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

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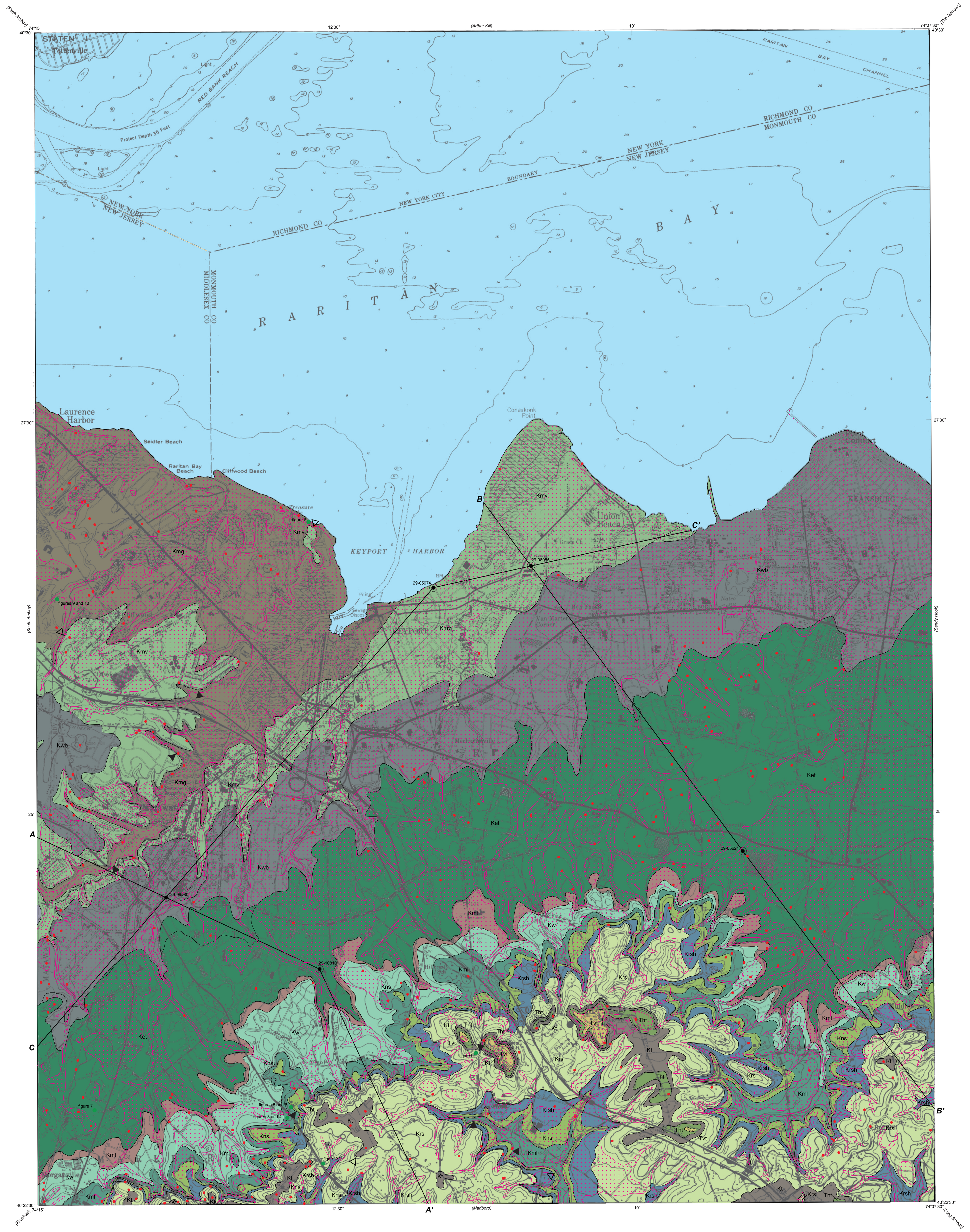

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Culture and drainage in part compiled from aerial photographs taken 1941. Field checked 1943. Culture revised by the Geological Survey 1954.

Hydrography compiled from USC&GS charts 286 and 369, (1954). This information is not intended for navigational purposes.

Polyconic projection. 10,000-foot grid ticks based on New Jersey coordinate system and New York coordinate system, Long Island Zone 1000-meter Universal Transverse Mercator grid ticks, zone 18 shown in blue. 1927 North American Datum. To place on the predicted North American Datum 1983 move the projection lines 6 meters south and 34 meters west.

