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GEOLOGY OF THE WHITING QUADRANGLE
OCEAN AND BURLINGTON COUNTIES, NEW JERSEY
OPEN-FILE MAP SERIES OFM 113
pamphlet containing tables 1 and 2 accompanies map

INTRODUCTION

The Whiting quadrangle is in the Pine Barrens region of the New Jersey Coastal Plain, in the southeastern part of the state. Outcropping geologic materials in the quadrangle include surficial deposits of late Miocene to Holocene age that overlie the Cohansey Formation, a marginal marine deposit of middle to late Miocene age. The surficial deposits include river, wetland, estuarine, hillslope, and windblown sediments. The Cohansey Formation includes beach, nearshore, bay, and marsh sediments deposited when sea level was, at times, more than 200 feet higher than at present in this region. As sea level lowered after the Cohansey was laid down, rivers flowing on the emerging Coastal Plain deposited the Beacon Hill Gravel, forming a broad regional river plain. With continued lowering of sea level, the regional river system shifted to the west of the quadrangle, and local streams began to erode into the Beacon Hill plain. Through the latest Miocene, Pliocene, and Quaternary, stream and hillslope sediments were deposited in several stages as valleys were episodically deepened by stream incision, and widened by seepage erosion.

A brief summary of depositional settings of the Cohansey Formation, and of the geomorphic history of the quadrangle as recorded by surficial deposits and landforms, is provided in the two following sections. The age of the deposits and episodes of valley erosion are shown on the correlation chart. Table 1 (in pamphlet) lists the formations penetrated in selected wells and test borings, as interpreted from drillers' descriptions and geophysical logs. Lithologic logs for four test borings drilled for this study are provided in Table 2 (in pamphlet).

The map and sections show materials to a depth of 350-400 feet, which includes the Cohansey Formation, the Kirkwood Formation, and the uppermost part of the Shark River Formation, which was penetrated in two wells in the quadrangle (wells 99 and 103 in Table 1, section BB'). Most domestic wells in the quadrangle, many of which are for lawn irrigation, withdraw water from sand of the Cohansey Formation (unit Tchs) from depths of between 50 and 175 feet. Well 103 withdraws water from sand in the Kirkwood Formation, from a depth of 120 to 192 feet. Two test holes in the quadrangle (wells 100 and 101 in Table 1) penetrated below the Shark River, to total depths of 900 and 908 feet, respectively. Formations below the uppermost Shark River are described and shown on sections in Owens and others (1998) and Sugarman and others (2013). They are not shown or discussed on this map.

COHANSEY FORMATION

The Cohansey Formation consists of stacked successions composed of beach and nearshore sand (Sand Facies, Tchs) overlain by interbedded sand and clay (Clay-Sand Facies, Tchc) deposited in tidal flats, bays, and coastal wetlands (Carter, 1972, 1978). Pollen and dinoflagellates recovered from peat beds in the Cohansey at Legler, about 8 miles northeast of Whiting, 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. Lower parts of the Cohansey in updip settings like the map area may be age-equivalent to the upper Kirkwood downdip from the map area (for example, Kirkwood sequence 2, about 15-17 million years old (Ma), and sequence 3, 12-14 Ma, Sugarman and others, 1993) and may represent the coastal facies of the Kirkwood shallow continental-shelf deposits, as suggested by Lewis and Kummel (1940).

In the Whiting quadrangle, sands in the Cohansey range from thin beds (generally less than 6 inches thick) having horizontal-planar and low-angle cross-bedded structure to thick beds (as much as 3 feet thick) with tabular-planar to trough cross-bedded structure. The bedding structures indicate tidal-channel, tidal-flat, and beach depositional settings (Carter, 1972, 1978).

Clays in the Cohansey are in thin beds or laminas generally less than 6 inches thick, and are always interbedded with sand. Most are oxidized to white, yellow, and reddish colors. Brown to black organic clay and peat was penetrated in the Whiting 1 test boring (Table 2) and is reported in drillers' logs for many wells, particularly at depths greater than 50 feet, where they have not been exposed to oxidation (intervals noted as "Tchco" in Table 1). Clayey strata are generally less than 25 feet thick, and less than one mile in lateral extent in outcrop. The clay stratum penetrated in the Whiting 2, 3, and 4 borings (section AA'), and in wells 102, 103, and 111 (section BB'), is continuous for more than five miles and is as much as 40 feet thick. Some strata are continuous for more than 8 to 10 miles both downdip (northwest to southeast) and along strike (northeast to southwest). For example, the clay bed that crops out at an elevation of 150 to 180 feet in the southeast corner of the map, beneath the 216-foot hill, can be traced along strike to the southwest for about 10 miles, and downdip to the southeast a similar distance, in the adjacent Keswick Grove, Brookville, and Woodmansie quadrangles (Stanford 2010, 2011, 2013). The laminated bedding and thin but extensive geometry of the clay 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 repetitive stacking of bay clays and beach sand (chiefly tidal-delta and nearshore deposits) indicates that the Cohansey was deposited during several rises and falls of sea level during a period of overall rising sea level.

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 hills in the quadrangle, above an elevation of 180 to 190 feet in four places in the east half of the map area (fig. 1), is the earliest record of this drainage. The Beacon Hill is a weathered quartz-chert gravel. Regionally, cross-beds, slope of the deposit, and gravel provenance indicate that the Beacon Hill was deposited by rivers draining southward from the Valley and Ridge province in northwestern New Jersey and southern New York (Owens and Minard, 1979; Stanford, 2009).

Also indicative of southward flow are rare chert pebbles containing coral, brachiopod, and pelecypod fossils of Devonian age found in the Beacon Hill and in upland gravels reworked from the Beacon Hill. These fossils indicate that some of the rivers feeding the Beacon Hill drained from north of what is now Kittatinny and Shawangunk Mountains in northwestern New Jersey and adjacent New York state, where chert-bearing Devonian rocks crop out.

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 to the west of the Whiting quadrangle. The area of the quadrangle became an upland from which local streams drained eastward to the Atlantic Ocean or westward to what is now the Delaware River valley. 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 20 and 50 feet below the level of the former Beacon Hill plain. These deposits are mapped as Upland Gravel, High Phase (unit Tg). Today, owing to topographic inversion, they cap interfluves and hilltops above elevations of 140 to 180 feet. They form more extensive mantles on the broad upland forming the divide between the Rancocas basin, which drains westward to the Delaware River, and the basins of Toms River and Cedar Creek, which drain eastward to the Atlantic Ocean (fig. 1). Purple arrows on figure 1 show drainage routes of streams at this time, as inferred from the location and elevation of the interfluve deposits.

