U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION AND ENERGY

WATER-RESOURCES INVESTIGATIONS REPORT 91-4126
SHEET 1 OF 5

WATER RESOURCES OF THE UNCONFINED AQUIFER SYSTEM OF THE GREAT EGG HARBOR RIVER BASIN, NEW JERSEY, 1989-90

By Martha K. Watt and Melissa L. Johnson

ABSTRACT

The Kirkwood-Cohansey aquifer system is the unconfined aquifer system in the 346-square-mile Great Egg Harbor River basin in southern New Jersey. This aquifer system is a major source of water in the basin, and withdrawals from it are expected to increase. A water-level map of the Kirkwood-Cohansey aquifer system was constructed from water levels measured in 142 wells and at 82 stream sites throughout the basin. Seasonal fluctuations of water levels in two observation wells typically range from 1 to 5 feet per year. The horizontal hydraulic conductivity of the unconfined aquifer system ranges from 20 to 250 feet per day, the transmissivity ranges from 4,000 to 20,000 feet squared per day, and the storage coefficient ranges from 0.0003 to 0.044. The vertical hydraulic conductivity of the underlying confining unit ranges from 0.00002 to 0.000052 foot per day.

A base-flow-separation technique was used to divide measurements of discharge in the Great Egg Harbor River into base-flow and direct-runoff components. Annual base flow during 1927-88 ranged from 39 to 112 cubic feet per second, which is 77 to 89 percent of total flow. Mean discharge and base flow were determined and low-flow-correlation analyses were made for 11 low-flow partial-record sites. Mean annual precipitation in the study area was 45.3 inches during 1930-88, and mean annual discharge of the Great Egg Harbor River was 20.5 inches during 1927-88, or 45 percent of precipitation. Annual potential evapotranspiration is estimated to be 27.6 inches.

Twenty ground-water-sampling sites distributed throughout the basin were selected for water-quality analysis. No constituents determined exceeded U.S. Environmental Protection Agency primary drinking-water regulations. In several samples, the U.S. Environmental Protection Agency secondary maximum contaminant levels for iron, manganese, and pH were exceeded. The predominant cations in the ground water are sodium plus potassium; the major anion is chloride. The predominant cations in the surface water are sodium plus potassium and calcium; the major anions are chloride and sulfate. Samples from upstream sites show a higher ionic concentration of certain contituents than samples from the downstream sites. Land use was found to affect the quality of both ground and surface water in the basin.

Total consumptive water use in the study area was nearly 2,500 million gallons in 1987: 1,192 million gallons for public and private domestic water supply, 1,154 million gallons for irrigation, and 128 million gallons for industry and mining. A water budget calculated for the Great Egg Harbor River basin shows that ground-water recharge is about 18 inches per year.

INTRODUCTION

The Kirkwood-Cohansey aquifer system, which is the unconfined aquifer system of the Great Egg Harbor River basin, is predominantly a water-table aquifer system that underlies a 3,000 mi^2 area of the Coastal Plain of New Jersey (Zapecza, 1989). (For definitions of abbreviations and conversion factors for units used in the text, see table 1-1.) This aquifer system currently is a major source of water in the Coastal Plain, and withdrawals from it are expected to increase in the future. A detailed study of the aquifer system was needed to obtain hydrologic information on which to base decisions that will ensure that the increasing demand for water will be met as the population of the area continues to grow. Therefore, in 1986 the U.S. Geological Survey (USGS), in cooperation with the New Jersey Department of Environmental Protection and Energy (NJDEPE)(formerly the N.J. Department of Environmental Protection), began to compile data on the ground- and surface-water systems of a number of river basins in the Coastal Plain of New Jersey. Information from this study of the aquifer system in the Coastal Plain can be used to plan for the optimal use of this water to meet the increased demand.

