DEPARTMENT OF ENVIRONMENTAL PROTECTION
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INTRODUCTION

The New Gretna Quadrangle is in the Barnegat Bay and Great Bay region of the New Jersey Coastal Plain, in the southeastern part of the state. The surficial deposits outcropping in this quadrangle are of late Miocene to Holocene age. They overlie the Cohansey and Kirkwood Formations, which are marginal marine to shelf deposits of Miocene age. Shelf deposits of early Oligocene and late Eocene age (the Atlantic City and Absecon Inlet formations) underlie the Miocene deposits. The surficial deposits consist of river, wetland, estuarine, hillslope, and windblown sediments. The Kirkwood Formation was deposited in marine delta and shallow shelf settings in the early to middle Miocene. The Cohansey Formation was deposited in coastal settings in the middle and late Miocene, when sea level in this region was at times more than 200 feet higher than at present (Stanford, 2014). As sea level lowered after deposition of the Cohansey Formation, rivers flowing on the emerging Coastal Plain deposited fluvial gravel. Continued lowering of sea level caused streams to erode into the gravel and the underlying Cohansey Formation. During the latest Miocene, Pliocene, and Pleistocene, about 8 million years ago (8 Ma) to 11,000 years ago (11 ka), stream and hillslope sediments were deposited in several stages as valleys were progressively deepened by stream incision, and widened by seepage erosion, in step with lowering sea level. During at least two interglacial periods in the middle and late Pleistocene, when sea level was higher than at present, estuarine sediments were laid down in terraces throughout the quadrangle. Most recently, alluvial, wetland, beach and estuarine deposits were laid down during the Holocene (11 ka to present).

A summary of the stratigraphy of the Kirkwood and Cohansey Formations in the quadrangle and the geomorphic history of the map area as recorded by surficial deposits and landforms, is provided below. The age of the deposits and erosional episodes are shown on the Correlation of Map Units. Table 1 in the accompanying pamphlet lists the formations penetrated in the selected well records analyzed for this map and borings drilled by the NJGWS, interpreted from samples taken while drilling and from geophysical logs. Cross section A-A' shows materials to a depth of 700 feet below sea level, which includes the Cohansey Formation, the Kirkwood Formation, the Atlantic City Formation, and part of the Absecon Inlet Formation. Most domestic water wells in the quadrangle tap sands in the Cohansey Formation at depths between 70 to 130 feet. A thick aquifer sand in the Kirkwood Formation (Unit 5 on section A-A') provides water to several public-supply wells in Little Egg Harbor Township. This aquifer is known as the "Atlantic City 800-foot sand" (Zapecza, 1989). Formations below an elevation of -700 feet are described in Owens and others (1998) and Miller and others (1998).

KIRKWOOD FORMATION

The Kirkwood Formation consists of marine-delta, and shallow shelf sediments. These sediments were sampled in the Bass River corehole (well 96), which is located along cross section A-A' (Miller and others, 1998) and are described in four sequences. These four sequences, shown in green on cross sections A-A' and B-B' (well 5), can be traced laterally through southern Ocean County to the northeast of the quadrangle using geophysical well logs (Stanford, 2014; Stanford and Sugarman, 2017). In the Bass River corehole, these four sequences consist of six lithic units, shown in black on cross sections A-A' and B-B' (Well 5), that are described in the Island Beach corehole located 24 miles to the northeast. The Kirkwood 1a sequence (Kw1a) includes units 6 and 5, which is equivalent to the informal Lower Member of Owens and others (1998), also known as the Brigantine Member of Miller and others (1997). Shells at the base of unit 6 in the Bass River corehole yield strontium stable-isotope ages of 20.8, 20.9, 21.1, and 21.4 Ma (Miller and others, 1998), indicating an early Miocene age for this sequence. The Kirkwood 1b sequence (Kw1b) of Sugarman and others (1993) includes unit 4 and most of unit 3. It is equivalent to the Shiloh Marl member of Owens and others (1998). The Kirkwood 2 sequence (Kw2a and Kw2b) of Sugarman and others (1993) includes the upper part of unit 3, unit 2, and unit 1 and are equivalent to the Wildwood member of Owens and others (1998). Diatoms in this sequence indicate an early to middle Miocene age (Miller and others, 1998). A boundary between sequences 2a and 2b of Sugarman and others (1993) may be present in the lower part of unit 1. In the Bass River corehole Kw1a is a basal prodelta clay (unit 6) overlain by delta- front sand (unit 5), in turn overlain by a thin prodelta clay (unit 4) and nearshore sand (unit 3), Kw1b which is overlain by thin prodelta clay (unit 2) which is overlain by interbedded inner-shelf, nearshore, and back-bay sand and clay (unit 1), (Kw2a and Kw2b).

COHANSEY FORMATION

The Cohansey Formation consists of stacked successions composed of beach and shoreface sand overlain by interbedded sand and clay deposited in tidal flats, bays, and coastal swamps (Carter, 1972, 1978). Pollen and dinoflagellates recovered from peat beds in the Cohansey at Legler, in northern Ocean County, are indicative of a coastal swamp tidal marsh environment (Rachele, 1976). The Legler pollen (Greller and Rachele, 1983), pollen recovered from a corehole near Mays Landing, New Jersey (Owens and others, 1988), and dinocysts obtained from coreholes in Cape May County, New Jersey (deVerteuil, 1997; Miller and others, 2001), indicate a middle to early-late Miocene age for the Cohansey. The Cohansey generally lacks datable marine fossils, particularly in updip areas where it has been weathered. As discussed above, lower parts of the Cohansey in updip settings like the map area may be age-equivalent to the upper Kirkwood downdip (for example, Kirkwood sequence 2, about 17-15 Ma, and sequence 3, 12-14 Ma, (Sugarman and others, 1993) and may represent the coastal facies of the Kirkwood shallow-shelf deposits.

In this map area, clays in the Cohansey are in beds or laminas generally less than 6 inches thick, but as much as 3 feet thick, and are commonly interbedded with sand. In the subsurface, dark organic clays are reported in a few drillers' logs and are labeled as Tchco (e.g. Well 74). Gamma-ray and lithologic logs (section A-A') show three clay beds in the subsurface, two of which extend northward into the Oswego Lake quadrangle (Stanford, 2017).

The laminated bedding and thin but areally extensive geometry of the clayey beds are indicative of bay or estuarine intertidal settings. Alluvial clays generally are thicker and more areally restricted because they are deposited in floodplains and abandoned river channels. The representative stacking of bay clays and beach sand (predominantly tidal-delta and shoreface deposit) indicated the Cohansey Formation was deposited during several rises and falls of sea level during a longer period of overall rising sea level (Stanford, 2012).

