Prepared in cooperation with the
U. S. GEOLOGICAL SURVEY
NATIONAL GEOLOGIC MAPPING PROGRAM

INTRODUCTION

The Trenton East and Trenton West quadrangles are located in the Piedmont and Coastal Plain physiographic provinces, in central New Jersey. Surficial deposits in the quadrangles include artificial fill and fluvial, estuarine, wetland, eolian, and hillslope sediments that overlie unconsolidated sediments of Cretaceous age and pre-Cretaceous bedrock. They are as much as 80 feet thick locally but are less than 30 feet thick throughout most of the map area. The deposits record several periods of fluvial, glaciofluvial, and estuarine deposition, separated by episodes of river downcutting and valley erosion, within the past four million years. The *Previous Work and Stratigraphic Nomenclature* section below, which is excerpted and modified from Stanford (2010a), reviews earlier interpretations of these sediments. The *Geomorphology and Fluvial History* section describes the origin of the deposits and the history of deposition and erosion in the map area. Aquifer properties of the deposits are briefly described in the *Hydrologic Characteristics* section. Their age and relation to the episodes of valley erosion are shown in the *Correlation of Map Units*. Bedrock formations are shown on a separate map (Volkert and Stanford, in press).

PREVIOUS WORK AND STRATIGRAPHIC NOMENCLATURE

Early workers on the surficial deposits of the Trenton area include Lewis (1880), who recognized a younger gravel (the "Trenton gravel", map unit Qwf), which he considered to be a postglacial fluvial deposit, inset into an older gravel (the "Philadelphia red gravel", equivalent to the Pensauken Formation, map unit Tp), which he considered to be a glacial deposit. Cook (1880) considered the Trenton gravel to be of glacial origin and recognized that it was distinct from, and younger than, the quartz gravels of the Coastal Plain. R. D. Salisbury and G. N. Knapp (in Bascom and others, 1909) completed the first systematic surficial geologic map of the Trenton area, and defined the Pensauken and Cape May formations (Salisbury and Knapp, 1917). They placed the Trenton gravel and Coastal Plain stream-terrace deposits in the Cape May Formation. They recognized that the Cape May included estuarine, glaciofluvial, and non-glacial fluvial sediments, but did not separately map these facies, in part because they thought that periods of high sea level coincided with glacial maximums rather than with interglacials. MacClintock and Richards (1936) recognized the correlation of high sea levels with interglacials, and low sea level with glacials. They redefined the Cape May Formation as an interglacial marine and estuarine deposit, and used "Trenton gravel" to refer to the younger glaciofluvial gravel inset into the Cape May deposits. Peltier (1959) proposed several periods of deposition for the Trenton gravel in Bucks County, Pennsylvania by correlating various terrace levels to periods of advance of the Wisconsinan glacier as recognized in New York state. Owens and Minard (1975, 1979) subdivided the Trenton gravel in the Trenton area into an upper terrace (their "Spring Lake beds" or "Graywacke 1", equivalent to Qwf on this map) and a lower terrace (their "Van Sciver Lake beds" or "Graywacke 2", equivalent to units Qstu and Qstl on this map), both of which they considered to be of Sangamonian interglacial age. They correlated the Van Sciver Lake beds to the Cape May Formation on the Cape May peninsula, and the older Spring Lake beds to an estuarine clay (the "Fish House clay") in the Cape May Formation in Pennsauken, Camden County, and restricted any glaciofluvial deposits in the Trenton area to elevations at or below the modern river. Berg and others (1980) followed Owens and Minard (1979) and mapped both the Cape May and glaciofluvial sediments in Pennsylvania as "Trenton gravel". Newell and others (2000) also partially followed the correlations of Owens and Minard (1979), identifying the Spring Lake beds as an interglacial fluvial facies of the Cape May Formation, and placing glaciofluvial gravel possibly in the Van Sciver Lake beds. Newell and others (2000) also recognized postglacial fluvial deposits at and north of Duck Island (equivalent to units Qstu and Qstl on this map), which they named "alluvium at Duck Island", but did not map them downstream of Duck Island. Subsequent quadrangle mapping in the Delaware valley between Trenton and Camden, and north of Trenton, demonstrates that the upper terrace in the Trenton area (unit Qwf, equivalent to the Spring Lake beds) is the downstream continuation of the late Wisconsinan glaciofluvial deposit in the Delaware valley, that it is inset into the Cape May Formation in the vicinity of Burlington City (12 miles downstream from Trenton), and descends below sea level downvalley from Burlington (Stanford, 2010a). The lower terraces in the Trenton area (units Qstu and Qstl, equivalent to the Van Sciver Lake beds and the "alluvium at Duck Island") are veneers on postglacial straths, or fills in postglacial channels (in the case of unit Qstl in places) cut into the late Wisconsinan glaciofluvial deposit. Thus, the Spring Lake and Van Sciver Lake beds do not correlate to interglacial deposits. Given these miscorrelations, and the confusing history of the term "Trenton gravel", this report uses the descriptive terms "glaciofluvial deposit", "stream-terrace deposits", and "postglacial stream-terrace deposits" to refer to Pleistocene glaciofluvial, non-glacial fluvial, and postglacial fluvial sediments, respectively, in the map area.

GEOMORPHOLOGY AND FLUVIAL HISTORY

The oldest surficial deposit in the map area is the Pensauken Formation (unit Tp), a fluvial sand and gravel that forms an eroded plain that formerly covered the entire map area. The Pensauken was deposited by a large river that flowed southwesterly along the inner edge of the Coastal Plain from the New York City area to the Delmarva Peninsula. This river system included precursors of the Hudson and Raritan rivers, and rivers from southern New England. The map area is in the center of this former river valley. Paleocurrent measurements in the Trenton area (Owens and Minard, 1975) and regionally (Owens and Minard, 1979; Martino, 1981; Stanford and others, 2002), record the southwesterly flow. The elevation of the base of the Pensauken in the map area is between 90 and 110 feet in the northwest and southeast corners, between 50 and 80 feet in the belt approximately between the New Jersey Turnpike and Interstate 295, and as low as -10 feet in the axis of a channel beneath the Assunpink valley, where the Pensauken is covered by younger deposits (sections AA', CC'). The variation in basal elevation records southwest-trending fluvial channeling into the underlying Cretaceous sediments and pre-Cretaceous bedrock, before deposition of the Pensauken. These channels include a mainstem beneath the present Assunpink valley, along the Cretaceous-bedrock contact (fig. 1), and shallower branch or tributary channels extending easterly and northeasterly from the mainstem. This pattern, which extends beneath the Pensauken in the lowland northeast of Trenton (Stanford and others, 2002), indicates that the main Pensauken River downcut along the inner edge of the Coastal Plain, and tributary streams eroded back from the main channel into the Coastal Plain upland to the southeast. After channeling was complete, the Pensauken aggraded, in response to rising sea level at the mouth of the valley, to form a fluvial braidplain with a surface elevation of about 130 feet in the map area, burying the main channel and shallow tributary channels.

The age of the Pensauken is not firmly established. Berry and Hawkins (1935) describe plant fossils from the Pensauken near New Brunswick, New Jersey that they consider to be of early Pleistocene age. Owens and Minard (1979) assigned a late Miocene age based on correlation with marine deposits in the Delmarva Peninsula. Pollen from a black clay bed within the Pensauken near Princeton, New Jersey, includes cool-temperate species and a few pre-Pleistocene taxons. This assemblage suggests a Pliocene age (Stanford and others, 2002). The Pensauken is overlain by early Pleistocene till in Somerset County, New Jersey, and lies in a valley deeply eroded into middle and late Miocene marine and fluvial deposits. These relationships indicate a Pliocene to early Pleistocene age (Stanford, 1993).

The Pensauken River was diverted southeastward to the Atlantic Ocean in the New York City area during a glaciation in the early Pleistocene between 2.5 million and 800,000 (800 ka) years ago (Stanford, 1993). Following the diversion, a new local drainage network was established on the abandoned Pensauken plain. The Delaware River, formerly a tributary to the Pensauken River, became the master stream in the valley southwest of Trenton. The big bend to the southwest of the river at Bordentown is an inheritance of this deflection into the former Pensauken valley. Tributaries to the Delaware, including Assunpink, Crosswicks, and Blacks creeks, and their tributaries, became established on the former Pensauken plain. In the map area, the earliest record of post-Pensauken streams are sand and gravel deposits capping lower interfluves in the Crosswicks Creek basin (unit TQg). The base of these deposits grades from an elevation of about 70 feet near Crosswicks and Edgebrook to as low as 10 feet at the base of a thick valley-fill between Groveville and Sylvan Glen, just south of the present Crosswicks Creek valley (fig. 1). The westward decline of the base of the deposits, and their elongate westerly to northwesterly trend, indicate that they were laid down by west-draining precursors of Crosswicks, Doctors, and Back creeks. The thick valley fill west of Groveville indicates that this drainage pattern persisted as the Delaware incised through the early Pleistocene, allowing tributary incision to elevations as low as 10 feet. This incision was followed by alluviation to elevations of 70 to 75 feet, perhaps in response to one or more periods of high sea level in the early and middle Pleistocene. Estuarine deposits of early or middle Pleistocene age (Cape May Formation, unit 1) occur up to elevations of about 70 feet downstream from the Florence-Burlington area in the Delaware valley (Stanford, 2008). The Groveville valley fill may be of the same age.

Sea level through most of the early and middle Pleistocene was lower than at present, enabling the Delaware and its tributaries to downcut and erode. The Miry Run and Pond Run valleys were inset 50 to 70 feet into the former Pensauken plain. Crosswicks Creek and its tributaries shifted laterally from the courses marked by the TQg deposits, incised an additional 10 to 40 feet, and established valleys also 50 to 70 feet below the former Pensauken plain (outlined by purple dashed lines on fig. 1). In the Crosswicks Creek valley, particularly in the Groveville-Yardville-Edgebrook area, a broad strath capped by terrace deposits (unit Qtu) developed at this level, with surface elevation between 50 and 60 feet. This strath-terrace indicates an extended period of stable baselevel during which the Delaware and its tributaries were not incising deeply. In the Trenton area such stability occurs during both sea-level highstands, when sea levels at and above the present estuary prevent downcutting, and during glacial periods, when gravel sourced from glaciers in the upper Delaware valley aggrades in the Trenton area, promoting tributary alluviation and preventing incision. The upper terrace deposits (Qtu) were probably laid down chiefly during the Illinoian glaciation (with a peak about 150 ka), when glaciofluvial gravel (unit Qif) aggraded in the Delaware valley to an elevation of about 60 to 65 feet in Trenton, and the following Sangamonian interglacial period (peak at 125 ka), when sea level rose to about 20 to 30 feet higher than present, as indicated by estuarine deposits in the Delaware valley (Cape May Formation, unit 2) at and downstream from the Burlington City area (Stanford, 2008).

