DISCUSSION

The Delaware Geological Survey Hydrologic Map Series provides detailed information on the occurrence, availability, and quality of ground water. This information is useful to persons interested in understanding, developing, protecting, or regulating water resources in Delaware.

The hydrogeologic framework of the Seaford area is characterized by complexly interlayered hydrogeologic units (aquifers and confining beds). Individual hydrogeologic units locally consist of two or more lithostratigraphic units (cross section A-A'). In general, individual lithostratigraphic units thicken and dip to the southeast.

This report focuses on the hydrogeologic units that are encountered in the map area during construction of water supply wells. Beneath these units there are about 3700 to 4000 feet of Mesozoic and Cenozoic sedimentary rocks (Benson, 1984). Because these rocks are not used for water supply their hydrogeologic and water-quality characteristics are poorly understood.

On this map I have used the stratigraphic nomenclature of Ramsey and Schenck (1990). Descriptions of individual lithostratigraphic units reflect observations in the map area and, therefore, may not exactly conform to earlier published descriptions. Readers interested in the usage and derivation of lithostratigraphic and hydrostratigraphic nomenclature are referred to Jordan (1964), Groot et al. (1990), Ramsey and Schenck (1990), and Andres (1986, 1991a).

The shallowest water-bearing unit is the Columbia aquifer. Included in the aquifer are the following lithostratigraphic units, the Beaverdam Formation and, where present, the Manokin and Columbia formations, and Nanticoke deposits. Over most of the map area, the St. Marys Formation is the base of the aquifer. In some areas, fine-grained beds of the Manokin formation are the base of the aquifer. Fresh water marsh and swamp, and tidal marsh deposits cover the aquifer along much of the Nanticoke River and its tributaries and in discontinuous patches in upland areas.

The Columbia aquifer is very important to the environment and economy in the Seaford area. It is recharged by precipitation and discharges water that maintains streamflow. Johnston (1976) determined that ground-water discharge accounts for an average of about 75 percent of total fresh water flow of the Nanticoke River. As a result, stream flow quantity and quality in the map area are highly dependent on ground-water conditions. The aquifer yields most of the fresh water used in the area. It is also the receiving aquifer for discharges from individual on-site wastewater disposal and industrial wastewater spray irrigation systems.

The Columbia aquifer functions both as an unconfined and a semi-confined aquifer. Saturated thickness, or thickness of water-bearing sands, ranges from approximately 30 to 100 ft. The variation in aquifer type and thickness is due to the complex interlayering of aquifer and confining beds. Water levels in the aquifer usually range from less than one foot to about 15 ft below land surface, with yearly fluctuations of 5 to 10 ft. Specific capacities range from 5.8 to 59 gallons per minute per foot of drawdown (gpm/ft). Yields exceeding 1,000 gpm are reported in some locations. Transmissivities are highly variable, because of local variations in permeability and saturated thickness. The aquifer is rated fair to excellent in water-yielding characteristics.

Ground-water recharge potential areas show the relative capabilities of earth materials to transmit water through a layer extending from land surface to a depth of 20 feet (Andres, 1991b). In general, more water will move through the ground more rapidly in higher (excellent and good) recharge potential areas than in areas with lower (fair and poor) recharge potentials. This type of map can be used to identify the areas having the best potential for transmitting water, and contaminants, into the Columbia aquifer.

Natural water quality is generally good although the aquifer is highly susceptible to contamination by surface or near-surface sources. Water in many wells has been contaminated by nitrate as a result of agricultural and wastewater disposal practices. Locally, iron concentrations are high enough to require treatment for most uses. In some locations, low pH also causes corrosion and dissolution of metallic plumbing components.

In the southeast portion of the map area, a few well logs show that the Manokin formation may form a discrete hydrologic unit, the Manokin aquifer. Well log data indicate that the overlying confining unit is not areally continuous. As a result, when pumped at high rates the Manokin aquifer likely functions with the overlying Columbia aquifer as a single hydrologic unit.

The next water-bearing units beneath the Columbia aquifer occur within the Choptank Formation (not shown on cross-section). These unnamed units occur in relatively thin and discontinuous sandy and shelly beds and function as confined aquifers. They receive recharge through leakage from the overlying Columbia aquifer, both within the map area and in updip areas where they occur closer to land surface. They are tapped by a small number of domestic, agricultural, industrial, and public wells in the map area. Because of the small number of wells, not much information about these aquifers is available.

