, J., and Gibbard, P. L., eds., Quaternary Glaciations – Extent and Chronology, Part II, North America: Elsevier, p. 237-242.

Chamberlin, T. C., and Salisbury, R. D., 1906, Geology v. III: Earth History, Mesozoic-Cenozoic, 624 p.: New York, Henry Holt, 624 p.

Cook, G. H., 1880, Glacial drift: Annual Report of the State Geologist for the year 1880, Geological Survey of New Jersey, p. 16-97.

Herman, G. C., Houghton, H. F., Monteverde, D. H., and Volkert, R. A., 1992, Bedrock geologic map of the Pittstown and Flemington quadrangles, Hunterdon and Somerset Counties, New Jersey: New Jersey Geological Survey Open-File Map OFM 10, scale 1:24,000.

Munsell Color Company, 1975, Munsell soil color charts: a Division of Kollmorgan Corp., (unnumbered text and illustrations).

Richmond, G. M. and Fullerton, D. S., 1986, Summation of Quaternary Glaciations in the United States of America, *in* Sibrava, V., Bowen, D. Q., and Richmond, G. M. eds., Quaternary Glaciations in the Northern Hemisphere: Quaternary Science Reviews, v. 5, p. 183-196.

Richmond, G. M., Fullerton, D. S., and Christiansen, A. C., 1991, Quaternary geologic map of the Blue Ridge 40 x 60 quadrangle, United States: U.S. Geological Survey Map I-1420, scale 1:1,000,000.

Ridge, J. C., 2004, The Quaternary glaciation of western New England with correlations to surrounding areas, *in* Ehlers, J. and Gibbard, P. L., eds., Quaternary Glaciations -- Extent and Chronology, Part II, North America: Elsevier, p. 169-199.

Salisbury, R. D., 1894, Surface geology: Annual Report of the State Geologist for the year 1893, Geological Survey of New Jersey, p. 35-325.

Salisbury, R. D., 1902, Glacial geology: New Jersey Geological Survey, Final Report of the State Geologist, v. 5, Trenton, N.J., 802 p.

Stanford, S. D., 1997, Pliocene-Quaternary geology of northern New Jersey: an overview, *in* Stanford, S. D. and Witte, R. W., eds., Pliocene-Quaternary geology of northern New Jersey, guidebook for the 60th annual reunion of the Northeastern Friends of the Pleistocene, p. 1-1 to 1-26.

Stanford, S. D., 2016, Surficial geologic map of the Califon quadrangle, Hunterdon and Morris Counties, New Jersey: New Jersey Geological and Water Survey Open-File Map Series OFM 111, scale 1:24,000.

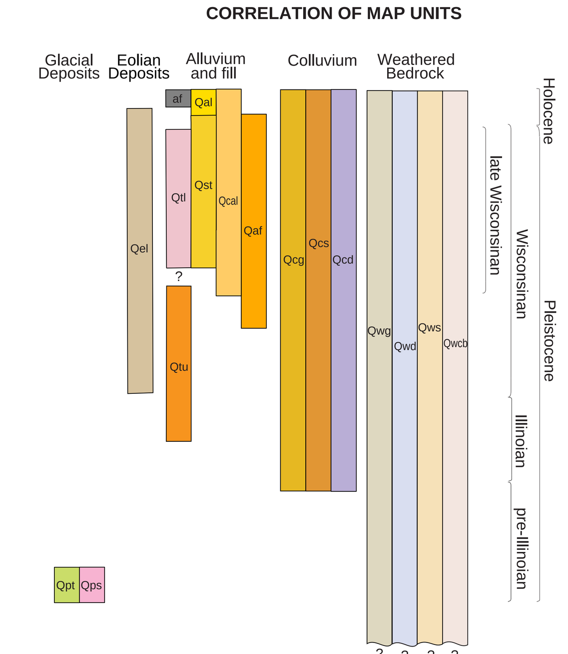
Stanford, S. D., Ashley, G. M., and Brenner, G. J., 2001, Late Cenozoic fluvial stratigraphy of the New Jersey Piedmont: a record of glacioeustasy, planation, and incision on a low-relief passive margin: Journal of Geology, v. 109, p. 265-276.

