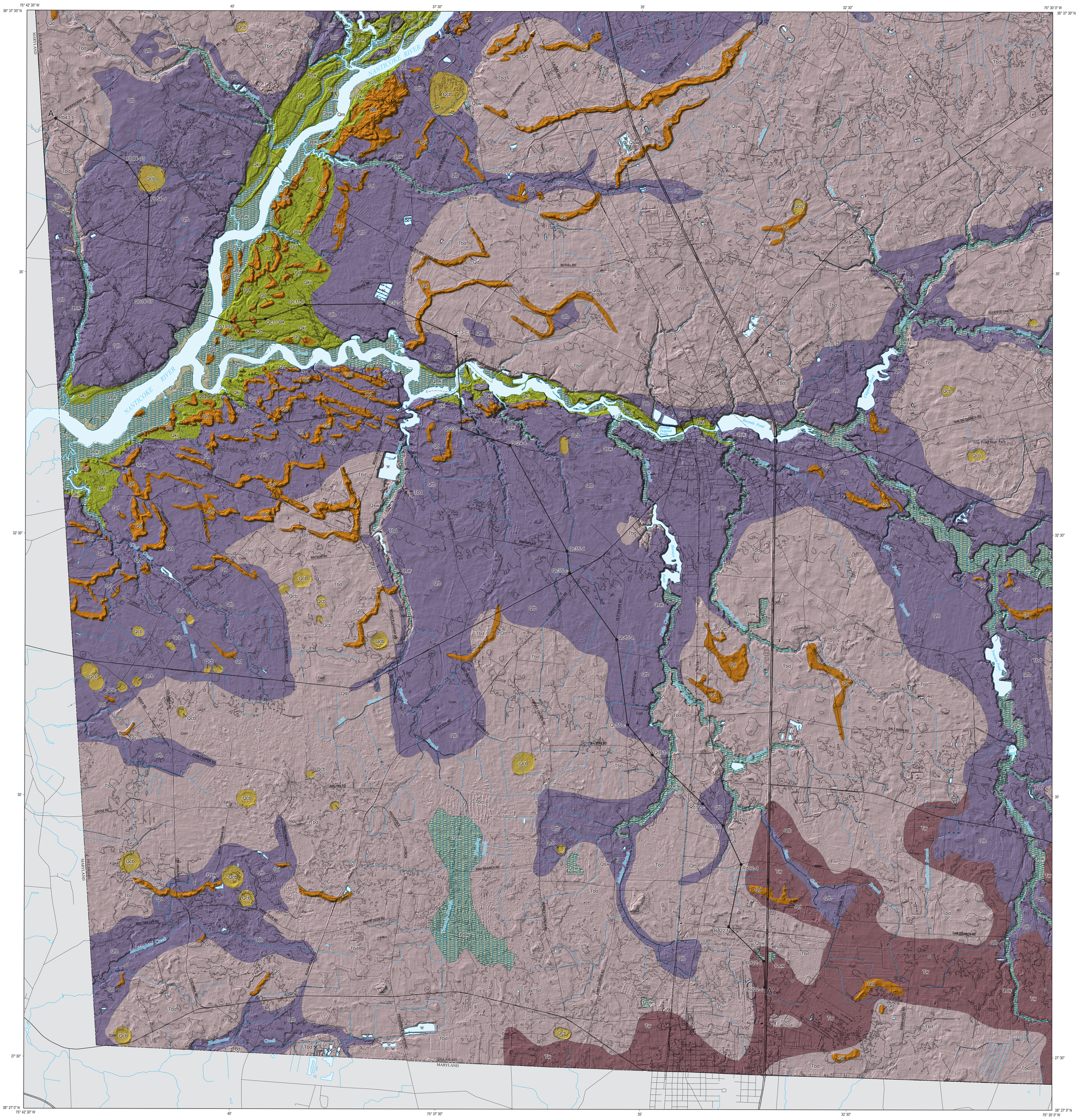

GEOLOGIC MAP OF THE SHARPTOWN, LAUREL, HEBRON, AND DELMAR QUADRANGLES, DELAWARE

by

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SCALE 1:24,000

1 0.5 0 1 2 Kilometers

1 0.5 0 1 Miles

1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000 10,000 Feet

10-foot Index with a 6-foot Intermediate Contour Interval
NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)