The late Wisconsinan glaciofluvial gravel (unit Qwf), deposited between about 25 and 15 ka, also aggraded to form a plain with a surface elevation of 55 to 60 feet in Trenton, similar to the Illinoian plain, and some upper terrace deposits are likely of late Wisconsinan age. A date of 29,960±190 radiocarbon years BP (34530-34850 calibrated years BP) (Beta 353009) on organic silt beneath seven feet of upper terrace sand and silt one mile south of Crosswicks, and a second date of 26,800±1000 (29600-31690 calibrated years BP) (W-1193, Sirkin and others, 1970) on wood from organic clay beneath six feet of upper terrace sand formerly exposed in the gravel pit at Crosswicks (Owens and Minard, 1975), indicate a late Wisconsinan age of the upper terrace there (dates plotted on map and on fig. 1). Thick upper terrace deposits south of Gropp Lake and at Sylvan Glen (fig. 1) indicate filling of a valley cut at the downstream ends of Back and Crosswicks creeks into the strath that underlies the upper terrace. This valley, like the earlier Groveville valley, was likely incised during a period of low sea level, before deposition of glaciofluvial gravel in the Delaware valley prevented downcutting. It may have been cut during the early Illinoian, or early Wisconsinan, and then filled by alluvium laid down by Crosswicks and Back creeks as glaciofluvial gravel aggraded in the Delaware valley. The fill may thus be as young as late Wisconsinan.

Glaciofluvial deposits include sand and gravel of late Wisconsinan age (Qwf) and an older, eroded, weathered gravel of probable Illinoian age (Qif). The Illinoian glaciofluvial deposit crops out in two low hills that protrude five to 10 feet above the surrounding late Wisconsinan terrace at and south of Hutchinson Mills (fig. 1), and was observed in several excavations through unit Qwf in Trenton. Its subsurface extent is unknown, because the deposits cannot be positively identified from well and boring records. It may be more continuous beneath unit Qwf than is shown on sections AA' and CC'. Feldspar minerals in gneiss, granite, and arkosic sandstone clasts in unit Qif are fully or partially weathered to clay, iron-bearing minerals have been oxidized to produce yellow to orange stains, and carbonate clasts are completely decomposed, in comparison to the unweathered gneiss, granite, and sandstone clasts, and pitted and weathered but not fully decomposed carbonate clasts, in unit Qwf. These weathering features, and the slightly higher top surface of the deposit, are similar to Illinoian glaciofluvial deposits upstream in the Delaware valley (Brainards outwash of Stone and others, 2002). They are probably of Illinoian age (about 150 ka) but may be older.

The late Wisconsinan deposit forms a terrace with a surface elevation of 60 to 65 feet in the Delaware valley upstream from downtown Trenton, which broadens to a wide plain in east Trenton and Hamilton, extending northeasterly in the Assunpink valley, with a surface elevation of 55 to 60 feet. This deposit extends up the Delaware valley to the late Wisconsinan terminal moraine near Belvidere, New Jersey, about 45 miles north of Trenton, where it includes a plain laid down as ice advanced to and stood at the terminus (Belvidere outwash of Stone and others, 2002), and also an inset glaciofluvial terrace laid down chiefly during glacial retreat (Delaware terrace deposits of Stone and others, 2002). These units merge downvalley, and the deposit in the Trenton area includes sediment laid down during advance and retreat of late Wisconsinan ice. Based on regional radiocarbon dates and varve chronology, late Wisconsinan ice was in the Delaware basin between about 25 and 15 ka (radiocarbon years) (Ridge, 2004), and deposition of the glaciofluvial deposit in the Trenton area may span this interval. A date of 23,680±120 radiocarbon years BP (26,650-28,230 calibrated years BP) (Beta 354600) on organic silt beneath 15 feet of glaciofluvial sand and pebbly sand in a terrace remnant near Lambertville, New Jersey, about 12 miles upstream from Trenton, confirms this age.

As the glacier margin retreated northward in the Delaware basin much glacial sediment was trapped in the upper valley. In the lower valley, including the Trenton area, the Delaware River, still conveying glacial meltwater from upvalley but with less glacial sediment load, began to incise into the glaciofluvial deposit. In the map area, after 20 to 30 feet of downcutting, the river stabilized and eroded a strath into the glaciofluvial gravel, on which it laid down a veneer of sand (Qstu). This postglacial strath terrace is about 25 to 30 feet above the present river. North of downtown Trenton, it is the main valley-bottom surface, and the glaciofluvial terrace is limited to narrow erosional remnants against the valley wall. Unit Qstu also veneers the broad strath cut into unit Qwf in the Pennsylvania part of the Trenton West quadrangle, between the Delaware River and the Pennsylvania Canal, with a surface elevation of 20 to 30 feet (fig. 1).

Renewed incision, perhaps when sediment entering the river was further reduced as dense forest became established with warming climate, cut a second, narrow strath, about 10 feet lower than the upper strath, in the valley upstream of downtown Trenton. In this reach of the valley, the lower postglacial terrace (Qstl) is restricted to high parts of two islands in the river, and a sliver along Riverside Drive in Trenton. Downstream from the Riverview Cemetery area, the river crosses from bedrock onto Cretaceous sand and clay (fig. 1). After it had cut through the 40 to 60 feet of glaciofluvial gravel in this area it encountered bedrock and Cretaceous sediment. It eroded Cretaceous sediment much more rapidly than bedrock, and incised more deeply downstream from the contact, to an elevation as low as -60 feet, and carved bluffs on the east side of the valley between Riverview Cemetery and Fieldsboro. As incision slowed, sand and gravel eroded from units Qwf and Qstu upstream were deposited in the incised valley. These deposits, which are silt and sand at the surface but are gravelly at depth, as reported in test-boring logs, form low islands with surfaces 5 to 10 feet above the present tidal marsh and river. They are the downstream, aggraded phase of unit Qstl.

Following deposition of unit Qstl, a final period of incision created the present-day Delaware River channel and floodplain. Upstream of the railroad bridge at Trenton, the channel is floored by bedrock and is confined by high banks cut into the bordering stream terraces. In this area, the active floodplain is restricted to the river channel and a few alluvial islands, although large floods inundate low parts of the bordering terraces. Downstream from Riverview Cemetery the river is not confined by high banks and flows on sediment rather than bedrock. Here, it can erode more deeply and migrate laterally more easily, and the river eroded channels into the Qstl valley fill (fig. 1). Channeling left erosional remnants of the Qstl deposits as islands, including Duck, Newbold, and Biles islands, and as narrow benches and small perched valley fills along the base of the bluffs on the east side of the valley. These channels were cut to elevations as low as -50 to -60 feet, similar to the depth of the channels before deposition of unit Qstl. As sea level rose during the past 10 ka, the channels were filled with gravelly alluvium (Qal) overlain away from the main Delaware channel by fine-grained, organic-rich tidal-marsh and estuarine deposits (Qm). Colluvium (Qc) accumulated in narrow aprons at the base of bluffs where there were no streams to erode the footslope material. Landfilling and dredging since the mid-nineteenth century has blocked or restricted flow in these side channels, particularly those to the east of Duck Island, focusing present alluviation in the main Delaware channel.

Incision of Qwf, strath formation, deposition of Qstu and Qstl, and incision to the modern floodplain (Qal), were completed between the later stages of glacial retreat from the Delaware basin at 15-16 ka and the onset of deposition in the modern floodplain. A date of 13,200±400 radiocarbon years BP (15,200-16,420 calibrated years BP) (W-1195, Sirkin and others, 1970) on organic silt and twigs beneath 8 feet of stream-terrace sand and gravel in Levittown, Pennsylvania, about six miles southwest of Trenton, indicates that the stream terrace there was deposited after about 13 ka. The onset of floodplain deposition is dated to 10-11 ka by radiocarbon dates on wood and peat at the base of floodplain deposits in central New Jersey (Sirkin and others, 1970; Stanford and others, 2002), and by a date of 8580±100 radiocarbon years BP (9480-9670 calibrated years BP) (Beta 10457) on peat from a depth of 19.3 feet beneath alluvial and tidal-marsh silt from a core (well 270 in Table 1) northeast of Duck Island (Southgate, 2010). In the same core, a date of 3900±60 radiocarbon years BP (4250-4420 calibrated years BP) (Beta 10456) at a depth of 2.8 feet indicates 16 feet of silt accumulation between 8600 and 3900 radiocarbon years ago (about 1 mm/yr), much of which is due to sea-level rise. Expansion of this marsh onto wooded upland, as documented by aerial photography since 1930 (available at www.nj.gov/dep/gis/geowebsplash.htm), indicates continued sea-level rise.

Radiocarbon dates indicate that agricultural and urban land clearing by humans may have contributed to recent floodplain deposition. A date of 600±30 radiocarbon years BP (1290-1410 calibrated years AD) (Beta 353007) on peaty sand beneath 2 feet of gravelly sand along a tributary stream in Yardville, and a date of 1250±30 radiocarbon years BP (680-870 calibrated years AD) (Beta 353011) on organic silt beneath 4 feet of alluvial-fan sand near Groveville, record pulses of clastic sediment into the floodplains after those times. Both locations are at the base of steep escarpments where clearing of vegetation would lead to gully erosion. Plant fibers beneath 5 feet of silt in the Miry Run floodplain yielded modern carbon, indicating an age no older than about 1950 AD for the silt (Beta 353005). The silt here was likely washed into the floodplain from suburban development in the last half of the twentieth century.

The episodes of incision and alluviation in the Delaware valley after deposition of unit Qwf also affected tributary valleys. In the Crosswicks Creek basin and Blacks Creek valley, as described above, downstream reaches were probably alluviated to the level of the upper terraces (elevation 50 to 60 feet) when deposition of Qwf in the Delaware valley was completed. Both creeks empty into the Delaware River in the reach where it channeled deeply (to elevation -60 feet) into Cretaceous sediments after deposition of Qwf and before sea-level rise in the Holocene. Thus, streams in the Crosswicks basin, and Blacks Creek, also downcut into the upper terraces in step with Delaware River incision, forming narrow valleys inset 30 to 50 feet into the upper terraces (outlined by heavy black lines, fig. 1). Small, discontinuous terraces within these inset valleys, with surfaces 5 to 10 feet above the modern floodplain, are mapped as lower terrace deposits (Qtl). They grade downvalley to unit Qstl in the Delaware valley and so are likely of similar postglacial age, at least in their downstream positions. Upstream, above the limit of postglacial incision, for example, in the Allentown quadrangle to the east (Stanford, 2010b), they probably span a longer period and are in part equivalent to Qwf.