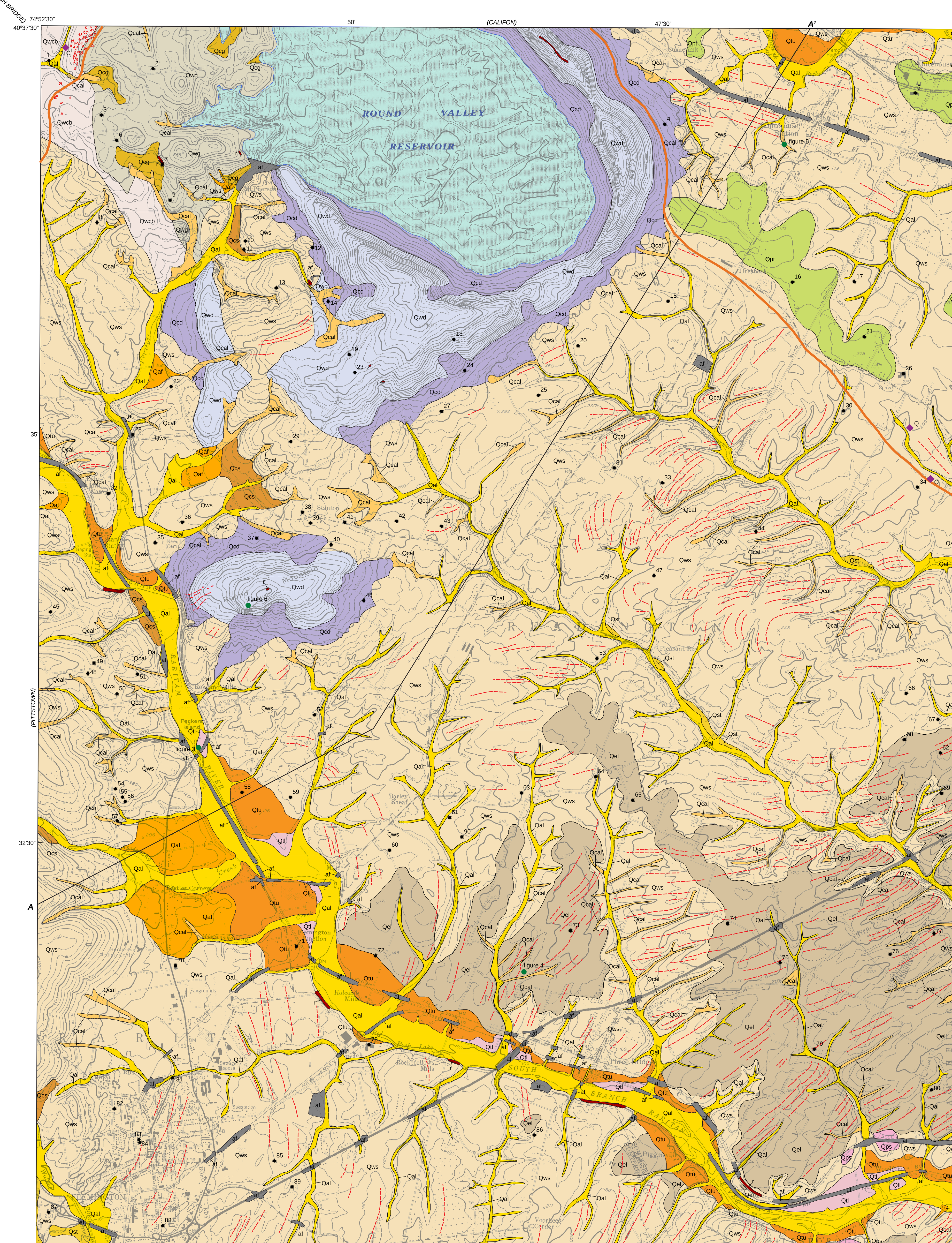
Stone, B. D., Stanford, S. D., and Witte, R. W., 2002, Surficial geologic map of northern New Jersey: U.S. Geological Survey Miscellaneous Investigations Map Series I-2540-C, scale 1:100,000.