LOCATION IN NEW JERSEY

SCALE 1:24,000

1 MILE

7000 FEET

1 KILOMETER

CONTOUR INTERVAL 20 FEET

APPROXIMATE MEAN DECLINATION, 1970

Bedrock geology mapped by P.J. Sugarman and S.D. Stanford in 1984, 1996 and 2011.
Digital cartography by R.S. Pristas and N.L. Malerba
Reviewed by R.K. Olsson, J.W. Jengo and D.H. Monteverde

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Bedrock Geologic Map of the Keyport Quadrangle
Middlesex and Monmouth Counties, New Jersey

by
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and Corie Hlavaty

2014

INTRODUCTION

Geologic formations of the Keyport quadrangle consist of unconsolidated sand, silt, clay, glauconite sand, and sandstone deposited in fluvial, coastal, nearshore-marine, and continental–shelf settings 95 to 60 million years ago. The sediments consist of 15 formations. Lithology and age of the formations are provided in the *Description of Map Units*. Cross sections A-A', B-B', and C-C' show the subsurface geometry of the formations along the line of section. Surficial sand and gravel, silty sand, and organic silt and clay, of late Miocene, Pliocene, and Quaternary age overlie the bedrock in most of the quadrangle (Stanford, 2002). The surficial deposits include fluvial, estuarine, and nearshore-marine sediments. They are shown by an overprint pattern on the map where more than 5 feet thick.

Mapping of the Keyport quadrangle was facilitated by a long history of economic mining of clay for brick manufacturing in the Matawan and Cliffwood areas. While these clay pits (e.g. Oschwald Brick Works in Cliffwood), and manufacturing facilities (e.g. Cliffwood Brick Company in Matawan) are no longer operating, historical descriptions of these sites in the permanent notes of the New Jersey Geological and Water Survey, along with numerous geologic field trips guides (e.g. Owens and Sohl, 1969), provided photos and descriptions of the geology exposed in these pits prior to their closure. Most of these pits excavated clay from the Magothy, Merchantville, and Woodbury Formations.

Another source of geologic information was obtained by examining existing and past water supply wells in the quadrangle. The Englishtown, Magothy and Raritan (Farrington Sand Member) Formations contain thick sands that form prolific aquifers in the region. Geophysical logs from selected wells drilled into these aquifers (Table 1) were used to help construct the three cross-sections (A-A', B-B', and C-C') illustrated on this map.

DESCRIPTION OF MAP UNITS

Tvt **Vincentown Formation** – Quartz sand, massive-bedded, deeply weathered and oxidized to moderate olive brown, mostly medium grained, fine and coarse. Glauconite (2-5 percent), mica (clear) and feldspar are minor sand components. Very glauconitic and clayey in basal part, including finer sand. Caps the highest hills in the quadrangle including Crawford and Telegraph Hills. The Vincentown is very fossiliferous in other areas of the Coastal Plain (Weller, 1907; Greacen, 1941), especially in its calcareous facies, but is nonfossiliferous in this quadrangle. It is late Paleocene based on the occurrence of nannofossil zones NP 6, 8, and 9a (Harris and others, 2010). Maximum thickness 35 feet.

Tht **Hornerstown Formation** – Glauconite sand, clayey, massive-bedded, containing traces of fine quartz sand, mica, pyrite, and lignite. Colors range from greenish-black to dark-gray where fresh, to moderate reddish brown and dusky yellowish-green where weathered. Glauconite is mainly medium-grained and botryoidal. Glauconite sand commonly alters to clay in deeply weathered outcrops, and can compose as much as 50% of the formation. Poorly sorted, fine to very coarse-grained quartz sand can reach as much as 25 percent at the base of the formation. Cemented by goethite and siderite into thin layers in places. Underlies the highest hills in the quadrangle including Crawford and Telegraph Hills.

The Hornerstown is early-to-middle Paleocene (Olsson and others, 1997; Landman and others, 2004). Unconformably overlies the Tinton Formation. Maximum thickness 15 feet.