Assunpink Creek, in contrast to Crosswicks and Blacks creeks, joins the Delaware where its channel runs on bedrock upstream from the deep postglacial incision on Cretaceous sediment. Thus, the Assunpink did not incise deeply into unit Qwf. As a result, the lower stream terraces along its tributaries Miry Run and Pond Run grade to the Qwf plain in the Assunpink valley, not to postglacial stream terraces. With the exception of a terrace segment along the south side of Miry Run at Mercerville, there are no upper terraces in the Miry and Pond Run valleys. This absence is likely because the Illinoian glaciofluvial deposit (Qif) provided a base level for the valleys during the Illinoian glaciation and Sangamonian interglacial that was at a similar elevation as the Qwf plain, keeping the lower terrace deposits, of late Wisconsinan age, at a similar elevation as the older terrace.

During glacial periods, cold climate led to the growth of permafrost and tundra-like vegetation in the area. Prevailing winds from the west and northwest blew sand and silt from the glaciofluvial plain and, to a lesser extent, from the upper terraces, onto the low Pensauken uplands to the east and southeast. In a few places on and adjacent to the glaciofluvial plain and upper terrace, the windblown sediment is more than 5 feet thick and forms low dunes (Qe). Dunefields near Yardville, east of Riverview Cemetery, and at Greenwood Cemetery, are next to basins on their north sides that may be blow-out features from which the sand forming the dunes was eroded. East of the Qwf plain, between Yardville and Mercerville, windblown deposits are widespread but thin. Elsewhere they are thin and patchy. They are indicated by the letter "e" on the map where penetrated in hand-auger holes.

As climate warmed between 15 and 10 ka, permafrost melted. Melting of ice-rich lenses produced small subsidence features known as thermokarst basins (symboled on map). These basins are best-developed and most numerous on sandy deposits where the water table is shallow. Permafrost was thicker and more continuous here, producing more subsidence when it melted.

HYDROGEOLOGIC CHARACTERISTICS

Surficial deposits affect the movement of water into and out of streams, bedrock, and Cretaceous formations. Glaciofluvial sand and gravel (Qwf, Qif) is highly permeable (estimated hydraulic conductivity between 10 and 10^3 feet/day), particularly in the Delaware valley and in the northwestern half of the plain in the Assunpink valley. The deposit in these locations is gravelly; elsewhere, it is sandy and silty-sandy. In the Delaware valley upstream of downtown Trenton, unit Qwf underlies sand of units Qstu and Qstl, which is generally less than 10 feet thick, and so is more extensive than its outcrop suggests. Several shallow (<50 feet deep) domestic and industrial wells draw water from gravelly Qwf where it overlies less-permeable bedrock (wells 2, 86, 88, 93, 94, 95, 99, 105, 107, 108, 109 in table 1). In general, though, the deposit is too thin and easily contaminated for use as a reliable aquifer.

The Pensauken Formation (Tp), a sand and pebbly sand, with pebble-to-cobble gravel locally at its base, is also permeable (estimated hydraulic conductivity between 10^{-1} and 10^2 feet/day). However, weathering of feldspars to clays, and interbeds of silty sand and glauconitic sand, reduce the permeability in parts of the deposit, particularly in the uppermost 10-15 feet, where it is weathered. A few wells draw from the Pensauken where it is thick and low-lying (wells 99, 101, 102, 211 in Table 1) but throughout most of the map area it is too thin and high-standing to be an aquifer.

The terrace and alluvial deposits (TQg, Qtu, Qtl, Qstu, Qstl, Qal) generally consist of sand to silty sand, with sparse thin beds of pebble gravel. Thick gravel beds are rare, except in the Delaware River alluvium and at the base of units Qstl and Qstu. These deposits are moderately permeable (estimated hydraulic conductivity between 10^{-3} and 10 feet/day) and are generally too thin to be aquifers.

DESCRIPTION OF MAP UNITS

ARTIFICIAL FILL—Sand, silt, gravel, clay; gray to brown; demolition debris (concrete, brick, wood, metal, etc.), cinders, ash, slag, glass. Unstratified to weakly stratified. As much as 30 feet thick. In highway and railroad embankments, dams, dikes, made land, and filled floodplains, wetlands, and ravines. In urban areas, fill is mapped only where it forms distinct topography or where the former extent of floodplains and wetlands is known from historic mapping. Many areas of fill in urban and suburban areas, particularly along former streams, are not mapped. In the Duck Island area, much of the fill is sand and gravel, with fragments of white, yellow, and red Cretaceous clay, excavated from the Delaware River, mixed with fine coal fragments and traces of slag and other industrially produced materials.

afd DREDGE SPOILS—Fine-to-medium sand, silty fine-to-medium sand, minor coarse sand; gray, very pale brown; pebble-to-cobble gravel; minor red, yellow, and white clay, and fragments of schist and gneiss. Gravel consists chiefly of white to gray quartz and quartzite, gray siltstone and sandstone, minor gray chert and gneiss, and minor red siltstone and sandstone. Unstratified to weakly stratified, locally thinly bedded to laminated. May contain minor amounts of demolition debris. As much as 40 feet thick. In disposal cells along the Delaware River. Consists largely of sediment excavated from units Qm and Qal, and from underlying Cretaceous sediment and bedrock, during dredging of ship channels.

aft TRASH FILL—Trash mixed and covered with silt, clay, sand, and minor gravel. As much as 40 feet thick. In solid-waste landfills. Small areas of trash fill are included within artificial fill.

Qal ALLUVIUM—Sand, silt, minor clay and peat; brown, yellowish-brown, gray; and pebble gravel to pebble-to-cobble gravel; cobble-to-boulder gravel in Delaware River. Contains varied amounts of wood and fine organic matter. Sand and silt are unstratified to weakly stratified. Gravel occurs in unstratified to weakly stratified beds generally less than 2 feet thick in tributary valleys, as much as 10 feet thick in the Delaware River. Sand consists chiefly of quartz with rock fragments in the Delaware River and Piedmont floodplains, and quartz with some glauconite and mica in Coastal Plain floodplains. Gravel consists chiefly of gray siltstone, sandstone, and chert, and gray to white quartz and quartzite, with some red siltstone and sandstone, gray to white gneiss and schist, and white to purple conglomerate, in the Delaware channel; chiefly white to gray quartz and quartzite with gray and red siltstone and sandstone in Piedmont tributary channels; and chiefly white, gray, and yellow-stained quartz and quartzite, with minor chert and ironstone, in Coastal Plain tributary channels. Total thickness of deposit as much as 40 feet in Delaware valley, 15 feet in tributary valleys. Sand, silt, clay, and peat are deposited in overbank areas of the floodplain and typically overlie gravel and sand deposited in channels.

Qs SWAMP AND MARSH DEPOSITS—Clayey silt, dark brown to black, with organic matter. As much as 5 feet thick. Deposited in non-tidal wetlands.

Qm TIDAL-MARSH AND ESTUARINE DEPOSITS—Silt, fine sand, peat, clay; brown, dark brown, gray, black. Contain abundant organic matter. As much as 30 feet thick. Deposited in tidal marshes, tidal flats, and tidal channels during Holocene sea-level rise, within the past 10 ka.

Qaf ALLUVIAL-FAN DEPOSITS—Fine-to-medium sand, minor pebble gravel. Sand consists of quartz with some glauconite (in fans adjacent to units Qtu and TQg) and some gray siltstone and feldspar (in fans adjacent to unit Qwf). Gravel is quartz with some gray siltstone in fans adjacent to unit Qwf. As much as 10 feet thick. Form small fans at mouths of gullies eroded into units Qwf, Qtu, and TQg.

Qc COLLUVIUM—Fine-to-medium sand, silty fine sand; brown, yellowish-brown, reddish-yellow; with a few (1-5% by volume) to some (5-10%) pebbles. Sand and gravel composition as in surficial deposit on adjacent hillslope. Unstratified to weakly stratified. As much as 10 feet thick. Forms narrow footslope aprons that grade to the modern tidal marsh or to unit Qstl.

Qstl LOWER POSTGLACIAL STREAM-TERRACE DEPOSIT—Very fine-to-fine sand, fine-to-medium sand, silty very fine-to-fine sand; yellowish-brown, light reddish-brown, light gray; some pebble-to-cobble gravel in lower part of deposit, particularly where it thickens downstream from Riverview Cemetery. Well-stratified to moderately stratified. Gravel composition as in Delaware River alluvium. Sand consists of quartz with some gray and red siltstone, minor chert and gneiss fragments. As much as 60 feet thick in Duck Island area; less than 20 feet thick upstream from Riverview Cemetery. Forms a postglacial stream terrace with surface 5 to 20 feet above the Delaware floodplain and estuary.

Qstu UPPER POSTGLACIAL STREAM-TERRACE DEPOSIT—Very fine-to-fine sand, fine-to-medium sand, silty fine sand; yellowish-brown, light reddish-brown; some pebble-to-cobble gravel in lower part of deposit. Well-stratified to moderately stratified. Sand consists of quartz with some gray and red siltstone and minor chert and gneiss fragments. Gravel composition as in unit Qwf. As much as 15 feet thick. Forms a postglacial stream terrace capping a strath cut into unit Qwf, with surface 25 to 35 feet above the Delaware floodplain.

Qe EOLIAN DEPOSITS—Very fine-to-fine sand, light reddish-brown to very pale brown. Unstratified to weakly stratified. Sand consists chiefly of quartz with some gray to red siltstone (from unit Qwf) and glauconite (from unit Qtu). As much as 10 feet thick. Mapped where they form low dunes and are more than 5 feet thick. Elsewhere, eolian deposits are discontinuous and lack distinctive morphology and so are not mapped. Where penetrated by hand-auger hole, they are indicated on the map by the letter "e" followed by a thickness, in feet.