A renewed period of lowering sea level in the Pliocene and early Pleistocene (approximately 3 Ma to 800,000 years ago (800 ka)) led to another period of valley incision. Groundwater seepage and channel and slope erosion reworked both the Beacon Hill and Upland gravels and deposited the Upland Gravel, Lower Phase (unit TQg) in shallow valleys 20 to 50 feet below the Upland Gravel, High Phase. These deposits today cap low interfluves and, on the Rancocas-Atlantic divide upland, form extensive mantles in head-of-valley areas and upper slopes. The base of these deposits descends from an elevation of 150 to 160 feet on the divide upland to an elevation of 100 to 120 feet in valleys on the east and west edges of the quadrangle. Stream drainage at this time, inferred from interfluve deposits, is shown by red arrows on figure 1.

Continuing stream incision in the middle and late Pleistocene (about 800 to 20 ka) formed the modern valley network. Sediments laid down in modern valleys include Upper and Lower Terrace Deposits (units Qtu and Qtl), inactive deposits in dry valleys (unit Qald), and active floodplain and wetland (Qals) deposits in valley bottoms. Like the upland gravels, the terrace and floodplain 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 accumulations of organic matter in swamps and bogs.

Upper Terrace Deposits form terraces and pediments 5 to 25 feet above modern valley-bottom wetlands. They include sediments laid down in the middle and late Pleistocene during periods of cold climate and during periods of temperate climate when sea level was high. During cold periods, permafrost formed an impermeable layer at shallow depth, which increased runoff and slope erosion, increasing the amount of sediment entering valleys. During periods of high sea level, the lower reaches of streams downstream from the Whiting quadrangle were close to sea level, favoring deposition.

In a few places the Upper Terrace Deposits cross drainage divides, or occupy abandoned valleys, indicating drainage changes during downcutting from the upper to lower terraces. These locations (green arrows on fig. 1) include 1) upper terraces that cross the divide between the Pole Bridge Branch and the North Branch of Mount Misery Brook valleys at two places west of Buckingham, and a terrace occupying an abandoned valley to the west of Goose Pond, 2) upper (and lower) terraces that cross the divide between the headwaters of the Middle Branch and the South Branch of Mount Misery Brook to the west of Bullock, and 3) the broad upper terrace that crosses the divide between the South Branch of Mount Misery Brook and McDonalds Branch in the southwest corner of the map area, and a narrow upper terrace that occupies an abandoned valley just north of this divide. In each of these places streams that formerly flowed to the west or southwest were captured or diverted by northwesterly flowing streams, perhaps because the northwesterly flowing streams had steeper gradients and downcut faster than southwesterly flowing streams. Ingrown meanders and embayed seepage scarps at the edge of the modern floodplain along some of these streams, which form as a result of their steeper gradients, mark the downcutting (fig. 2). Steeper gradients, in turn, may be the result of the shallower depth of the clay bed in the Cohansey Formation beneath the Gaunts Brook and Pole Bridge Branch valleys (section AA') compared to the Mount Misery Brook basin (section BB'). Shallow clay increases the volume of groundwater discharging to streams, accelerating seepage erosion and downcutting. The broad lowland comprising the Gaunts Brook and Pole Bridge Branch valleys, which has large expanses of wet lower terrace and floodplain, contrasts with the dominance of dry upland in the Mount Misery basin. This morphologic difference reflects the greater extent of seepage erosion in the Gaunts-Pole Bridge lowland.

Lower Terrace Deposits (unit Qtl) form low, generally wet, terraces less than 5 feet above modern floodplains. They are of much smaller extent than the upper terraces except in the Gaunts-Pole Bridge lowland, where they are extensive. The lower terraces formed from stream and seepage erosion of the Upper Terrace Deposits, probably during or slightly after the last period of cold climate around 25 ka. Braided channels scribe the lower terraces in the Gaunts Brook lowland (fig. 2). These braided networks indicate that streams were choked with sand and gravel during deposition of the terraces, causing channels to aggrade and split. The high sediment supply indicates increased erosion by groundwater seepage and runoff, most likely when permafrost impeded infiltration. Dry-valley alluvium (unit Qald), which grades to the lower terraces in places, was likely also laid down at this time.

Windblown deposits (Qe) form narrow, linear dune ridges as much as 1.5 miles long (orange lines on fig. 1) and dunefields as large as a square mile (figs. 1 and 3). Individual dunes are up to 15 feet high but are commonly 3 to 6 feet high. Their long axes are oriented east-west to northeast-southwest. A few have crescentic form, with crescents opening to the south or southeast. These orientations indicate that winds were blowing from the north and northwest during deposition of the dunes. Most dunes occur on the upper terraces or on upland surfaces above the upper terraces. Some occur on the lower terraces, including several prominent, long dune ridges in the Gaunts-Pole Bridge lowland. Based on this distribution, the windblown deposits were laid down after deposition of the upper terraces, and continuing during deposition of the lower terraces, during the period of intermittently cold climate between about 80 and 15 ka known as the Wisconsinan in North American glacial-stage terminology. A date of 4170+/-30 radiocarbon years BP (4585-4830 calibrated years, 95% probablility) (Beta 445819) on organic clay beneath 3 feet of windblown sand in the Old Hurricane Brook valley (plotted on map) indicates that some eolian deposition continued in the Holocene, perhaps when sand was exposed by intense forest fires. Some of the windblown deposits in the Old Hurricane Brook valley are within the modern floodplain, indicating that they are younger than elsewhere in the quadrangle. Modern floodplain and wetland deposits (unit Qals) were laid down within the past 10 ka, based on radiocarbon dates on basal peat in alluvial wetlands elsewhere in the Pine Barrens (Buell, 1970; Florer, 1972; Stanford, 2000).

During cold climate at glacial maxima in the middle and late Pleistocene, permafrost was present in the Pine Barrens region (Wolfe, 1953; French and others, 2007). During thaws, permafrost at depth acted as an impermeable layer and supported groundwater at a higher elevation than in temperate climate. Seepage features, including inactive channels, scarps, and amphitheater-shaped hollows, were developed in landscape positions that are dry today. These are indicated by symbols on the map. Other permafrost-related features include thermokarst basins and cryoturbation structures. Thermokarst basins are shallow depressions that form when subsurface ice lenses melt (Wolfe, 1953). These basins (symboled on map, see also fig. 3) typically form in sandy deposits in lowlands with high water table, or, more rarely, in upland settings where shallow clay layers provide a perched water table. Basins within, or bordered by, eolian deposits tend to be larger than other thermokarst basins and were likely formed or enlarged by wind erosion (French and Demitroff, 2001). Cryoturbation structures are folds and involutions in the upper several feet of surface materials. These structures formed by density flow of waterlogged sediment during melting of permafrost (French and others, 2005). They are common throughout the quadrangle, especially on older surficial deposits (units TQg, Tg, and Tbh) and outcropping Cohansey clays (Tchc) where clayey soil horizons provide cohesion and water retention (fig. 4).