SURFICIAL DEPOSITS AND GEOMORPHIC HISTORY

Sea level in the New Jersey region began a long-term decline following deposition of the Cohansey Formation. As sea level lowered, the inner continental shelf emerged as a coastal plain. River drainage was established on this plain. The Beacon Hill Gravel, which caps the highest elevations in the Coastal Plain, is the earliest record of this drainage. It is absent in the map area but may be present at elevations above 150 feet to the north of the map area in the Oswego Lake quadrangle. The Beacon Hill is quartz-chert gravel deposited by rivers draining southward from the Valley and Ridge province in northwestern New Jersey and southern New York (Stanford, 2009).

Continued decline of sea level through the late Miocene and early Pliocene (approximately 8 to 3 Ma) caused the regional river system to erode into the Beacon Hill plain. As it did, it shifted well to the west of the map area into what is now the Delaware River basin. The map area became an upland from which local streams drained southeastward to the Atlantic Ocean. These local streams eroded shallow valleys into the Beacon Hill Gravel. Groundwater seepage, slope erosion, and channel erosion reworked the gravel and deposited it in floodplains, channels, and pediments, between 40 and 60 feet below the level of the former Beacon Hill plain. These deposits are referred to as upland gravel, high phase but are not present on the New Gretna quadrangle. The upland gravel, high phase is found to the north on the Oswego Lake quadrangle. Today, owing to topographic inversion, they cap ridgetops above an elevation of between 100 and 150 feet.

A renewed period of lowering sea level in the late Pliocene and early Pleistocene (approximately 3 Ma to 800 ka) led to another period of valley incision. Groundwater seepage and channel and slope erosion reworked the upland gravel, high phase and deposited the upland gravel, lower phase unit TQg in shallow valleys 20 to 50 feet below the higher gravels. These deposits today cap interfluves and form more extensive mantles in head-of-valley areas and upper slopes. These deposits are found in the northeast part of the New Gretna Quadrangle.

Continuing incision in the middle and late Pleistocene (about 800 to 11 ka) formed the modern valley network. Fluvial sediments laid down in modern valleys include upper and lower terrace deposits (units Qtu and Qtl). Like the upland gravels, the terrace deposits represent erosion, transport, and redeposition of sand and gravel reworked from older surficial deposits and the Cohansey Formation by streams, groundwater seepage, and slope processes. Wetland deposits are formed by accumulation of organic matter in swamps and bogs.

Upper terrace deposits (Qtu) form terraces and pediments 10 to 30 feet above modern floodplains. They also occur as thin fills in some headwater valleys that do not contain active streams. They were laid down chiefly during periods of cold climate in the late Pleistocene. During cold periods, permafrost impeded the infiltration of rainfall and snowmelt and this, in turn, accelerated groundwater seepage, runoff, and slope erosion, increasing the amount of sediment entering valleys, leading to terrace deposition. Some of the deposits may have been laid down during periods of temperate climate when sea level was high, because at their downstream limit the upper terraces grade to the Cape May 2 marine terrace (Qcm2). This topographic equivalence indicates that some of the upper terrace deposits aggraded during the Cape May 2 highstand. The upper terraces are inset into the Cape May 1 (Qcm1) estuarine deposits, indicating that they are younger than the Cape May 1 highstand.

Lower terrace deposits (unit Qtl) form low, generally wet, terraces with surfaces less than 5 feet above modern valley bottoms. Like the upper terrace, they also form thin fills in some valleys that lack active streams. They are inset into the upper terrace and the Cape May 2 and Cape May 3 (Qcm3) terrace, and were laid down in shallow valleys and lowlands eroded after deposition of the Cape May 2 and 3. This erosion occurred during a period of lower-than-present sea level and colder-than-present climate known as the Wisconsinan stage, between about 80 ka and 11 ka.

Lower terraces are most prominent along the Wading River in the northwestern corner of the quadrangle. These deposits are also found along the Bass River in the central northern part of the quadrangle and along the tributaries of Nacote Creek in the southeastern part of the quadrangle. Here, the lower terrace is scribed in places by a network of shallow braided channels (figure 1). These channels are wetter than the adjacent unchanneled terrace and are marked by grass and shrub glades, distinct from pine forest on the slightly higher terrace. The braided channels formed when permafrost impeded infiltration and thus increased seepage and runoff. The increased runoff washed sand from uplands into valleys, choking streams with sediment and causing channels to aggrade and split to form a braided pattern.

The lower terrace deposits were laid down chiefly during or slightly after the last period of cold climate between 25 and 15 ka. Near Manahawkin, northeast of the quadrangle, sand and gravel of the lower terrace overlie an organic silt dated to 34,890±960 radiocarbon years (GX-16789-AMS, Newell and others, 1995) (38,410-40,550 calibrated years with one sigma error, calibrated using Reimer and others, 2013). In the Chatsworth quadrangle, to the north of the New Gretna quadrangle, organic sediment within lower terrace sand dated to 20,350±80 radiocarbon years (Beta 309764, Stanford, 2012) (24,450-24,150 calibrated years with one sigma error). These dates indicate deposition of the terrace deposits in the late Wisconsinan.

Another feature related to permafrost are thermokarst basins. These are shallow closed basins, circular to oval in shape, generally less than an acre in area, and less than 5 feet in depth (symbolled on map). In the New Gretna quadrangle, they were formed on Cape May 3 and some are partially filled in with Holocene wetland deposits (Qals and Qm). Most formed when ice-rich lenses at shallow depth in the frozen sediments melted, leaving small depressions (Wolfe, 1953; French and Demitroff, 2001; French and others, 2005).

Modern floodplain and wetland deposits (unit Qals) were laid down within the past 10 ka, based on radiocarbon dates on basal peat in other alluvial wetlands in the region (Buell, 1970; Florer, 1972; Stanford, 2000). Pollen in organic silt at a depth of 4 feet in unit Qals on the Oswego Lake quadrangle, to the north of New Gretna, contains 50% spruce, 38% birch, 3% pine, 1% oak, and 6% herb (Watts, 1979). This pollen assemblage indicates an age no younger than about 10 radiocarbon ka (about 12,000 calibrated years) for the onset of deposition of the alluvial deposit here, based on the youngest occurrence of spruce in the region (Sirkin and others, 1970).

