DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES MANAGEMENT
NEW JERSEY GEOLOGICAL AND WATER SURVEY

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U.S. GEOLOGICAL SURVEY
NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM

BEDROCK GEOLOGY OF THE PITMAN EAST QUADRANGLE
CAMDEN AND GLOUCESTER COUNTIES, NEW JERSEY
OPEN-FILE MAP OFM 143

INTRODUCTION

The bedrock of the Pitman East quadrangle consists of unconsolidated Coastal Plain formations that include gravel, sand, silt, clay, and glauconite sand in varied percentages. The formations were deposited in marine continental shelf and marginal marine environments between approximately 90 and 12 Ma (million years before present). The Cohansey Formation is the last major bedrock deposit in this area. Subsequent sea-level fall exposed the marine shelf to broad downcutting fluvial sytems and floodplains. These fluvial deposits compose the surficial Bridgeton Formation. Extensive cover by surficial deposits, especially the Bridgeton Formation, obscure the Coastal Plain bedrock in much of the quadrangle. The only exposed bedrock formations in this quadrangle are the Cohansey and Kirkwood Formations, which formed 22-12 Ma. Sections A-A' and B-B' show the subsurface geometry of the units along the lines of section. These sections are based on geophysical logs (gamma) and were correlated with the 460-foot stratigraphic core hole at Wilson Lake (well E2016032265). The sections reach a depth of 800 feet. The lithology and age of the formations are provided in the Description of Map Units. The Bridgeton Formation is the sole surficial unit represented on this map. Extensive Quaternary-age surficial deposits consisting of alluvial, colluvial and eolian silts, sands, gravels and peat overlie the mapped formations in much of the quadrangle, particularly in valleys. These are generally less than 10 feet thick and are not shown on this map.

DESCRIPTION OF MAP UNITS

Outcropping Units

Tb **BRIDGETON FORMATION -** Fine to very coarse quartz sand; brownish-yellow, reddish-yellow, minor greenish. Gravel-sized pebbles to minor cobbles are rounded to subrounded quartz, quartzite, chert and minor sandstone that range in color from white to brown to red. The sand is quartz and feldspar, with a small percentage of heavy minerals. Sand grains are commonly coated by reddish clay. Chert and sandstone clasts are deeply weathered. Hand-augering shows abrupt (inches to feet) changes in grain size, color, and sorting, with scattered gravel beds. These changes are indicative of channel deposits from a broad southeast-flowing fluvial system on the coastal plain exposed by the drop in sea level during the middle to late Miocene (Stanford, 2003). These channels cut into the underlying Cohansey Formation. Bridgeton deposits cover the majority of the quadrangle above approximately 100 feet in elevation in the southern part of the quadrangle to 150 feet on the northern edge. Total thickness ranges from approximately 10 to 45 feet in the quadrangle.

The Bridgeton Formation does not contain dateable material, but the deep weathering of its constituent materials and the age of the underlying Cohansey Formation help constrain its age to late Miocene (Stanford, 2019). The Bridgeton Formation covers much of the quadrangle and is well exposed only in active excavations. The underlying contact with the Cohansey Formation is unconformable and was observed in only two locations.

Tch **COHANSEY FORMATION -** Quartz sand, gravelly in places, typically cross-stratified with mainly trough crossbeds. Fine- to coarse-grained; in places gravel is concentrated in the base of channels. Beds up to 10-feet thick. Interbedded with laminated sand and sandy clay, lignitic, slightly micaceous and rarely burrowed. Yellow- to light-gray clay beds with silty laminations and finely disseminated lignite are common near the top of the formation (Minard, 1965; Carter, 1978; Miller and others, 2017). Detrital heavy minerals may be up to several percent and ilmenite dominates among the opaque minerals. Contains local concentrations of small to large clay-lined *Ophiomorpha nodosa* burrows. A corehole at Wilson Lake (well E2016032265) contains intervals of interbedded laminated sand and sandy clay with rare burrows and common organic matter (Miller and others, 2017). Approximately 75 feet thick at Wilson Lake corehole (hereafter, "Wilson Lake"); overlain by 25 feet of the Bridgeton Formation. Maximum thickness for the quadrangle is approximately 150 feet.

No datable material was recovered from the Cohansey Formation in this quadrangle. Owens and others (1998) place it as middle Miocene in age, owing to the similarity of its palynomorphs to those of the Kirkwood Formation. Recent strontium (Sr) isotope age estimates for the upper part of the Kirkwood Formation (Sugarman and others, 1993) indicate that the Cohansey Formation is no older than 12 Ma (middle Miocene in age).