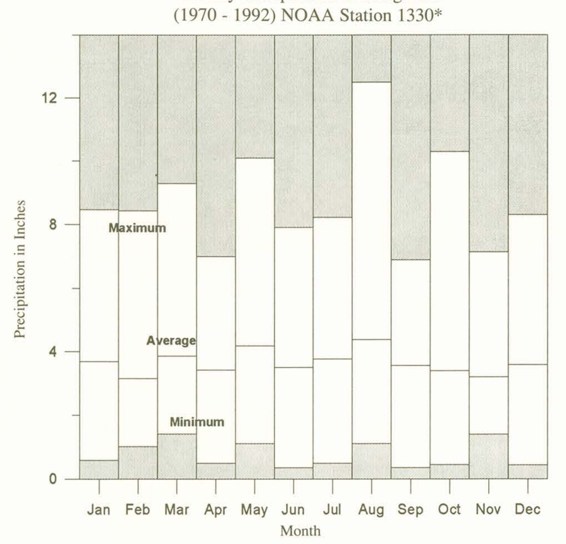
Water levels in aquifers in the Choptank Formation range from above land surface to about 20 ft below land surface. Flowing artesian wells have been drilled in low-lying areas along the Nanticoke River. Saturated thicknesses of individual aquifers range up to several tens of feet. Reported yields to individual wells range from 5 to approximately 500 gpm. Specific capacities range from 1.0 to 6.5 gpm/ft. These aquifers are rated from poor to good in water-yielding capability.

Water samples from seven wells in the Choptank Formation aquifers indicate that natural water quality is variable. Hardness, caused by iron or by dissolution of shelly material may require treatment. Sodium concentrations can be a problem for those who must restrict their intake of this ion. In the map area the aquifers are protected from surface and near-surface sources of contamination.

ACKNOWLEDGMENTS

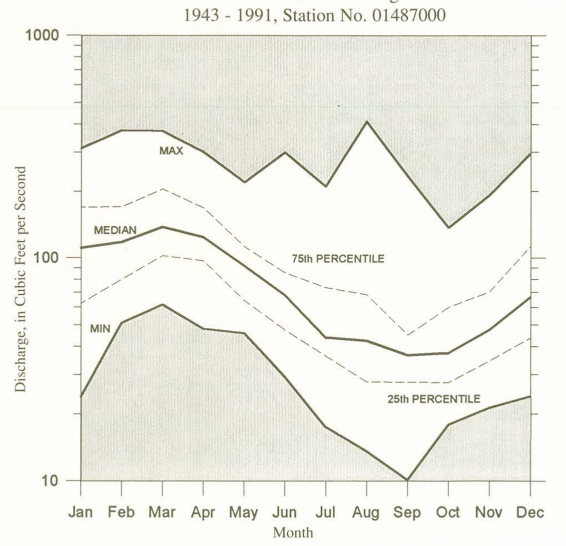
A number of people contributed to the collection of data and production of this map. Joel P. Zickler, Narender Pendkar, Dawn A. Denham, C. Scott Howard, Bruce W. Brough, Jennifer E. Athey, and John P. Fulton assisted in the collection and compilation of data. Ronald E. Graber and Paul J. Janiga (Department of Natural Resources and Environmental Control), and Edward G. Hallock (Department of Health and Social Services) provided assistance in gathering information. John H. Talley, Nenad Spoljaric, Kelvin W. Ramsey, William S. Schenck, and Richard N. Benson are thanked for their reviews and assistance with map layout and production.

Monthly Precipitation at Bridgeville
(1970 - 1992) NOAA Station 1330*

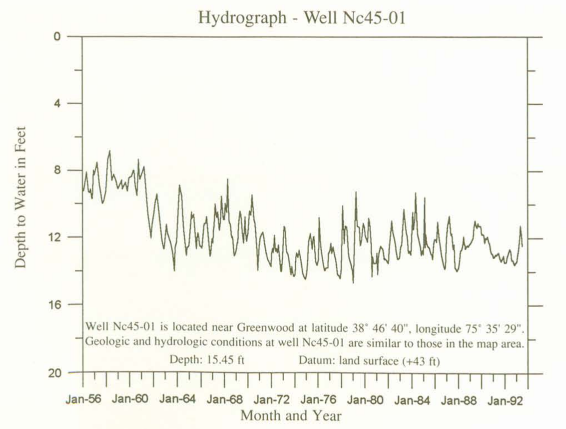


*Note: Station located as shown until October 1988. Station moved to latitude 38° 50', longitude 75° 35' in October 1988. New station number is 3595. Statistics calculated with combined data.

