DEPARTMENT OF ENVIRONMENTAL PROTECTION
LAND USE MANAGEMENT
NEW JERSEY GEOLOGICAL SURVEY

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

SURFICIAL GEOLOGY OF THE SALEM AND DELAWARE CITY QUADRANGLES
SALEM COUNTY, NEW JERSEY
OPEN-FILE MAP OFM 76

INTRODUCTION

Surficial deposits are unconsolidated sediments that discontinuously overlie Coastal Plain bedrock formations and that are the parent material for agronomic soils. In the Salem and Delaware City quadrangles, surficial deposits include artificial fill and river, wetland, windblown, hillslope, and estuarine sediments. They are as much as 140 feet thick beneath and adjacent to the Delaware River and as much as 100 feet thick in the lower reaches of the Salem River and Alloway Creek valleys, but are generally less than 40 feet thick elsewhere. They record six main periods of deposition, separated by five episodes of valley erosion. The deposits are described below. The age of the deposits and the episodes of valley erosion are shown on the correlation chart. The underlying Coastal Plain bedrock formations were mapped by Stanford and Sugarman (2009).

DESCRIPTION OF MAP UNITS

ARTIFICIAL FILL--Sand, silt, gravel, clay; gray to brown; demolition debris (concrete, brick, wood, metal, etc.), cinders, ash, slag, glass, trash. Unstratified to weakly stratified. As much as 20 feet thick, generally less than 15 feet thick. In highway and railroad embankments, and filled wetlands and flood plains. Many small areas of fill, particularly along streams in urban areas, are not mapped. The mapped extent of natural deposits beneath fill and dredge spoils is based in part on the position of shorelines and salt marshes shown on topographic map sheet 81 (New Jersey Geological Survey, c. 1880, scale 1:21,120).

DREDGE SPOILS--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. Unstratified to weakly stratified, locally thinly bedded to laminated. In large disposal cell along the Delaware River north of Fort Mott. As much as 50 feet thick.

TRASH FILL--Trash mixed and covered with silt, clay, sand, and minor gravel. As much as 40 feet thick. In solid-waste landfills. Small areas of trash fill may be included in artificial fill and dredge spoils.

Qal ALLUVIUM--Sand, silt, peat, minor clay; brown, yellowish-brown, gray; and pebble gravel. Contains variable amounts of organic matter. Peat and organic silt and clay typically overlie sand and pebble gravel. Sand and silt are unstratified to weakly stratified. Gravel occurs in massive to weakly stratified beds generally less than 2 feet thick. Sand consists chiefly of quartz with some glauconite and mica. Gravel consists of white, gray, and yellow quartz and quartzite, and a trace of gray chert. Beneath the Delaware River (section AA'), the lowermost alluvium may include late Pleistocene glaciofluvial sand and pebble-to-cobble gravel that is the downstream extension of the glaciofluvial gravel that crops out in the Delaware River valley north of the Burlington, New Jersey, area. This gravel was termed the Trenton Gravel by Cook (1880) and Lewis (1880). The same deposit was later named the "Van Sciver Lake" and "Spring Lake" beds by Owens and Minard (1979), although they considered it to be of interglacial age. This glaciofluvial deposit was laid down about 20,000 to 15,000 years ago, during the late Wisconsinan glacial maximum. The glaciofluvial gravel includes much gray sandstone and mudstone, and some red sandstone and mudstone, gray gneiss and schist, black chert, and purple-red conglomerate, in addition to white and gray quartz and quartzite. Alluvium is as much as 30 feet thick beneath the Delaware River, and as much as 15 feet thick elsewhere (estimated). Deposited in modern flood plains and stream channels, and in former flood plains and channels beneath estuarine deposits before Holocene sea-level rise.

Qm SALT-MARSH AND ESTUARINE DEPOSITS--Silt, fine sand, peat, clay; brown, dark-brown, gray, black; and minor medium sand and pebble gravel. Contain abundant organic matter and some mica and shells. As much as 100 feet thick beneath and adjacent to the Delaware River; as much as 80 feet thick in the lower Salem River and Alloway Creek valleys. Deposited in tidal wetlands, salt marshes, tidal flats, and tidal channels during Holocene sea-level rise, within the past 10,000 years.