The contact between the Cohansey and Kirkwood Formations was not observed in outcrop, although it is believed to be represented by a 2.5-inch gravel and sandstone layer at Wilson Lake. Where observed, the contact is irregular and unconformable (Owens and others, 1998).

Tkw **KIRKWOOD FORMATION -** Predominantly fine- to very fine-, minor medium- grained sand; in weathered outcrops it is quartz with minor feldspar, mica, and extensive iron oxide (Leisegang) banding. Some silt and clay. *Ophiomorpha* burrows approximately 1 inch in diameter common in some beds in the adjacent Runnemede quadrangle (Sugarman, 2011). Thin weathered mollusk shells were found in an outcrop along the South Branch of Raccoon Creek in the adjacent Pitman West quadrangle (Sugarman and others, 2021). Locally can contain several percent ilmenite. Deeply weathered in outcrop to shades of orange (dark yellowish orange, grayish orange), yellow, reddish-brown, and light gray. Maximum thickness is approximately 110 feet.

At Wilson Lake, where it reaches 110 feet in thickness, the Kirkwood Formation grades down to a darker (grayish-brown) clayey, micaceous organic rich clay, laminated clay silt, shelly silty clayey fine sand, and sandy silts and clays (Miller and others, 2017).

Miller and others (2017) report Sr-isotope age estimates of 22.6-19.4 Ma (upper Miocene in age) for the Kirkwood at Wilson Lake, and correlated it with the Brigantine and Shiloh Marl Members (Owen and others, 1998). Miller and others (2017) also considered the Wildwood Member present at the site based on sequence stratigraphic analysis, although there was no shell material or Sr-isotope age estimates to confirm this correlation. Unconformably overlies the Shark River Formation.

Subsurface Units (shown only in cross-section)

Tsr **SHARK RIVER FORMATION -** Slightly glauconitic (0-5%) shelly sandy (up to 30%) and clayey silt to silty clay. Sand is very fine to fine, greenish to greenish gray and commonly fills burrows. Transitions down section to an olive brown glauconitic (~25%) clay to dark greenish gray clayey glauconite sand. At Wilson Lake the Shark River Formation is approximately 90-feet thick and is predominantly a thick ash-colored marl over 6 feet of glauconite sand. This is reflected in the gamma log pattern where there is a strong positive response at the base of the formation and a medium response above. This unit reaches a maximum 100-foot thickness near Wilson Lake. It is assigned to a middle to latest early Eocene age based on nannofossils (Browning and others, 2011). Unconformably overlies the Manasquan Formation.

Tmq **MANASQUAN FORMATION -** Clayey glauconite sand overlain by laminated clay. Foraminifera are common. Upper "ash marl" clay is laminated, with approximately 10% very fine quartz sand. The lower glauconite sand is intensely burrowed. Like the Shark River, the Manasquan shows a gamma log pattern with a high gamma response at the base and a medium gamma response above reflecting the glauconite sand overlain by the sandy laminated clay. At Wilson Lake the Manasquan is approximately 17 feet thick (Miller and others, 2017) but ranges to 30 feet thick in other locales.

The Manasquan is early Eocene in age based on nannoplankton zone NP10-11 at Wilson Lake. (Gibson and others, 1993). Unconformably overlies the Marlboro Formation.

Tmb **MARLBORO FORMATION -** Clay, dark green, laminated, traces of mica and glauconite (increasing to a few percent in the basal few feet). Dominant clay minerals are kaolinite and illite-smectite (Gibson and others, 2000). The unit is 48 feet thick at Wilson Lake, and is lowermost Eocene in age based on nannoplankton zone NP9 and the onset of the CIE (carbon isotope excursion) at the base of the formation marking the Paleocene/Eocene boundary (Miller and others, 2017). Maximum thickness of approximately 50 feet. Unconformably overlies the Vincentown Formation.

Tvt **VINCENTOWN FORMATION -** Sandy silt, laminated in places, with up to 50% quartz sand. Minor mica and pyrite. Intensely bioturbated in certain intervals. Grades down to a clayey glauconite sand with up to 20% glauconite. Colors vary from greenish gray to grayish green to dark green. Scattered shell fragments and a shell bed of *Gryphaea dissimilaris* are present near the base. This shell bed lies above the contact of the older glauconitic sands of the Hornerstown Formation, although some geologists (e.g., Miller and others, 2017) place the shell bed at the top of the underlying Hornerstown Formation. Contact can also be consolidated (to 1 ft thick) and contain quartz and phosphatic granules. The Vincentown is as much as 25 feet thick in the quadrangle.