Purpose and Scope

This report presents the results of a 2-year study conducted from 1989 through 1990 to gather information on the availability, use, and ambient quality of water both in the Kirkwood-Cohansey aquifer system and in the surface-water system of the Great Egg Harbor River basin. The report includes the results of water-level measurements in 142 wells and at 82 surface-water sites, and the results of analyses of samples collected from 20 wells and 11 surface-water sites for selected inorganic and organic constituents. Results of base-flow-separation analysis of discharge measurements from the streamflow-gaging station on the Great Egg Harbor River and results of low-flow correlations of 11 low-flow partial-record stations are presented. A hydrologic budget was derived from climate data, including precipitation, temperature, estimates of potential evapotranspiration, and calculations of water use to estimate recharge in the basin.

Well-Numbering System

The well-numbering system used in this report is based on the system used by the USGS in New Jersey since 1978. It consists of a county code number and a sequence number of the well within the county. County codes used in this report are Atlantic (1), Camden (7), and Gloucester (15). For example, well number 1-699 represents the 699th well inventoried in Atlantic County. Construction details for wells with this type of identifier are stored in the USGS Ground Water Site Inventory (GWSI) data base.

Acknowledgments

The authors gratefully acknowledge the cooperation of the well owners who allowed us access to their wells for water-level measurements and collection of water-quality samples.

Description of the Study Area

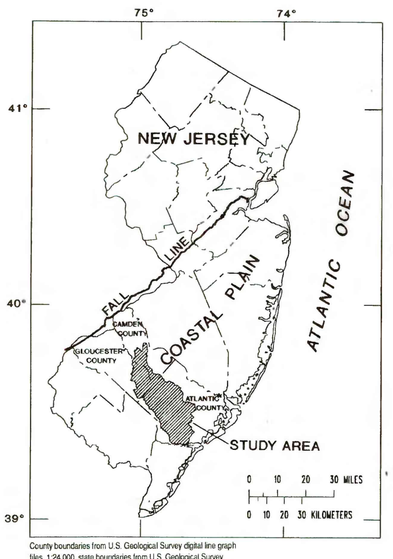
The Great Egg Harbor River basin comprises an area of approximately 346 mi^2 in parts of Atlantic, Camden, and Gloucester Counties (fig. 1-1) and in parts of 19 municipalities (fig. 1-2). Its boundary can be defined by either the topographic divide or the ground-water-drainage divide for the Great Egg Harbor River, which are nearly coincident and, for the purposes of this report, are considered to be the same. The Great Egg Harbor River has its headwaters in Berlin, N.J., and flows about 50 miles to the southeast into the Atlantic Ocean. The topography is relatively flat but slopes gently toward the coast. The elevation of the land surface ranges from 170 ft near Berlin, Camden County, to sea level at the mouth of the river near English Creek, Atlantic County. Approximately 70 percent of the study area is covered by forest and wetlands (fig. 1-3). Urban areas, composed of cities and small towns scattered throughout the basin, and agricultural areas comprise about 24 percent of the study area.

Table 1-1.--Conversion factors and vertical datum

Multiply	by	To obtain
Length		
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
Area		
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
Volume		
million gallon (Mgal)	3,785	cubic meter
Flow		
inch per year (in/yr)	2.54	centimeter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per day (gal/d)	0.003785	cubic meter per day
million gallons per day (Mgal/d)	0.04381	cubic meter per second
Transmissivity		
foot squared per day (ft^2/d)	0.09290	square meter per day
Hydraulic conductivity		
foot per day (ft/d)	0.3048	meter per day

Temperature conversion formula: $^{o}F = 1.8 \times {}^{o}C + 32$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.