Kt **Tinton Formation** – Feldspathic, glauconitic quartz sandstone, to feldspathic quartz-glauconite sandstone, clayey, massive-bedded, and poorly sorted. Cemented by finely crystalline iron oxides and iron carbonates (siderite). Sand is stained by iron oxides and deeply weathered to a dark yellowish-orange and light-brown; light-olive brown to light olive-gray where less weathered. Glauconite concentration is highly varied, ranging from 15-20 percent of the sand fraction in the lower part of the formation, to 60-80 percent in the upper part of the Tinton. Micaceous , including clear, green, and brown plates of coarse-sand size. Clay-silt may compose 10 to 30 percent of the sand fraction.

The Tinton underlies and caps some small outliers in the southern part of the Keyport quadrangle. At Crawford Hill and the neighboring Sandy Hook quadrangle, a concentric concretionary pattern formed by cemented iron oxide and iron carbonate is visible (Minard, 1969, fig. 5). At Beers Hill, the cemented upper few feet of the Tinton form a ledge of sandstone beneath the unconsolidated Hornerstown Formation (NJGS permanent notes; fig. 1) as described by Dorf and Fox (1957).

The Tinton is late Cretaceous (Upper Maastrichtian) based on the macrofossils *Sphenodiscus lobatus* and *Scabrotigonia cerulia* (Owens and others, 1977). Many fossils, including pelecopods, gastropods, cephalopods and crustaceans occur at Beers Hill and have been described by Weller (1907, p.146). The contact with the underlying Red Bank Formation appears to be unconformable, but is obscured by iron-staining across the contact. Maximum thickness 20 feet.

Red Bank Formation – Subdivided into two members: an upper Shrewsbury Member and a lower Sandy Hook Member (Olsson, 1963).

Krs **Shrewsbury Member** (upper member) – Quartz sand, feldspathic, and slightly glauconitic. Cross-beds (trough) in fresh exposures. Grain size coarser upward, from silty, fine-to-medium sand in lower section to medium-to-coarse sand and some granules in upper section. Colors vary from moderate reddish brown, pale yellowish brown, light brown and yellowish gray; to grayish olive green and olive gray where unweathered in the subsurface. Glauconite content lower upward, from roughly 5 to 1 percent, mica also lower upward to mere trace at the top. Rock fragments, including sandstone, shale and schist are abundant in the upper section (Minard, 1969), and *Callianassa* burrows. Thin ledges of ironstone are common in outcrop (fig. 2). Underlies many of the higher hills in the quadrangle.

The Shrewsbury is coarser grained and less glauconitic than the underlying Sandy Hook but grades into it (fig. 2). Transition to Sandy Hook Member is marked by higher gamma-ray intensity and lower resistance on geophysical well logs. Maximum thickness 100 feet.

Krsh **Sandy Hook Member** (lower member) – Clayey, silty glauconitic quartz sand, commonly bioturbated. Dusky-to-moderate-brown where fresh; pale yellowish-brown and light-brown where weathered. Glauconite content only 5 percent at top but 20 percent at its base. Sand size is generally very fine to fine, angular clear quartz (and a small proportion of milky grains). Grain size finer downward. Sand-sized lignite, mica (mostly clear, some green and brown) and feldspar are common, as are phosphatic organic remains. Excellent exposures of the Sandy Hook occur in many of the river valleys and their tributaries in the southern part of the quadrangle.

May be highly fossiliferous at some localites including marine mollusks. For description of megafossils, see Owens and others (1977) and Weller (1907, p. 138-141); for foraminifera see Olsson (1960, 1964). The Red Bank is late Cretaceous (late Maastrichtian) based on the calcareous nannofossil *Nephrolithus frequens* (Sugarman and others, 1995). Sr-isotope age estimates for the Red Bank are approximately 66 Ma (Sugarman and others, 1995). The contact with the underlying Navesink is gradational and placed at the contact of clayey glauconite sand of the Navesink and the more clastic, micaceous, silty glauconite-quartz sand of the Sandy Hook (fig. 3). Maximum thickness 40 feet.

Kns **Navesink Formation** – Clayey, glauconite sand, massive-bedded, bioturbated (fig. 3). Glauconite is botryoidal and medium-to-coarse grained. Clay-silt content as much as 30 percent. Olive-gray, olive-black and dark greenish-black where fresh; shades of gray and brown where weathered. Accessories include pyrite, mica, quartz sand, and fragments of claystone, ironstone, and phosphate. The contact with the underlying Mount Laurel is unconformable (fig. 4). The basal few feet of the Navesink is a thick-bedded glauconite quartz sand containing granules and phosphatized fossil fragments reworked from the underlying Mount Laurel. Fossils locally abundant. Owens and others (1977, p. 83-87) and Weller (1907, p. 105-130) described the macrofossil fauna. The Navesink is late Cretaceous (Maastrichtian) based on the occurrence of the planktonic microfossils *Globotrucana gansseri* (Olsson, 1964) and *Lithraphidites quadratus* (Sugarman and others, 1995). Local thickness is 25 feet.