Mean Monthly Discharges
Nanticoke River Near Bridgeville
1943 - 1991, Station No. 01487000



Hydrograph - Well Nc45-01



Water Quality Summary

	PH	Specific Cond. µmho	Temperature deg C	Alkalinity mg/l as $CaCO_3$	K mg/l	Na mg/l	Ca mg/l	Mg mg/l	Fe total mg/l	Total Hardness mg/l as $CaCO_3$	NO_3-N mg/l	Cl mg/l	SO_4 mg/l	SiO_2 mg/l	Dissolved Solids mg/l
Columbia aquifer															
Number	32	20	20	32	15	32	16	16	32	28	32	30	16	14	15
Minimum	4.3	58	13.9	<1	1.30	2.33	1.90	0.63	<0.01	6	<0.1	5.7	<1	7.5	36
Mean	5.46	114	15.2	11	2.35	9.66	5.73	2.89	0.19	18	6.93	14	6	15	96
Maximum	7.33	304	18	106	4.05	81.3	21.0	13.0	3.50	49	18.0	61	39	23	302
Variance	0.267	3934.38	1.0315	353.942	0.598	174.2	24.30	0.429	9.327	116.930	19.8861	115.474	83.6992	17.8292	3753.76
Choptank Fm. aquifers															
Number	7			7		7			7	7	7	7			7
Minimum	8.10			260		110			<0.05	19	<0.4	11			344
Mean	8.25			294		148			0.023	47	<0.4	27			426
Maximum	8.30			340		220			0.1	176	<0.4	64			524
Variance	0.004			627.746		1549.			0.001	2820.03	<0.4	277.210			3907.25

Note: Data obtained from Denver (1986), James et al., (1988), and Delaware Division of Public Health.

DESCRIPTIONS OF GEOLOGIC UNITS

MARSH AND SWAMP DEPOSITS — Qmsw

Gray to black, organic-rich, silty clay to medium sand associated with marsh and swamp environments.

NANTICOKE DEPOSITS — Qn

Brown to light gray, fine to medium sand; finely laminated to massive, gray to brown, clayey sandy silt and silty clayey sand; capped by well-sorted, fine to medium sand associated with dunes.

COLUMBIA FORMATION — Qcl

Yellow-orange, brown, and light gray, fine to coarse sand, silty sand, and minor fine gravel, with yellow-orange, brown, and light to dark gray, sandy clayey silt, silty clay, and clayey silt. Found only in northwestern portion of map area. (Not shown on cross section.)

BEAVERDAM FORMATION — Tbd

Fining-upward sandy sequence consisting of two distinctive rock types: a lower unit of, predominately light gray to light yellow-orange, medium to coarse sand, gravelly sand, and sandy gravel with rare beds of dark gray, blue- to green-gray, silty clay and clayey silt, and rare cobbles and boulders, lowermost beds are commonly gravel; and, an upper unit of commonly yellow- orange, light brown, and light gray, silty, fine to medium sand, sandy silt, fine to medium sand, clayey sandy silt, and clayey silt, white to light yellow silt or clay matrix common in upper half. Lower unit unconformable on Manokin or St. Marys formations.

MANOKIN FORMATION — Tm

Coarsening upward sand sequence, divided informally into subunits A and B. The lower Manokin A - gray, blue-gray, and brown-gray silty clayey sand and silty sand, with beds of fine to coarse sand, few reported occurrences of shell; conformable on the St. Marys but not everywhere present in updip areas; usually grades into the upper Manokin B - light to medium gray, or yellow-orange to red-orange (where weathered), medium to fine to coarse sand, beds of gravelly sand are common, clayey to silty sand beds are rare. Manokin A appears to have been completely removed prior to deposition of Manokin B in northern part of map area. Manokin A partially removed prior to deposition of Manokin B in southern part of map area.

ST. MARYS FORMATION — Tsm

Blue-gray, green-gray, or gray, silty sandy (fine) clay, clayey sandy silt, and silty clay, with beds of fine to medium sand, and fine to medium gravel in a mud matrix; unconformable on the Choptank Formation.