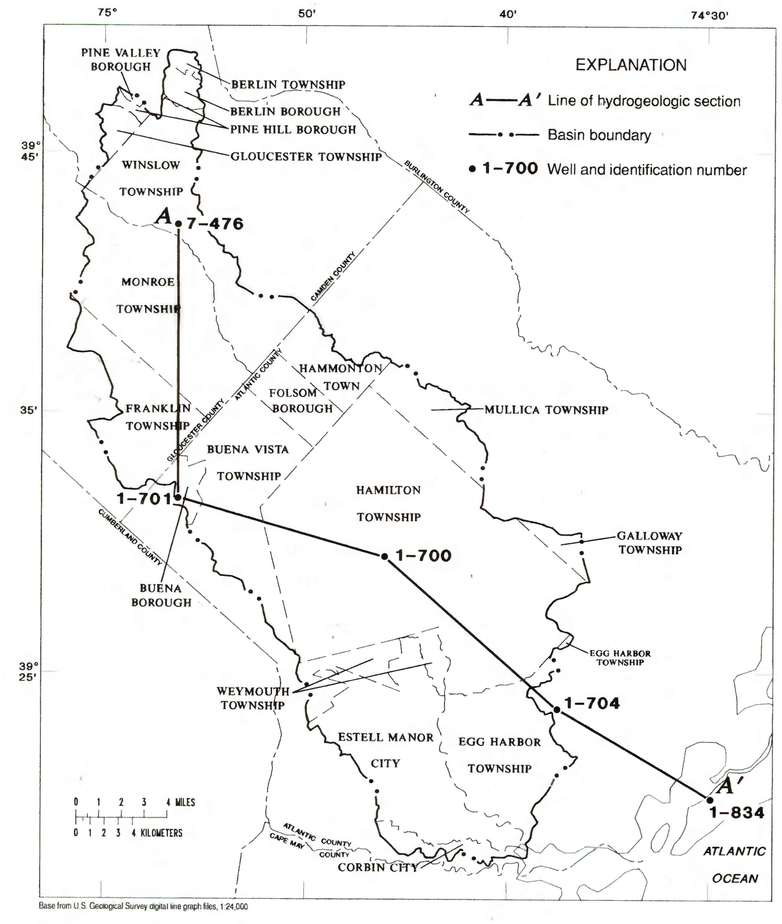
County boundaries from U.S. Geological Survey digital line graph files, 1:24,000; state boundaries from U.S. Geological Survey digital line graph files, 1:2,000,000

Figure 1-1.--Location of the Great Egg Harbor River basin study area.

Table 1-2.--Stratigraphy and hydrogeologic characteristics of the Kirkwood Formation, Cohansey Sand, and younger surficial deposits in the Great Egg Harbor River basin study area

(Modified from Zapecza, 1989, table 2)

SYSTEM	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISTICS
Quaternary	Alluvial deposits	Sand, silt, and black mud.	Undifferentiated	Surficial material, commonly hydraulically connected to underlying aquifers. Locally some units may act as confining layers. Thicker sands are capable of yielding large quantities of water.
	Beach sand and gravel	Sand and quartz, light colored, medium to coarse grained, pebbly.		
	Cape May Formation	Sand, quartz, light colored, heterogeneous, clayey, pebbly.		
Tertiary	Bridgeton Formation		Kirkwood-Cohansey aquifer system	Major aquifer system. Ground water generally occurs under water-table conditions.
	Cohansey Sand	Sand, quartz, light colored, medium to coarse grained, pebbly, local clay layers.		
	Kirkwood Formation	Sand, quartz, gray, tan, fine to medium grained micaceous and dark diatomaceous clay.	Confining unit	Thick, diatomaceous clay units occur along the coast and for a short distance inland. A thin, water-bearing sand is found within the middle of this unit.
			Rio Grande water-bearing zone	
			Confining unit	
			Atlantic City 800-foot sand	Major aquifer along the coast.



Base from U.S. Geological Survey digital line graph files, 1:24,000

Figure 1-2.--Municipalities in the Great Egg Harbor River basin study area and location of hydrogeologic section A-A'. (Hydrogeologic section A-A' shown in figure 1-7.)