Kml **Mount Laurel Formation** – Quartz sand; lithology and thickness are varied. Medium to coarse, slightly feldspathic and glauconitic (1-5 percent), although glauconite (burrowed downward from the overlying Navesink; Jengo, 1982) may constitute more than 50 percent of the sand fraction within the top 2-3 feet (Minard, 1969). Quartz granules and small pebbles are also very common in the upper few feet reflecting an overall coarsening-upward pattern. Cross-bedding (trough and planar tabular) and burrows of large *Ophiomorpha* and smaller *Skolithes* tubes are locally present (fig. 5). Another facies includes intercalated thin-bedded, fine-to-medium glauconitic quartz sand and silty clay containing mica and common carbonaceous material (fig. 6). Quartz sand is light olive-gray and dark greenish-gray where unweathered, and dark-yellowish-orange, light to moderate olive-brown, and pale greenish-yellow where weathered. Clay-silt is dark-gray and brownish-black.

The formation interfingers with, and conformably overlies, the Wenonah Formation. The contact is gradational and roughly marked by the transition from the intercalated, thin-bedded, sand-and-silt clay sequence, to the dark massive silty fine sand of the Wenonah. The upper Mount Laurel is very fossiliferous, containing common *Exogyra cancellata*, *Pycodonte mutabilis*, and *Belemnitella americana* (Jengo, 1982). The formation is late Campanian based on nannofossil zone CC22b (Sugarman and others, 1995).

Kw **Wenonah Formation** – Quartz sand, very fine to fine, and silt, thick- to massive bedded, except for occasional thin-bedded sequences containing ripple-laminated sands. Pale yellowish-brown to moderate yellowish-brown where weathered; grayish-black, olive-black, and moderate-brown where fresh. Bioturbated, showing the trace fossils *Ophiomorpha*, *Rossella* and *Zoophycus* (Martino and Curran, 1990). Mica (colorless and green), feldspar, and lignitized wood are abundant; glauconite is a minor constituent. Pyrite occurs as grain coatings, or as individual crystals. Formation crops out along river valleys and adjacent lowlands. The contact with the underlying Marshalltown Formation is gradational, and is marked by more abundant glauconite, and less abundant quartz sand and mica.

Descriptions of the macrofauna for the Wenonah and Mount Laurel Formations may be found in Jengo (1982). Weller (1907) reported that at Hop Brook *Flemingostrea subspatulata* in the Wenonah is assigned to the late Campanian (Reinhardt and Gibson, 1980). The maximum combined thickness of the Mount Laurel and Wenonah is about 90 feet.

Kmt **Marshalltown Formation** – Quartz glauconite sand. Massive-bedded, burrowed, fine-grained, silty and micaceous. Glauconite comprises 20 to 60 percent of the sand. Greenish-black where fresh, weathers grayish-orange to shades of yellowish-brown. The Marshalltown is the basal transgressive unit of an unconformity-bounded coarsening-upward sequence that includes the overlying Wenonah and Mount Laurel.

The Marshalltown is unfossiliferous in the Keyport quadrangle. Fossils have been identified in the Marshalltown in the southern New Jersey Coastal Plain where the formation has been assigned to calcareous nannoplankton Zones CC20/21 of Perch-Nielsen (1985), indicating a middle Campanian age (Sugarman and others, 1995). The Marshalltown unconformably overlies the Englishtown Formation. Where the contact is exposed, quartz and glauconite sand from the overlying Marshalltown Formation are burrowed down into the Englishtown. Poor outcrops occur in the southern part of the quadrangle. Thickness ranges from 10 to 20 feet.