Witte, R. W., 1997, Late history of the Culvers Gap River: a study of stream capture in the Valley and Ridge, Great Valley, and Highlands physiographic provinces, northern New Jersey, *in* Stanford, S. D. and Witte, R. W., eds., Pliocene-Quaternary Geology of northern New Jersey, guidebook for the 60th annual reunion of the Northeastern Friends of the Pleistocene, p. 3-1 to 3-16.

Witte, R. W., and Stanford, S. D., 2018, Surficial geologic map of the Pittstown quadrangle, Hunterdon County, New Jersey: N. J. Geological and Water Survey Open-File Map OFM 123, scale 1:24,000.

CORRELATION OF MAP UNITS





Base from U.S. Geological Survey, 1954.
Topography from aerial photographs by stereophotogrammetric methods. Photographs taken 1942.
Field checked 1942. Culture revised 1954.
Photorevised 1970 from aerial photographs taken 1970.
Polyconic projection. 1927 North American datum.

TRUE NORTH
MAGNETIC NORTH
12°
APPROXIMATE MEAN DECLINATION 2021

SCALE 1:24000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

NEW JERSEY
QUADRANGLE LOCATION

Geology mapped by S. D. Stanford (1988, 1990) and R. W. Witte (2015-2016). GIS application by M. Girard. Digital cartography by R.W. Witte and S. D. Stanford. Well search by Z. C. Schagrin.

Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G13AC00182. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

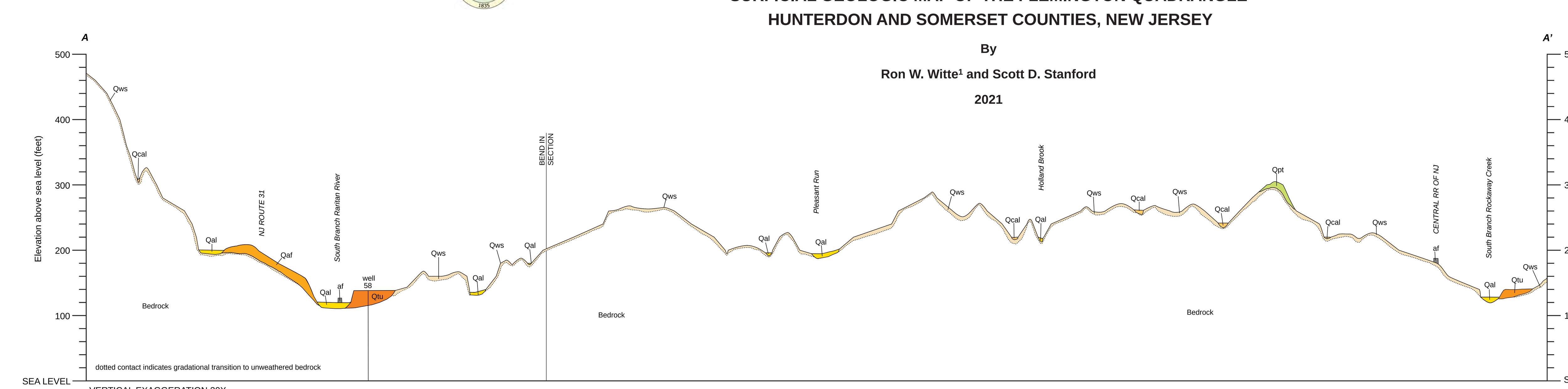
SURFICIAL GEOLOGIC MAP OF THE FLEMINGTON QUADRANGLE
HUNTERDON AND SOMERSET COUNTIES, NEW JERSEY