Geologic and Hydrogeologic Units

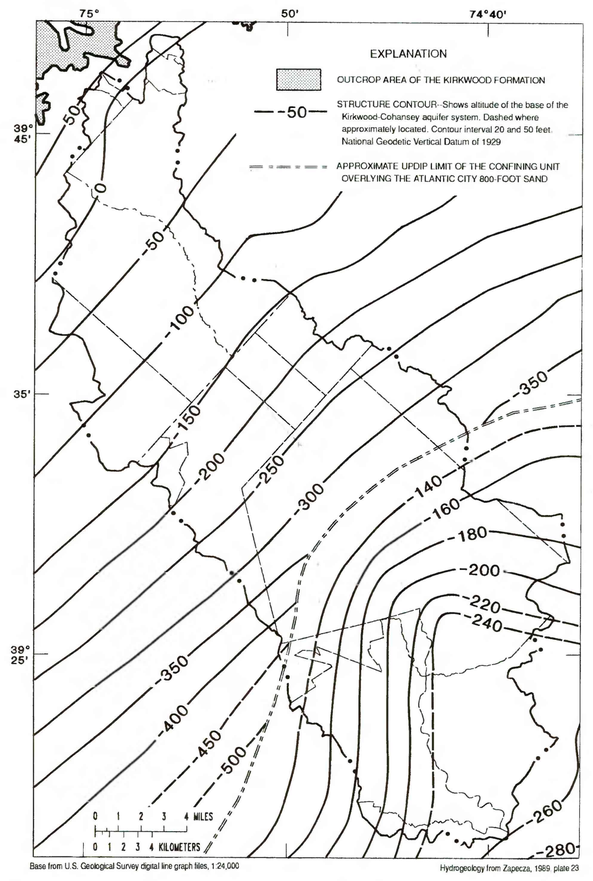
The Great Egg Harbor River basin is located in the Coastal Plain physiographic province of New Jersey, a seaward-dipping wedge of unconsolidated sediments that range in age from Cretaceous to Holocene. The Kirkwood-Cohansey aquifer system is part of the Coastal Plain, but contains only sediments of Tertiary to Quaternary age (table 1-2). The Kirkwood-Cohansey aquifer system consists of the Kirkwood Formation, the Cohansey Sand, and, in some locations, the Bridgeton Formation and younger surficial deposits (fig. 1-4).

The Kirkwood Formation, the oldest formation in the aquifer system, underlies the entire study area and crops out just northwest of the basin. The lithology of the Kirkwood Formation is variable, consisting of gray and tan, very-fine- to medium-grained micaceous quartz sand and dark-colored diatomaceous clay (Zapecza, 1989, p. B19). Along the coast and in the basal part of the formation the clay units predominate; updip from the coast the fine- to medium-grained sand and silty sand are more extensive. The Cohansey Sand, which overlies the Kirkwood Formation, is the predominant surficial formation, cropping out in more than half of the basin. It is composed of medium- to coarse-grained, light-colored quartz sand with local clay layers. The Cohansey Sand is overlain discontinuously by surficial deposits of the Bridgeton and Cape May Formations. The Bridgeton Formation, directly overlying the Cohansey Sand, consists of coarse-grained sand and gravel. Younger surficial deposits of the Cape May Formation are present only in the southeastern half of the basin adjacent to the river and wetland area. This formation consists of light-colored, clayey quartz sand. (See Zapecza, 1989, p. B19.)

The thickness and altitude of the base of the aquifer system within the basin are shown in figures 1-5 and 1-6, respectively. A noticeable feature in these two figures is the updip limit of a confining unit overlying the Atlantic City 800-foot sand. The discontinuity is also visible in hydrogeologic section A-A' (fig. 1-7). The geometry of the Kirkwood-Cohansey aquifer system changes depending on whether the aquifer system is southeast or northwest of this discontinuity. In the southeastern part of the basin, the basal surface of the Kirkwood-Cohansey aquifer system is the top of the thick confining unit overlying the Atlantic City 800-foot sand (fig. 1-7). The Kirkwood-Cohansey aquifer system here has a base altitude ranging from less than 140 to 260 ft below sea level, with a thickness that ranges from about 150 to about 300 ft (fig. 1-6) and increases to the southeast.