CHOPTANK FORMATION — Tch

Multiple fining upward sequences consisting of olive-gray, gray, and brown-gray, fine to coarse sand, shelly and gravelly, that grades into green-gray, brown-gray, and blue-gray sandy clayey shelly silt. Unit penetrated by only a few drill holes in the map area. (Not shown on cross-section)

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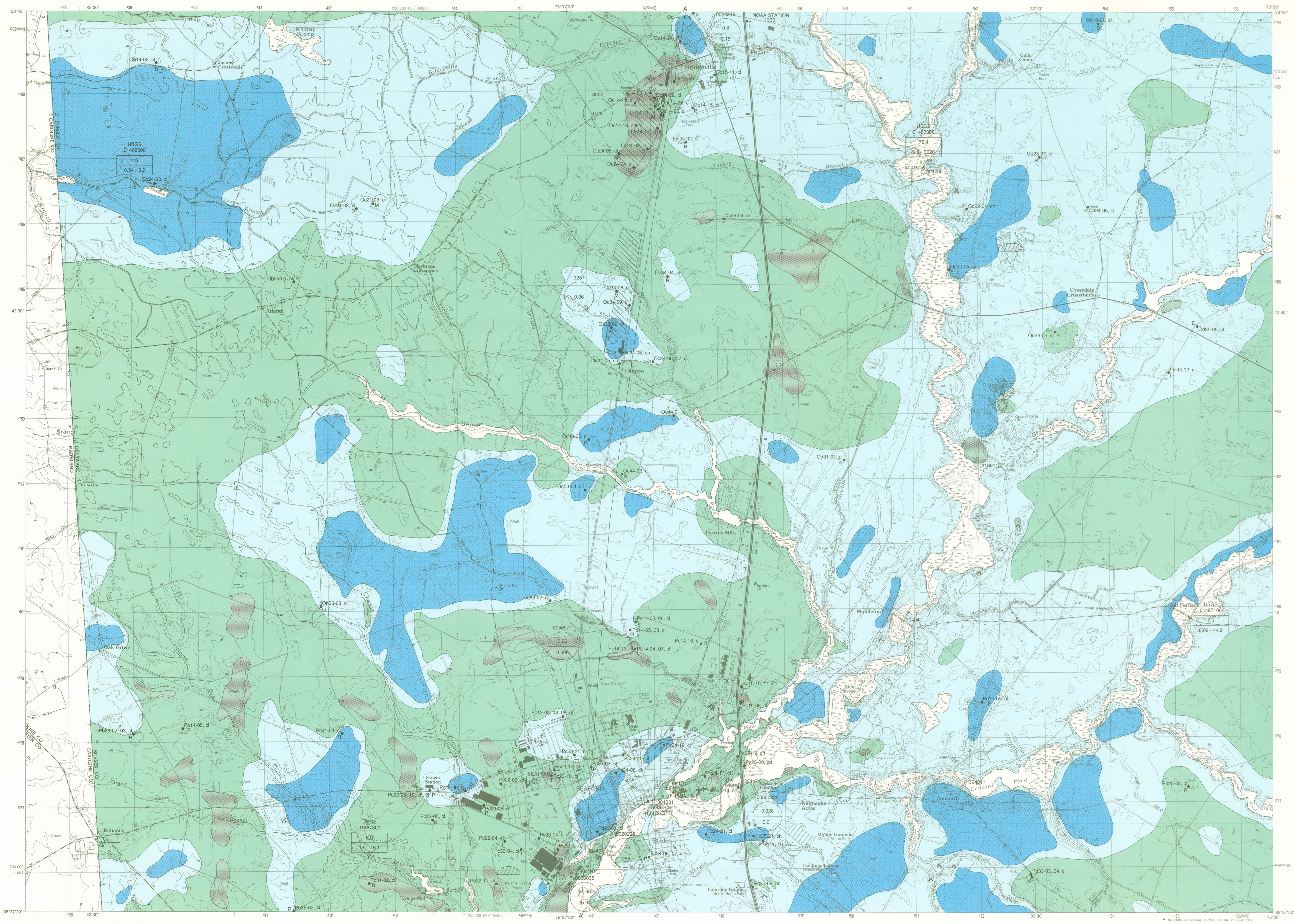
Aquifer Test Data