Quadrangle Location

1991 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

QUATERNARY
Holocene: Qsw, Qm
Pleistocene: Qcb, Qd, Qki, Qtb
TERTIARY
Pliocene: Tw, Tbd
Miocene: Tcat

SYMBOLS *(on cross section)*
pebble
gamma log
clean sand
clayey silt to silty clay
fine to coarse, silty to clayey sand with scattered clay laminae
slightly clayey, slightly silty sandy silt
clay
silt
shell

Colors for geologic formations on the cross sections appear lighter than shown on the map explanation and stratigraphic chart because they do not include the shading effect of the DEM used on the map.

SYMBOLS *(on map)*
Pb44-03 Well or borehole
Pb43-b Soil auger boring
Sandpit
State Park and Wildlife Areas
Municipal Boundary
State Boundary
Power Transmission Line
Contact

EXPLANATION

MODIFIED LAND

ml

Areas of land where the surficial deposits have been modified by human activity to the point that surficial deposits can no longer be reliably determined. The unit is mapped in areas large enough to be shown on the map but does not include local disturbances on the scale of an individual housing lot or shallow disturbances such as large parking lots or retail areas. An example of modified land is shown on the northern edge of the map just west of the Nanticoke River. It is a formerly excavated pit which has subsequently been filled. Recent.

SWAMP DEPOSITS

Qsw

Gray to brown, silty and clayey, gravelly sand overlain by organic-rich, fine to coarse sand and silt. Swamp deposits are found in the upper reaches of the modern stream valleys, along the margins of the Nanticoke River and in poorly-drained areas on the uplands. In the stream valleys, swamp deposits consist of 1 to 3 ft of gray to brown, silty and clayey gravelly sand at the base overlain by organic-rich, fine to coarse sand. Along the margins of the Nanticoke River, swamp deposits are up to 15 ft thick and have several feet of organic silt near the land surface. On the uplands, the swamp deposits are less than 3 ft thick and consist of organic sand and silt with a woody material component (twigs and leaves; Qd15-c, Table 1). Holocene.

MARSH DEPOSITS

Qm

Light-gray to brown, organic-rich, clayey silt. Peat beds consisting of finely comminuted organic fragments (primarily marsh grass) are common near the base of the unit and scattered throughout. Marsh deposits are generally less than 10 ft thick. Holocene.

CAROLINA BAY DEPOSITS

Qcb

Well-sorted medium to fine-grained white to pale-yellow sand in raised rims (dunes) with silty fine to medium sand in the interior of the circular morphologic features. The deposits are less than 5 ft thick in their interiors and up to 10 ft thick where the sand rims are best developed. Latest Pleistocene to Holocene.

DUNE DEPOSITS

Qd

White to pale-yellow, well-sorted, medium to fine sand. Laminae of coarse sand are common. Thin, brown silty soil lamellae are commonly found at depths of 1 to 3 ft within the dunes. Dune deposits, which are up to 15 ft thick, are very abundant on the eastern side of the Nanticoke River. Dunes that have well-developed and deep (>3 ft) soil profiles may be older than latest Pleistocene and are middle to late Pleistocene in age. Middle Pleistocene to Holocene.

KENT ISLAND FORMATION

Qki

White to pale-yellow, medium to very coarse sand. On the east side of the Nanticoke River, the sand overlies greenish-gray silt to clayey silt with scattered pieces of wood. The silt layer grades downward into gray, coarse to very coarse sand with pebbles and thin beds of organic, woody sand. The formation is typically 5-20 ft thick (cross section A-A') but is up to 50 ft thick at Phillips Landing. The Kent Island Formation is found adjacent to the Nanticoke River beneath terrace flats at elevations of 4 to 12 ft. Late Pleistocene.