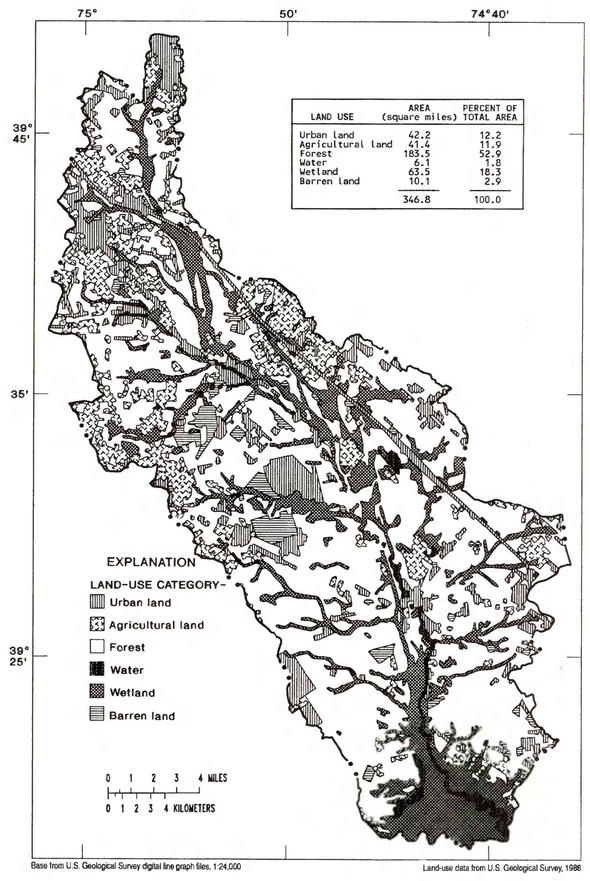
The thickness of the confining unit increases in the downdip direction from less than 100 ft near May's Landing, Atlantic County, to more than 300 ft beneath the Atlantic City area (Zapecza, 1989, p. B18). Near the middle of the confining unit a relatively thin aquifer that is of minor importance in the basin, the Rio Grande water-bearing zone, is found. This confining unit is absent in the northwestern part of the basin, where the base of the Kirkwood-Cohansey aquifer system is the top of a clay unit lying within the lower part of the Kirkwood Formation (fig. 1-7). The clay unit is the updip extension of the confining unit underlying the 800-foot sand (Zapecza, 1989, p. B19).

The altitude of the base of the Kirkwood-Cohansey aquifer system in the northwestern part of the basin ranges from 50 ft above sea level to 350 ft below sea level (fig. 1-6). The aquifer system's thickness here ranges from 400 ft to approximately 100 ft in the extreme northwestern corner of the basin.



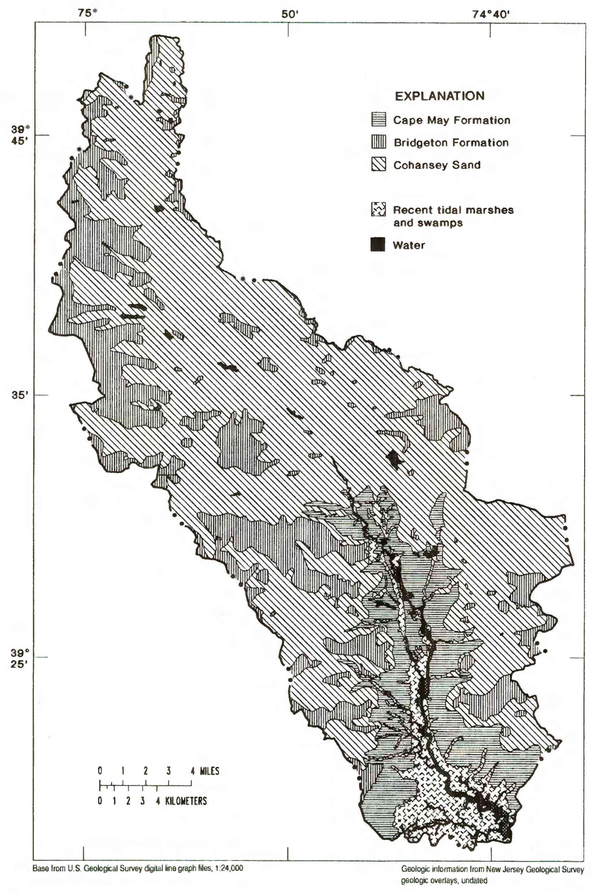
Base from U.S. Geological Survey digital line graph files, 1:24,000 — Hydrogeology from Zapecza, 1989, plate 23

Figure 1-6.--Altitude of the base of the Kirkwood-Cohansey aquifer system in and near the Great Egg Harbor River basin study area.