Ket **Englishtown Formation** – Quartz sand and clay; laminated and thin- to thick-bedded, in horizontal and cross-stratified beds. Sand is light-olive to olive gray in unweathered beds, fine to coarse, mostly quartz and muscovite, and minor glauconite and feldspar. Clay lenses are dark-gray to olive-black where fresh (fig. 7); various shades of brown where weathered, micaceous, and lignitic; and are several inches to a few feet thick. Dark lignite layers are common, and are thin-to-thick-bedded. Pyrite is common, especially in the carbonaceous beds, forming individual crystals, nodules and clusters that cement thin beds. Locally the sand is cemented into massive beds of ironstone. Minard (1969) identified a hill directly to the west along Laurel Avenue in Keansburg that is capped by 8 feet of ironstone in the formation. The Englishtown underlies the low hills bordering the Mount Pleasant Hills north of Morganville and Middletown. Wolfe (1976) assigned an early Campanian age to the formation on the basis of a distinctive assemblage of palynomorphs. Miller and others (2006) assigned an early Campanian age to the Englishtown based on the occurrence of nannofossil zones CC19 and 20 at the ODP 174X Sea Girt site. The contact with the underlying Woodbury is gradational, and is marked by fewer coarse clastics and carbonaceous material. It reaches a maximum thickness of 180 feet.

Kwb **Woodbury Formation** – Clayey silt and very fine quartz sand, occasional lenses of finely disseminated pyrite, lignite, and siderite. Dark gray to olive black. Bedding is massive to finely laminated, with alternating layers of very fine sand and clay-silt. Glauconite sand may make up as much as 10 percent of lower part of formation. Excellent exposures occur in gullies in the Matawan area. Wolfe (1976) used palynomorph assemblages, and Gohn (1992) ostracode assemblages, to assign an early Campanian age to the Woodbury. The contact with the underlying Merchantville is gradational and is arbitrarily drawn where glauconite is not a major sand constituent. Maximum thickness 50 feet.

Kmv **Merchantville Formation** – Quartz-glauconite sand and clayey quartz silt; thick-to-massive-bedded, highly bioturbated. Glauconite sand is grayish-olive, greenish-olive, or dark greenish-gray where fresh; clayey silt beds are shades of black and gray where fresh. Layers of fossiliferous siderite concretions also occur, in addition to pyrite and limonite. The Merchantville is the basal transgressive bed of the unconformity-bounded coarsening-upward sequence which includes the overlying Woodbury and Englishtown Formations. In the adjacent South Amboy quadrangle, the Cheesequake Formation, a lignitic, micaceous, glauconitic clay-silt, was mapped beneath the Merchantville (Sugarman and others, 2005). Because of limited exposures in the Keyport Quadrangle, it was included in the base of the Merchantville Formation, where present. Weller (1907, p. 47-49) described the geology and fossils in the Merchantville along the west bank of Matawan Creek, north of the town of Matawan at the site of the former Pennsylvania Clay Company. The pit bottoms in the uppermost Magothy. Above it is a 25 foot thick black clay that contains rare fossils, in contrast to the more typical Merchanville. This bed might be the Cheesequake equivalent. The Merchantville is best exposed in the gullies of Lake Lefferts and Matawan Creek. Examination of exposures at the Oschwald Pit that are no longer present (Owens and others, 1968) and Cliffwood Beach (fig. 8; Brosius and Lev, 1983) made possible a more detailed descriptions of the Merchantville and its contained fossils.

The Merchantville is lower (but not lowermost) Campanian, based on the ammonite *Scaphites hippocrepis III* (Owens and others, 1977). The Cheesequake and Merchantville Formations are a maximum of 100 feet thick in the quadrangle.

Kmg **Magothy Formation** – Quartz sand, white, yellow, light-gray; commonly interbedded with carbonaceous, thin-to-thick, dark-gray clay and silt. Sand is typically cross-stratified (fig. 9), although laminated intervals (fig. 10) are common. Crops out in Matawan Creek and low-lying areas to northwest where it is more than 200 feet thick. Formerly exposed in the Oschwald Brick Works clay pit (figs 9-10). The Magothy includes from oldest to youngest, the following informal members: South Amboy Fire Clay, Old Bridge Sand, Amboy Stoneware Clay, Morgan beds, and Cliffwood beds. These members were mapped on the adjacent South Amboy quadrangle, but not in Keyport because of limited exposures and meager historical information. An excellent description of the Cliffwood Beach Member may be found in Brosius and Lev (1983) and Owens and others (1968), before then, the Magothy bluff was still exposed at Cliffwood Beach (fig. 8) prior to its covering over with engineering materials to prevent erosion. Of unique interest for Cliffwood Beach are the fossiliferous concretions found at the base of the bluffs that generated numerous paleontological studies (e.g. Berry 1903; Weller, 1907; Richards et al., 1958, 1962). The sandy concretions contain casts and molds of pelycopods and gastropods. The Cliffwood beds contain a marine tongue of sediments within the predominantly nonmarine-to-marginal-marine Magothy Formation.