By

Ron W. Witte[1] and Scott D. Stanford

[1]Retired

2021



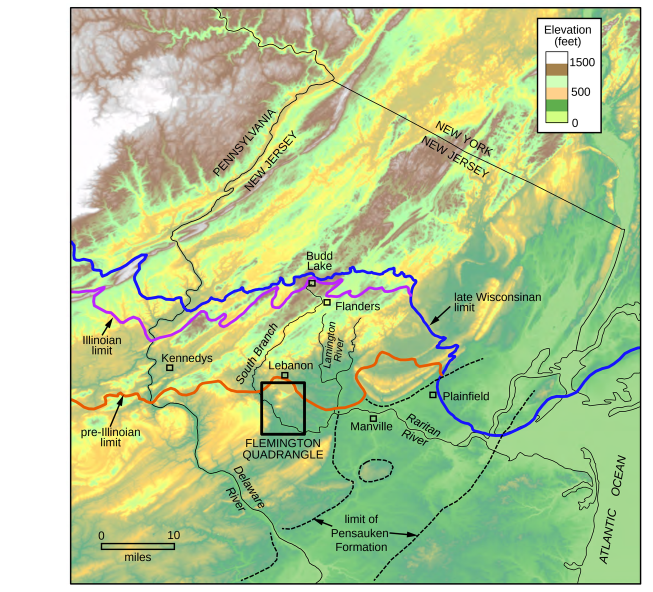


Figure 1. Extent of glaciations in New Jersey and location of the Pensauken Formation, places named in text, and the Flemington quadrangle (box). Glacial limits are from Braun (1994), Stanford (1997) and Stone and others (2002).

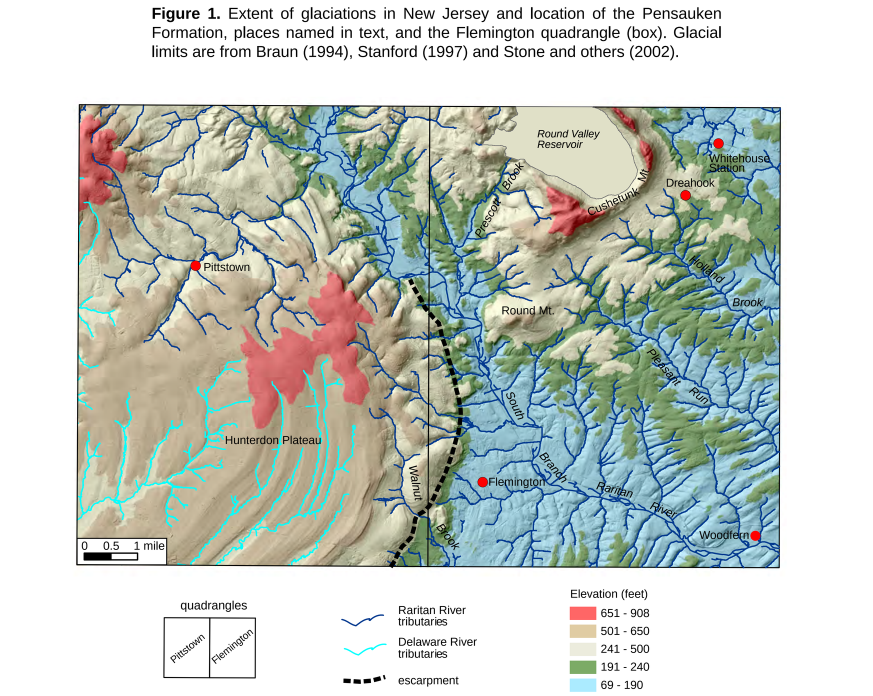


Figure 2. Hillshade relief image of the Pittstown and Flemington quadrangles. Blue and green areas are lowlands cut mostly on shale. Within these shale lowlands, the higher green surface is a Pliocene and early Pleistocene erosion surface on grade with the Pensauken Formation, a Pliocene fluvial deposit southeast of the map area (fig. 1). Westward and lying across a pronounced topographic escarpment (black dashed line) is a higher erosional surface (the Hunterdon Plateau), which may have formed largely during a long period of erosion in the Oligocene and early and middle Miocene. This surface, which is mostly in the Delaware River basin, is cut on shale, sandstone, argillite, and conglomerate. Cushetunk and Round mountains are underlain by diabase and the upland on the west side of Round Valley Reservoir is underlain by gneiss.