TURTLE BRANCH FORMATION

Qtb

On the west side of the Nanticoke River: Clean, well-sorted, white to pale-yellow, fine sand grading down into fine to coarse sand overlying greenish-gray fine sand with scattered zones of chalky *Crassostrea* (oyster) shells. The shelly fine sand overlies a greenish-gray clayey silt to silty clay. At the base of the deposit is a fine to coarse, gray, pebbly sand with layers of organic silt and woody material (twigs and roots).

Along stream valleys tributary to the east side of the Nanticoke River: Clean, well-sorted, white to pale-yellow, fine sand grading down to interlaminated fine to coarse sand with opaque heavy mineral laminae (cross section A-A'), granules, and pebbles at its base. Rare to common scattered, light-gray to light-grayish-brown, clayey silt laminae occur in the sand beds. In the map area, the unit is commonly less than 10 ft thick. The Turtle Branch Formation is distinguished from the adjacent Beaverdam Formation by better sorting and the absence of the white silty matrix, which is characteristic of the Beaverdam (Ramsey and Tomlinson, 2011). It is distinguished from adjacent and overlying dune deposits by having a better developed soil profile and by the common presence of opaque heavy mineral laminae, which are rare in the dune deposits. Middle Pleistocene.

WALSTON FORMATION

Tw

Slightly to moderately silty, very fine to medium, olive-brown to gray sand underlain by compact gray to light-gray, mottled clayey silt to silty clay. The Walston Formation consists of 1 to 15 ft of dry, compact, gray silty clay to clayey silt with yellow to olive-yellow mottles. Thin laminae of light-gray to olive-yellow, fine to coarse silty sand are common. The clay and silt are often overlain by 1 to 3 ft of slightly to moderately silty, very fine to fine olive-brown to gray sand. The thickness of the formation ranges from a few feet along its surficial contact with the Beaverdam Formation to 30 ft east of the map area (Tomlinson and Ramsey, 2014) along the Delaware-Maryland state line. The Walston Formation overlies the Beaverdam Formation (cross section A-A'). Late Pliocene.

BEAVERDAM FORMATION

Tbd

Heterogeneous unit ranging from very coarse sand with pebbles to silty clay. The predominant lithologies at the land surface are white to mottled light-gray and reddish-brown, silty to clayey, fine to coarse sand. Laminae and beds of very coarse sand with pebbles to gravel are common. Laminae and beds of blush-gray to light-gray silty clay are also common. In a few places near the land surface, but more commonly in the subsurface, beds from 2 to 20 ft thick of finely laminated, very fine sand and silty clay are present. The sands of the Beaverdam Formation have a white silt matrix that gives samples a milky appearance when wet. This white silt matrix is the most distinguishing characteristic of the unit and readily differentiates the Beaverdam Formation from the adjacent cleaner sands of the Turtle Branch Formation and the upper sands of the Walston Formation, where in lateral contact. It ranges from 50 to 100 ft thick in the map area. Late Pliocene.

CAT HILL FORMATION *subsurface only*

Tcat

Clean, interbedded light-gray, fine to medium sand with laminae of coarse to granule sand, and coarse to medium sand with abundant very coarse sand, granules, and small pebbles. Beds of gray silt to clayey silt beneath the interbedded sands (cross section A-A') occur on the west side of the Nanticoke River. The Cat Hill Formation is distinguished from the overlying Beaverdam Formation by the lack of the characteristic white silt in the sands. The Cat Hill is approximately 100 ft thick in the map area. Late Miocene.