The Magothy is Late Cretaceous (Turonian-Santonian) based on pollen (Christopher, 1979, 1982).

Raritan Formation – does not crop out in the Keyport quadrangle. It is subdivided into two members in the subsurface: the upper Woodbridge Clay member and the lower Farrington Sand Member. Shown in cross section only.

Krw **Woodbridge Clay Member** (upper member) – is recognized, based on geophysical logs, as predominantly clay and silt.

Krf **Farrington Sand Member** (lower member) – Fine- to-medium-grained quartz sand (Owens and others, 1998).

Kp_3 **Potomac Formation, Unit 3** – does not crop out in the Keyport quadrangle. In the subsurface the Potomac is recognized on geophysical logs as interbedded sand and silty clay. The clay is thin-to thick-bedded. Shown in cross section only.

O€u **Pre-Mesozoic crystalline rocks, undifferentiated** – Schist and gneiss, gray, coarse- to medium-grained, composed of quartz, plagioclase, biotite, muscovite, and garnet. Serpentine, light yellowish-green to dark green, fine-grained, massive rock. Where fresh it contains olivine, orthopyroxene, and chromian spinel. More commonly altered to rock composed of various serpentine minerals that may be spatially associated with light green, medium-grained foliated rock composed of talc and magnesiohornblende (Volkert and others, 1996). Shown in cross section only.

EXPLANATION OF MAP SYMBOLS

Contact - Approximately located. Solid triangle indicates contact observed in outcrop. Open triangle indicates contact formerly observed, as reported in permanent note collection of the New Jersey Geological and Water Survey.

29-09888 Well used in cross sections showing formations penetrated - Location accurate to within 200 feet. Identifiers of the form 29-xxxx are New Jersey Department of Environmental Protection well permit numbers.

Formation observed in outcrop or excavation, or penetrated in hand-auger hole.

figure 5 Photograph location.

Gamma-ray geophysical log - On cross section. Intensity of gamma-ray radiation increases to the right.

Formation covered by surficial deposits of Quaternary, Pliocene, and late Miocene age. Continuous and generally more than 5 feet thick.

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New Jersey Permit Number	Municipality	Latitude (ddmmss)	Longitude (ddmmss)	Elevation (feet)	Total Depth (feet)
29-09580	Matawan Boro	402609	741352	58	498
29-10810	Aberdeen Township	402353	741240	90	566
29-08985	Union Beach Boro	402633	740550	11	532
29-05621	Holmdel Township	402444	740902	66	799
29-05974	Keyport Boro	402625	741140	15	297

Table 1. New Jersey permit number, location, and total depth of wells used in cross-sections.

CORRELATION OF MAP UNITS

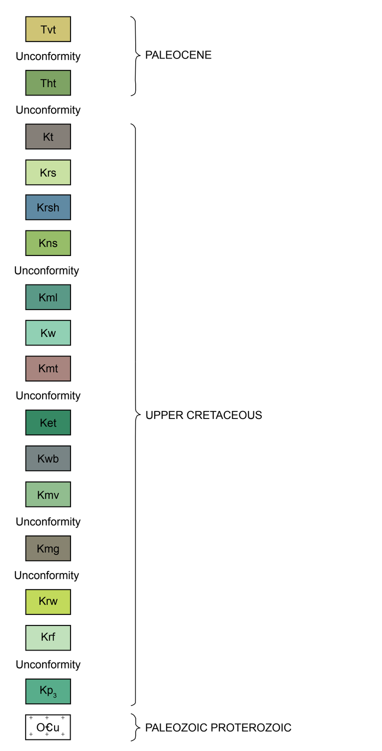

Figure 1. Photograph of outcrop at Beers Hill of the Hornerstown, Tinton, and Red Bank Formations (NJGS permanent notes, December 7, 1932). The ledges of cemented Tinton Formation are evident in the photo.

Figure 2. Former pit behind the Ern Construction Company on Route 34 showing the thin ironstone ledges and cross-bedding in the Shrewsbury Member of the Red Bank Formation (A) and the transition to the finer-grained Sandy Hook Member (B).