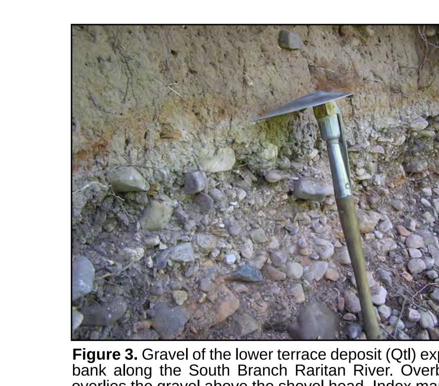


Figure 3. Gravel of the lower terrace deposit (Qtl) exposed in bank along the South Branch Raritan River. Overbank silt overlies the gravel above the shovel head. Index map shows location of photo in Flemington quadrangle. Photo by S. D. Stanford.

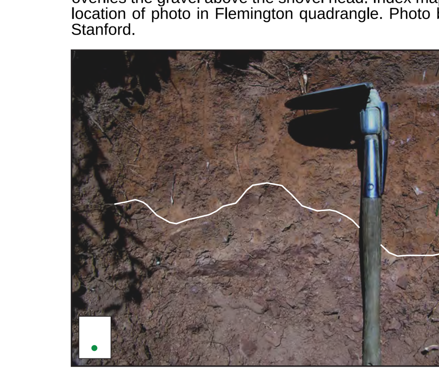


Figure 4. Eolian silt (Qel, above line) over weathered shale (Qws) exposed in roadcut. Silt contains some shale fragments mixed in by bioturbation and cryoturbation. Index map shows location of photo in Flemington quadrangle. Photo by S. D. Stanford.

Figure 5. Bank along stream exposing about 5 feet of reddish brown clayey silt with sparse shale fragments interbedded with thin layers and lenses of sand and pebbly sand Sediment is a mix of colluvium and alluvium laid down in narrow upstream valleys (Qcal). Index map shows location of photo in Flemington quadrangle. Photo by R. W. Witte.

Figure 6. Frost-shattered joint blocks (felsenmeer) of diabase near the top of Round Mountain. Rubbly areas of weathered diabase (Qwd) occur along the crest of Cushetunk and Round mountains in places where bedrock is very near the surface. Elsewhere, weathered diabase consists of matrix-supported decomposition residuum that forms a thicker mantle. Tree in center of photo is about 2 feet in diameter. Index map shows location of photo in Flemington quadrangle. Photo by R. W. Witte.

Surficial Geology of the Flemington Quadrangle
Hunterdon and Somerset Counties, New Jersey

New Jersey Geological and Water Survey
Open-File Map OFM 138
2021

pamphlet to accompany map

Table 1. Records of selected wells. These wells were drilled for private and public water supply and groundwater monitoring. Well data are from driller's reports on file at the Bureau of Water Allocation, New Jersey Department of Environmental Protection. The locations of the wells are based on tax parcels. They are generally accurate to within 500 feet of the actual location.

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
1	24-43621	5	0-35	Yellow clay mixed with broken limestone
			35-355	Hard limestone
2	24-43309	2.5	0-15	Clay, sand, broken rock
			15-620	Gray gneiss
3	24-37227	40	0-30	Yellow clay mixed with rock fragments
			30-130	Soft granite
			130-305	Hard gray granite
4	24-29289	40	0-59	Blue clay
			59-330	Gray and blue slate
5	P200913678	0.5	0-10	Red sand clay
			10-20	Weathered shale
			20-50	Weathered shale
6	24-27698	N/A	0-20	Clay and broken rock
			20-200	Limestone
7	24-39185	30	0-40	Clay and sand
			40-60	Weathered granite
			60-340	Granite

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
8	24-25943	0.25	0-6	Sand
			6-42	Red shale
9	24-41029	4	0-2.5	Clay
			2.5-340	Limestone
			340-360	Granite
10	24-20875	N/A	0-2	Overburden
			2-10	Clay
			10-200	Limestone (gray)
11	24-17568	25	0-4	Overburden
			4-300	Gray, green, maroon, brown rock
12	24-24911	5	0-50	Overburden
			50-725	Limestone
13	24-38849	2-3	0-0.25	Blacktop
			0.25-1	Gravel
			1-15	Clay
			15-230	Gray gneiss
			230-655	Granite
14	24-34398	2	0-2	Topsoil
			2-750	Limestone
15	24-43886	N/A	0-1	Fill
			1-3	Red brown medium sands; trace silt; trace clay
			3-18	Weathered red shale
16	24-45795	80-100	0-3	Fill
			3-90	Red shale
			90-100	Orange clay seam
			100-160	Red shale
17	25-52235	5	0-1	Grass and top soil
			1-6	Red silt and clay
			6-15	Red weathered shale