Based on its foraminifera, the Vincentown is late Paleocene in age (Olsson and Wise, 1987). At Wilson Lake, the Vincentown was assigned to calcareous nannoplankton Zone NP9 (upper Paleocene in age; Miller and others, 2017). Unconformably overlies the Hornerstown Formation.

Tht **HORNERSTOWN FORMATION -** Glauconite sand, slightly clayey to very clayey, dusky green to dusky blue green where freshly exposed. Primarily fine-to medium- grained glauconite sand, bottyoidal shaped, with some accordion forms. Traces of quartz, mica, feldspar, and phosphatic material. No bedding seen due to extensive burrowing. Its dusky green clay matrix, composed mostly of glauconite, helps distinguish it from the underlying Navesink Formation. The Hornerstown is as much as 10 feet thick in the quadrangle.

The contact with the underlying Navesink Formation is irregular, unconformable and heavily bioturbated, and marked by glauconite-filled burrows containing bright green Hornerstown glauconite in the upper 1-2 feet of the Navesink Formation. The contact is well exposed in a gully in Mullica Hill on the neighboring Pitman West quadrangle (Sugarman and others, 2021) where the base of the Hornerstown is deeply weathered. Partly cemented clayey glauconite sand irregularly overlying a dark, clayey glauconite sand with lighter nests of pyrite rich burrows were observed just below the contact.

Based on its foraminifera, the Hornerstown is early Paleocene in age (Olsson and others, 1997).

Kns **NAVESINK FORMATION -** Clayey glauconite sand, massive-bedded, bioturbated (burrows up to one inch in diameter that can be pyrite filled), olive-gray, olive-black and dark greenish-black. Glauconite is bottyoidal and predominantly medium to coarse grained. Clay-silt content as much as 30 percent. Accessories include pyrite, mica, quartz sand, and phosphatic fragments. Vivianite is present in places as a replacement for shell material (Weller, 1907). The basal few feet of the Navesink contains a thick-bedded glauconitic quartz sand with granules and sand-size lignite fragments (reworked from the underlying Mount Laurel Formation), and black phosphate pebbles. Maximum thickness in the quadrangle is approximately 30 feet.

The Navesink is Late Cretaceous (Maastrichtian) in age based on the occurrence of the planktonic microfossils *Globotruncana gansseri* (Olsson, 1964) and *Lithraphidites quadratus*. The presence of the calcareous nannoplankton *Nephrolithus frequens* in the Navesink at Wilson Lake (Miller and others, 2017) also documents its late Maastrichtian age.

The contact with the underlying Mount Laurel Formation is unconformable. This contact is easily distinguished in the subsurface by the sharp positive gamma-ray response at the base of the Navesink.

Kml **MOUNT LAUREL FORMATION -** Mostly medium quartz sand, massive to crudely bedded, slightly glauconitic and feldspathic (5-10%), with scattered dark, ovoid-shaped medium grained phosphate pellets. Generally weathered to a light brown, pale yellowish brown or light gray. Coarser in the upper 5 feet with granules and pebbles; this interval also contains reworked glauconite (from the Navesink above) concentrated in burrows. The Mount Laurel fines downward to a clayey fine-to-medium grained quartz sand, with a noticeable increase in glauconite and mica. Maximum thickness is approximately 80 feet.

Where fossiliferous, fossils are poorly preserved as weathered casts although *Belemnitella americana* and *Gryphaea* have been identified. The Mount Laurel is uppermost Campanian in age. A Sr-isotope age estimate of 70.1 Ma was obtained from a shell in the Mount Laurel at Wilson Lake (Miller and others, 2017); slightly older ages of 71.1-71.6 Ma were obtained from belemnites from the Mullica Hill outcrop (Sugarman and others, 1995). The Mount Laurel grades down into the underlying Wenonah Formation.

Kw **WENONAH FORMATION -** Quartz sand, fine- to very-fine grained, massive, clayey, very micaceous (muscovite and lesser chlorite), with abundant carbonaceous matter, and varying amounts of glauconite (3-20%; most abundant in the lower 3-5 feet), light olive gray, brownish gray, and light brown where weathered; medium-dark gray to dark gray where freshly exposed. The Wenonah is late Campanian in age based on ammonites (Owen and others, 1998). Maximum thickness is 50 feet. Grades down into the Marshalltown Formation.