Eolian deposits (Qe) are present in the New Gretna quadrangle. They include elongate dune ridges, generally oriented east-west or northwest-southeast, as much as 1/2-mile long and 10 feet thick. A few dune ridges are curved or crescentic, with the crescents opening to the west or northwest (figure 1.) These orientations suggest that the dunes were formed by winds blowing from the west and northwest. The windblown deposits occur chiefly on upper terraces, the Cape May 2 terrace in the northwestern corner of the quadrangle, the Cape May 3 terrace in the southwestern corner of the quadrangle and older surfaces but are generally absent from lower terraces and modern floodplains. In many places, windblown deposits were laid down at the upland edge of lower terraces, most notably along the edge of the lower terraces and floodplains along the Bass River and Wading River. This association suggests the windblown sand in these settings was blown from the lower terrace deposits as the terrace deposits were laid down. The distribution of eolian deposits shows that the deposits largely postdate the Cape May 2 and Upper terrace deposits and, in places are the same age, or slightly younger than, the Lower terrace deposits. These relations indicate that deposition was mostly during the Wisconsinan stage (80-11 ka). Deposits on older surfaces, such as the Cape May 1 terrace, may be older.

During at least two periods of higher-than-present sea level in the middle and late Pleistocene, beach and estuarine deposits were laid down in terraces throughout most of the quadrangle. These marine deposits are grouped into the Cape May Formation. The Cape May includes an older, eroded terrace Cape May Formation, unit 1, Qcm1 with a maximum surface elevation of 65 feet, a younger, less eroded terrace with a maximum surface elevation of 35 feet (Cape May Formation, unit 2, Qcm2), and the youngest beach and estuarine deposit, Cape May Formation, unit 3, Qcm3, which has a maximum surface elevation of 15 feet. The Cape May 1 deposits lie within wide valleys which are inset into the upland gravel, lower phase. The valleys were shallower and broader at the time of deposition of the Cape May 1 than they are today, because the base of the Cape May 1 is higher than that of the upper and lower terrace deposits, and of modern floodplain sediments.

Amino-acid racemization ratios (AAR), optically stimulated luminescence ages, and radiocarbon dates from the Delaware Bay area (Newell and others, 1995; Lacovara, 1997; O'Neal and others, 2000; O'Neal and McGeary, 2002; O'Neal and Dunn, 2003: Sugarman and others, 2007; Stanford and others, 2016) suggest that the Cape May 1 is of middle Pleistocene age (possibly oxygen-isotope stage 11, around 420 ka, or stage 9, around 330 ka, or older) and that the Cape May 2 is of Sangamonian age (stage 5, 125-80 ka). AAR data from vibracores on the inner continental shelf off Long Beach Island northeast of the quadrangle indicate that the Cape May Formation correlate there is of Sangamonian age (Uptegrove and others, 2012). Unit Qcm3 was deposited during sea-level fall from the highstand that is represented by the Qcm2 deposits and is of Sangamonian or early Wisconsinan age.

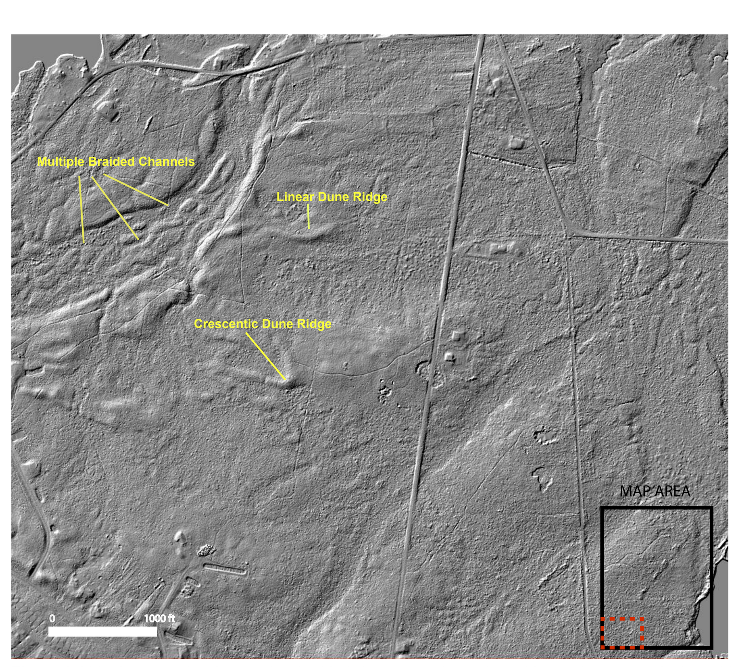

Figure 1. Lidar imagery showing multiple braided channels, a linear dune ridge and a crescentic dune ridge. This image is showing the southwestern most corner of the New Gretna Quadrangle. Area shown is approximately 1.3 square miles.

DESCRIPTION OF MAP UNITS

Artificial Fill—Sand, pebble gravel, minor clay and organic matter; gray, brown, very pale brown, white. In places includes minor amounts of man-made materials such as concrete, asphalt, brick, cinders, and glass. Unstratified to poorly stratified. As much as 20 feet thick. In road and railroad embankments; dams; filled wetlands and low ground; and infilled sand and clay pits. Small areas of fill in urban areas are not mapped.

afd — **Dredge Spoil**—Fine sand, silt, clay, minor medium-to-coarse sand and gravel; gray to brown. Contain variable amounts of organic matter and mica, and minor amounts of man-made materials. As much as 10 feet thick.

Qals — **Wetland and Alluvial Deposits**— Fine-to-medium sand and pebble gravel, minor coarse sand; light gray, yellowish-brown, brown, dark brown; overlain by brown to black peat and gyttja (gel-like organic mud). Peat is as much as 10 feet, but generally less than 4 feet thick. Sand and gravel are chiefly quartz with a trace (<1%) of chert and are generally less than 3 feet thick. Sand and gravel are stream-channel deposits; peat and gyttja form from the vertical accumulation and decomposition of plant debris in swamps and marshes. In floodplains and alluvial wetlands on modern valley bottoms.

Qs — **Freshwater Swamp and Marsh Deposits**—Peat and gyttja, black to brown, with wood in places. As much as 10 feet thick. Deposited in areas of groundwater seepage along the bay shore and upstream of salt-marsh deposits.

Qm — **Salt-Marsh and Estuarine Deposits**—Peat, clay, silt, fine sand; brown, dark-brown, gray, black; minor medium-to-coarse sand and pebble gravel. Contains abundant organic matter and shells. As much as 30 feet thick; deposits along the inland edge of the salt-marsh are generally less than 5 feet thick and overlie the Cape May Formation. Deposited in salt marshes, tidal flats and bays during Holocene sea level rise, chiefly within the past 9 ka in the map area.