Discussion

The geological history of the surficial geologic units in western Sussex County is that of deposition of the Beaverdam Formation and its subsequent modification by erosion and deposition related to the sea-level fluctuations during the Pleistocene. The geology reflects this complex history by the cut and fill geometry of the middle and late Pleistocene deposits into the Beaverdam Formation. The geology is further complicated by periglacial activity that produced dune deposits and Carolina Bays in the map area, which modified the land surface. Mapping was conducted using field maps at a scale of 1:12,000 with 2-ft contours. Stratigraphic boundaries drawn at topographic breaks reflect detailed mapping using contours not shown on this map.

The Cat Hill Formation is found in the subsurface in the map area and underlies the Beaverdam Formation or the Turtle Branch Formation where the Beaverdam has been eroded (cross section A-A'). It is a sand-dominated unit (Cat Hill B; Andres, 2004, Ramsey, 2010b) with minor beds of silt and clay. In some locations, rare silty clay beds are found near the contact with the overlying Beaverdam Formation. In the map area, these silt beds are absent. The sands of the Cat Hill are differentiated from the overlying Beaverdam Formation in that they are cleaner and better sorted. The age of the Cat Hill Formation is poorly constrained due to the lack of age-definitive fossils or age-datable material within the unit, but it is interpreted to be a late Miocene, very shallow marine to marginal marine (shoreface) deposit (McLaughlin, et al., 2008).

The Beaverdam Formation consists of stacked, 1- to 5-ft thick beds of very coarse sand and gravel that commonly fine upwards to fine to medium sand and rarely to very fine silty sand to silty clay. These types of deposits are typical of either fluvial or estuarine environments (Ramsey, 2010a, b). Rare burrows have been observed in the Beaverdam Formation elsewhere in Delaware that indicate at least a marginal estuarine setting (DGS unpublished data; Owens and Denny, 1979). The Beaverdam Formation is exposed at the surface throughout a large portion of the map area and underlies all the younger deposits. Along the margins of the Nanticoke River where erosion during the middle to late Pleistocene removed the Beaverdam prior to the deposition of the Turtle Branch and Kent Island Formations, these younger units overlie the Cat Hill Formation. The age of the Beaverdam Formation is uncertain due to the lack of age-definitive fossils within the unit. Stratigraphic relationships in Delaware indicate that it is no older than late Miocene and no younger than early Pleistocene, and is most likely late Pliocene (Groot et al., 1990; Ramsey, 2010a, b).

Discussion (cont.)

The Walston Formation is found in the southeastern portion of this map area and extends east of the map area where it is approximately 30 ft thick. Over its extent in the map area, it thins from approximately 15 ft thick to the east to less than 5 ft thick at its surficial contact with the Beaverdam Formation to the north and west. The Walston Formation overlies the Beaverdam Formation but no geomorphic feature, such as a scarp, marks the contact at the land surface. Silts and clays of the Walston Formation are more densely compacted and darker gray in color than the clay and silt beds found in the Beaverdam. The sands of the Walston Formation are slightly silty and olive-brown to gray while those of the Beaverdam are silty and light-gray to white. The depositional environment of the Walston Formation is unknown but the it is believed to be either a Pliocene back barrier deposit or a regressive facies of the Beaverdam Formation (Owens and Denny, 1979). Warm flora pollen found in the Walston Formation indicate that it is late Pliocene in age (Sirkin and Owens, 1998).