Qs SWAMP DEPOSITS--Peat and organic silt and fine sand, minor organic clay; brown to black. As much as 10 feet thick (estimated). Deposited in non-tidal wetlands.

Qcl LOWER COLLUVIUM--Fine-to-medium sand, minor silt and clay; light gray, very pale brown; minor pebble gravel. Sand consists chiefly of quartz and is unstratified to weakly stratified. Gravel is scattered within the sand, and occurs as a sparse lag at the base of the deposit. Gravel consists of white, gray, and yellow quartz and quartzite, and minor gray chert. As much as 10 feet thick (estimated). Forms foot-slope aprons that grade to the modern flood plain. Deposited by mass movement and unchanneled washing of material on hillslopes.

Qtl LOWER TERRACE DEPOSITS--Fine-to-medium sand, minor silt and clay; yellow, brown, olive-yellow; and pebble gravel. Sand is unstratified to well-stratified. Gravel occurs in thin beds (generally less than 6 inches thick) within and at the base of the deposit. Sand consists chiefly of quartz and glauconite. Gravel consists of white, gray, and yellow quartz and quartzite, and a trace of gray chert. In deposits beneath the Delaware River and its fringing marshes, gravel also includes gray and red sandstone and mudstone, gray gneiss and schist, and purple-red conglomerate. As much as 30 feet thick beneath the Delaware River, 10 feet thick (estimated) elsewhere. In tributary valleys, form stream terraces with surfaces 2 to 10 feet above modern estuaries and flood plains. Beneath the Delaware River and its fringing marshes, form eroded stream-terrace remnants, now covered by estuarine deposits, with top surfaces rising to about -30 feet in elevation.

Both the tributary-valley terraces and the terrace deposits in the main Delaware River valley were laid down in valleys cut into the Cape May Formation, units 2 and 3. After the lower terrace sediments were deposited, the Delaware River eroded as much as 100 feet into and through the lower terrace before depositing glaciofluvial gravel, and then postglacial alluvium and estuarine sediment. These relationships indicate that the lower terrace deposits beneath the river were laid down during the period of lower-than-present sea level known as the early and middle Wisconsinan in North American stage terminology. This period was between the interglacial highstand of sea level about 125,000 years ago (the Sangamon interglacial) and the last glacial maximum about 20,000 years ago (the late Wisconsinan glacial), when sea level was at its lowest late Pleistocene level of about 350 feet below that at present. Radiocarbon dates of 31,380+/-630-2880 (GX 22966) and 29,330+/-600 (Beta 190911) radiocarbon years before present on wood within the lower terrace deposits in Marcus Hook, Pennsylvania, about 18 miles northeast of Salem, confirm this age range (Jengo, 2006). Older, higher stream-terrace deposits (known as "Upper Terrace Deposits") occur in the upper Salem River and Alloway Creek valleys but do not extend into the map area.

Qcu UPPER COLLUVIUM--Fine-to-medium sand, minor silt, very pale brown, yellow, reddish-yellow; and pebble gravel. Sand consists chiefly of quartz and is unstratified to weakly stratified. Gravel is scattered within the sand and occurs as thin layers within, and at the base of, the deposit. Gravel consists of white, gray, and yellow quartz and quartzite and minor gray to white chert. As much as 10 feet thick. Forms foot-slope aprons that grade to the Cape May Formation, unit 1. Deposited by mass movement and unchanneled washing of material on hillslopes.

CAPE MAY FORMATION (Salisbury and Knapp, 1917)--Estuarine and fluvial-estuarine deposits of middle and late Pleistocene age. Divided into three units (Qcm1, Qcm2, Qcm3) based on surface elevation and age (Newell and others, 1995). Fossils, pollen, and amino-acid racemization ratios in shells from unit Qcm2 elsewhere in the Delaware estuary and Delaware Bay area indicate that it is of Sangamon age (about 125,000 years ago), when sea level was approximately 20-30 feet higher than at present in this region (Newell and others, 1995; Lacovara, 1997; Wehmiller, 1997). Unit Qcm1 is an older estuarine deposit laid down during a pre-Sangamon interglacial sea-level highstand and is of early or middle Pleistocene age (Lacovara, 1997; O'Neal and McGeary, 2002). Unit Qcm3 was deposited during sea-level fall from the highstand represented by the Qcm2 deposits and is of Sangamon or early Wisconsinan age. Unit Qcm2 is equivalent to the Lynch Heights Formation in Delaware and unit Qcm3 is equivalent to the Scotts Corners Formation in Delaware (Ramsey, 2005).