Qwf LATE WISCONSINAN GLACIOFLUVIAL DEPOSIT—Fine-to-medium sand, medium-to-coarse sand, very fine-to-fine sand, silty fine sand; brown, light reddish-brown, grayish-brown, yellowish-brown; pebble gravel, pebble-to-cobble gravel. Sand is well stratified, gravel is unstratified to weakly stratified (fig. 2). Sand consists of quartz with many rock fragments, including chiefly gray and red siltstone, and some gray quartzite, chert, gneiss, and schist. Gravel is chiefly gray siltstone and sandstone, gray to white quartzite and conglomerate; some red siltstone and sandstone, red to purple conglomerate, and gray chert; few white quartz, gray to white gneiss; and a trace (<1%) of gray carbonate rock. Carbonate clasts are pitted and partially decomposed, the other clasts are unweathered. As much as 40 feet thick. Pebble-to-cobble gravel is common in the deposit in the Delaware valley upstream of Riverview Cemetery. The plain to the east and northeast of the Delaware valley is predominantly sand and pebble gravel, grading to very fine-to-fine sand and silty fine sand on the east edge. Gravelly and medium-to-coarse sandy beds are generally brown to gray because the gravel and coarser sand is mostly gray siltstone. Fine sand and silty beds are reddish-brown because red siltstone fragments are more abundant in finer grain sizes. Forms an eroded terrace in the Delaware valley, with a surface 50 to 60 feet above the modern floodplain, and a plain in the Assunpink valley with a surface elevation between 50 and 60 feet.

Qif ILLINOIAN GLACIOFLUVIAL DEPOSIT—Fine-to-medium sand, medium-to-coarse sand, slightly clayey and silty; light reddish-brown, light brown, yellowish-brown; pebble-to-cobble gravel. Sand consists of quartz with some gray siltstone and feldspar. Gravel is chiefly white, light gray quartzite, quartz, and quartzite-conglomerate, with few gray and red siltstone and sandstone, gray chert, and white gneiss. Feldspar minerals in the arkosic sandstone and gneiss clasts are partially weathered to yellow and white clay. Iron-bearing minerals are oxidized to form yellow and orange surface stain on some gravel clasts. As much as 30 feet thick.

Qtl LOWER STREAM-TERRACE DEPOSITS—Fine-to-medium sand, silty fine sand, fine-sandy silt, minor clayey silt and coarse sand; yellowish-brown, reddish-yellow, very pale brown, olive-yellow, light gray; pebble gravel. Sand consists chiefly of quartz, with some glauconite, feldspar, and mica. Sand is unstratified to well-stratified, locally cross-bedded. Gravel occurs in thin beds and as a basal lag, and consists chiefly of white, gray, and yellow-stained quartz and quartzite, with minor dark brown and reddish-brown ironstone and a trace of gray and brown chert. As much as 15 feet thick. Form stream terraces in tributary valleys with surfaces 5 to 15 feet above modern floodplains.

Qtu UPPER STREAM-TERRACE DEPOSITS—Fine-to-medium sand, minor silt, very fine sand, and coarse sand; very pale brown, yellowish-brown, reddish-yellow, brownish-yellow, light gray, olive-yellow; pebble gravel. Sand consists chiefly of quartz with some glauconite, minor mica, and a trace of feldspar in places. Sand is unstratified to well-stratified, locally cross-bedded (fig. 3). Gravel occurs in thin beds and as a basal lag and consists chiefly of white, gray, and yellow-stained quartz and quartzite, with a trace of gray and brown chert and brown and reddish-brown ironstone. As much as 50 feet thick but generally less than 20 feet thick. Form stream terraces in the Crosswicks Creek and Blacks Creek valleys, and along Miry Run in Mercerville, with surfaces 20 to 50 feet above modern floodplains.

TQg UPLAND GRAVEL, LOWER PHASE—Fine-to-medium sand, silty fine-to-medium sand, minor clayey silt; yellow, brownish-yellow, reddish-yellow, olive-yellow; pebble gravel. Sand consists chiefly of quartz with some glauconite. Sand is unstratified to weakly stratified. Gravel consists chiefly of white, gray, and yellow-stained quartz and quartzite, with a trace of brown to reddish-brown ironstone and gray to brown chert. As much as 60 feet thick west of Groveville, where it fills a paleovalley; less than 30 feet thick elsewhere. Occurs as erosional remnants of former flood plains on low interfluves. These deposits are inset into the Pensauken plain, and so postdate the Pensauken Formation, and are in turn inset by the upper terraces, and so predate the upper terrace deposits.

Tp PENSAUKEN FORMATION (Salisbury and Knapp, 1917)—Fine-to-coarse sand to clayey sand, minor silty fine sand and very coarse sand; reddish-yellow, yellow, very pale brown, light gray; pebble gravel, minor pebble-to-cobble gravel. Unstratified to well-stratified, commonly with tabular, planar cross-beds in sand. Pebble gravel occurs as thin layers (generally less than 3 inches thick) within the sand and as thicker, unstratified beds in places at the base of the formation, where it locally includes cobble gravel and a few boulders (fig. 4). Sand consists chiefly of quartz with some feldspar, mica, and glauconite, and a trace of rock fragments (chert and shale). The feldspar is partially or fully weathered to white clay. Gravel consists chiefly of yellow, reddish-yellow (from iron staining), white, and gray quartz and quartzite; a little brown to gray chert and reddish-brown ironstone; and a trace of brown, reddish-brown, and gray sandstone and shale, and white-to-gray gneiss. The chert, sandstone, shale, and gneiss commonly are partially weathered or fully decomposed. As much as 80 feet thick. On footslopes, swales, and low-lying areas of outcropping Pensauken there is a discontinuous light gray, white, to very pale brown silt, silty very fine sand, to fine-sandy silt, as much as 8 feet thick, but generally less than 3 feet thick, overlying, and mixed with, Pensauken sand and gravel. This fine-grained material includes windblown deposits and accretion-gley sediment transported from upslope by rillwash, sheetwash, and soil throughflow, and mixed by cryoturbation and bioturbation in places. It is too patchy to map but is indicated by "g" and a thickness value (in feet) where penetrated by hand-auger hole.

Qwcp WEATHERED COASTAL PLAIN FORMATIONS—Exposed formations of Cretaceous age. Soil zone generally includes some lag pebbles from eroded surficial deposits. Unit includes patchy colluvial, alluvial, or eolian sediments less than 3 feet thick. Not shown on sections because depth of weathering is highly variable.

Qws WEATHERED SANDSTONE—Medium-to-coarse sand, coarse-to-very-coarse sand, minor fine-to-medium sand; white, very pale brown, yellow, reddish-yellow, reddish-brown; locally clayey, pebbly, and micaceous. Sand and pebbles are quartz and partially weathered rock fragments. Coarse sand grains are angular to subangular. Sandy material grades laterally and vertically into partially weathered and unweathered rock. Zones of unweathered rock may overlie or interbed with zones of weathered rock. Coarse-grained arkosic sandstone weathers more deeply and thoroughly than finer, more quartzose sandstone. As much as 60 feet thick.

Qwsc WEATHERED SCHIST AND GNEISS—Clayey sand, sandy clay, silty clay, clayey silt; white, gray, brown, olive brown; micaceous, with some subangular to subrounded pebbles and cobbles of partially weathered gneiss, schist, and quartzite. As much as 80 feet thick. Thick weathered schist and gneiss is present beneath Cretaceous sediments (wells 150, 154-156 in table 1), indicating that some of the weathering is of Cretaceous or earlier age.

MAP SYMBOLS

Contact—Solid where well-defined by landforms, long-dashed where approximately located, short-dashed where gradational or featheredged, dotted where removed by excavation.

3 ● Qtl5/Tp — Material observed in exposure, excavation, or penetrated in 5-foot hand-auger hole—Number, if present, indicates thickness of surficial material, in feet. No number indicates surficial material thicker than 5 feet. Where more than one surficial material was exposed, the thickness (in feet) of the upper unit is indicated next to its symbol and the lower unit is indicated following the slash.

Material formerly observed in exposure or excavation—From N. J. Geological and Water Survey permanent notes.

Material formerly observed in exposure or excavation—From field notes of J. P. Owens, U. S. Geological Survey.

e2 — Eolian deposit—Very fine-to-fine sand to silty very fine sand, overlying mapped surficial unit. Penetrated in hand-auger hole, number indicates thickness in feet.

g2 — Accretion gley—Light gray silt, silty very fine-to-fine sand, to clayey silt, overlying mapped surficial unit. Penetrated in hand-auger hole, number indicates thickness in feet.

fig. 2 — Photograph location

29960+/-190 (Beta 353009) — Radiocarbon date—Age in radiocarbon years BP, with error and lab number.

201 — Well or boring with log in table 1—Location accurate to within 200 feet.

216 — Well or boring with log in table 1—Location accurate to within 500 feet.

8 — Thickness of surficial material in power-auger boring—From Owens and Minard (1964).

Shallow topographic basin—Line at rim, pattern in basin. Depth generally less than 5 feet but as much as 15 feet. Most were formed by melting of permafrost. Those adjacent to eolian deposits may have formed from wind erosion (indicated by "e"). Drawn from 1979 stereo air photos and 2010 LiDAR imagery.

Excavation perimeter—Line encloses excavated area.

Quarry—Inactive in 2013.

Sand and gravel pit—Inactive in 2013.

Sand and gravel pit—Active in 2013.

Fluvial scarp—Line at top of scarp, ticks on slope.

Active slump—Line at top of slope, barbs on slump material. Observed in 2012-2013.

Paleoflow—Arrow shows direction of former river flow, as measured on cross-beds observed at point "x". Bar through symbol indicates measurement is from Owens and Minard (1975).

r — Large bedrock outcrop—Refer to Volkert and Stanford (in press) for locations of small outcrops.

25 — Elevation of bedrock surface—Contour interval 25 feet, 50 feet in places. Bedrock surface includes top of Cretaceous formations and weathered bedrock.

47 — Well or boring on cross sections—Projected to line of section in places.