Qe — **Eolian Deposits**— Fine-to-medium quartz sand; very pale brown, white. As much as 10 feet thick. Form elongate dune ridges on the upper and lower terrace and Cape May 2 and 3 terraces. Likely formed during one or more periods of cold climate in the Wisconsinan when terrace sands were exposed to wind erosion.

Qtl — **Lower Terrace Deposits**—Fine-to-medium sand, pebble gravel, minor coarse sand, light gray, brown, dark-brown. As much as 15 feet thick. Sand and gravel are quartz. Form terraces and pediments in valley bottoms with surfaces 2 to 10 feet above modern wetlands. Include both stratified stream-channel deposits and unstratified pebble concentrates formed by seepage erosion of older surficial deposits. Sand includes gyttja in places, and peat less than 2 feet thick overlies the sand and gravel in places. The gyttja and peat are younger than the sand and gravel and accumulate due to poor drainage. Gravel is more abundant in the lower terrace deposits than in upper terrace deposits due to removal of sand by seepage erosion.

Qtu — **Upper Terrace Deposits**—Fine-to-medium sand, pebble gravel, minor coarse sand; very pale brown, brownish-yellow, yellow. As much as 25 feet thick. Sand and gravel are quartz. Form terraces and pediments with surfaces 5 to 25 feet above modern wetlands. Include stratified stream-channel deposits and poorly stratified to unstratified deposits laid down by groundwater seepage on pediments.

Cape May Formation—Fluvial-estuarine and beach sand and gravel deposits of middle and late Pleistocene age forming an upper (Qcm1), middle (Qcm2), and lower (Qcm3) marine terrace, and fine-grained estuarine valley-fill deposits in the Mullica River valley (Qcm2f).

Qcm3 — **Cape May Formation, Unit 3**—Fine-to-medium sand, pebble gravel, minor coarse sand; yellow, very pale brown, yellowish-brown. Sand and gravel are quartz. As much as 40 feet thick. Forms eroded terraces with a maximum surface elevation of 15 feet. Includes beach, dune, tidal-flat, tidal-channel, and shoreface sediment.

Qcm2 — **Cape May Formation, Unit 2**—Fine-to-medium sand, pebble gravel, minor coarse sand; yellow, very pale brown, yellowish-brown. Sand and gravel are quartz. As much as 30 feet thick. Forms eroded terraces with a maximum surface elevation of 30 feet. Includes beach, dune, tidal-flat, tidal-channel, and shoreface sediment.

Qcm2f — **Cape May Formation, Unit 2, Fine-Grained Facies**—Silt, clay, minor sand; gray, light gray. As much as 130 feet thick. In subsurface only. Forms a valley fill in the Mullica, Wading and Bass Rivers.

Qcm1 — **Cape May Formation, Unit 1**—Fine-to-medium sand, pebble, gravel, minor clayey sand to sandy clay, and coarse sand; yellowish-brown, yellow, very pale brown. As much as 20 feet thick. Sand and gravel are quartz with minor weathered chert. Forms eroded terraces with a maximum surface elevation of 65 feet. Includes beach, dune, tidal-flat, tidal-channel, and shoreface sediment.

TQg — **Upland Gravel, Lower Phase**—Fine-to-medium sand, clayey in places, and pebble gravel; minor coarse sand; yellow, very pale brown, reddish-yellow. Sand and gravel are quartz (<5%) with brown weathered chert in the coarse sand-to-pebble fraction. Clay is chiefly from weathering of chert. As much as 20 feet thick, generally less than 10 feet thick. Occurs as erosional remnants on interfluves, and as more continuous deposits in headwater valleys, between 65-90 feet in elevation. Includes stream-channel deposits, poorly stratified deposits laid down by groundwater seepage on pediments, and pebble concentrates formed from older surficial deposits and the Cohansey Formation as sand is removed by groundwater sapping or surface runoff.

Tb — **Bridgeton Formation**— Fine-to-coarse sand to clayey sand, reddish-yellow, brownish- yellow, reddish-brown; pebble gravel (Salisbury and Knapp, 1917).Unstratified to well stratified, with some cross-beds in sand. Cemented by iron in places. Sand consists of quartz with some weathered feldspar and a little weathered chert. Gravel consists of quartz with some chert. Most chert pebbles are weathered to white and yellow clay. As much as 20 feet thick. Occurs as erosional remnants in the southwestern corner of the quadrangle. These are the easternmost remnants of a large river-plain deposit that extends across southern New Jersey. This plain was laid down by an easterly to southeasterly flowing river system (Owens and Minard, 1979; Martino, 1981). Stratigraphic position and petrologic correlations with marine deposits in the Delmarva Peninsula indicate a late Miocene age (Owens and Minard, 1979; Pazzaglia, 1993)

Cohansey Formation—The Cohansey Formation is a fine-to-medium quartz sand, with some strata of medium-to-very coarse sand and fine gravel, very fine sand, and interbedded clay and sand, deposited in estuarine, bay, beach, and inner shelf settings. The Cohansey is here divided into two map units: a sand facies and a clay-sand facies, based on gamma-ray well logs and surface mapping using 5-foot hand-auger holes, exposures, and excavations. Total thickness of the Cohansey in the map area is as much as 150 feet.

Tchs — **Sand Facies**—Fine-to-medium sand, some medium-to-coarse sand, minor very fine sand, minor very coarse sand to very fine pebbles, trace fine-to-medium pebbles; very pale brown, brownish-yellow, white, reddish-yellow, rarely reddish-brown, red, and light red. Well-stratified to unstratified; stratification ranges from thin, planar, subhorizontal beds to large-scale trough and planar cross-bedding in sets as much as 3 feet thick. Sand is quartz; coarse-to-very coarse sand may include as much as 5% weathered chert and a trace of weathered feldspar. Coarse-to-very coarse sands commonly are slightly clayey; the clays occur as grain coatings or as interstitial infill. This clay-size material is from weathering of chert and feldspar rather than from primary deposition. Pebbles are chiefly quartz with minor gray chert and rare gray quartzite. Some chert pebbles are light gray, partially weathered, pitted, and partially decomposed; some are fully reddish-brown hard sands or ironstone masses. Locally, sand facies includes isolated lenses of interbedded clay and sand like those within the clay-sand facies described below. The sand facies is as much as 130 feet thick.