Qcm3 CAPE MAY FORMATION, UNIT 3--Fine-to-medium sand, minor coarse sand, silt, clay, and peat; yellow, brownish-yellow, very pale brown, light gray; and pebble gravel, minor cobble gravel. Unstratified to laminated; sand and pebble gravel may be cross-bedded. Sand consists of quartz with a little glauconite and a trace of mica, feldspar, and chert. Feldspar and chert grains may be partially or completely weathered. Gravel consists of white, gray, and yellow quartz and quartzite, with minor gray chert, gray gneiss and schist, gray to red sandstone and mudstone, and white to gray clay rip-up clasts. Schist, gneiss, sandstone, and mudstone, and a few chert, pebbles are partially to completely weathered. As much as 40 feet thick. Forms a terrace with a maximum surface elevation of about 15 feet.

Qcm2 **Qcm2l** CAPE MAY FORMATION, UNIT 2--Fine-to-medium sand, minor coarse sand, silt, clay, and peat; yellow, brownish-yellow, very pale brown, light gray; and pebble gravel, minor cobble gravel. Unstratified to laminated; sand and pebble gravel may be cross-bedded. Sand consists of quartz with a little glauconite and a trace of mica, feldspar, and chert. Feldspar and chert grains may be partially or completely weathered. Gravel consists of white, gray, and yellow quartz and quartzite; minor gray chert; and a trace of gray gneiss, gray schist, and gray to red sandstone and mudstone. Schist, gneiss, sandstone, and mudstone, and a few chert, pebbles are partially to completely weathered. As much as 50 feet thick. In the subsurface in the Pennsville paleovalley beneath Supawna Meadows, and in a paleovalley in the Oakwood Beach area, logs of wells and borings record gray to dark-gray silt, clayey silt, and sandy silt, with some peat and wood, as much as 70 feet thick. These fine-grained sediments are mapped separately as unit Qmc2l on sections AA' and BB'. Qcm2 forms a terrace with a maximum surface elevation of about 35 feet.

Qcm1 **Qcm2/Tg** CAPE MAY FORMATION, UNIT 1--Fine-to-medium sand, some silt and very fine sand; very pale brown, yellow; and pebble gravel. Unstratified to weakly stratified. Sand consists of quartz with a little glauconite. Gravel consists of white and yellow quartz with minor gray chert. As much as 15 feet thick. In eroded remnants of a terrace with a maximum surface elevation of 65 feet. "Qcm1/Tg" indicates areas where the Cape May Formation, unit 1, is generally less than 6 feet thick over Upland Gravel.

Tp PENSAUKEN FORMATION (Salisbury and Knapp, 1917)--Fine-to-coarse sand, clayey sand, minor silt and very coarse sand; reddish-yellow to yellow; pebble gravel. Unstratified to well-stratified; tabular, planar cross-beds are common in sand. Pebble gravel occurs in thin layers (generally less than 3 inches thick) within the sand and in thicker, massive beds in places at the base of the formation, where it may include some cobble gravel. Sand consists chiefly of quartz with some feldspar, rock fragments (chert and shale), mica, and glauconite. The feldspar and chert grains are partially or completely weathered to a white clay. Gravel consists of yellow, reddish-yellow (from iron-staining), white, or gray quartz and quartzite; a little brown to gray chert; and a trace of brown, reddish-brown, and gray sandstone and shale, and white-to-gray gneiss. The chert, sandstone, shale, and gneiss pebbles are partially weathered or fully decomposed. As much as 30 feet thick (estimated). Crops out in the Mannington Creek valley, with a maximum surface elevation of about 65 feet. The base of the deposit descends from an elevation of about 30 feet northeast of Mannington Creek to about -30 feet on the east edge of the Pennsville paleovalley, where it is covered by the Cape May Formation and was penetrated in boring SL-12. This pattern records thickening of the deposit towards the main Delaware River valley and indicates that the Pensauken was deposited as an aggraded valley fill. This geometry, regional paleoflow data (Owens and Minard, 1979; Martino, 1981), and the provenance of the sand and gravel in the formation, indicate that the Pensauken was deposited by a large river flowing southwesterly from the New York City area to the Delmarva Peninsula. The map area is on the southeastern edge of the former river valley.