Well	Well type	Aquifer	Specific Capacity (gpm/ft)	Pumping Period (hours)	Yield (gpm)	Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d)
Ob24-03	O	Columbia	—	—	—	—	17
Ob55-03	O	Columbia	—	—	—	—	11
Oc14-18	O	Columbia	—	—	—	—	7.3
Oc14-19	O	Columbia	—	—	—	—	3.2
Oc14-20	O	Columbia	—	—	—	—	72
Oc14-21	O	Columbia	—	—	—	—	16
Oc14-22	O	Columbia	—	—	—	—	1.7
Oc14-23	O	Columbia	—	—	—	—	18
Oc24-03	O	Columbia	—	—	—	—	13
Oc24-04	O	Columbia	—	—	—	—	18
Oc24-05	O	Columbia	—	—	—	—	5.6
Oc34-05	P	Unnamed aquifer in Choptank Fm.	9.5	6.5	505	4100	—
Oc53-02	P	Columbia	33	8	550	—	—
Od24-05	P	Columbia	35	8	1016	—	—
Od31-01	P	Columbia	42	6	130	—	—
Od33-05	P	Columbia	28	8	1200	—	—
Od44-02	O	Columbia	—	—	—	—	36
Pb14-05	P	Columbia	30	4	1250	—	—
Pb23-02	P	Columbia	28	8	1000	12500	—
Pb23-03	P	Columbia	28	8	985	—	—
Pc13-02	P	Columbia	20	8	200	—	—
Pc13-03	P	Columbia	41	25	1509	—	—
Pc14-03	O	Columbia	—	—	—	—	14
Pc14-04	O	Columbia	—	—	—	—	140
Pc14-05	O	Columbia	—	—	—	—	.62
Pc14-06	O	Columbia	—	—	—	—	640
Pc14-07	O	Columbia	—	—	—	—	2.8
Pc14-08	O	Columbia	—	—	—	—	490
Pc14-10	P	Columbia	16	5	800	—	—
Pc14-13	P	Columbia	16	24	330	11700	—
Pc21-04	P	Columbia	59	5	704	—	—
Pc22-03	P	Columbia	5.8	8	150	—	—
Pc22-05	P	Columbia	24	8	500	—	—
Pc22-06	P	Columbia	33	24	1012	—	—
Pc22-08	P	Columbia	18	24	300	—	—
Pc23-01	P	Columbia	8.4	36	307	—	—
Pc23-03	P	Columbia	27	13	790	—	—
Pc23-04	P	Columbia	19	24	650	—	—
Pc23-10	P	Columbia	26	8	128	—	—
Pc23-11	P	Columbia	7	8	128	—	—
Pc24-08	P	Columbia	16	10	400	—	—
Pc24-16	P	Columbia	7	24	122	—	—
Pc24-17	P	Columbia	15	8	150	—	—
Pc24-19	P	Columbia	12	7.5	150	—	—
Pc24-20	P	Columbia	18	8	250	—	—
Pc24-21	P	Columbia	12	5	100	—	—
Pc25-16	P	Unnamed aquifer in Choptank Fm.	1	24	100	—	—
Pc33-11	P	Columbia	13	8	625	—	—

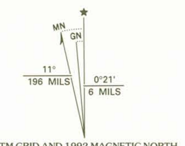
Notes:
1. Some data from this table were obtained from Johnston (1973) and Sundstrom and Pickett (1970).
2. Hydraulic conductivities determined from individual well slug tests using method of Bouwer (1989).
3. Well type O = Observation well, well type P = pumping well.
4. Units: gpm/ft = gallons per minute per ft of drawdown; ft = feet; d = day



Base Maps from U.S. Geological Survey Seaford East and Seaford West, Delaware-Maryland Quadrangles 7.5 Minute Series, 1993.

North American Datum of 1983 (NAD 83) 1927 North American Datum (NAD 27) is shown by dashed corner ticks.