Tchc — **Clay-Sand Facies**— Clay interbedded with clayey fine sand, very fine-to-fine sand, fine-to-medium sand, less commonly with medium-to-coarse sand and pebble lags. In subsurface only. Clay beds are commonly 0.5 to 3 inches thick, rarely as much as 2 feet thick, sand beds are commonly 1 to 6 inches thick but are as much as 2 feet thick. Clays are white, yellow, very pale brown, reddish-yellow, and light gray; a few clay beds are brown to dark brown and contain lignitic organic matter. Sands are yellow, brownish-yellow, very pale brown, reddish-yellow, as much as 30 feet thick.

Tkw — **Kirkwood Formation**— Fine sand, fine-to-medium sand, sandy clay, and clay, minor coarse sand and pebbles; gray, dark gray, brown. Sand is quartz with some mica and lignite. In subsurface only. Approximately 450 feet thick in the northern part of the quadrangle. The Kirkwood consists of 6 clay-sand lithic units that comprise 4 depositional sequences traceable on gamma-ray logs and sampled in the Bass River corehole (Well 96) (Miller and others, 1998, see discussion under "Kirkwood Formation" above). These units are shown by tie lines on sections A-A' and B-B'. The Kirkwood in the quadrangle is of early to middle Miocene age, based on strontium stable-isotope ratios and diatoms (Miller and others, 1998).

Tac — **Atlantic City Formation**—Silty, clayey, glauconitic (as much as 10%) fine-to-medium quartz sand, minor coarse sand; olive, olive-brown, brown, dark gray; with mica, shells, and shell fragments. In subsurface only. As much as 100 feet thick in the northern part of the quadrangle. Assigned to Atlantic City Formation of Pekar and others (1997) based on the presence of this formation in the Bass River corehole (Well 96) (Miller and others, 1998). Of early Oligocene age, based on strontium stable-isotope ratios and calcareous nannofossils (Miller and others, 1994, 1998; Pekar and others, 1997).

Tai — **Absecon Inlet Formation**—Clayey, glauconitic to very glauconitic (as much as 25%) fine-to-medium quartz sand; olive, olive-brown, olive-gray; with mica, shells, and shell fragments. In subsurface only. The formation is 171.2 feet thick in the Bass River corehole along cross section A-A'. Calcareous nannofossils of Zones NP19- 20 are present in this formation in the Bass River corehole. These fossils indicate a late Eocene age (Miller and others, 1998).

CORRELATION OF MAP UNITS

Map units	Epoch	Period
afd, Qm, Qals, Qs	Holocene	
Erosion		
Qcm3, Qtl, Qe	late	Pleistocene
Erosion		
Qcm2f, Qcm2, Qtu	late	Pleistocene
Erosion		
Qcm1	middle	Pleistocene
Extensive Erosion		
TQg	early	Pleistocene
Extensive Erosion	Pliocene	
Tb	late	Miocene
Unconformity		
Tchs, Tchc	middle	Miocene
Unconformity		
Tkw	early	Miocene
Unconformity		
Tac	Oligocene	
Unconformity		
Tai	Eocene	

EXPLANATION OF MAP SYMBOLS

Contact—Solid where well-defined by landforms as visible on LiDAR imagery, dashed where approximately located. Dotted within excavations.

Material penetrated by hand-auger hole or observed in exposure or excavation. Hand-auger holes were dug to five feet or until refusal. Material descriptions of each hand-auger hole are written in field notes.

47 Well or test boring—Location accurate to within 200 feet. Log of formations penetrated shown in table 1.

Gamma-ray log—On sections. Radiation intensity increases to right.

Shallow topographic basin—Line at rim, pattern in basin. Includes thermokarst basins formed from melting permafrost.

Excavation perimeter—Line encloses excavated area.

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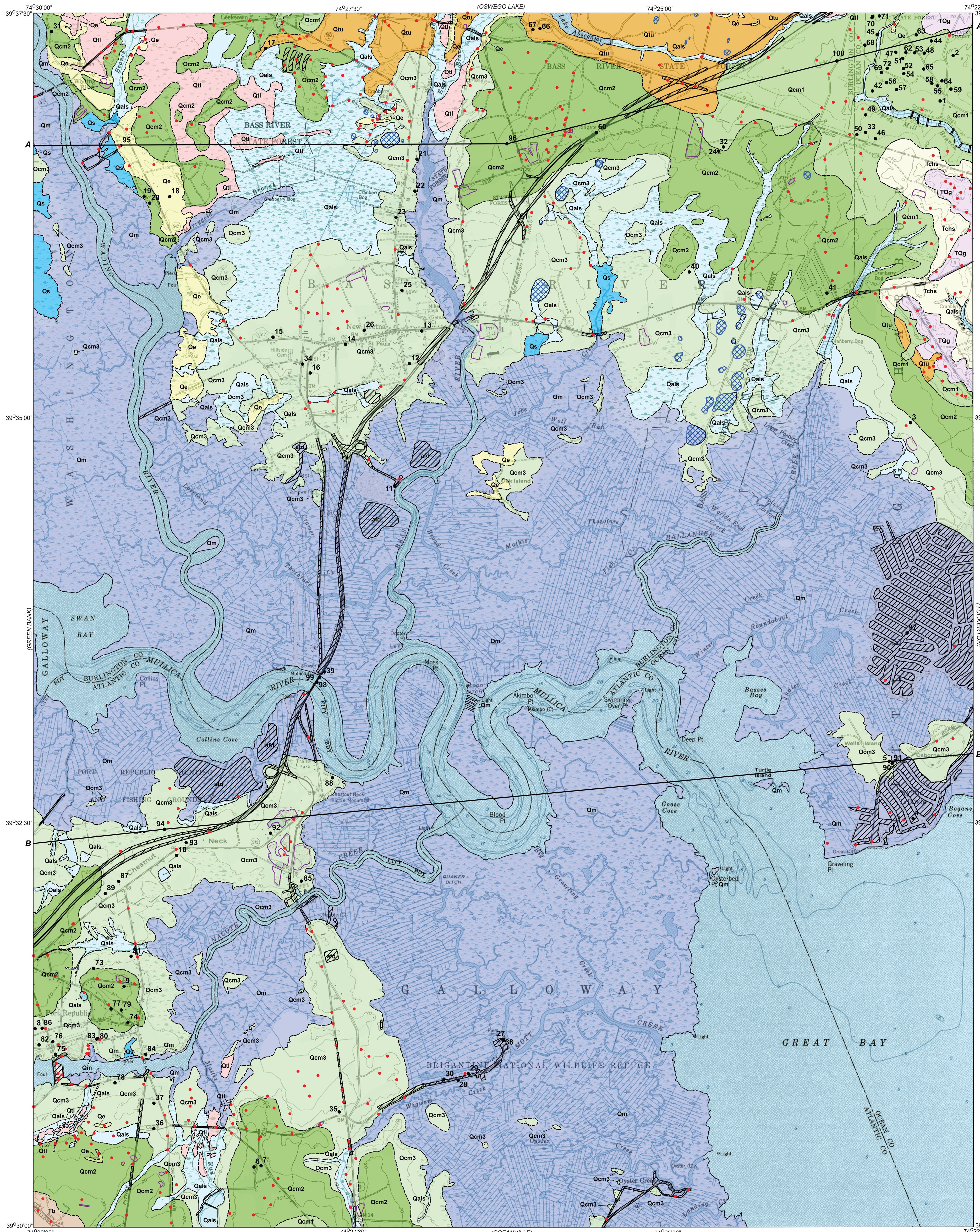