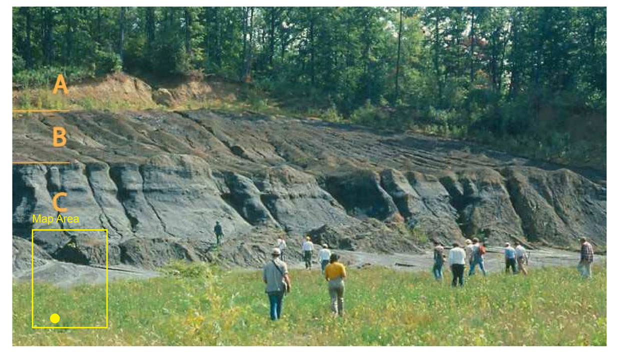

Figure 3. Pit near Route 34 showing the transition from the Red Bank Formation (Shrewsbury Member = A) to the Red Bank Formation (Sandy Hook Member = B) to the Navesink Formation (= C).

Figure 4. Contact of the Navesink (darker) and Mount Laurel (lighter) Formations in a pit near Route 34.Common reworking and burrowing of material are conspicuous along this contact.

Figure 5. Former sand pit off of Route 34 showing the cross-stratified quartz sand of the Mount Laurel Formation. Also present are abundant occurrences of the trace fossils *Ophiomorpha* and *Asterosoma*.

Figure 6. The intercalated facies of the Mount Laurel Formation in a pit along Route 34.

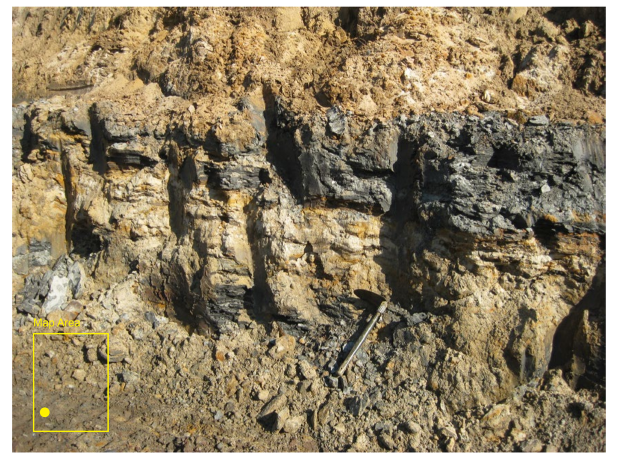

Figure 7. The intercalated Englishtown Formation by Route 79 and Lloyd Road exposed during construction in 2013.

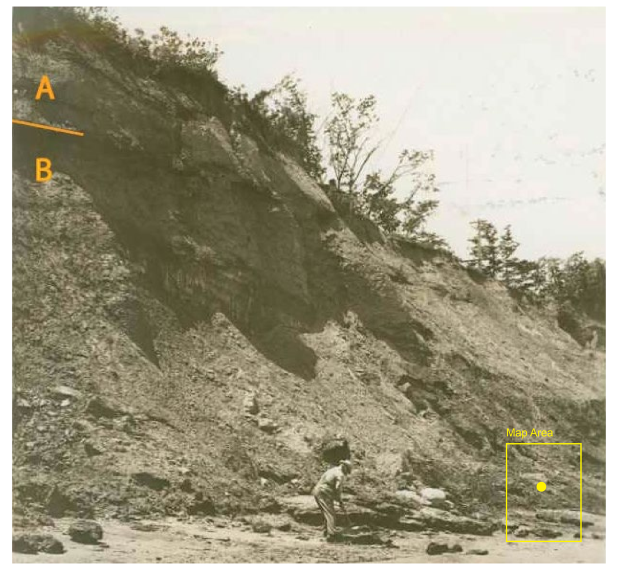

Figure 8. Exposure of the Merchantville Formation (A) overlying the Magothy Formation (B) at Cliffwood Beach. The Magothy was described as a fine-grained, well stratified, white sand with bands of clayey, micaceous lignitic sand (NJGS permanent notes, June 19, 1933).

Figure 9. Magothy Formation exposed in the Oschwald Brick Works pit at Cliffwood. (NJGS permanent notes, September 10, 1931).

Figure 10. Laminated beds of the Cliffwood Beach Member of the Magothy Formation exposed in the Oschwald Brick Works pit.