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
18	24-27654	25	0-28	Sand and clay mixed
			28-105	Hard gray granite
19	24-34395	40	0-16	Overburden
			16-340	Gray granite
20	24-35174	20+	0-2	Clay
			2-200	Sandstone
21	25-60174	0.5	0-1	Top soil, fill, boulders
			1-3	Red-brown medium sand trace clay
			3-150	Red shale
22	24-44640	< 5	0-11	Quarry process
			11-19.5	Dark brown clays, some sands, some gravels
23	24-46168	4.5	0-28	Clay and broken boulders
			28-605	Hard gray granite
24	24-29780	3.5	0-15	Clay mixed with broken rock
			15-605	Hard gray granite
25	24-38249	20	0-5	Clay
			5-130	Sandstone
			130-130.5	Clay
			130.5-335	Sandstone
26	25-45726	100	0-20	Soft clay
			20-305	Red Brunswick shale
27	24-42890	N/A	0-6	Soil and clay
			6-40	Granite
28	24-27868	N/A	0-6	Siltstone gravel; red silt loam
			6-25	Dark red siltstone shale
			25-31	Gray siltstone shale
			31-50	Dark red siltstone shale
			50-52	Gray siltstone shale
			52-57	Dark red siltstone shale
			57-58	Gray siltstone shale

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
			58-65	Dark red siltstone shale
			65-70	Dark red siltstone shale
29	24-30440	15	0-4	Soil/broken rock
			4-150	Granite
30	25-47815	70	0-5	Red clay
			5-200	Red Brunswick shale
31	24-40061	N/A	0-2	Top soil
			2-12	Red sand and shale
			12-22	Red shale
32	24-31636	N/A	0-5	Medium to fine sand, silty
			5-250	Rock
33	24-26558	20	0-7	Soil
			7-215	Red shale
			215-232	Gray shale
			232-300	Red shale
34	25-70787	20	0-30	Clay/sand
			30-60	Red rock
			60-250	Red rock
35	24-38989	40+	0-3	Fill
			3-10	Clay and rock
			10-200	Sandstone
36	24-29600	30	0-3	Soil
			3-150	Shale and sandstone
37	24-25242	30	0-15	Sand, soil, and clay
			15-250	Granite
38	24-6770	N/A	0-8	Overburden
			8-198	Blue rock
39	24-39579	50	0-8	Clay and broken rock
			8-180	Sandstone

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
40	24-24719	20	0-5	Clay
			5-90	Gray gneiss
			90-160	Limestone
41	24-24681	4	0-4	Soil
			4-170	Argillite
			170-340	Limestone mixed
42	24-41366	6.5	0-8	Clay and broken rock
			8-300	Sandstone
43	24-27652	15	0-3	Overburden
			3-20	Red gneiss
			20-22	Gray gneiss
			22-26	Red gneiss
			26-29	Gray gneiss
			29-47	Brown gneiss
			47-70	Black gneiss
44	24-35175	30	0-4	Clay
			4-220	Shale
45	24-44599	15	0-12	Overlay
			12-200	Sandstone
46	24-21638	10	0-4	Overburden
			4-33	Shale
			33-150	Brown sandstone
47	24-30878	35	0-3	Red clay
			3-205	Red Brunswick shale
48	24-17933	12	0-50	Red rock
			50-70	Fractured limestone
			70-150	Shale
49	24-42806	> 1	0-7	Clay and broken rock
			7-43	Sandstone/shale