QUADRANGLE LOCATION



UTM GRID AND 1992 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

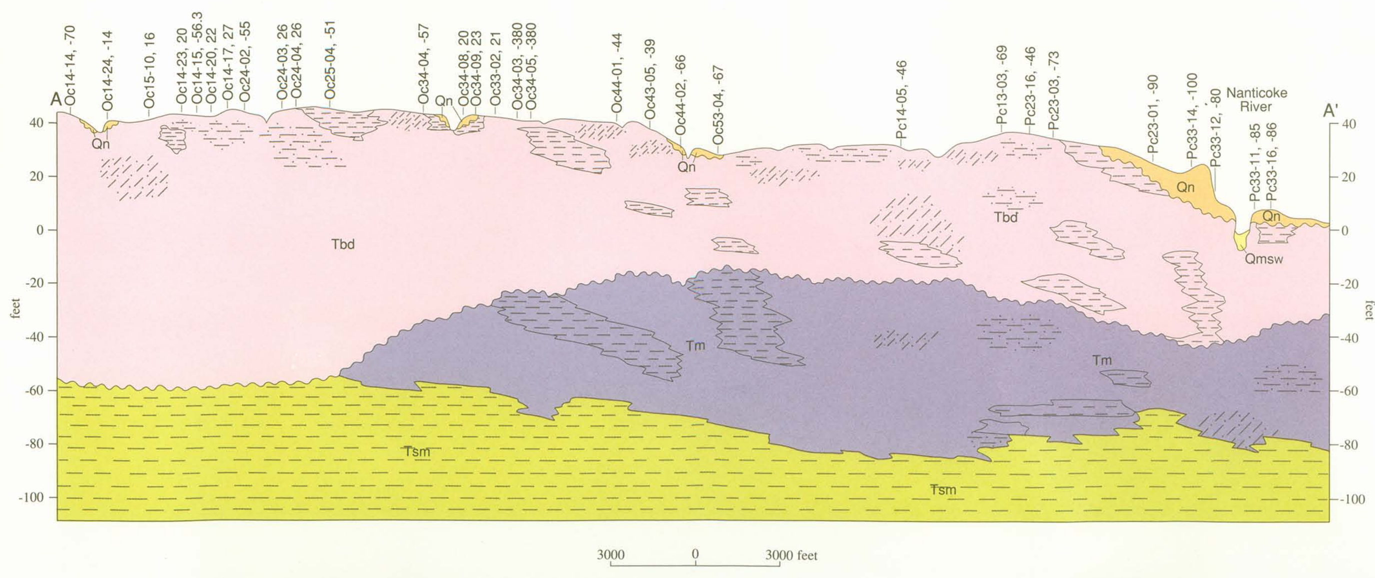
GEOHYDROLOGY OF THE SEAFORD AREA, DELAWARE

by

A. Scott Andres
February 1994

SCALE 1:24 000

CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)
(TO CONVERT ELEVATIONS TO THE NORTH AMERICAN VERTICAL DATUM OF 1988, SUBTRACT 1 FOOT)



EXPLANATION OF SYMBOLS
(map and cross section)

●	Well location
Ob24-03	Well identifier
I	Industrial well
P	Public supply well
R	Irrigation well
T	Test well
M	Monitor well
O	Observation well
D	Domestic well
⚒	– active sand-gravel pit
⚒	– abandoned sand-gravel pit

Recharge potential areas
(methodology described by Andres, 1991b)

- Excellent
- Good
- Fair
- Poor
- Water, swamp, or marsh

A — A' Line of hydrogeologic cross-section.

1330 NOAA precipitation station number

Abandoned landfill

Sewage treatment plant

- 00500725 — Permit number
- 0.028 — Maximum permitted discharge, MGD
- 0.01 — Average daily discharge, MGD (1988-91)
- MGD = million gallons per day

Spray irrigation facility

- Spray field
- 3257 — Permit number
- 0.06 — Average daily discharge, MGD (1988-91)

Symbols (cross-section)

- Silty sand
- Clayey sand
- Primarily sand
- Primarily silt/clay
- Unconformity
- Pc14-05,-46 — Well identifier, elevation (ft) at total depth

Hydrogeologic units

- cl — Columbia aquifer
- ch — Aquifer in Choptank Formation

Tide and streamgages

- ▲ Continuous–record tide gage
- Δ Continuous–record streamgage
- ∇ Partial–record streamgage
- d discontinued

Streamgage data

USGS 01487100
- 7.5 — Drainage basin area (square miles)
- 0.08 - 44.2 — Lowest recorded flow – Highest recorded flow (cubic feet per second)
- □ 304471 — DNREC surface water quality sampling station

Other abbreviations

- USGS — U.S. Geological Survey
- DNREC — Delaware Department of Natural Resources and Environmental Control

This map is a statement of knowledge at the time of production. It was derived from data-points unevenly located across the map area. Thus, the lines on the map and cross section must be considered on the basis of the scale at which they are shown and the data from which they were derived. Precise location of any individual map feature requires investigation on a more detailed scale. Data used in constructing the map are available at the Survey offices.

This map uses data compiled from two editions of the topographic base maps. As a result, there are minor differences between hydrographic symbols shown on the topographic base map and the interpreted hydrogeologic data. Map users needing additional information should contact the Survey.