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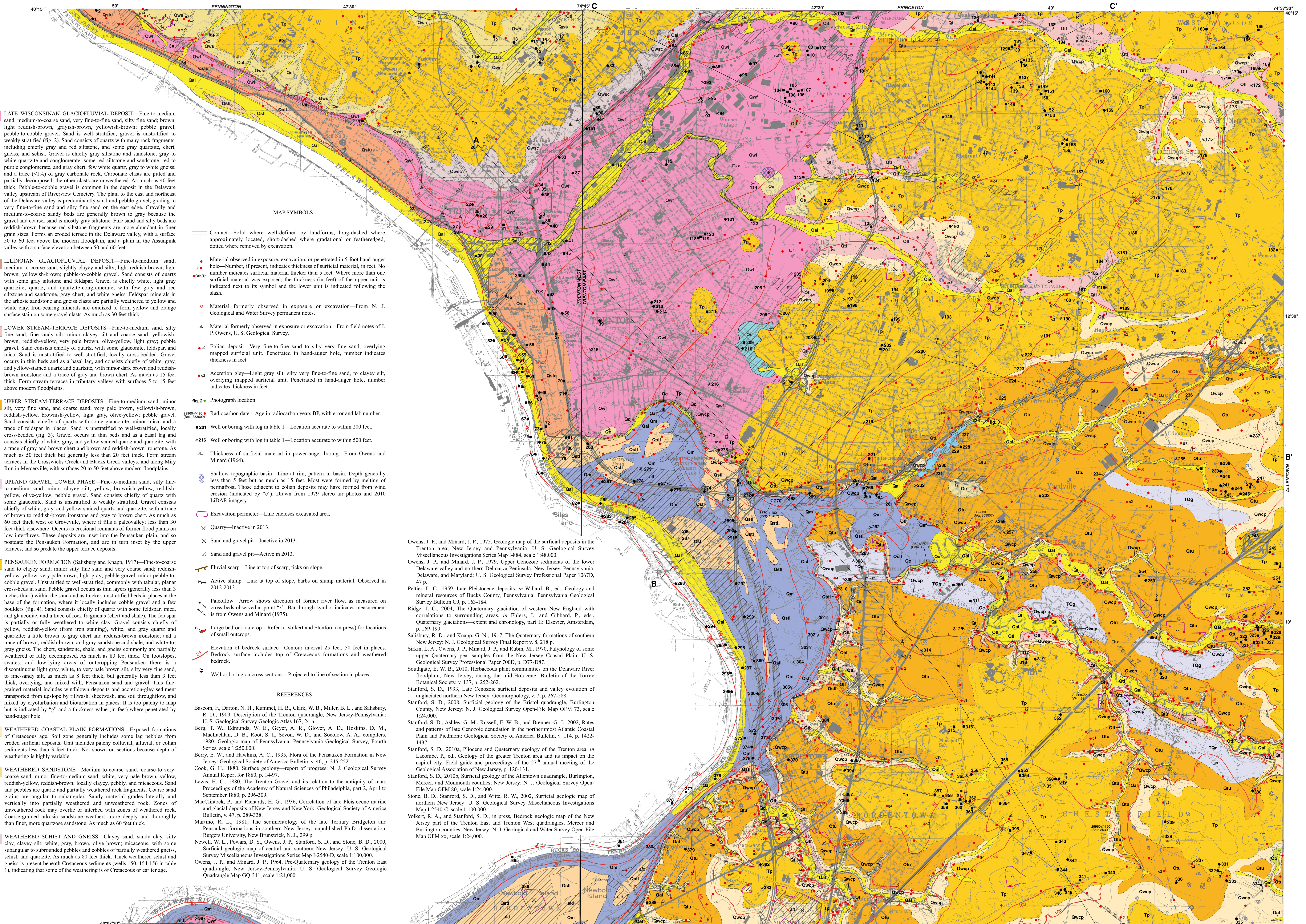


Base map from U. S. Geological Survey Trenton East and Trenton West quadrangles, 1995. North American Datum of 1983.

Geology mapped 2012-13
Sand mineralogy by F. L. Mueller
Cartography by S. Stanford

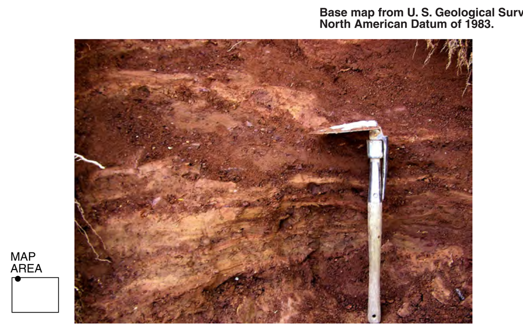


Figure 2.—Interbedded silt and fine sand (light brown) and pebbly sand (reddish brown) of the late Wisconsinan glaciofluvial deposit (Qwf) along Gold Run. Gravel includes rounded gray and red sandstone and mudstone, chert, and quartzite washed down the Delaware valley and some angular local sandstone washed down Gold Run. Inset shows photo location.

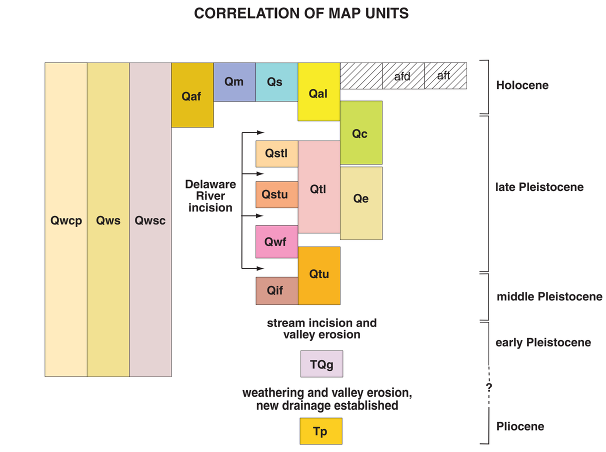
Figure 3.—Interbedded sand and pebble gravel of the upper stream terrace deposit (Qtu) along Back Creek. Planar-tabular cross bedding in the sand (above shovel head) records stream flow to the southwest (left). Inset shows photo location.

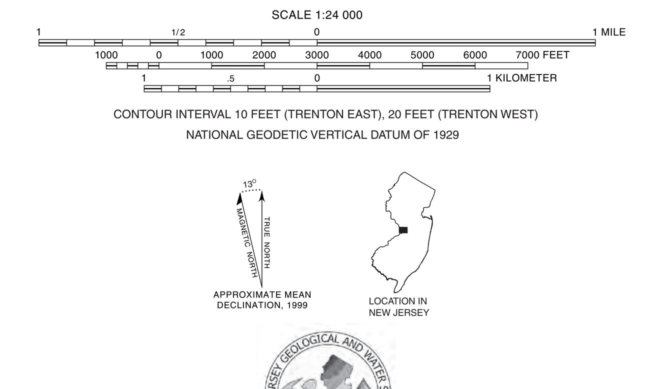
SURFICIAL GEOLOGY OF THE TRENTON EAST AND TRENTON WEST QUADRANGLES
BURLINGTON AND MERCER COUNTIES, NEW JERSEY

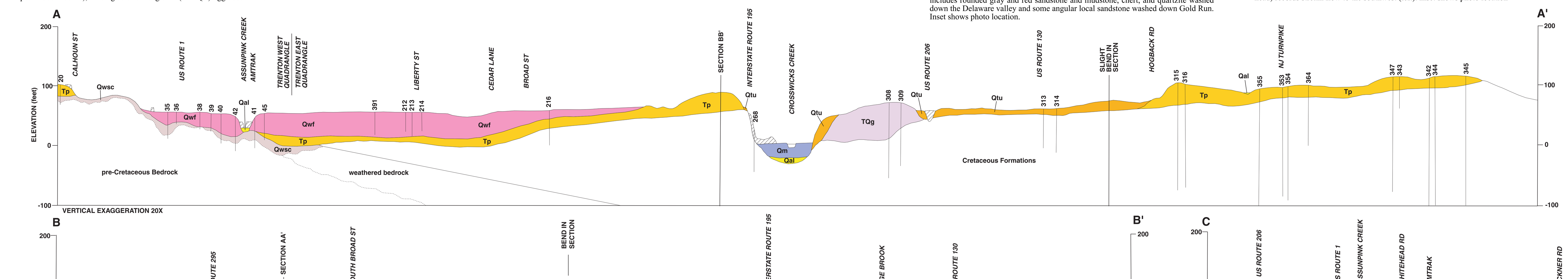
by
Scott D. Stanford
2014

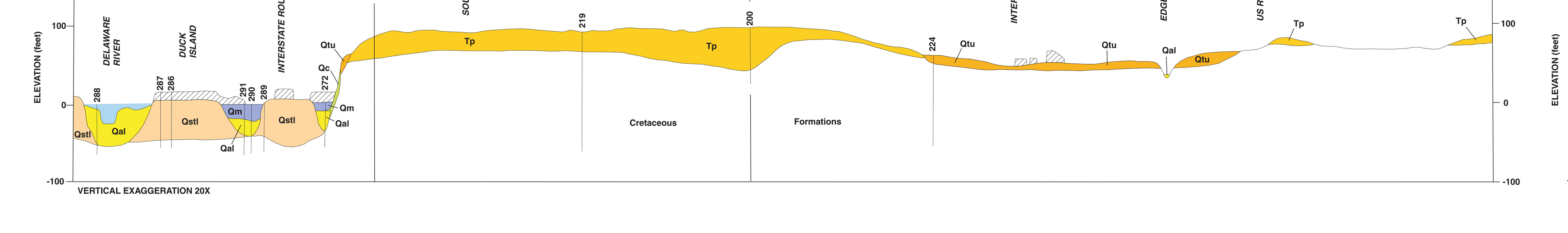
Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G12AC20227. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

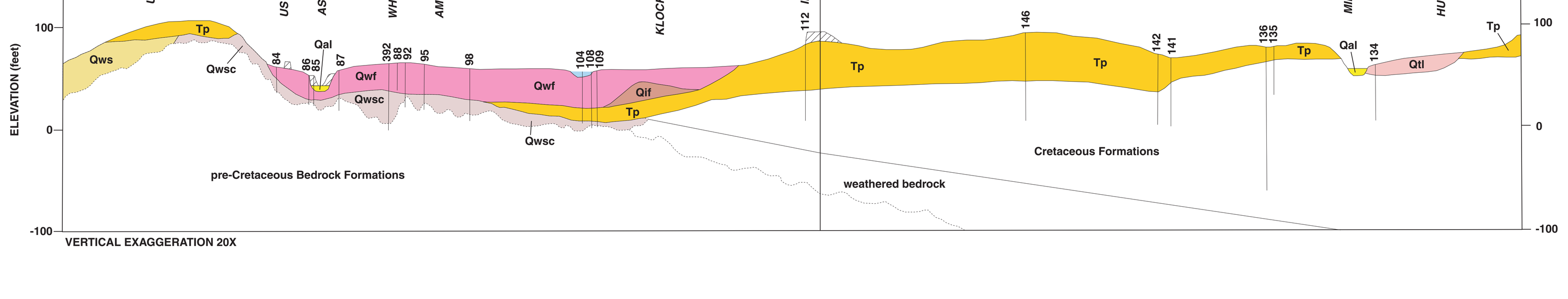
CORRELATION OF MAP UNITS











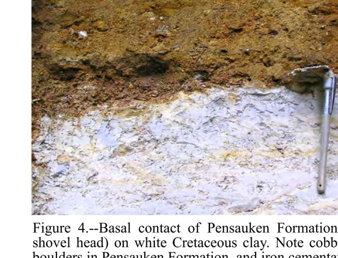


Figure 4.—Basal contact of Pensauken Formation (Tp) (above shovel head) on white Cretaceous clay. Note cobbles and small boulders in Pensauken Formation, and iron cementation along the contact (ledge on left side of photo). Inset shows photo location.