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. Nonstratified to poorly stratified. As much as 15 feet thick. In road and railroad embankments, dams, berms, dikes around cranberry bogs, and filled low ground.

aft TRASH FILL—Trash mixed and covered with sand, silt, clay, and gravel. As much as 20 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. Peat is as much as 8 feet, but generally less than 4 feet, thick. Sand and gravel are chiefly quartz 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.

Qald DRY-VALLEY ALLUVIUM—Fine-to-medium sand and pebble gravel, minor coarse sand; very pale brown, white, brown, dark brown, light gray. As much as 5 feet thick. Sand and gravel are quartz. In dry valley bottoms forming headwater reaches of streams. These valleys lack channels or other signs of surface-water flow. They may have formed under cold-climate conditions when permafrost impeded infiltration, increasing surface runoff. The deposits are therefore largely relict. Narrow, erosional dry channels without mappable alluvium are shown by line symbol.

Qe EOLIAN DEPOSITS—Fine-to-medium quartz sand; very pale brown, white. As much as 15 feet thick. Form long, linear dune ridges and dune fields. Sand is from wind erosion of the Cohansey Formation, upper terrace deposits, and, less commonly, lower terrace and upland surficial deposits.

Qtl LOWER TERRACE DEPOSITS—Fine-to-medium sand, pebble gravel, minor coarse sand; light gray, brown, dark brown. As much as 10 feet thick. Sand and gravel are quartz. Form terraces and pediments in valley bottoms with surfaces 2 to 5 feet above modern floodplains. Include both stratified stream-channel deposits and nonstratified 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 generally is more abundant in lower terrace deposits than in upper terrace deposits due to winnowing of sand from the lower terraces 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 20 feet thick, generally less than 10 feet thick. Sand and gravel are quartz. Form terraces and pediments with surfaces 5 to 25 feet above modern floodplains. Include stratified stream-channel deposits and poorly stratified to nonstratified deposits laid down by groundwater seepage on pediments.

TQg UPLAND GRAVEL, LOWER PHASE—Fine-to-medium sand, minor coarse sand, slightly clayey in places, and pebble gravel; yellow, very pale brown, reddish-yellow (fig. 4). Sand and gravel are quartz with a trace (<1%) of white weathered chert in the coarse sand-to-fine pebble gravel fraction. Clay is chiefly from weathering of chert. As much as 10 feet thick, generally less than 5 feet thick. Occurs as erosional remnants on lower interfluves and hilltops between 120 and 160 feet in elevation, and as more continuous deposits in headwater valleys, above 160 feet in elevation. Includes stratified stream-channel deposits, poorly stratified deposits laid down by groundwater seepage on pediments, and pebble concentrates formed by winnowing of sand from older surficial deposits and the Cohansey Formation by groundwater sapping or surface runoff.

Tg UPLAND GRAVEL, HIGH PHASE—Fine-to-medium sand, some coarse sand, clayey in places, and pebble gravel; yellow, brownish-yellow, reddish-yellow, very pale brown. Sand and gravel are quartz, with as much as 2% chert, and traces of weathered feldspar, in the coarse sand-to-fine pebble gravel fraction. Most chert is weathered to white and yellow clay, some chert pebbles are gray to dark gray and unweathered to partially weathered. Clay-size material chiefly is from weathering of chert and feldspar. As much as 15 feet thick. Occurs as erosional remnants on hilltops in the southwestern part of the quadrangle, between 140 and 160 feet in elevation, and as more continuous deposits on the broad upland in the eastern part of the quadrangle, between 160 and 190 feet in elevation. Includes stratified and cross-bedded stream-channel deposits and poorly stratified to nonstratified pebble concentrates formed by washing of sand and clay from the Beacon Hill Gravel by groundwater sapping or surface runoff.

Tbh BEACON HILL GRAVEL—Medium-to-very coarse sand, some fine-to-medium sand, clayey to very clayey in places, pebble gravel; reddish-yellow, yellow, brownish-yellow, red, very pale brown. Clay-size material chiefly is from weathering of chert and feldspar. Sand and gravel are quartz with as much as 10% brown and dark gray chert; gravel includes red and gray sandstone and siltstone and white granite and gneiss as rarities; sand includes traces of weathered feldspar. Rarely, chert pebbles contain fossil molds of brachiopods, pelecypods, and corals of Paleozoic age. Most chert is weathered to white and yellow clay-size material. As much as 15 feet thick. Generally nonstratified, or poorly stratified, owing to weathering, cryoturbation, and bioturbation. Tabular, planar cross bedding is locally preserved. Caps highest hills in the quadrangle, above 180 feet in elevation.

COHANSEY FORMATION—The Cohansey Formation is a fine-to-medium quartz sand, with some strata of medium-to-very coarse sand, 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 test drilling, gamma-ray well logs, and surface mapping using 5-foot hand-auger holes, exposures, and excavations. Total thickness of the Cohansey in the quadrangle is as much as 230 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. Well-stratified to unstratified; stratification ranges from thin, planar, subhorizontal beds to large-scale trough and planar cross-bedding (fig. 4). 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 weathered to white clay. In a few places, typically above clayey strata, and where iron-bearing heavy minerals are abundant, sand may be hardened or cemented by iron oxide, forming red, reddish-yellow, and 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 70 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. Clay beds are commonly 0.5 to 3 inches thick, rarely as much as 3 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, light gray; sands are yellow, brownish-yellow, very pale brown, reddish-yellow (fig. 4). Rarely, clays are brown, dark brown, dark gray, and black, and contain organic matter. As much as 40 feet thick, generally less than 20 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. Contains mollusk shells in places. In subsurface only (section BB'). As much as 150 feet thick in central and southern part of quadrangle, thins to 100 feet in northern part of quadrangle. Kirkwood sediments in the quadrangle are within the "lower Kirkwood sequence" of Sugarman and others (1993) and within the lower and Shiloh Marl members of Owens and others (1998). These members are of early Miocene age, based on strontium stable-isotope ratios and diatoms (Sugarman and others, 1993).

Tsr SHARK RIVER FORMATION—Clayey glauconitic quartz sand, gray to dark green. In subsurface only (section BB'). Approximately 120 feet thick in the map area (Owens and others, 1998). The Shark River is of middle Eocene age based on dinoflagellates, foraminifers, calcareous nannofossils, and strontium stable isotope ratios from mollusk shells (Browning and others, 2011)

MAP SYMBOLS

Contact of surficial deposits—Solid where well-defined by landforms as visible on 1:12,000 stereo airphotos and LiDAR imagery, long-dashed where approximately located, short-dashed where gradational or featheredged, dotted where covered by fill or water or where removed by excavation.

Contact of Cohansey facies—Approximately located. Dotted where concealed by surficial deposits.

Tchc Concealed Cohansey facies—Covered by surficial deposits. Where not labeled, concealed unit is the Sand Facies.