Kmt **MARSHALLTOWN FORMATION -** Quartz glauconite sand, fine- to medium-grained, massive and clayey. Glauconite is very abundant in the lower few feet but increases upward to a nearly equal mixture of quartz and glauconite. Greenish black weathering to a greenish gray, moderate olive brown and light brown. While quartz and glauconite constitute the bulk of the formation, feldspar, mica, finely disseminated pyrite, and phosphatic fragments are present. Macrofossil assemblages containing *Exogyra ponderosa* and *Ostrea falcata* (Minard, 1965) are abundant locally. Reaches 30 feet thick.

The Marshalltown is the basal transgressive unit of an unconformity-bounded cycle of sedimentation that includes the overlying Wenonah and Mount Laurel Formations.

The Marshalltown has been assigned to a middle Campanian age based on nannofossil Zones CC 20-21 in southwestern New Jersey (Sugarman and others, 1995). The Marshalltown unconformably overlies the Englishtown Formation; along the contact, the Englishtown is extensively bioturbated with burrows filled with glauconite sand from the overlying Marshalltown Formation.

Ket **ENGLISHTOWN FORMATION -** Fine-to coarse- grained quarz sand, locally interbedded with thin to thick beds of dark clay and silt. Medium-dark gray to dark gray. Sand contains considerable carbonaceous matter, feldspar, mica and glauconite; carbonaceous matter and pyrite are common in the clays (giving them a dark-gray color where unweathered). Maximum 40 feet in thickness.

Wolfe (1976) assigned an early Campanian age to the Englishtown based on a distinctive assemblage of palynomorphs. Grades downward into the Woodbury Formation.

Kwb **WOODBURY FORMATION -** Clay, grayish-black to black, massive, and sandy (very fine-grained quartz). Conspicuously micaceous with major amounts of finely dispersed pyrite and carbonaceous material; locally contains several percent glauconite. Iron oxides fill fractures and occur in layers in most weathered beds.

The Woodbury is early Campanian in age (Owens and others,1998). Maximum thickness is approximately 110 feet. Grades down into the Merchantville Formation.

Kmv **MERCHANTVILLE FORMATION -** Intercalated, thick-bedded sequence of glauconitic sand and silt and micaceous clayey silt. The glauconitic sand is grayish-olive, greenish-black, or dark greenish-gray; the clay-silt is shades of black and gray. Quartz and glauconite are the major sand components; feldspar, mica (colorless and green), and pyrite are minor constituents. Siderite-cemented layers are common. The formation is highly bioturbated and reaches 20 feet thick.

The Merchantville is the basal transgressive bed of the unconformity-bounded coarsening-upward cycle which includes the overlying Woodbury and Englishtown formations.

The Merchantville is early Campanian in age based on the ammonite *Scaphites hippocrepis III* (Owens and others, 1977). Uncomformably overlies the Magothy Formation.

Kmg **MAGOTHY FORMATION -** Intercalated quartz sand and clay, thin- to thick-bedded. Sand is light- to medium-gray or brownish-gray; clay is olive-black to grayish-black. Bedding is horizontal (laminated) and cross-stratified. The sand is fine to very coarse, well sorted within each bed, predominantly quartz, and includes minor feldspar and mica. Pyrite-cemented and pyrite-coated sand concretions are common. Carbonaceous material is abundant. As much as 100 feet thick.

The Magothy is Late Cretaceous (Santonian) in age based on pollen (Christopher, 1977). Uncon-formably overlies the Potomac Formation.

Kpu **POTOMAC FORMATION, UNIT 3 -** Fine to coarse cross-bedded sand, occasional gravel interbedded with clays that are white or variegated red and yellow. Beds of dark gray woody clays are less common. Maximum thickness is 300 feet.

The pollen from the Potomac unit 3 is assigned to Zone III (early Cenomanian in age; Doyle and Robbins, 1977).