Base from U. S. Geological Survey, 1951.
North American Datum of 1927.
Topography compiled 1950. Planimetry derived from imagery taken 1950. Photorevised using imagery dated 1977.

APPROXIMATE MEAN DECLINATION, 1994

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

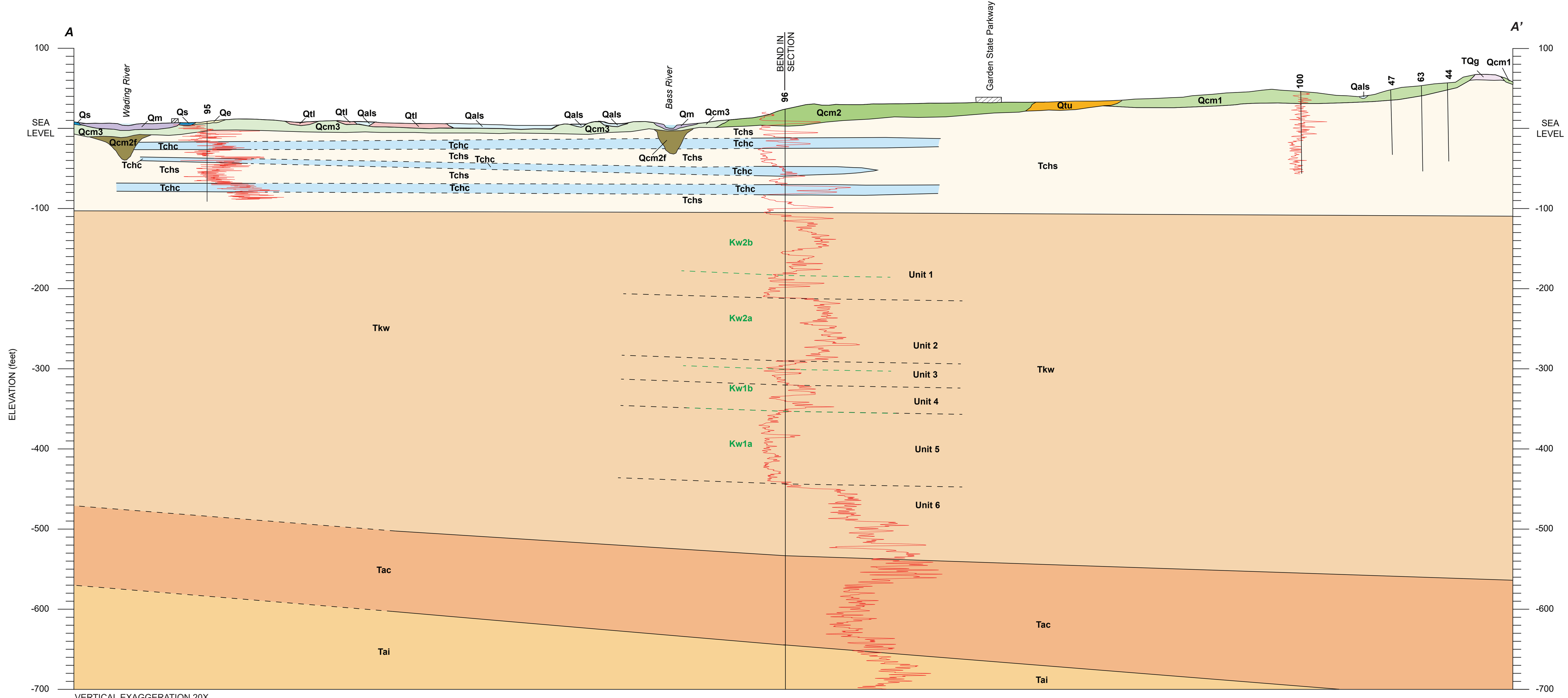
LOCATION IN NEW JERSEY

Geology mapped 2017
Drilling by B. Buttari with assistance from I. Snook
Geophysical logging by M. Spencer
Cartography by M. Castelli

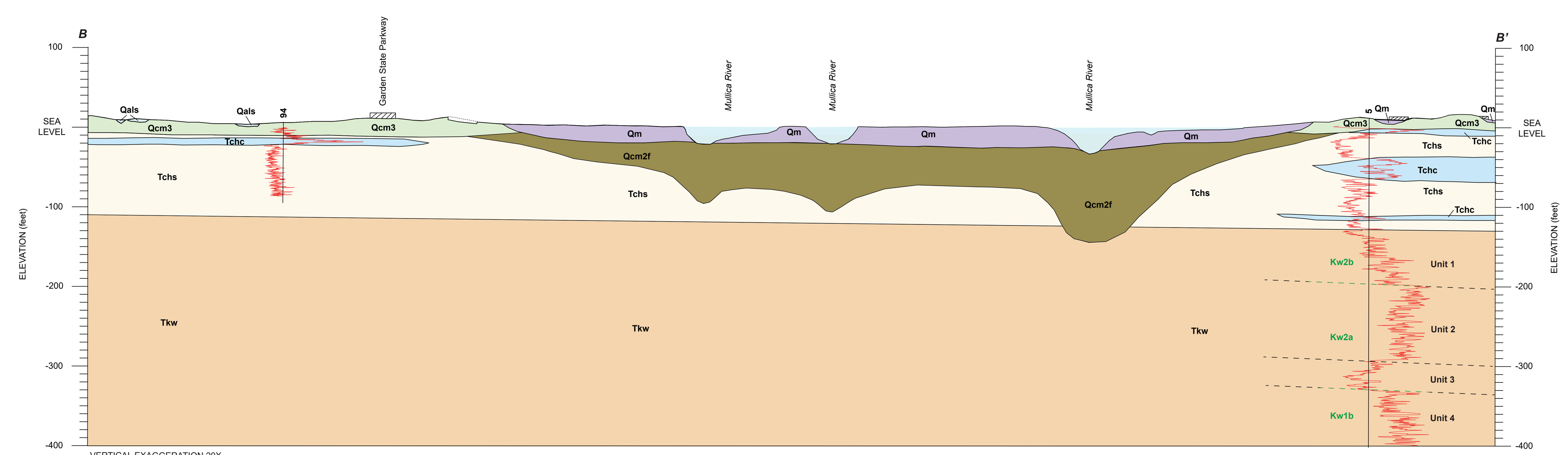
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under Statemap award number G17AC00256. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