3 Qe4/Qtu Material penetrated by hand-auger hole, or observed in exposure or excavation. Number indicates thickness of surficial material, in feet, where penetrated. Symbols without a thickness value within surficial deposits indicate that the surficial material is more than 5 feet thick. Where more than one unit was penetrated, the thickness (in feet) of the upper unit is indicated next to its symbol and the lower unit is indicated following the slash. Unit "Tchc" indicates clay within Cohansey Formation, Sand Facies.

4170+30 Beta 445819 Radiocarbon date—Age in radiocarbon years, witrh error and laboratory number.

figure 3 Photograph location

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

74 Well or test boring—Location accurate to within 500 feet. Log of formations penetrated shown in Table 1.

Whiting 4 Test boring drilled by N. J. Geological and Water Survey—Log in Table 2.

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

Head of seepage valley—Line at top of scarp, ticks on slope. Marks head of small valleys and hillslope embayments formed by seepage erosion. Scarps that do not occur above active seeps are relict. They mark valleys formed during times when the water table was higher than present.

Active seepage scarp—Line at foot of scarp. Water drains downhill from this position. Active seepage also occurs at the upland edge of unit Qals and, in places, unit Qtl.

Dry channel—Line in channel axis. Marks inactive channels on dry uplands.

Abandoned channel—Line in channel axis. Marks braided-channel network on lower terraces in Gaunts Brook lowland.

Dune ridge—Line on crest.

Shallow topographic basin—Line at rim, pattern in basin. Includes thermokarst basins formed from melting of permafrost, and deflation basins formed from wind erosion.

Excavation perimeter—Line encloses excavated area. Topography within these areas differs from that on the base map.

Sand pit—Inactive in 2016.

Clay pit—Inactive in 2016.

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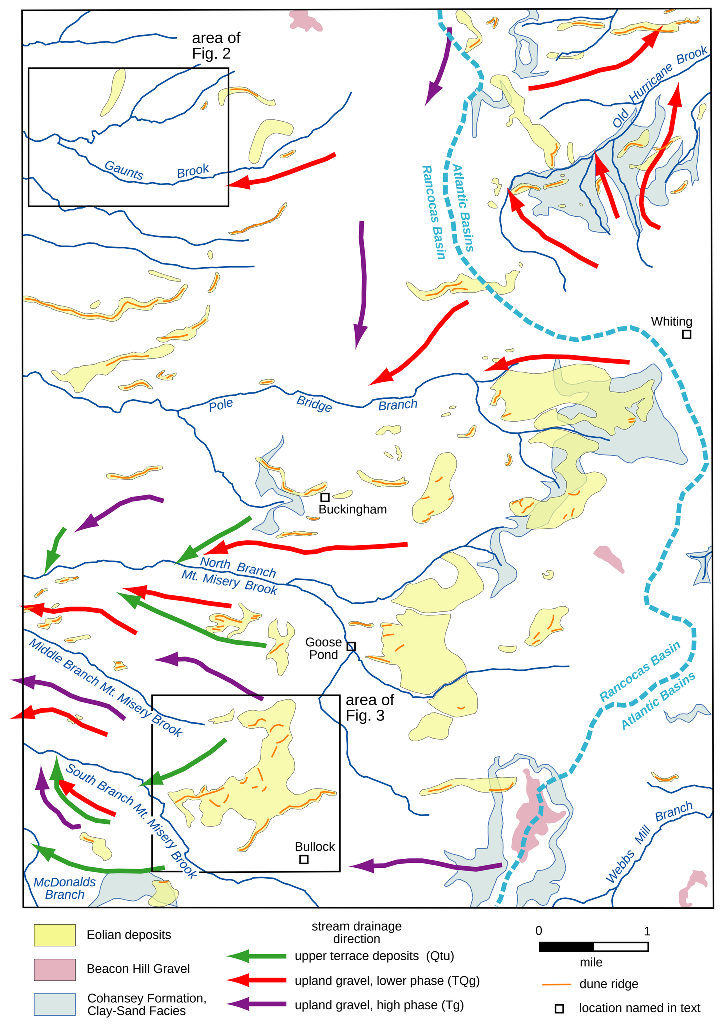


Figure 1. Eolian deposits, paleodrainage, and outcrop of Cohansey Formation, Clay-Sand Facies, in the Whiting quadrangle. Drainage during deposition of the Beacon Hill Gravel was generally north-to-south.

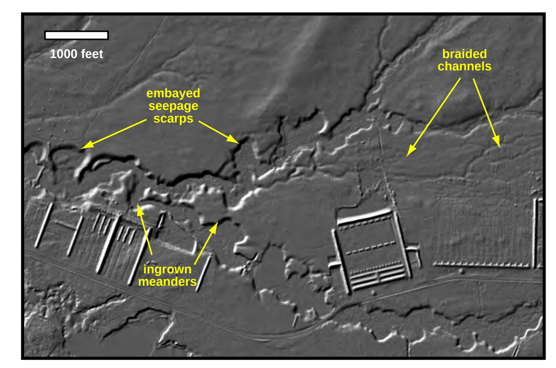


Figure 2. Shaded-relief LiDAR image showing ingrown meanders and embayed seepage scarps at the edge of the modern floodplain, and braided channels on the lower terrace, in the Gaunts Brook valley. Location shown on figure 1.

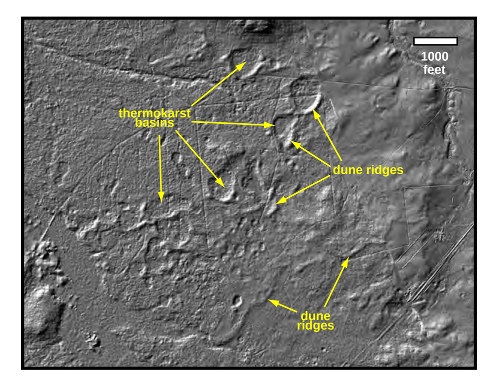


Figure 3. Shaded-relief LiDAR image showing thermokarst basins and dune ridges in an area of eolian deposits near Bullock. Location shown on figure 1.