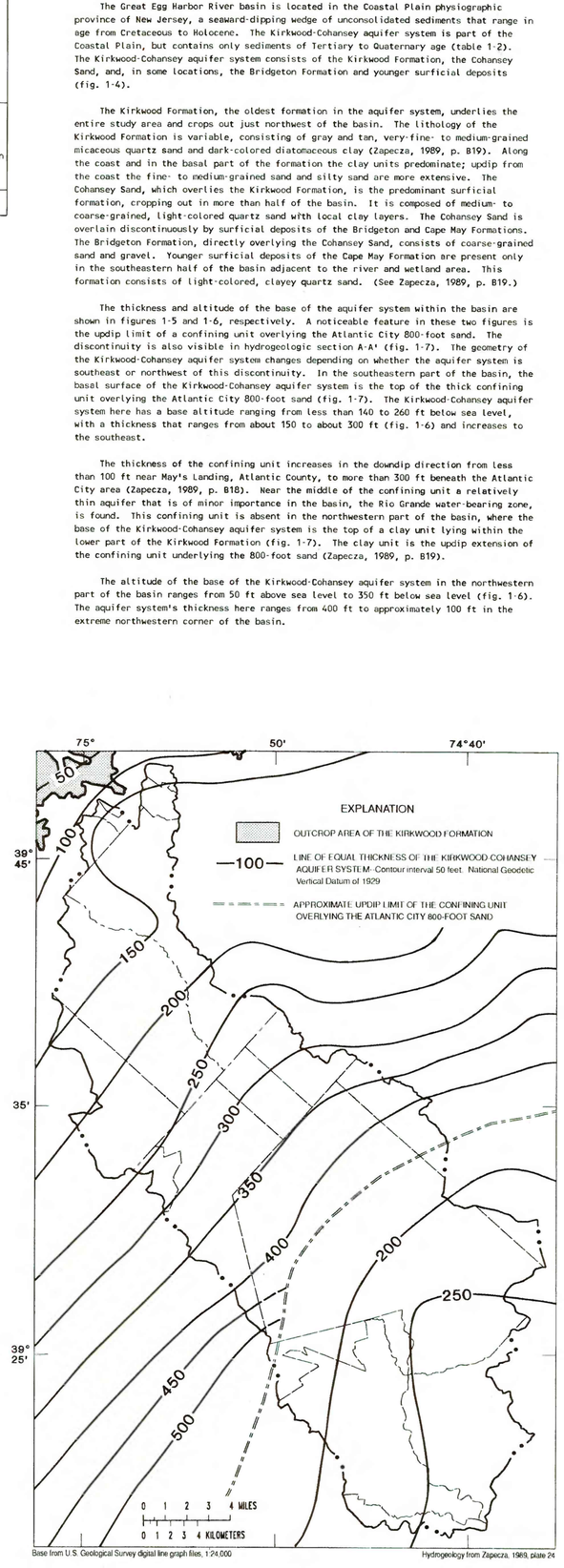
Base from U.S. Geological Survey digital line graph files, 1:24,000 — Land-use data from U.S. Geological Survey, 1986

Figure 1-3.--Land use in the Great Egg Harbor River basin study area.



Base from U.S. Geological Survey digital line graph files, 1:24,000 — Geologic information from New Jersey Geological Survey geologic overlays, undated

Figure 1-4.--Surficial geology of the Great Egg Harbor River basin study area.