The age of the Pensauken is not firmly established. Berry and Hawkins (1935) describe plant fossils from the Pensauken near New Brunswick, New Jersey that they consider to be of early Pleistocene age. Owens and Minard (1979) assign a late Miocene age based on correlation to units in the Delmarva Peninsula. In Delaware, the Columbia Formation, which is a fluvial sand similar in lithology and topographic position to the Pensauken, contains pollen indicating a Pleistocene age (Groot and Jordan, 1999). Pollen from a black clay bed within the Pensauken near Princeton, New Jersey, includes cool-temperate species and a few pre-Pleistocene taxa. This assemblage suggests a Pliocene age (Stanford and others, 2002). The Pensauken is overlain by late Pliocene or early Pleistocene till in Somerset County, New Jersey, and lies in a valley deeply eroded into middle and late Miocene marine and fluvial deposits (Stanford, 1993). These relationships indicate a Pliocene to early Pleistocene age.

Tg UPLAND GRAVEL--Fine-to-medium sand, minor silt and coarse sand, very pale brown, yellow, brownish-yellow; pebble gravel. Sand consists of quartz with minor glauconite, feldspar, and chert. Feldspar and chert grains are partially or fully weathered. Gravel consists of white, yellow, and gray quartz and quartzite with minor gray chert. Most chert pebbles are partially or fully weathered. As much as 20 feet thick. Occurs as erosional remnants of deposits capping interfluves and ridgetops along the western edge of the map area. Elevation of the base of the deposits ranges from 90 to about 40 feet. The upland gravel is thus younger than the Bridgeton Formation, which is at higher elevation, and is partly on grade with, and so of the same age as, the Pensauken Formation. The deposit was, in part, laid down by slope wash and stream deposition in valleys that were tributary to the Pensauken river. Post-Pensauken stream erosion resulted in a topographic inversion, with the former valley-bottom deposits now capping interfluves.

Tb BRIDGETON FORMATION (Salisbury and Knapp, 1917)--Fine-to-coarse sand to clayey sand, reddish-yellow, brownish-yellow, reddish-brown; pebble gravel. 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 and quartzite with some chert. Most chert pebbles are weathered to white and yellow clay. As much as 20 feet thick. Occurs as erosional remnants atop Burden Hill east of Quinton, above 90 to 120 feet in elevation. These are the westernmost remnants of a large river-plain deposit that extend 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; Puzzaglia, 1993).

Qwcp COASTAL PLAIN FORMATIONS--Exposed formations of Cretaceous and Tertiary age, oxidized and weathered to varied depths. Upper several feet generally include some quartz pebbles from eroded surficial deposits, mixed into the formation by bioturbation and cryoturbation. Map unit includes thin, patchy colluvial or alluvial sediments less than 3 feet thick. Not shown on sections owing to varied depth of weathering.

MAP SYMBOLS

Contact--Solid where well-defined by landforms; dashed where approximately located; short-dashed where featheredged or gradational; dotted where covered by water or where artificially exposed within excavated areas.

30-8605 15 **Thickness and stratigraphy of surficial material in well or boring**--Location accurate to within 200 feet. Upper number is identifier; lower number is thickness in feet of surficial material, inferred from driller's log. Where multiple surficial units were penetrated, the depth of the base of the unit (in feet below land or water surface) is indicated next to the unit symbol. A ">" indicates that the base of the unit was not reached at depth shown. A "<" indicates that thickness of surficial material is less than depth shown. Identifiers of the form 30-xxxx and 34-xxxx are well permits issued by the N. J. Department of Environmental Protection, Bureau of Water Allocation. Identifiers of the form SL-x and DC-x are auger borings drilled by J. P. Owens and D. S. Powars of the U. S. Geological Survey. Identifiers of the form Dcxx-xx and Ddxx-xx are from Talley (1985). Identifiers of the form 33-xxx are U. S. Geological Survey Ground Water Site Inventory numbers and are shown only for wells without N.J. Department of Environmental Protection permit numbers.