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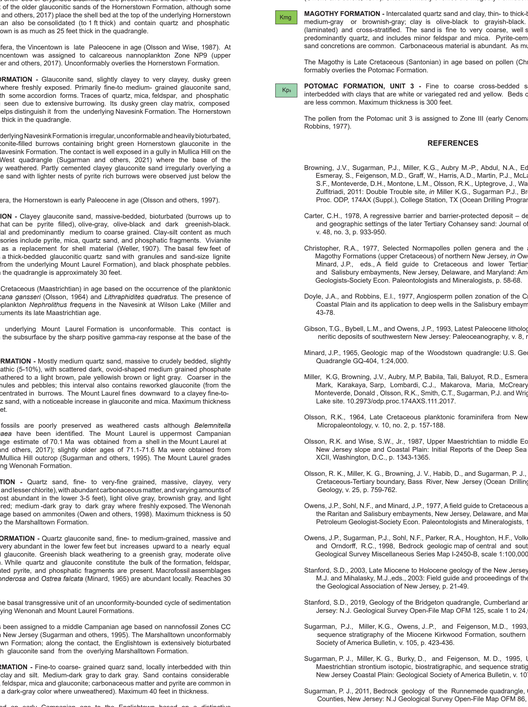
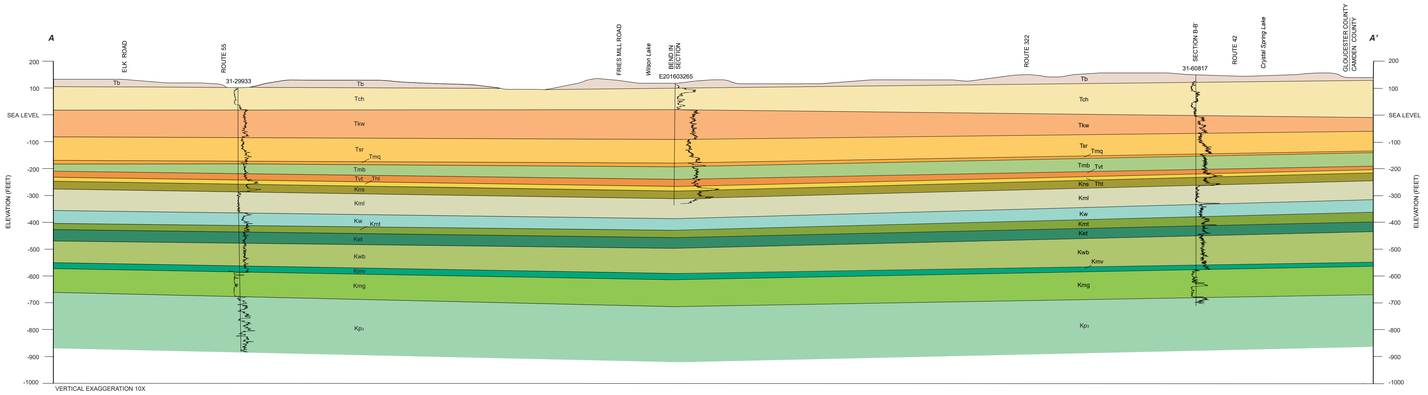
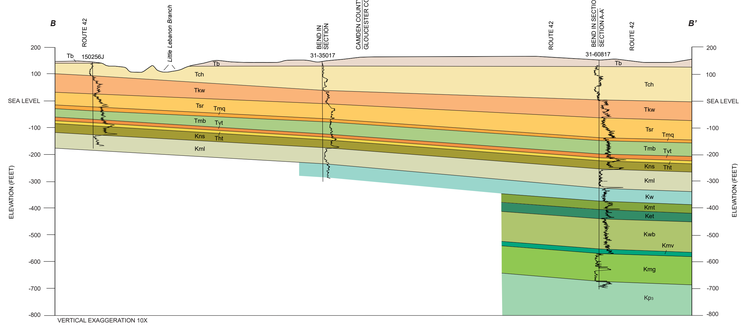
CORRELATION OF MAP UNITS