Base from U.S. Geological Survey digital line graph files, 1:24,000 — Hydrogeology from Zapecza, 1989, plate 24

Figure 1-5.--Thickness of the Kirkwood-Cohansey aquifer system in and near the Great Egg Harbor River basin study area.

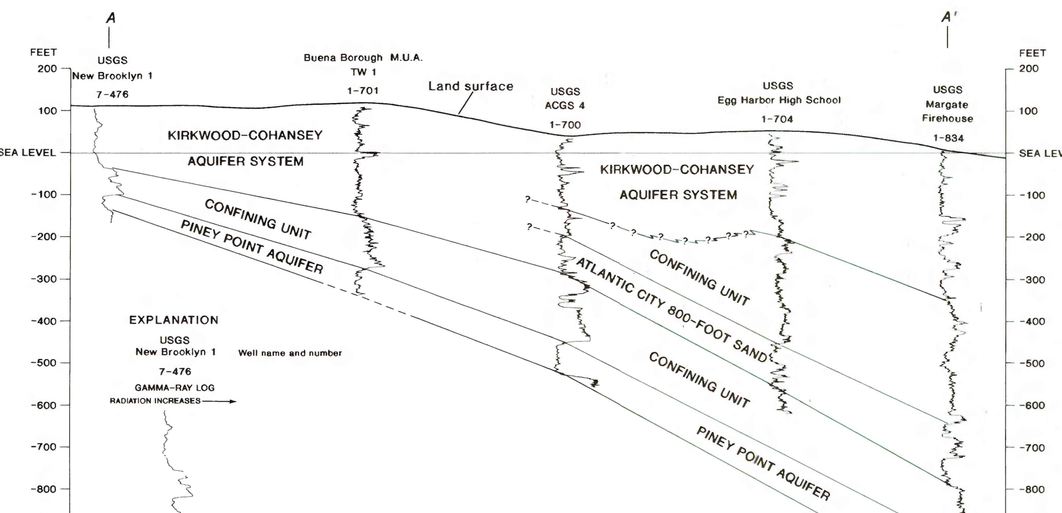


Figure 1-7.--Hydrogeologic section A-A', based on gamma-ray logs. (Line of section shown in figure 1-2.)

Hazardous-Waste Sites and Sanitary Landfills

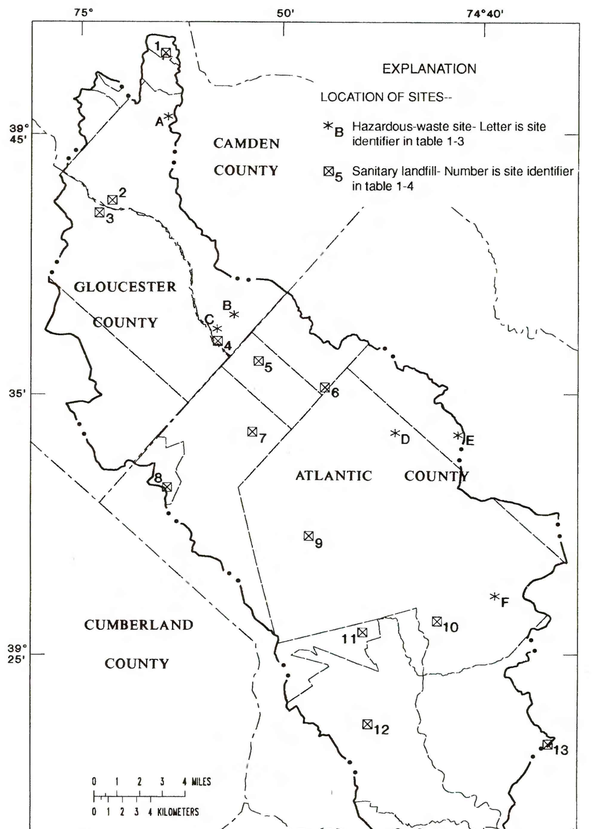
Six hazardous-waste sites have been identified in the Great Egg Harbor River basin by the NJDEPE. All information on these six sites presented in this report is found in the status and site-status reports prepared in October 1989 by the NJDEPE Hazardous Waste Management Program (N.J. Department of Environmental Protection, 1989a and 1989b).