34-3641 35 **Thickness of surficial material in well or boring**--Location accurate to within 500 feet. Identifiers and thickness values as above.

Material observed in exposure or excavation, or penetrated in hand-auger hole--Number next to symbol indicates thickness of surficial material, in feet. No number indicates thickness is greater than 5 feet.

Windblown deposits overlying map unit--Windblown very fine sand and silt (indicated by symbol "Qv") observed in hand-auger hole or exposure. Number following symbol is thickness of windblown deposit, in feet. These deposits are discontinuous and lack distinctive morphology and so are not mapped separately from the underlying surficial unit.

Dune ridge--Line along crest of ridge. Dune formed by wind-shaping of underlying Cape May Formation.

Paleocurrent measurement--Observation at "x", arrow indicates paleoflow direction. Measured on cross-beds in the Bridgeton Formation. Observations with cross-bar are reported by J. P. Owens of the U. S. Geological Survey (undated field notes on file at the N. J. Geological Survey).

Excavation perimeter--Marks limit of sand pit or other large excavation. Topography within these areas may differ from that on the base map. Contacts within excavated areas show the approximate distribution of surficial materials in 2007.

Sand and gravel pit--Inactive in 2007.

Sand and gravel pit--Active in 2007.

Shallow topographic basin--Line at rim, pattern in basin. Marks shallow surface depressions generally less than 5 feet deep, as seen on stereo aerial photographs taken in 1979 and color infrared planimetric aerial photographs taken in 1995. Most basins are on the Cape May Formation, a few are on the Pensauken Formation, Upland Gravel, or weathered Coastal Plain formations. They are most abundant on flat surfaces where the water table is at shallow depth. They do not occur on lower terraces or modern flood plains and tidal marshes. A few basins are visible beneath thin tidal marsh deposits; these are mapped within unit Qm although they are developed on the underlying Cape May 3. May contain peat or organic silt less than 3 feet thick; basins with thicker organic sediment are mapped as unit Qs. Basins were likely formed by melting of permafrost 18,000 to 15,000 years ago; some may have been formed by wind erosion or groundwater processes.

35 **Elevation of base of surficial deposits**--Contour interval 25 feet. Shown only where thickness of surficial deposits exceeds 20 feet. Shows topography of erosional surface at top of Cretaceous through middle Miocene Coastal Plain formations. Refer to Woodruff (1986) for information on the thickness of surficial deposits in the Delaware part of the map area.