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
50	24-21057	30	0-6	
			6-180	Gravel and clay
				Red shale
51	24-38233	40	0-30	Yellow shale
			30-190	Red shale
52	24-41277	30+	0-2	Soil
			2-300	Red and gray shale
53	24-33195	14	0-12	Red clay
			12-198	Red slate
54	24-28407	20	0-10	Overlay
			10-250	Sandstone
55	24-25410	111	0-30	Soil, overburden, and some stone cobbles
			30-318	Red shale
56	24-28026	8	0-8	Overlay
			8-350	Gray and red argillite
57	24-45148	2	0-8	Medium brown mason's sand/fill
			8-10	Stone/fill
			10-14	Yellow/brown shale
			14-18	Dark gray granite
58	24-37466	10	0-20	Overburden
			20-150	Red rock
59	24-35655	30	0-15	Clay
			15-20	Clay and gravel
			20-260	Shale
60	24-24617	15	0-6	Soil
			6-275	Red shale
61	24-29909	20	0-5	Overburden
			5-20	Red shale
			20-28	Gray shale

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
			28-56	Red shale
			56-58	Gray shale
			58-220	Red rock
62	24-61245	20	0-6	Clay
			6-255	Red shale
63	24-45884	N/A	0-8	Fill sand
			8-35	Highly fractured and weathered shale
64	24-24042	22	0-3	Clay-like shale
			3-62	Hard red shale
			62-170	Red sandstone
65	24-26707	1	0-2	Fill
			2-15	Brown silty clay, little fine sand
			15-33	Soft red shale; very hard purple red shale with gray layers
66	24-18030	35	0-40	Clay
			40-150	Red rock
67	25-31449	30	0-3	Clay
			3-305	Red shale
68	25-43540	35	0-5	Red clay
			5-205	Sandstone or shale
69	25-60048	50	0-3	Soil
			3-48	Red shale
			48-51	Blue shale
			51-69	Red shale
			69-73	Blue shale
			73-300	Red shale
70	24-30173	< 3	0-1	Asphalt
			3-42	Red-brown coarse to medium gravel; some coarse to fine sand; little clayey silt (shale)
71	24-29108	1	0-6	Gravel
			6-15	Sandy reddish clay
			15-25	Red shale

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
72	24-44935	30+	0-10	Sand and gravel
			10-250	Red shale
73	24-30015	30	0-4	Red clay
			4-195	Red shale Brunswick Formation
74	24-44048	3	0-5	Red sand, silt
			5-10	Weathered shale
75	24-43646	5	0-8	Weathered red shale
			8-9	Red shale; competent bedrock
			12-45	Gray shale; competent bedrock
76	24-20994	25	0-4	Clay
			4-275	Shale
77	25-35045	30	0-2	Top soil
			2-100	Gray shale
			100-150	Hard shale
			150-230	Reddish shale
78	24-28630	50	0-6	Fill
			6-7	Coal
			7-19	Red clay/soil
			19-104	Shale
79	24-45320	< 0.5	0-4	Brown silty clay with rock fragments
			4-15	Weathered rock fragments, soft drilling
80	25-53708	0.5	0-1	Asphalt and stone
			1-4	Red-brown sand
			4-6	Weathered red shale
			6-7	Hard gray rock, basalt
81	24-35198	5	0-16	Red clay with some sand
			16-40	Red shale
82	24-43892	0.5	0-7	Silt and clay
			7-10	Weathered shale

Well Number	Permit Number[1]	Well Yield[2] (gpm)	Depth in Feet[3]	Driller's Log
			10-45	Red shale
83	24-27906	0.5	0-8	Sandy dirt fill
			8-15	Weathered red shale
			15-40	Red shale
84	24-25745	N/A	0-14	Silt with some gravel
			14-38	Weathered shale
			38-42	Shale
85	24-38829	0.5	0-2	Red-brown silty sand
			2-25	Red shale
86	24-29286	40+	0-3	Top soil
			3-130	Shale
			130-140	Gray shale
			140-240	Red shale
87	24-35456	1	0-0.5	Black top
			0.5-2	Gravel
			2-14	Clay
88	24-46089	Seepage	0-5	Fill
			5-15	Weathered shale
			15-40	Red shale
89	24-25621-8	N/A	0-8	Loamy red-brown soil
			8-60	Weathered red-brown shale
90	24-42387	Dried up	0-6	Fine red-brown sand, silt
			6-33	Red shale bedrock

[1]N. J. Department of Environmental Protection well permit numbers.

[2]Well yield in gallons per minute (gpm) as reported by driller at time of drilling.

[3]Depth below land surface.