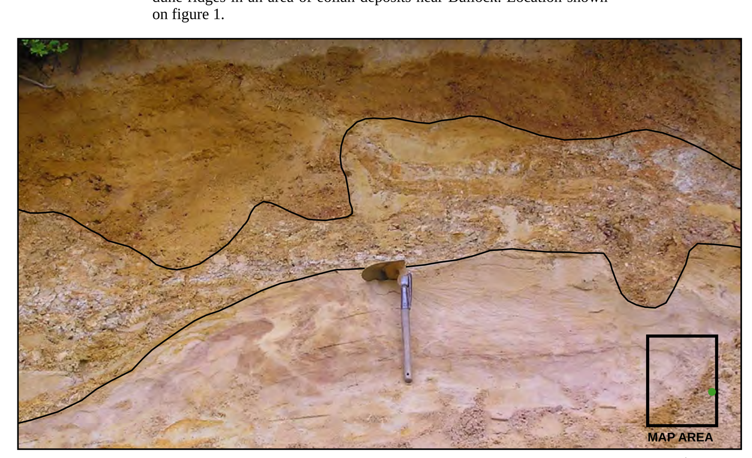
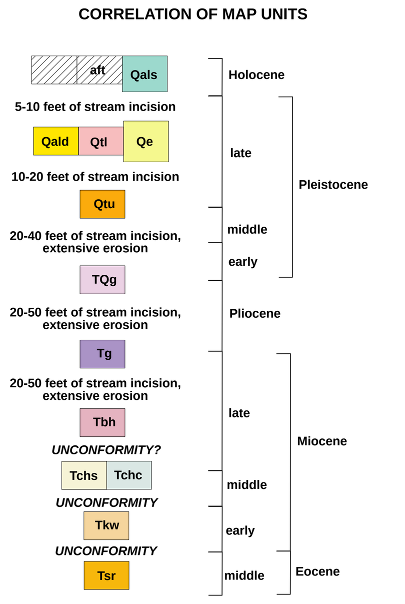
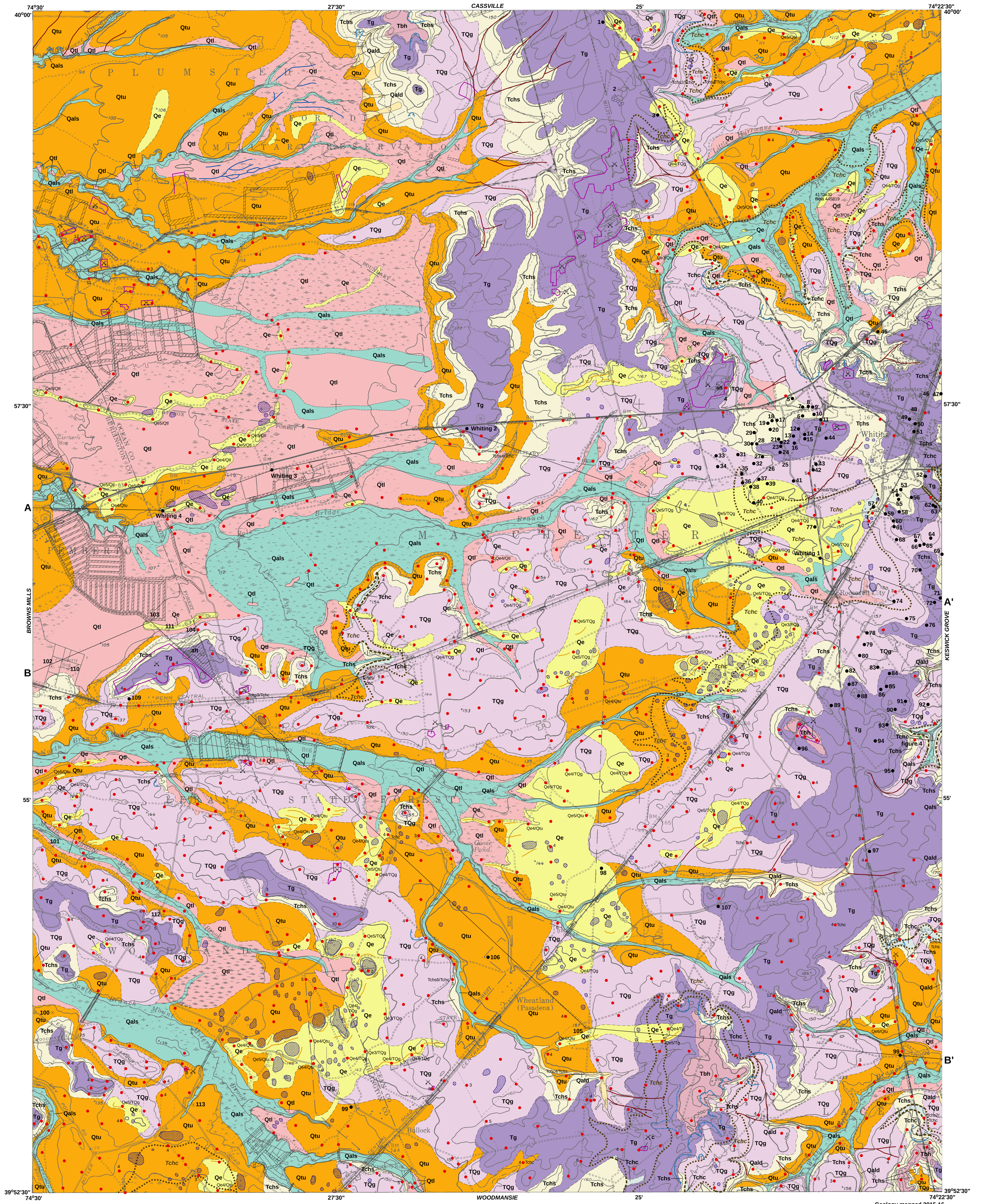


Figure 4. Upland Gravel, Lower Phase (above top line) overlying Cohansey Formation, Clay-Sand Facies (between lines), overlying Cohansey Formation, Sand Facies (below lower line). Contacts and sediments are deformed by cryoturbation. Clay beds are white to light gray. Note cross bedding in sand to right of shovel, and recumbent fold from cryoturbation to left of shovel. Location shown on map and inset.

CORRELATION OF MAP UNITS





Base from U. S. Geological Survey, 1957
Photorevised 1971
North American Datum of 1927

APPROXIMATE MEAN DECLINATION, 1971

SCALE 1:24 000
1 1/2 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

LOCATION IN NEW JERSEY

Geology mapped 2015-16
Drilling by B. Buttari and G. Steidl
Geophysical logging by J. Curran, M. Gagliano, and M. Kuhn
Drilling assistance by I. Snook, M. Castelli, Z. Schagrin, F. Rea, L. Lugrin, and F. Beetle-Moorcroft
Cartography by S. Stanford