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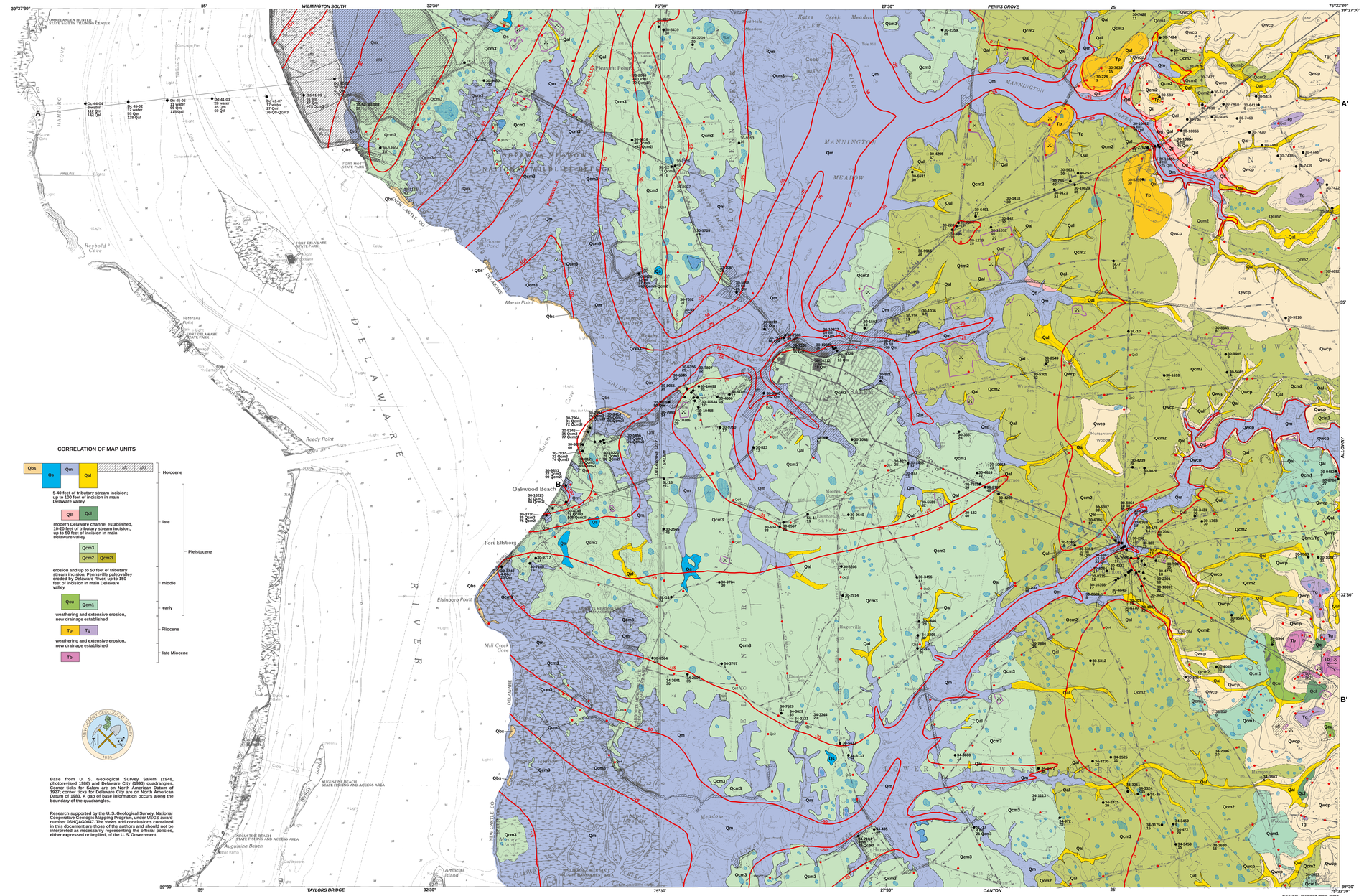
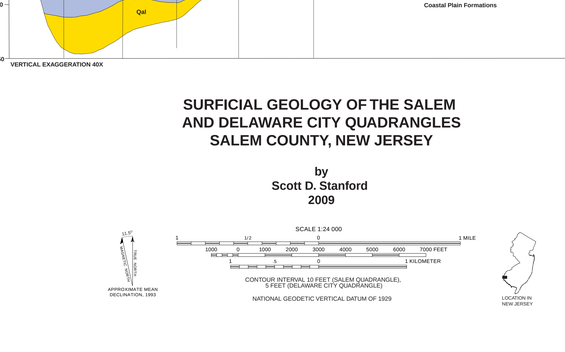


Base from U. S. Geological Survey Salem (1948, photorevised 1986) and Delaware City (1993) quadrangles. Corner ticks for Salem are on North American Datum of 1927; corner ticks for Delaware City are on North American Datum of 1983. A gap of base information occurs along the boundary of the quadrangles.

Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number 06HQAG0047. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

CORRELATION OF MAP UNITS



SURFICIAL GEOLOGY OF THE SALEM AND DELAWARE CITY QUADRANGLES SALEM COUNTY, NEW JERSEY

by
Scott D. Stanford
2009

SCALE 1:24 000

1 MILE
1 KILOMETER
CONTOUR INTERVAL 10 FEET (SALEM QUADRANGLE), 5 FEET (DELAWARE CITY QUADRANGLE)
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1993

LOCATION IN NEW JERSEY

Geology mapped 2006-2007.
Cartography by S. Stanford and M. Girard.