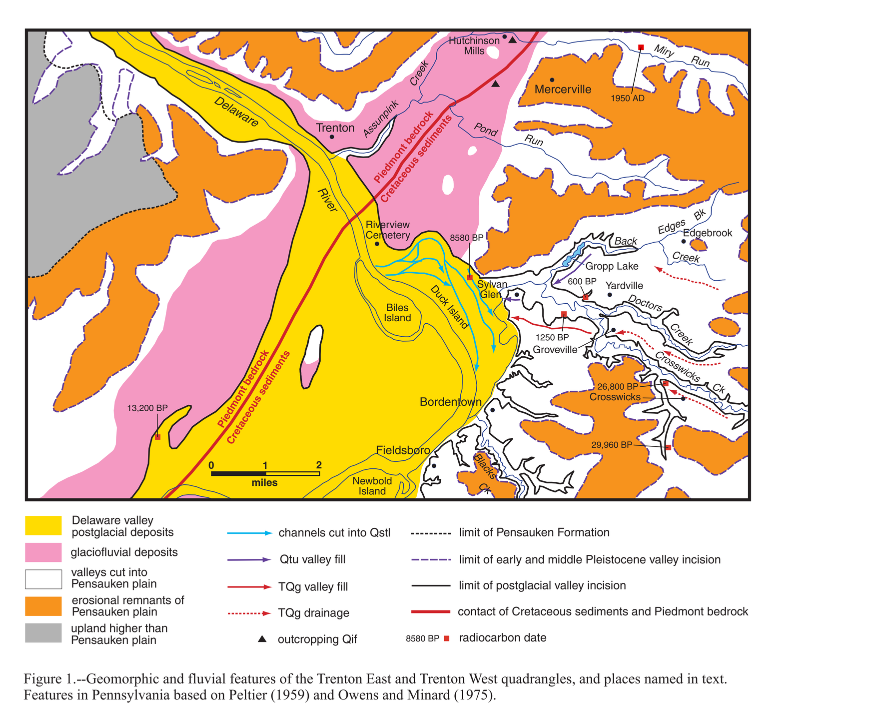


Figure 1.—Geomorphic and fluvial features of the Trenton East and Trenton West quadrangles, and places named in text. Features in Pennsylvania based on Peltier (1959) and Owens and Minard (1975).

Surficial Geology of the Trenton East and Trenton West Quadrangles Burlington and Mercer Counties, New Jersey

New Jersey Geological and Water Survey
Open-File Map 102
2014

pamphlet with table 1 to accompany map

Table 1. Selected well and boring records.

Well Number	Identifier[1]	Formations Penetrated[2]
1	27-1664	34 Qt+Qwf 100 ss&sh
2	27-5896	33 Qt+Qwf, cased to 33, yield 25 gpm
3	27-2918	5 Qwf 51 sh
4	27-2751	40 Qt+Qwf 90 ss
5	27-2288	15 Tp 402 ss
6	27-8783	8 Qwf 25 w ss
7	27-10012	15 Qwf 37 w ss 65 ss&sh
8	28-3500	18 Tp 22 ss
9	28-5471	12 Tp 70 ss
10	27-331	25 Tp+wss 41 ss 70 sh
11	27-2550	15 Qal+wss 75 ss
12	28-28045	19 wss
13	27-2587	62 wss 200 ss
14	28-94	40 wss 201 ss
15	27-2747	28 wss 96 ss 337 gn
16	28-16103	50 wss 170 ss 290 gn
17	28-493	20 Tp+wss 48 wss 198 ss 265 gn
18	28-28456	4 Tp 35 w ss
19	28-29954	20 Tp+wss 46 w ss
20	27-10250	20 Tp 29 wsc 31 sc
21	27-10911	52 wss
22	27-11256	8 Qwf 12 wsc
23	27-11959	5 f 21 Qt+Qwf 25 gn
24	27-11962	13 f 33 Qwf 41 gb
25	27-10985	5 f 13 Qwf 37 wr
26	28-29900	2 f 15 wsc 20 sc
27	27-11068	15 f 42 Qwf 43 wr 60 r
28	28-31375	19 f 29 Qwf 30 wgn 35 gn
29	27-8253	13 f 22 Qwf 27 gn
30	DOT 163W-17	19 Qal+Qwf 29 sc
31	28-23426	10 f 40 Qwf 41 sc
32	28-23520	5 f 14 Qwf 24 gn&sc
33	DOT 379W-8	36 Qwf
34	28-20864	3 f 10 Qwf 17 wr
35	28-25242	6 f 22 Qwf 42 wsc
36	28-22049	5 f 14 Qwf 16 wr
37	DOT 439W-24	21 Qwf

Well Number	Identifier[1]	Formations Penetrated[2]
38	28-23512	28 Qwf 30 r
39	28-21509	9 f 23 Qwf 29 wgn 30 gn
40	28-22999	4 f 32 Qwf 43 wgn 50 gn
41	28-17885	6 f 16 Qwf 50 gn&cg
42	28-22175	35 f+Qwf 60 wsc&sc (average of numerous borings in small area)
43	28-30064	18 f 34 Qwf 60 wr
44	DOT L94A	9 f 25 Qwf 40 sc
45	28-25963	42 Qwf 43 wr?
46	DOT 379W-17	23 Qt+Qwf 25 wgn 30 gn
47	28-23692	38 Qwf 39 sc
48	DOT 125W-194	46 Qwf
49	28-28263	45 Qwf
50	DOT B1001	30 f+Qwf 49 gn 58 q
51	DOT DR 1	5 w 6 Qal 11 gn
52	DOT DR 3	13 w 14 Qal 19 sc
53	DOT DR 4	4 w 22 Qal 26 sc
54	DOT DR 5	13 w 17 Qal 22 gn
55	28-19648	30 f+Qwf 98 wsc 113 sc
56	28-28324	40 Qwf
57	DOT L68	15 f 40 Qt+Qwf
58	DOT L31	9 f 28 Qt+Qwf 39 q
59	28-32138	7 f 17 Qt 27 Qwf 47 wsc
60	DOT DR 7	3 w 26 Qal 31 q&sc
61	DOT DR 9	8 w 53 Qal
62	DOT DR 10	4 w 24 Qal 30 sc
63	DOT DR 11	8 w 60 Qal
64	DOT DR 12	7 w 53 Qal 60 q
65	DOT DR 13	5 w 38 Qal 60 Kp
66	DOT DR 15	6 w 28 Qal 63 Kp
67	DOT DR 17	4 w 17 Qal 60 Kp
68	28-4078	5 f 28 Qt+Qwf 80 Tp? 200 Kp
69	DOT L53	11 f 40 Qt+Qwf
70	DOT 125W-190	9 f 45 Qt+Qwf 50 Tp?
71	DOT 125W-77	7 f 43 Qt+Qwf
72	DOT 125W-101	29 f 41 Qwf 43 Kp
73	DOT W-12	45 Qal 66 Kp
74	DOT DR 19	5 w 23 Qal 60 Kp
75	DOT DR 20	31 w 50 Qal 60 Kp
76	DOT DR 22	12 w 44 Qal 60 Kp
77	DOT DR 23	37 w 50 Qal 60 Kp
78	DOT DR 25	9 w 46 Qal 59 Kp
79	28-13021	13 f 21 Qt 30 Qwf 42 Kp
80	28-13022	22 f 41 Qt+Qwf 66 Kp
81	DOT 125W-122	32 Qt+Qwf 56 Kp
82	DOT DR 37	4 w 28 Qal 60 Kp
83	28-1600	50 Tp+wr 78 wr 194 ss
84	28-13146	4 f 17 Qwf 22 wr?
85	28-15648	6 f 19 Qwf 20 wsc
86	28-13787	27 Qwf 30 q, screened 20-30, yield 60 gpm
87	28-29354	9 f 19 Qwf 23 wgn 40 gn
88	28-10291	30 Qwf, screened 28-30, yield 12 gpm
89	28-28670	6 f 27 wsc
90	DOT 439W-15	9 f 15 wgn 20 gn
91	DOT 379W-10	19 Qwf 29 gn
92	DOT S9	3 f 32 Qwf 43 gn
93	28-575	36 Qwf, screened 26-36, yield 140 gpm
94	28-699	38 Qwf 39 r, screened 18-38, yield 72 gpm

Well Number	Identifier[1]	Formations Penetrated[2]
95	28-2711	37 Qwf 42 r, screened 22-38, yield 50 gpm
96	28-27883	25 Qwf 40 wgn 87 gn
97	28-26479	15 Qwf 16 gn
98	28-23390	48 Qwf 49 r
99	28-5502	54 Tp 55 wr?, screened 50-53, yield 10 gpm
100	28-7173	41 Qwf 45 wr
101	28-3437	24 Qwf 45 Tp?
102	28-6961	22 Qwf 41 Tp?
103	28-4896	40 Qwf 70 wsc, logged by F. J. Markiewicz 10/13/64, screened 40-46, yield 10 gpm
104	28-15574	48 Qwf 53 wr
105	28-9906	46 Qwf 47 wr 50 r, screened 40-50, yield 40 gpm
106	28-7910	50 Qwf, screened 45-50, yield 28 gpm
107	28-6972	55 Qwf, screened 47-50, yield 30 gpm
108	28-8437	52 Qwf 53 r, screened 49-52, yield 25 gpm
109	28-9951	51 Qwf 55 wr, screened 45-50, yield 60 gpm
110	DOT S11	4 f 56 Qwf 63 Kp
111	DOT S19	33 Tp 61 Kp
112	DOT S26	45 Tp 71 Kp
113	28-3578	12 Qwf 52 Kp
114	28-5562	45 Qwf 61 Kp
115	28-25965	27 Qwf
116	28-4480	15 f 28 Qwf 42 wr?
117	28-15680	30 Qwf 33 Kp
118	27-1815	17 Qwf 35 Kp
119	28-1576	17 Qwf 30 Kp
120	27-1792	18 Qwf 30 KP
121	28-3694	30 Qwf 79 Kp
122	28-11247	15 Qwf 100 Kp
123	28-2356	41 Tp 134 Kp
124	DOT S36	3 f 26 Qt 35 Kp
125	DOT S219	31 Qt 51 Kp
126	28-5500	30 Qt 51 Kp
127	28-3667	20 Tp 60 Kp
128	28-9467	30 Tp 56 Kp
129	28-6643	15 Tp 73 Kp
130	28-5958	12 Tp 65 Kp
131	28-3554	18 Tp 60 Kp
132	28-12801	14 Qt 40 Tp 58 Kp
133	28-3184	6 Qt 53 Kp
134	28-3185	10 Qt 55 Kp
135	28-25629	11 Tp 44 Kp
136	28-29222	11 Tp 138 Kp
137	28-8376	25 Tp 80 Kp
138	28-5559	28 Tp 71 Kp
139	28-7130	8 Tp 71 Kp
140	27-4395	23 Tp 70 Kp
141	28-5986	15 Tp 69 Kp
142	28-6011	39 Tp 71 Kp
143	28-5699	38 Tp 61 Kp
144	28-2788	16 Tp 61 Kp
145	28-3646	18 Tp 71 Kp
146	28-6576	38 Tp 85 Kp
147	28-6418	25 Tp 100 Kp
148	28-7896	16 Tp 90 Kp
149	28-1350	11 Tp 82 Kp
150	28-2927	7 Tp 155 Kp 160 wr
151	DOT 379W-9	25 Qwf 33 gn