The Turtle Branch Formation (Ramsey, 2010a) consists of clean, well-sorted sand with scattered, clayey silt laminae grading down to interlaminated fine to coarse sand with opaque heavy mineral laminae, granules, and pebbles at its base on the east side of the Nanticoke River. In its type area on the west side of the Nanticoke River, the Turtle Branch Formation is up to 50 ft thick and consists of clean, well-sorted sand underlain by estuarine silts and clays with oyster shells, and with woody sand at the base (Ramsey, 2010a). Adjacent to modern drainages on the east side of the Nanticoke River, it is typically less than 10 ft thick and consists primarily of clean, fine sand grading down to coarse sand with pebbles. These sediments are the result of fluvial, estuarine, and beach deposition on the west side of the present Nanticoke River, and to the east, are the result of fluvial, tidal channel, and beach deposition in the distal upstream reaches of an ancestral Nanticoke River estuary associated with the highstand. The scattered clay laminae adjacent to the modern drainages become more common proximal to the modern Nanticoke River and are interpreted to be tidal flat deposits and shoreline deposits. Some of the clean sand deposits mapped as the Turtle Branch Formation on the uplands are likely the result of late Pleistocene dune migration across the area which left scattered sand sheets in low-lying areas. These late Pleistocene sands are texturally similar to the Turtle Branch Formation sands and cannot be differentiated in the field. The Turtle Branch Formation is older than 39,900 yrs B.P. (Table 1) and interpreted to represent middle Pleistocene (425,000 yrs B.P. and/or 325,000 yrs B.P.; MIS 11 and 9) sea-level highstand deposits (Ramsey, 2010a).

The Kent Island Formation occupies a low terrace adjacent to the Nanticoke River. On the western side of the Nanticoke, the terrace is underlain by medium to very coarse sand with pebbles. On the eastern side of the Nanticoke, the terrace is underlain by medium to fine sand overlying a clayey silt to silt with a basal woody, gravelly sand. Several radiocarbon dates from wood from the Kent Island Formation indicate that the age of the unit is >43,500 yrs B.P (Qb25-06, Table 1). The Kent Island is interpreted to be fluvial, estuarine, and beach deposits associated with a sea-level highstand at approximately 80,000 yrs B.P. (Ramsey, 2010a).

Dune deposits on the uplands are fine to medium, well-sorted sands found scattered throughout the map area and found in abundance on the east side of the Nanticoke River. The more frequent occurrence of these dune fields on the east side of the Nanticoke is attributed to winds from the northwest (Markewich et al., 2009) depositing sand on the lee side of the river valley during glacial periods. The dunes have a pronounced surficial expression as curvilinear features that rise above the surrounding landscape. Some of these dunes are probably latest Pleistocene to early Holocene in age (Andres and Howard, 2000; Ramsey and Tomlinson, 2014), but some could possibly be as old as late Pleistocene. Radiocarbon dates from organic deposits associated with dunes just to the north of the map area indicate deposition continued into the early Holocene. Dune features are also associated with the rims of Carolina Bays that are found in the southern portion of the map area. Both the dunes and the Carolina Bays are cold-climate related features located where winds moved sand across a landscape barren of forests (Ramsey, 1997; Markewich et al., 2009). The exact process by which the distinctive circular shape of the Carolina Bays was formed is unknown.

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Table 1. Radiocarbon dates. Locations of boreholes shown on map.

Radiocarbon Lab ID	DGSID	Land Surface Elevation (ft)	Sample Elevation (ft)	Conventional Radiocarbon Date (yrs B.P.)	Conventional Radiocarbon Error Range (yrs)	Calibrated Date (2 Sigma Median) (yrs B.P.)	Strat Unit
Beta-356194	Qb25-06	5	-12.0	>43500		Dead to carbon	Qki
I-4155	Qc23-01	20	-13.2	>39900		Dead to carbon	Qtb
Beta-356191	Qd15-c	30	28.0	170	30	185	Qsw

MAP CREDITS

Base Map
Delaware state plane coordinate system
Transverse mercator projection
North American Datum of 1983 (NAD83) HARN
The Delaware Department of Transportation Centerline for Delaware, 2009
The Delaware Office of State Planning Coordination Delaware Municipal Boundaries, 2014
USGS National Hydrography Dataset, 2009
USGS Delaware LiDAR Contours, 2005
USGS Delaware Miscellaneous Features, 1993
Delaware Department of Agriculture State Forest Areas, 2009
Delaware Division of Natural Resources and Environmental Control Park Areas, 2009

Other
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