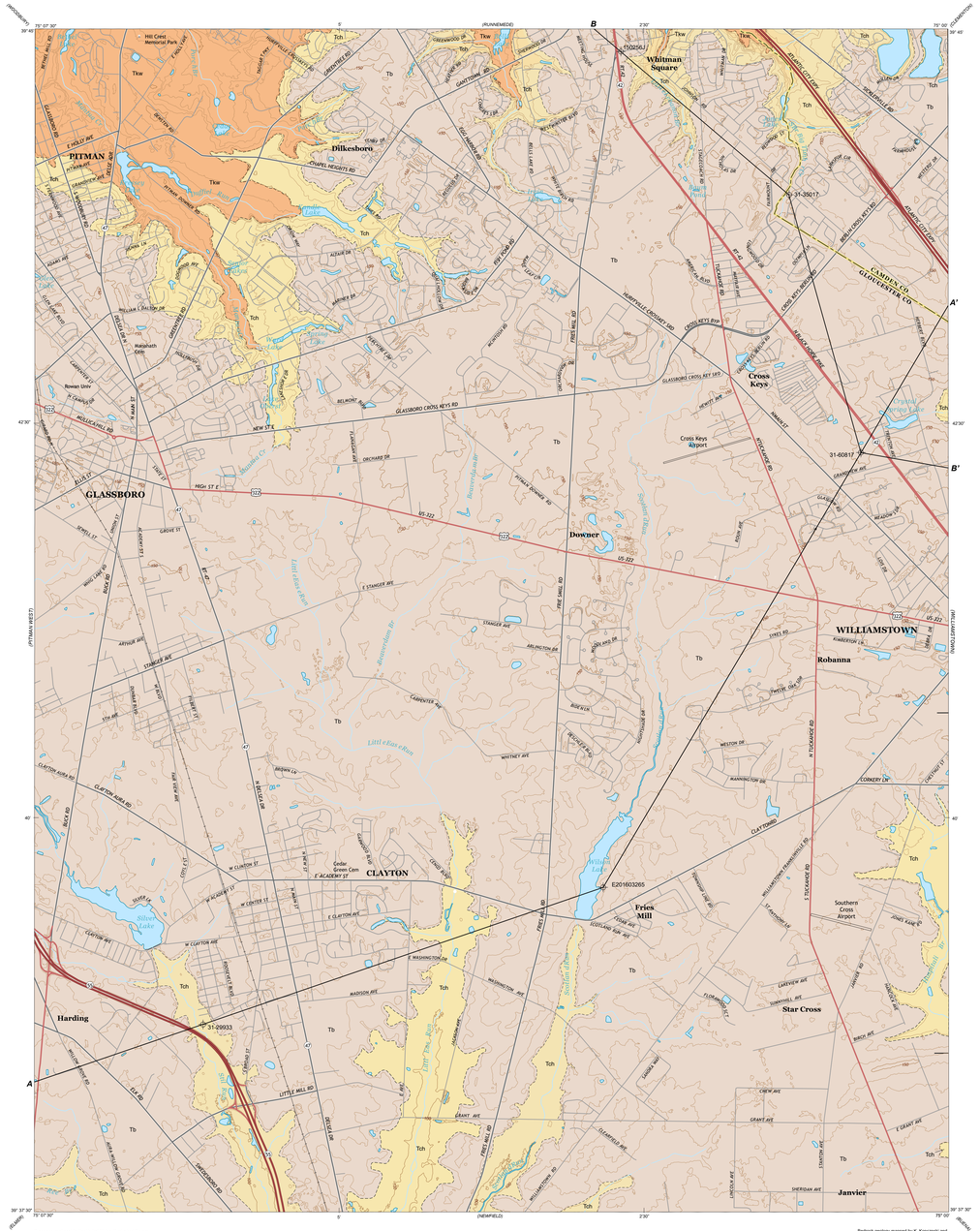


EXPLANATION OF MAP SYMBOLS

Contact of deposits – Approximately located

Gamma-ray log – On sections, vertical line shows location and depth of penetration of well. Gamma intensity increases to the right.

31-29933 Well with geophysical log – Location accurate to within 500 feet. Identifiers of the forms 31-xxxxx and E2016xxxx are New Jersey Department of Environmental Protection well permit numbers. Identifiers of the form 15xxxxJ are United States Geological Survey Groundwater Site numbers.



Basemap produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1000-meter grid: Universal Transverse Mercator, Zone 18S
10,000-foot ticks: New Jersey Coordinate System of 1983

Imagery.....NAIP, July, 2010
Roads.....HERE, 02013
Names.....GNIS, 2013
Hydrography.....Nation Hydrography Dataset, 2012
Contours.....National Elevation Dataset, 2012
Boundaries.....Multiple sources; see metadata file 1972 - 2013

SCALE 1:24 000

1 0.5 0 KILOMETERS 1 2
1000 500 0 METERS 1000 2000
1 0.5 0 1
MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
FEET

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

UTM GRID AND 2015 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

ROAD CLASSIFICATION
Expressway
Local Connector
Secondary Hwy
Local Road
Ramp
4WD
Interstate Route
US Route
State Route

Bedrock geology mapped by K. Kopczynski and P.J. Sugarman in 2019-2020.
Digital cartography by K. Kopczynski.

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