Well Number	Identifier[1]	Formations Penetrated[2]
152	28-2427	30 Tp 89 Kp
153	28-5201	18 Tp 101 Kp
154	28-6625	34 Tp 218 Kp 236 wr
155	28-161	40 Tp 213 Kp 220 Kp or wr
156	28-1363	40 Tp 215 Kp 235 wsc, logged by F. J. Markiewicz
157	28-26569	32 Tp 55 Kp
158	28-2792	20 Tp 30 Kmg 230 Kp
159	28-4218	45 Tp 120 Kp
160	28-5306	28 Tp 113 Kp
161	28-13775	6 Qt 105 Kp
162	28-13557	48 Tp 78 Kp
163	28-10701	34 Tp 100 Kp
164	28-12799	45 Tp 56 Kmg 180 Kp
165	28-31367	25 Tp 65 Kmg 100 Kp
166	28-7380	10 Tp 65 Kmg 70 Kp
167	28-15342	50 Kmg 75 Kp
168	28-6017	7 g 8 Qt 90 Kmg
169	SC 137	8 Qt 128 Kmg
170	28-6222	10 Qt 62 Kmg
171	28-19775	15 Qt 113 Kmg 150 Kp
172	SC 138	12 Qt 125 Kmg
173	SC 139	131 Kmg
174	SC 140	6 Qt 128 Kmg
175	SC 141	143 Kmg
176	SC 142	11 Kmv 85 Kmg 149 Kp
177	SC 143	6 g 20 Tp 89 Kmg
178	SC 144	20 Tp 93 Kmg 162 Kp
179	SC 145	10 Tp 85 Kmg 150 Kp
180	SC 147	16 Tp 108 Kmg 148 Kp
181	SC 148	68 Kmg 134 Kp
182	28-31032	36 Tp 96 Kmv 160 Kmg
183	28-26539	12 Tp 50 Kmv 100 Kmg
184	SC 149	9 Qt 134 Kmg
185	SC 150	15 Qt 70 Kmg 131 Kp
186	28-7031	8 Tp 61 Kmg
187	SC 151	10 Qal 126 Kmg
188	SC 152	75 Kmg 135 Kp
189	28-9905	31 Tp 43 Kmv 117 Kmg 160 Kp
190	SC 153	28 Tp 90 Kmg 144 Kp
191	SC 154	19 Kmv 79 Kmg 143 Kp
192	28-49883	151 Kp
193	28-7667	36 Tp 140 Kp
194	28-6241	38 Tp 109 Kp
195	DOT S54	4 f 61 Kp
196	28-22497	18 Tp 52 Kp
197	28-5081	34 Tp 96 Kp
198	28-5010	18 Tp 97 Kp
199	28-30274	31 Tp 45 Kmg
200	28-12399	55 Tp 68 Kmg
201	28-17124	2 f 43 Tp
202	28-19133	2 f 35 Tp
203	DOT S63	8 f 24 Tp 81 Kp
204	28-3105	16 Tp 92 Kp
205	28-30002	20 Qwf 59 Kp
206	28-29938	40 Qwf 70 Kp
207	28-1152	4 f 8 Tp 60 Kp
208	28-1551	170 Kp 185 sc, logged by E. S. Lenker

Well Number	Identifier[1]	Formations Penetrated[2]
209	28-7150	2 f 5 Qs 15 Qwf 109 Kp
210	28-6061	4 f 10 Qwf 68 Kp
211	28-30969	70 Tp
212	28-16493	35 Qwf
213	28-30994	5 f 40 Qwf
214	28-29315	32 Qwf
215	28-21-485	46 Qwf 98 Kp 179 w sc
216	28-7129	10 Qwf 59 Kp
217	DOT S69	22 Tp 86 Kp
218	28-9204	18 Tp 38 Kmv 135 Kmg 170 Kp
219	28-11690	10 Tp 35 Kmv 135 Kmg 150 Kp
220	28-5202	28 Tp 40 Kmv 66 Kmg
221	28-4964	36 Qt 115 Kmg 124 Kp
222	SC 155	16 Tp 65 Kmg 128 Kp
223	SC 156	3 Tp 124 Kmg
224	SC 157	13 Qt 112 Kmg
225	SC 158	19 Qt 112 Kmg
226	SC 159	14 Qt 80 Kmg
227	SC 160	12 Qt 84 Kmg
228	28-7663	55 Qt 75 Kmg 115 Kp
229	SC 161	17 Qt 69 Kmg 81 Kp
230	SC 162	22 Qt 52 Kmg 78 Kp
231	SC 163	36 Qt 50 Kmg 82 Kp
232	SC 164	39 Qt 75 Kmg 108 Kp
233	28-5317	18 Qt 63 Kmv+Kmg 117 Kmg 178 Kp
234	28-2025	14 Qt 90 Kmv+Kmg 105 Kmg
235	28-2458	16 Qt 23 Kmv 134 Kmg 215 Kp
236	28-17765	9 Qt 45 Kmv 178 Kmg 200 Kp
237	28-10158	34 Kwb 93 Kmv 142 Kmg
238	28-16886	15 Qt 75 Kwb 90 Kmv 150 Kmg
239	28-7144	14 Qt 81 Kwb+Kmv 143 Kmg
240	28-25995	11 Qt 88 Kmv 172 Kmg
241	28-3824	12 Qt 70 Kwb+Kmv 140 Kmv+Kmg 162 Kmg
242	28-20542	10 Qt 95 Kwb+Kmv 130 Kmg
243	28-11057	6 Qt 23 Kwb 68 Kmv 145 Kmg
244	28-15230	8 Qt 45 Kwb 81 Kmv 132 Kmg
245	28-7253	8 Qt 100 Kwb+Kmv 168 Kmg
246	28-10299	4 g 11 Qt 85 Kwb+Kmv 91 Kmv 150 Kmg
247	28-14224	3 f 10 g 25 Qt 115 Kwb+Kmv 230 Kmg 285 Kp
248	28-1671	10 Tp 178 Kwb+Kmv 207 Kmg
249	28-7497	5 Tp 155 Kwb+Kmv 213 Kmg 238 Kp
250	28-28500	60 Kwb 80 Kmv 135 Kmv+Kmg 200 Kmg
251	28-19515	10 Tp 68 Kwb 105 Kmv 181 Kmg
252	28-31081	29 Tp 54 Kwb 121 Kmv 208 Kmg
253	28-7929	28 Qt 96 Kmv 165 Kmg
254	28-8677	24 Qt 90 Kmv 149 Kmg
255	28-4280	15 Qt 90 Kmv 119 Kmg
256	28-3956	20 Qt 90 Kmg, logged by D. G. Parrillo, 11/28/60
257	28-9231	4 f 6 Qt 26 Kmv+ Kmg 90 Kmg
258	28-1729	6 Qt 34 Kmv 108 Kmg
259	28-25886	15 Qt 49 Kmv 96 Kmg
260	28-14445	20 Qt 50 Kmv 115 Kmg
261	SC165	16 Qm 35 Kmg 57 Kp
262	SC 167	36 Qm 56 Kmg
263	SC 168	19 Qt 60 Kmg
264	28-5409	9 Qm 15 Kmg 140 Kp
265	28-8769	2 f 10 Qm 20 Kmg 137 Kp

Well Number	Identifier[1]	Formations Penetrated[2]
266	28-34305	12 f over Qm 22 Kmg 122 Kp
267	29-5150	8 Qt 16 Kmg 127 Kp
268	28-31914	14 Kmg 53 Kp
269	28-104	18 Qt 30 Kmg 120 Kp
270	core 1 (Southgate, 2010)	19 Qm
271	DOT S88	17 Qm 42 Qal 120 Kp
272	DOT SB341	10 Qm 43 Qal 55 Kp
273	DOT SB119	13 Qm 69 Qal 79 Kp
274	DOT SB50	13 Qm 51 Qal
275	28-26036	30 Qwf 145 Kp
276	DOT H41	3 f 12 Qm 30 Qal
277	DOT H40	6 f 17 Qm 35 Qal
278	DOT H38	9 f 17 Qm 30 Qal
279	28-25876	21 Qm 28 Qal 60 Kp
280	DOT 125W-161	12 Qm 28 Qal 36 Kp
281	DOT 125W-76	40 Qt 43 Kp
282	DOT DR 36	3 w 17 Qal 59 Kp
283	DOT DR 37	4 w 28 Qal 60 Kp
284	DOT DR 40	7 w 14 Qal 60 Kp
285	DOT DR 41	26 w 36 Qal 60 Kp
286	28-9524	25 f 63 Qt 73 Kp
287	28-9525	25 f 63 Qt 73 Kp
288	DOT DR 55	15 w 61 Qal
289	DOT SB 190	18 Qm 40 Qal 66 Kp
290	DOT SB223	21 Qm 40 Qal 61 Kp
291	DOT SB232	17 Qm 40 Qal 66 Kp
292	DOT H14	18 Qm 28 Qal 46 Kp
293	DOT H20	18 Qm 31 Qal
294	DOT DR 64	7 w 50 Qal 60 Kp
295	DOT DR 68	30 w 43 Qal 60 Kp
296	DOT DR 69	8 w 36 Qal 59 Kp
297	DOT DR 72	7 w 30 Qal 60 Kp
298	DOT DR 73	17 w 50 Qal 61 Kp
299	DOT DR 74	25 w 45 Qal 60 Kp
300	DOT F7	40 Qt 64 Kp
301	SC 172	23 Qm 27 Qal 55 Kmg
302	SC 173	32 Qm 47 Qal 55 Kp
303	SC 174	35 Qm 42 Qal 55 Kp
304	SC 175	20 Qm 55 Qal
305	SC 176	33 Qm 55 Qal
306	SC 177	12 Qm 18 Qal 55 Kp
307	SC 178	6 f 19 Qt 62 Kp
308	SC 169	62 Qt 127 Kmg+Kp
309	SC 170	38 Qt 106 Kmg
310	SC 171	20 Qt 85 Kmg 109 Kmg+Kp
311	28-9683	10 Qt 55 Kmv 123 Kmg
312	28-15804	10 Qt 55 Kmv 125 Kmg
313	28-20500	8 Qt 32 Kmv 65 Kmg
314	28-4291	12 Qt 45 Kmv 75 Kmg
315	28-29149	32 Tp 115 Kwb+Kmv 180 Kmg
316	28-16367	40 Tp 155 Kwb+Kmv 172 Kmg
317	28-249	13 Tp 35 Kwb 75 Kmv 276 Kmg 397 Kp
318	28-5042	15 Tp 110 Kwb+Kmv 239 Kmg 372 Kp
319	28-57004, G	10 Tp 110 Kwb+Kmv 245 Kmg 397 Kp
320	28-21105	29 Qt 49 Kwb 94 Kmv 162 Kmg
321	28-16829	16 Qt 85 Kwb 160 Kmv 205 Kmg