GEOLOGY OF THE NEW GRETNA QUADRANGLE, ATLANTIC, BURLINGTON AND OCEAN COUNTIES, NEW JERSEY

By
Michael V. Castelli
2021



VERTICAL EXAGGERATION 20X



VERTICAL EXAGGERATION 20X

Geology of the New Gretna Quadrangle
Atlantic, Burlington and Ocean Counties, New Jersey

New Jersey Geological and Water Survey
Open File Map OFM 137
2021

pamphlet with table 1 to accompany map

Table 1. Selected well and boring records, bolded well numbers are depicted in cross-section

Well Number	Identifier[1]	Formations Penetrated[2]
1	32-27137	15 Qcm1 40 Tchs+Tchc 60 Tchs
2	33-22428	15 Q 45 Tchs 50 Tchc 75 Tchs
3	32-10279	10 Qcm3 38 Tchc 75 Tchs 80 Tchc 97 Tchs 107 Tchc 135 Tkw
4	32-12943	20 Qm 70 Qcm2f
5	**32-12329G**	**BB' 8 Qcm3 117 Qcm2f 400 Tkw 579 Tac**
6	36-03042	10 Qcm2 107 Tchs 182 Tkw
7	36-08779	20 Qcm2 60 Tchs+Tchc 105 Tchs
8	36-32947	16 Qcm3 40 Tchs 67 Tchc 115 Tchs
9	36-28035	7 Qcm2 37 Tchs 68 Tchc 103 Tchs
10	P200901795	13 Qcm3 25 Tchc 75 Tchs+Tchc 115 Tchs
11	P200910255	11 Qm 148 Qcm2f 380 Tkw
12	32-28266	15 Qcm3 26 Tchs 37 Tchc 58 Tchs 91 Tchc 120 Tchs
13	32-30194	15 Qcm3 20 Tchc 40 Tchs 50 Tchc 100 Tchs
14	32-29861	13 Qcm3 38 Tchs 55 Tchc 63 Tchs 75 Tchc 96 Tchs
15	32-29765	20 Qcm3 60 Tchs+Tchc 70 Tchc 90 Tchs
16	32-26588	9 Qcm3 23 Tchs 49 Tchc 110 Tchs
17	32-19933	6 Qtu 20 Tchs 35 Tchc 80 Tchs
18	32-29809	10 Qcm2 40 Tchs 45 Tchc 70 Tchs 72 Tchc
19	32-16746	30 Q+Tchs 40 Tchc 130 Tchs 148 Tkw
20	32-29249	10 Qcm2 48 Tchs 105 Tchs+Tchc 120 Tkw
21	32-03600	2 Qcm3 103 Qcm2f 186 Tkw
22	32-28624	95 Q+Qcm2f
23	32-29405	16 Qcm3 57 Tchs 73 Tchc 115 Tchs
24	32-17745	11 Qcm3 26 Tchc 43 Tchs 48 Tchc 90 Tchs
25	32-27788	9 Qcm2 14 Tchc 86 Tchs
26	32-24149	12 Qcm3 19 Tchc 70 Tchs 72 Tchc 100 Tchs
27	36-05418	35 Qm 82 Qcm2f 87 Tkw
28	36-19237	4 af 24 Qm 74 Qcm2f 104 Tkw
29	36-31752	30 Qm 80 Qcm2f 120 Tkw
30	36-23162	20 Qm 80 Qcm2f 100 Tchs
31	32-26693	20 Qcm2 64 Qcm2f
32	32-22373	5 Qcm1 27 Tchs 39 Tchc 51 Tchs 60 Tchc 78 Tchs 85 121 Tchs 125 Tkw
33	32-27252	15 Qcm1 40 Tchs+Tchc 50 Tchc 70 Tchs
34	32-29764	12 Qcm3 36 Tchc 100 Tchs