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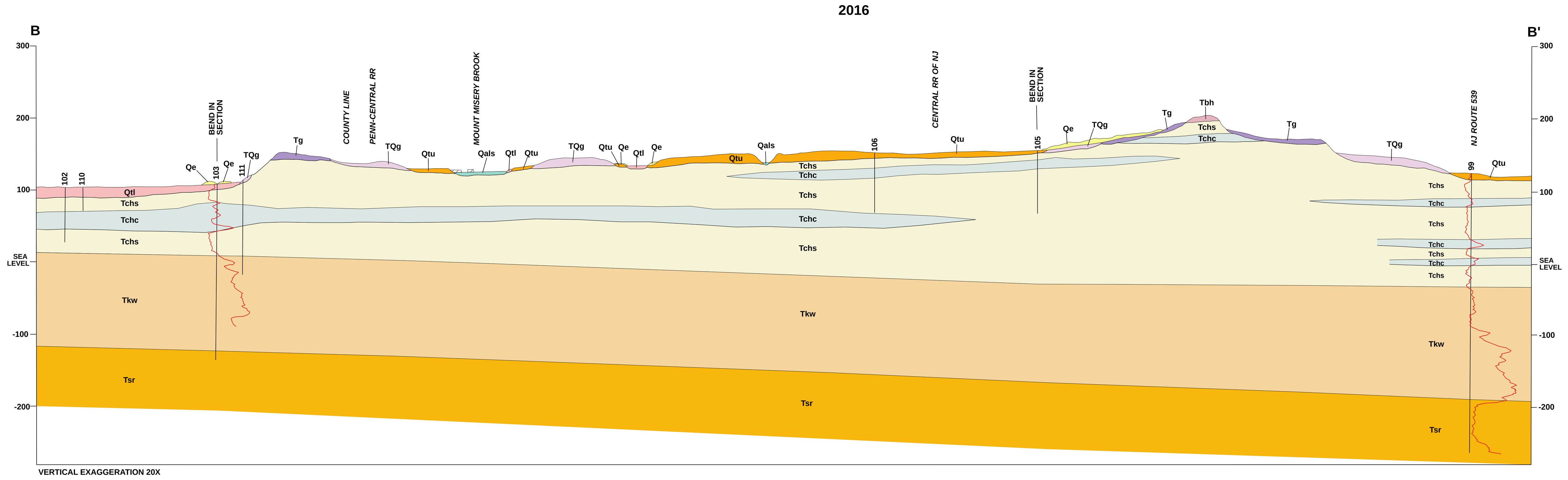
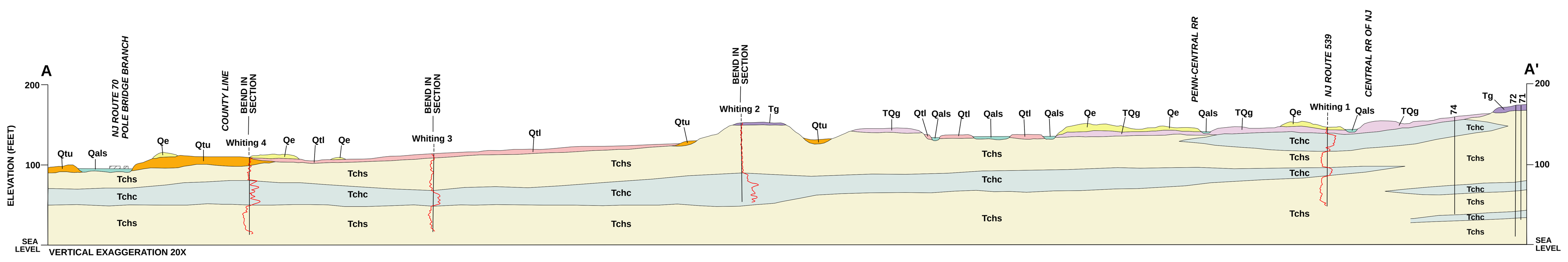
GEOLOGY OF THE WHITING QUADRANGLE OCEAN AND BURLINGTON COUNTIES, NEW JERSEY

by
Scott D. Stanford
2016





Geology of the Whiting Quadrangle
Ocean and Burlington Counties, New Jersey

New Jersey Geological and Water Survey
Open-File Map OFM 113
2016

Pamphlet with tables 1 and 2 to accompany map

Table 1. Selected well and boring records.

Well Number	Identifier[1]	Formations Penetrated[2]
1	32-15454	17 Q 24 Tchc 37 Tchs 39 Tchc 106 Tchs
2	32-8344	32 Tchs 34 Tchc 60 Tchs
3	32-10754	20 Q or Tchs 25 Tchc 30 Tchs 35 Tchc 80 Tchs 81 Tchc
4	32-11274	30 Tchs 35 Tchc 50 Tchs
5	32-12018	26 Tchs 28 Tchc 42 Tchs 62 Tchc 68 Tchs 72 Tchc 97 Tchs 115 Tchc 128 Tchs
6	32-15764	15 Tchc 50 Tchs 67 Tchc 78 Tchs
7	32-14502	10 Tchs 20 Tchs+Tchc 50 Tchs 58 Tchc 65 Tchs+Tchc 90 Tchs
8	32-14848	10 Tchs 20 Tchs+Tchc 50 Tchs 58 Tchc 65 Tchs+Tchc 90 Tchs
9	32-14753	10 Tchs 20 Tchs+Tchc 50 Tchs 58 Tchc 65 Tchs+Tchc 90 Tchs
10	32-15107	10 Tchc 30 Tchs+Tchc 45 Tchs 50 Tchs+Tchc 55 Tchs 60 Tchs+Tchc 65 Tchs 70 Tchs+Tchc 75 Tchc 80 Tchco 100 Tchs+Tchco 120 Tchs
11	32-13895	40 Tchs 60 Tchs+Tchc 80 Tchc+Tchs 105 Tchs
12	32-14102	20 Tchs 30 Tchs+Tchc 40 Tchs 50 Tchs+Tchc 60 Tchc+Tchs 80 Tchs
13	32-15030	15 Tchc 45 Tchs 50 Tchs+Tchc 55 Tchc 67 Tchco 79 Tchs
14	32-10387	15 Q or Tchs 55 Tchs 75 Tchc 93 Tchs
15	32-10386	60 Tchs 70 Tchc+Tchs 80 Tchco 95 Tchs
16	32-826	12 Tchs 37 Tchs+Tchc 57 Tchs 67 Tchc 68 Tchs 73 Tchc 107 Tchs 114 Tchs+Tchc 132 Tchc 134 Tchs+Tchc 173 Tchs 185 Tkw
17	32-6869	46 Tchs 49 Tchc 67 Tchs
18	32-6868	46 Tchs 49 Tchc 54 Tchs 57 Tchc 65 Tchs
19	32-10031	42 Tchs 54 Tchc+Tchco 70 Tchs
20	32-10030	42 Tchs 54 Tchc+Tchco 70 Tchs
21	32-12489	30 Tchs+Tchc 45 Tchs 55 Tchc 58 Tchco 59 Tchs 65 Tchco 89 Tchs
22	32-15627	10 Tchc 20 Tchs+Tchc 55 Tchs 60 Tchc 70 Tchco 90 Tchs
23	32-14954	40 Tchs+Tchc 50 Tchs 60 Tchc+Tchs 90 Tchs
24	32-12572	17 Tchs+Tchc 55 Tchs 65 Tchc 73 Tchco 88 Tchs
25	32-7928	30 Tchs+Tchc 32 Tchc 39 Tchs+Tchc 54 Tchc 78 Tchs
26	32-12882	43 Tchs 47 Tchc 65 Tchco 88 Tchs
27	32-10260	40 Tchs 45 Tchc 60 Tchco 85 Tchs
28	32-9842	42 Tchs 54 Tchc+Tchco 70 Tchs
29	32-15324	10 Tchs 15 Tchc 45 Tchs+Tchc 60 Tchc+Tchs 80 Tchs
30	32-10499	42 Tchs 54 Tchc+Tchco 70 Tchs
31	32-6864	46 Tchs 49 Tchc 65 Tchs
32	32-13898	10 Tchs 40 Tchs+Tchc 45 Tchc 53 Tchco 79 Tchs
33	32-6871	46 Tchs 49 Tchc 54 Tchs 57 Tchc 65 Tchs
34	32-9841	40 Tchs 52 Tchc+Tchco 65 Tchs
35	32-8246	34 Tchs 46 Tchc 70 Tchs
36	32-7927	13 Tchc 28 Tchs 31 Tchc 38 Tchs 51 Tchc 70 Tchs
37	32-10261	50 Tchs 55 Tchco 85 Tchs