Well Number	Identifier[1]	Formations Penetrated[2]
322	28-17754	15 Qt 65 Kwb 115 Kmv 145 Kmv+Kmg 200 Kmg
323	28-15414	25 Qt 125 Kwb+Kmv 140 Kmv 187 Kmg
324	28-8832	18 Qt 75 Kwb 95 Kmv
325	28-16759	16 Qt 80 Kwb 140 Kmv 193 Kmg
326	28-21288	21 Qt 84 Kwb 138 Kmv 212 Kmg
327	28-9479	20 Qt 76 Kwb 99 Kmv
328	28-28512	18 Qt 138 Kmv+Kwb 195 Kmg
329	28-20443	18 Qt 82 Kwb 124 kmv 231 Kmg
330	28-8462	5 Qt 90 Kwb 110 Kmv 190 Kmg
331	28-22529	9 Qt 58 Ket 128 Kwb 158 Kmv 187 Kmv+Kmg 257 Kmg
332	28-16280	12 Qt 60 Ket
333	28-15962	75 Ket
334	28-26457	62 Ket 141 Kwb 186 Kmv 260 Kmg
335	28-16335	70 Ket 150 Kwb 215 Kmv 265 Kmg
336	28-26253	7 Qt 40 Ket 136 Kwb 188 Kmv 240 Kmg
337	28-9803	63 Ket 65 Kwb
338	28-31209	60 Ket 196 Kwb+Kmv 220 Ket
339	28-4082, G	40 Ket 120 Kwb 190 Kmv 280 Kmg 290 Kp
340	28-21188	24 Tp 49 Ket 138 Kwb 184 Kmv 240 Kmg
341	28-31351	29 Tp 57 Ket 137 Kwb 176 Kmv 247 Kmg
342	28-23147	19 Tp 34 Ket 117 Kwb 176 Kmv 240 Kmg
343	28-7997	9 Tp 35 Ket 55 Kwb
344	28-31219	20 Tp 40 Ket 120 Kwb 158 Kmv 220 Kmg
345	28-30475	16 Tp 49 Ket 123 Kwb 146 Kmv 252 Kmg
346	28-21153	20 Tp 55 Ket 120 Kwb 160 Kmv 225 Kmg 280 Kmg +Kp
347	28-7701	16 Tp 108 Kwb 122 Kmv 192 Kmg
348	28-29752	14 Tp 27 Ket 112 Kwb 178 Kmv 240 Kmg
349	28-21985	23 Tp 81 Kwb 140 Kmv 200 Kmg
350	28-20780	21 Tp 65 Kwb 103 kmv 110 kmg
351	28-8826	19 Tp 70 Kwb 155 Kmv 185 Kmg
352	28-27525	30 Tp 85 Kwb 100 Kmv 220 Kmg
353	28-16500	28 Tp 99 Kwb 119 Kmv 180 Kmg
354	28-17488	28 Tp 97 Kwb 121 Kmv 190 Kmg
355	28-7592	32 Tp 80 Kwb 90 Kmv 144 Kmv+Kmg 199 Kmg
356	28-4837	7 Tp 55 Kwb 69 Kmv 79 Kmg
357	28-29913	75 Kwb 95 Kmv 160 Kmg
358	28-30763	12 Tp 60 Kwb 100 Kmv 180 Kmg
359	28-16751	35 Tp 90 Kwb 140 Kmv 180 Kmg
360	28-31199	40 Tp 76 Kwb 134 Kmv 160 Kmg
361	28-31200	39 Tp 76 Kwb 133 Kmv 158 Kmg
362	28-29216	14 Tp 133 Kwb+Kmv 180 Kmg
363	28-31201	40 Tp 76 Kwb 134 Kmv 160 Kmg
364	28-11221	5 g 18 Tp 65 Kwb 89 Kmv 100 Kmg
365	28-4846	10 Tp 64 Kwb+Kmv 70 Kmg
366	28-23133	23 Kmv
367	28-26010	12 Tp 30 Kmv
368	28-853	7 Tp 13 Kmv 87 Kmv+Kmg 115 Kmg
369	28-1828	22 f+Tp 60 Kmv 131 Kmg
370	28-27595	8 Qt 25 Kmv 46 Kmg
371	SC 179	10 Qm 22 Kmg 53 Kp
372	DOT DR 84	13 w 21 Qm 58 Qal 60 Kp
373	DOT SB 269	25 Qm 62 Qal 86 Kp
374	DOT SB 307	26 Qm 57 Qal 81 Kp
375	DOT SB 346	37 Qal 60 Kp
376	DOT DR 92	37 w 53 Qal 60 Kp
377	DOT DR 97	12 w 51 Qal 60 Kp
378	DOT DR 100	7 w 10 Qm 30 Qal 60 Kp

Well Number	Identifier[1]	Formations Penetrated[2]
379	28-30964	20 Qt 66 Kmg
380	28-3660	41 Qal 45 Kmg 89 Kp
381	DOT DR 112	15 w 28 Qm 38 Qal 60 Kp
382	28-456	30 Tp 110 Kmv+Kmg 155 Kmg 230 Kp
383	28-7196	12 Tp 95 Kwb+Kmv 165 Kmg
384	28-5083	130 Kmg 265 Kp, logged by F. J. Markiewicz, 11/18/64
385	DOT DR 130	7 w 11 Qm 60 Qal
386	28-7100	42 Qt 212 Kp
387	27-10794	17 Qwf 24 Kp
388	28-28810	24 Qt 55 Kmg 120 Kp
389	DOT SB 243	16 Qm 40 Qal 130 Kp
390	28-21-447	6 f 36 Qwf 39 sc
391	28-29302	40 Qwf
392	28-21-274	27 Qwf 59 wr? 61 r
393	28-3645	22 Qal 70 Kmv 145 Kmg 299 Kp, logged by R. Mayer, 12/14/59
394	28-1601	13 Tp 92 Kmv+Kmg 232 Kmg 397 Kp
395	28-16750	14 Qt 90 Kwb 150 Kmv 200 Kmg

[1] Identifiers of the form 27-xxxx and 28-xxxx are N. J. Department of Environmental Protection well-permit numbers. Identifiers of the form 28-xx-xxx are N. J. Atlas Sheet grid locations of wells in the state well files or the N. J. Geological and Water Survey permanent note collection that do not have permit numbers. Identifiers prefixed by "DOT" are N. J. Department of Transportation test borings available at http://www.state.nj.us/transportation/refdata/geologic/. Identifiers prefixed by "SC" are test borings made in the 1930s for a proposed ship canal that are on file at the N. J. Geological and Water Survey. The identifier "core 1 (Southgate, 2010)" is a pollen core from: Southgate, E. W. B., 2010, Herbaceous plant communities on the Delaware River floodplain, New Jersey, during the mid-Holocene: Bulletin of the Torrey Botantical Society, v. 137, p. 252-262. A "G" following the identifier indicates that a gamma-ray log is available for the well.

[2]Number is depth (in feet below land surface) of the base of the unit indicated by an abbreviation following the number. Final number is the total depth of the well rather than the base of the unit. For example, "12 Tp 34 Kmg 62 Kp" indicates Tp from 0 to 12 feet below land surface, Kmg from 12 to 34 feet, and Kp from 34 to bottom of hole at 62 feet. Formation abbreviations and the corresponding drillers' descriptive terms (in parentheses) used to infer the formation are as follows:

Surficial Deposits: w=water (for test borings drilled in the Delaware River), f=fill, g=accretion gley overlying surficial unit (brown, gray silty clay, sandy clay), Qal=alluvium (gray, brown, black, yellow sand, gravel, silty sand), Qm=tidal-marsh deposits (black, brown, dark gray silt, sand, and clay with peat or organic matter), Qs=swamp and marsh deposits (black soil), Qt=terrace deposits, undivided (includes map units Qstl, Qstu, Qtl, Qtu, TQg) (yellow, gray, tan, brown, reddish-brown sand, clayey sand, gravel, silty sand, loam), Qwf=glaciofluvial deposit (includes map units Qwf and Qif) (brown, reddish-brown, yellowish-brown sand and gravel, sand), Tp=Pensauken Formation (yellow, yellowish-brown, orange-brown, red sand and gravel, sand, clayey sand, silty sand, loamy sand).

Cretaceous Formations: Ket=Englishtown Formation (yellow, white, orange, gray sand, with clay, wood, mica), Kwb=Woodbury Formation (gray, black clay, silty clay), Kmv=Merchantville Formation (green, gray, black clay, marl, silty clay), Kmg=Magothy Formation (gray, white fine sand, fine-to-medium sand, silt, clay, with wood, lignite, mica), Kp=Potomac Formation (white, yellow, brown, red, gray clay, sand, coarse sand, gravelly sand).

Pre-Cretaceous bedrock lithologies (not assigned to formations) are: cg=conglomerate, gb=gabbro, gn=gneiss, r=rock, q=quartzite, sc=schist, sh=shale, ss=sandstone. A “w” preceding the rock identifier indicates that it is reported as “weathered” or “decomposed”: wgn=weathered gneiss, wr=weathered rock, wsc=weathered schist, wss=weathered sandstone.

Units joined with a “+” cannot be separately identified in the driller’s description. Units joined with an “&” are interbedded or intercalated. Queried units (for example, “Tp?”) are inferred from inconclusive descriptions. Units are interpreted from drillers’ or geologists’ lithologic descriptions on records from the sources indicated in footnote 1. Well cuttings logged by N. J. Geological and Water Survey staff are noted with the geologist’s name and date, if available. Units shown for wells may not match the map and sections due to variability in drillers’ descriptions. For wells tapping surficial deposits, the depth of the screened interval (in feet below land surface) and yield (in gallons per minute) are shown following the log.