35	36-30758	16 Qcm3 72 Tchs 75 Tchc 120 Tchs
36	36-11680	18 Qcm3 120 Tchs+Tchc 140 Tkw
37	36-12070	14 Qcm3 40 Tchs 45 Tchc 64 Tchs 68 Tchc 110 Tchs
38	36-24549	21 Qm 90 Qcm2f 152 Tkw
39	32-28922	30 Qm 89 Qcm2f 207 Tkw
40	32-28401	34 Q+Tchs 48 Tchc 56 Tchs 62 Tchc 90 Tchs
41	E201606840	4 Qcm2 90 Tchs
42	32-12963	15 Qcm1 60 Tchs+Tchc 83 Tchs
43	32-13674	10 Qcm1 30 Tchs 40 Tchc 80 Tchs
44	**32-12965**	**AA’ 12 Qcm1 28 Tchc 80 Tchs**
45	32-13399	15 Qcm1 30 Tchs 35 Tchc 75 Tchs
46	32-11680	15 Qcm1 35 Tchs 46 Tchc 60 Tchs
47	**32-12457**	**AA’ 16 Qcm1 35 Tchs 40 Tchc 75 Tchs**
48	32-14232	6 Qcm1 8 Tchc 90 Tchs
49	32-15593	10 Qcm1 40 Tchs 45 Tchc 80 Tchs
50	32-12705	15 Qcm1 35 Tchs 42 Tchc 90 Tchs
51	32-10111	12 Qcm1 38 Tchs 45 Tchc 80 Tchs
52	32-10879	24 Qcm1 32 Tchs 44 Tchc 70 Tchs
53	32-11679	20 Qcm1 40 Tchs 50 Tchc 75 Tchs
54	32-10717	20 Q+Tchs 30 Tchc 90 Tchs
55	32-13747	15 Qcm1 35 Tchs 55 Tchc 58 Tchs 60 Tchc 80 Tchs
56	32-13427	20 Q+Tchs 60 Tchc 80 Tchs
57	32-13520	10 Qcm1 20 Tchc 45 Tchs 60 Tchc 75 Tchs
58	32-13854	25 Q 45 Tchs 55 Tchc 75 Tchs
59	32-10737	10 Qcm1 40 Tchs 45 Tchc 80 Tchs
60	32-00139	13 Qcm2 22 Tchs 34 Tchc 52 Tchs
61	32-140	1 af 10 Qcm3 43 Tchs
62	32-26956	11 Qcm1 17 Tchs 21 Tchc 40 Tchs 46 Tchc 63 Tchc 80 Tchs
63	**32-19717**	**AA’ 4 Qcm1 18 Tchc 33 Tchs 46 Tchc 58 Tchs 67 Tchc 90 Tchs**
64	32-22301	12 Qcm1 80 Tchs
65	32-22209	5 Qcm1 39 Tchs 55 Tchc 80 Tchs
66	32-20423	9 Qtu 24 Tchs
67	32-20424	15 Qtu 24 Tchs
68	32-13602	16 Qcm1 20 Tchc 75 Tchs
69	32-12947	13 Qcm1 18 Tchs 20 Tchc 28 Tchs 40 Tchc 90 Tchs
70	32-13128	18 Qcm1 24 Tchs 42 Tchc 92 Tchs
71	32-13129	14 Qcm1 17 Tchc 26 Tchs 44 Tchc 92 Tchs
72	32-11539	18 Qcm1 93 Tchs
73	36-23913	10 Qcm2 30 Tchs 50 Tchc 100 Tchs 140 Tkw
74	36-23928	30 Q+Tchs 40 Tchc 50 Tchco 70 Tchc 110 Tchs
75	36-24888	42Tchs 47 Tchc 77 Tchs 92 Tchc 110 Tchs
76	36-24898	5 Qcm3 11 Tchc 37 Tchs 47 Tchc 56 Tchs 62 Tchc 110 Tchs+Tchc
77	36-25152	17 Qcm2 47 Tchs 77 Tchc 125 Tchs
78	36-25499	21 Qcm3 32 Tchc 37 Tch 47 Tchc 57 Tchs 62 Tchc 80 Tchs 84 Tchc 110 Tchs
79	36-25646	60 Q+Tchs 75 Tchc 120 Tchs
80	36-25678	30 Qcm3 Tchs 58 Tchc 72 Tchs 79 Tchc 110 Tchs
81	36-25750	24 Qcm3 42 Tchc 110 Tchs
82	36-25700	30 Qcm3 117 Tchs
83	36-26223	19 Qcm3 30 Tchs 62 Tchc 75 Tchs 78 Tchc 112 Tchs
84	36-24111	18 Qcm3 28 Tchc 42 Tchs 40 Tchc 71 Tchs 90 Tchc 115 Tchs
85	36-29627	15 Qcm3 20 Tchs 40 Tchc 45 Tchs 60 Tchc 86 Tchs
86	36-28534	10 Qcm3 49 Tchs 65 Tchc 100 Tchs 118 Tchc 136 Tkw

87	32-25632	25 Qcm3 47 Tchc 96 Tchs
88	32-23202	25 Qcm3 30 100 Qcm2f 272 Tkw
89	32-28246	15 Qcm3 20 Tchc 80 Tchs 90 Tchc 100 Tchs
90	P200804749	200 Q+Qcm2f 400 Tkw 602 Tac
91	E201513349	28 Qcm3 147 Qcm2f 400 Tkw 570 Tac
92	32-25791	14 Qcm3 24 Tchc 39 Tchs 42 Tchc 78 Tchs 82 Tchc
93	32-28088	10 Qcm3 30 Tchs 35 Tchc 120 Tchs
94	**E201804117G**	**BB’ 15 Qcm3 20 Tchs 30 Tchc 100 Tchs**
95	**E201803050G**	15 Qcm3 25 Tchs 35 Tchc 75 Tchs 90 Tchc 100 Tchs
96	**32-21761G**	**AA’ 20 Qcm2 59 Tchs 64 Tchc 71 Tchs 84 Tchc 96 Tchs 109 Tchc 134 Tchs 555 Tac 654 Tai 1956 TD**
97	32-07802	20 Qm 97 Qcm2f 352 Tkw
98	32-28922	45 Qm 113 Qcm2f 207 Tkw
99	32-28923	18 Qm 110 Qcm2f 202 Tkw
100	**E201807363G**	**AA’ 20 Qcm1 100 Tchs**

[1] N.J. Department of Environmental Protection well-permit numbers. 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 base of unit indicated by the abbreviation following the number. Final number is total depth of well rather than base of unit. For example, "15 Tchs 45 Tchc 82 Tchs" indicated Tchc from 0 to 15 feet below land surface, Tchc from 15 to 45 feet, and Tchs from 45 to bottom of hole at 82 feet. Formation abbreviations and the corresponding drillers' descriptive terms used to infer the formations are: Q = yellow, white, and gray sand and gravel surficial deposits of Pleistocene and Holocene age (units Qtu, Qtl, Qals, Qe, Qcm1, Qcm 2, Qcm3, Qm); Tb = orange, red, yellow, brown clayey sand and gravel to gravelly clay (Bridgeton Formation). Bedrock formations are: Tchc = white, yellow, gray, brown (minor red, orange) fine, medium and coarse sand (and minor fine gravel) (Cohansey Formation); Tkw =gray and brown clay, silt and sand (Kirkwood Formation); Tac= olive brown to dark gray silty ,clayey glauconitic fine, medium quartz sand (Atlantic City Formation); Tai= olive brown, olive gray clayey, glauconitic fine, medium quartz sand with mica, shell fragments (Absecon Inlet Formation). A "+" sign indicates that the units are interbedded or that the depth of the contact between them cannot be determined. “TD” indicates total depth of deep wells for which units below Tai are not listed. Units are inferred from drillers' or geologists' lithologic descriptions on well records filed with the N.J. Department of Environmental Protection and from geophysical well logs. Units shown for wells may not match the map and sections due to variability in drillers' descriptions and the thin, discontinuous geometry of many clay beds. In some well logs, surficial deposits cannot be distinguished from Cohansey sands; thus, the uppermost Tchs unit in well logs may include overlying surficial deposits. The letters AA’ or BB’ before map units and their depths indicated that the well is depicted in cross section AA’ or cross section BB’ respectively.