Well Number	Identifier[1]	Formations Penetrated[2]
38	32-8799	40 Tchs 48 Tchc+Tchco 55 Tchs+Tchc 65 Tchs
39	32-13612	10 Tchc 47 Tchs 51 Tchc 58 Tchco 79 Tchs
40	32-14818	10 Tchs 20 Tchs+Tchc 50 Tchs 58 Tchc 65 Tchs+Tchc 82 Tchs
41	32-13468	11 Tchs 14 Tchs+Tchc 43 Tchs 62 Tchc 73 Tchs+Tchc 80 Tchs 81 Tchc 86 Tchs
42	32-6687	22 Tchs+Tchc 43 Tchs 57 Tchs+Tchc 64 Tchco 81 Tchs
43	32-8198	5 Tchs 7 Tchc 20 Tchs+Tchc 41 Tchs
44	32-14649	52 Tchs 65 Tchs+Tchc 82 Tchs 90 Tchs+Tchc 125 Tchs 127 Tchc 136 Tchs+Tchc 142 Tchs
45	32-11879	36 Tchs 41 Tchc 58 Tchs+Tchc 88 Tchs 97 Tchs+Tchc 130 Tchs
46	32-108	15 Q or Tchs 71 Tchs 105 Tchc+Tchs 125 Tchs
47	32-11765	65 Tchs 103 Tchs+Tchc 116 Tchs 120 Tchs+Tchc
48	32-310	60 Tchs 65 Tchc+Tchs 71 Tchs
49	32-11799	72 Tchs 99 Tchc 118 Tchs 120 Tchc
50	32-69	11 Q 67 Tchs 70 Tchc 83 Tchs
51	32-14514	30 Tchs 52 Tchc 70 Tchs+Tchc 110 Tchs
52	32-10097	90 Tchs 100 Tchc+Tchco 105 Tchs
53	32-14883	15 Tchc 60 Tchs 70 Tchs+Tchc 80 Tchc 130 Tchs
54	32-13049	15 Tchc 60 Tchs 70 Tchs+Tchc 80 Tchc 126 Tchs
55	32-15747	40 Tchs+Tchc 60 Tchs 75 Tchs+Tchc 87 Tchc 109 Tchs
56	32-12967	50 Tchs 73 Tchs+Tchc 79 Tchc 87 Tchs 93 Tchco 118 Tchs
57	32-9402	5 Tchs 15 Tchco+Tchs 40 Tchs 55 Tchc 80 Tchs
58	32-15023	20 Tchc+Tchs 60 Tchs 75 Tchs+Tchc 80 Tchc 100 Tchs+Tchc 120 Tchs
59	32-11787	20 Tchs+Tchc 70 Tchs 75 Tchc
60	32-9538	8 Tchs 18 Tchc 65 Tchs 81 Tchs+Tchc 87 Tchc
61	32-14528	30 Tchs+Tchc 90 Tchs 98 Tchc 120 Tchs
62	32-12315	75 Tchs 87 Tchc 90 Tchs 95 Tchco 116 Tchs
63	32-8042	3 Q 7 Tchs 12 Tchc 16 Tchs 25 Tchc 80 Tchs
64	32-7599	22 Tchs+Tchc 90 Tchs
65	32-12487	95 Tchs 105 Tchc+Tchs 119 Tchs
66	32-12485	30 Tchs+Tchc 100 Tchs 103 Tchc 120 Tchs
67	32-10629	10 Tchs 15 Tchc 95 Tchs 100 Tchc 120 Tchs
68	32-14548	20 Tchs+Tchc 60 Tchs 80 Tchs+Tchc 92 Tchs 96 Tchc 120 Tchs
69	32-13360	70 Tchs 78 Tchc 80 Tchs 100 Tchc 105 Tchs
70	32-13512	30 Tchs 40 Tchs+Tchc 80 Tchs
71	32-13778	98 Tchs 107 Tchco 136 Tchs 140 Tchc
72	32-13625	8 Tchs 16 Tchs+Tchc 90 Tchs 98 Tchs+Tchc 110 Tchco 120 Tchs 127 Tchs+Tchc 162 Tchs
73	32-13126	55 Tchs 90 Tchs+Tchc 115 Tchs 120 Tchc+Tchs
74	32-13984	12 Tchs 21 Tchc 82 Tchs 92 Tchc 120 Tchs
75	32-2378	25 Tchs 37 Tchc+Tchs 60 Tchs
76	32-13867	54 Tchs+Tchc 90 Tchs 96 Tchc 117 Tchs 120 Tchs+Tchc
77	32-914	8 Tchs+Tchc 45 Tchs 65 Tchc 79 Tchs
78	32-11331	15 Q or Tchs 21 Tchc 43 Tchs 58 Tchc 73 Tchs
79	32-10871	32 Tchs 55 Tchc+Tchs 61 Tchs+Tchc 69 Tchco 79 Tchs
80	32-7917	32 Tchs 53 Tchs+Tchc 74 Tchs 95 Tchs+Tchc 117 Tchco+Tchs 131 Tchs
81	32-15344	17 Tchs 19 Tchc 30 Tchs 34 Tchc 61 Tchs 63 Tchc 76 Tchs 81 Tchc 97 Tchs
82	32-13112	5 Tchc 16 Tchs 19 Tchc 27 Tchs 30 Tchc 51 Tchs 59 Tchc 96 Tchs
83	32-13353	10 Tchc 40 Tchs 55 Tchc 74 Tchs 77 Tchc
84	32-14229	8 Tchs 22 Tchc 25 Tchs 46 Tchc 54 Tchs 60 Tchc 68 Tchs 74 Tchc 103 Tchs
85	32-8584	10 Tchs 40 Tchs+Tchc 80 Tchs 90 Tchs+Tchc 100 Tchs+Tchco 110 Tchco 136 Tchs
86	32-15669	13 Tchs 26 Tchc 39 Tchs 41 Tchc 50 Tchs 51 Tchc 70 Tchs 72 Tchc 89 Tchs 94 Tchc 101 Tchs
87	32-12700	18 Tchs 22 Tchc 55 Tchs 90 Tchs+Tchc 96 Tchc 100 Tchs
88	32-13981	30 Tchs+Tchc 38 Tchc 55 Tchs+Tchc 110 Tchs 112 Tchco
89	32-12873	15 Tchc 70 Tchs 85 Tchs+Tchc 110 Tchs 111 Tchc
90	32-8994	30 Tchs 45 Tchc 100 Tchs 115 Tchs+Tchc 135 Tchs
91	32-12649	25 Tchs 46 Tchc 100 Tchs
92	32-13366	25 Tchc+Tchs 29 Tchs 34 Tchc 37 Tchco 66 Tchs 70 Tchc 71 Tchs 91 Tchs+Tchc 101 Tchc 121 Tchs
93	32-13765	55 Tchs 60 Tchc 117 Tchs 118 Tchco

Well Number	Identifier[1]	Formations Penetrated[2]
94	32-13367	18 Q 30 Tchs+Tchc 120 Tchs
95	32-14500	10 Tchc+Tchs 51 Tchs 56 Tchc 60 Tchs 80 Tchs+Tchc 95 Tchs 98 Tchc+Tchs 100 Tchc
96	32-14358	21 Tchc 54 Tchs 58 Tchc 118 Tchs 120 Tchc+Tchs
97	33-25363	8 Tchs 9 Tchc 19 Tchs 26 Tchc 38 Tchs 41 Tchc 48 Tchs+Tchc 51 Tchc 130 Tchs
98	32-11791	50 Tchs 61 Tchc 75 Tchs
99	32-434, G	35 Tchs 50 Tchc 90 Tchs 105 Tchc 115 Tchs 125 Tchc 160 Tchs 315 Tkw 388 Tsr
100	32-30, R Transco 5	140 Tch 270 Tkw 900 TD
101	32-35, R Transco 7	141 Tch 210 Tkw 908 TD
102	32-11556	30 Tchs 55 Tchs+Tchc 75 Tchs
103	32-581, G	30 Tchs 35 Tchc 45 Tchs 50 Tchc 65 Tchs 75 Tchc 110 Tchs 240 Tkw 250 Tsr
104	32-10914	10 Q 22 Tchs
105	32-20230	8 Tchs 13 Tchc 21 Tchs 27 Tchc 87 Tchs
106	32-17195	20 Tchs 30 Tchc 45 Tchc+Tchs 73 Tchs 74 Tchc
107	32-20413	30 Tchs 50 Tchc 70 Tchs+Tchc 100 Tchs
108	32-19499	4 Tchs 11 Tchc+Tchs 14 Tchc 25 Tchs 27 Tchc 40 Tchs 42 Tchc 54 Tchs 60 Tchc 88 Tchs
109	32-18010	16 Tchs 18 Tchc 22 Tchs 25 Tchc 39 Tchs 46 Tchc 62 Tchs 65 Tchc 90 Tchs
110	32-18625	12 Q 30 Tchs
111	32-15238	37 Tchs 52 Tchs+Tchc 120 Tchs 130 Tkw
112	32-11440	10 Tchs
113	32-11461	5 Tchs 9 Tchc
114	32-8716	5 Tchs 20 Tchc+Tchs 65 Tchs

[1]Identifiers of the form “33-xxxx and 32-xxxx” are 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, an “R” indicates that a resistivity log is available.

[2]Number is depth (in feet below land surface) of base of unit indicated by abbreviation following the number. Final number is total depth of well rather than base of unit. For example, “12 Tchs 34 Tchc 62 Tchs” indicates Tchs from 0 to 12 feet below land surface, Tchc from 12 to 34 feet, and Tchs from 34 to bottom of hole at 62 feet. Formation abbreviations and the corresponding drillers’ descriptive terms used to infer the formation are: Q=yellow and white sand and gravel surficial deposits (units Tg, TQg, Qtu, Qtuo, Qtl, Qals). Bedrock formations are: Tchs=white, yellow, gray, brown (minor red, orange) fine, medium, and coarse sand (and minor fine gravel) of the Cohansey Formation; Tchc=yellow, white, gray (minor red, orange, black) clay, silty clay, and sandy clay of the Cohansey Formation; Tchco=gray, black, brown clay of the Cohansey Formation with organics, “bark”, or lignite. Tkw=gray and brown clay, silt and sand of the Kirkwood Formation. Tsr=green, glauconitic clay of the Shark River Formation. A “+” sign indicates that units are mixed or interbedded. “TD” indicates total depth of deep wells for which units below Tkw are not listed. Units are inferred from drillers’ or geologists’ lithologic descriptions on well records filed with the N. J. Department of Environmental Protection, or 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 most well logs, surficial deposits cannot be distinguished from Cohansey sands; thus, the uppermost Tchs unit in well logs generally includes overlying surficial deposits.

Table 2.—Lithologic logs of test borings. Gamma-ray logs provided on section AA'.

N. J. permit number and identifier	Lithologic log	
	Depth (feet below land surface)	Description (map unit assignment in parentheses) Color names from Munsell Soil Color Charts, 1975
E201604731 Whiting 1	0-10	pale brown to grayish-brown fine-to-medium sand with few to some very-fine-to-medium pebbles (TQg)
	10-31	very dark gray to black clay and clayey fine sand (Tchco)
	31-51	dark brown to dark grayish-brown fine-to-medium sand (Tchs)
	51-62	very dark gray to black clay and clayey fine sand (Tchco)
	62-98	grayish-brown to dark grayish-brown fine-to-medium sand (Tchs)
E201604732 Whiting 2	0-5	brown to dark yellowish-brown fine-to-medium sand with few to some fine-to-coarse pebbles (Tg)
	5-45	very pale brown fine-to-medium sand (Tchs)
	45-63	brownish-yellow to yellowish-brown medium-to-very-coarse sand with some fine pebbles (Tchs)
	63-98	gray, dark gray, black clay and grayish-brown to dark grayish-brown clayey fine sand (Tchc)
E201604733 Whiting 3	0-5	dark grayish-brown fine-to-medium sand with few to some fine pebbles (Qtl)
	5-47	very pale brown fine-to-medium sand (Tchs)
	47-62	yellow, white, yellowish-brown, reddish-yellow thinly bedded clay, very fine sand, and fine sand (Tchc)
	62-93	brown to yellowish-brown fine-to-medium sand, minor coarse sand (Tchs)
	93-98	red medium-to-coarse sand with some to many very-fine-to-fine pebbles (Tchs)
E201604734 Whiting 4	0-5	brown fine-to-medium sand with a few very-fine-to-fine pebbles (Qtu)
	5-30	yellow to very pale brown very-fine-to-fine sand (Tchs)
	30-53	yellow, yellowish-brown, and red thinly bedded clay and very-fine-to-fine sand (Tchc)
	53-98	reddish-yellow fine-to-medium sand, minor coarse-to-very-coarse sand (Tchs)