Figure 1-8 shows the locations of the six sites--three in Atlantic County and three in Camden County. Table 1-3 lists information about the sites and their locations. The column labeled "N.J. Superfund ranking" lists the relative positions of the two Superfund sites in the study area among the 109 U.S. Environmental Protection Agency (USEPA) Superfund sites in the State of New Jersey. The "funding" column gives the current (1989) source of funding for investigation or remediation. Public funding is derived from State or Federal sources, whereas private funding is provided by the responsible parties[1]. The "lead agency" column lists the agency that oversees site investigation and remediation at each of these six sites. In New Jersey, most hazardous-waste-site investigations and cleanup are overseen by the NJDEPE; activities at Superfund sites are overseen by the NJDEPE in conjunction with the USEPA.

As reported in NJDEP (1989b), each of the six hazardous-waste sites is at a different stage in the investigation and remediation process. Site A currently (1989) is under investigation, but the ground water has not yet been tested for possible contamination, and no remedial action has yet been undertaken. Site B is currently undergoing remediation. Contaminated soils have been excavated and disposed of, but the contaminated ground water has not yet been treated. At Site C, one of the Superfund sites in the study area, the investigation phase is nearly complete, and contamination of the soil, ground water, surface water, and sediments has been documented. The ground water at Site D currently is being monitored for contamination, and the source of contamination is being removed. Contaminated soil has been removed from Site E, and additional ground-water sampling is planned to ascertain whether any contaminated material remains at the site. At site F, the other Superfund site in the basin, contaminated soils have been removed, and plans for ground-water treatment currently are being made.

In addition to the 6 hazardous-waste sites, 13 sanitary landfills are present in the Great Egg Harbor River basin. The location of each site is shown in figure 1-8, and information about each site is given in table 1-4. Three of the landfills are privately owned; the 10 remaining landfills are municipally owned. All of the private landfills and three of the municipal landfills are closed. Although all of the remaining seven landfills described as open were due to be closed several years ago (1991), these sites are still considered to be open because the investigations and final reports associated with the site closings have not yet been completed (Marty Chemponis, N.J. Department of Environmental Protection, Division of Solid Waste Management, oral commun., 1990).

[1] Responsible party is defined as any person who has discharged a hazardous substance or is in any way responsible for any hazardous substance which the NJDEPE has removed or is removing pursuant to the NJDEPE Spill Compensation and Control Act, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the New Jersey Water Pollution Control Act (N.J. Department of Environmental Protection, 1989b).



Base from U.S. Geological Survey digital line graph files, 1:24,000 — Information on hazardous waste sites is from New Jersey Department of Environmental Protection, 1989a and 1989b. Landfill information is from New Jersey Department of Environmental Protection, Division of Solid Waste Management

Figure 1-8.--Locations of hazardous-waste sites and sanitary landfills in the Great Egg Harbor River basin study area.

Table 1-3.--Hazardous-waste sites in the Great Egg Harbor River basin

[Twp, Township; USEPA, United States Environmental Protection Agency; NJ, New Jersey; --, data unavailable; NJDEP, New Jersey Department of Environmental Protection]

Site identifier (fig. 1-8)	Site name[2]	County	Municipality	USEPA number	NJ Superfund ranking	Latitude	Longitude	Funding	Lead agency
A	Pettinos Sand Company	Camden	Winslow Twp	NJD980530141		394543	745543	Private	NJDEP
B	Quill Corporation-Winslow asphalt plant	Camden	Winslow Twp	--		393806	745226	Private	NJDEP
C[1]	King of Prussia landfill	Camden	Winslow Twp	NJD980505341	39	393733	745316	Private	NJDEP/ USEPA
D	Scholler, Incorporated	Atlantic	Hamilton Twp	--		393333	744427	Private	NJDEP
E	Egg Harbor Rope Products, Incorparated	Atlantic	Mullica Twp	--		393328	744120	Private	NJDEP
F[1]	D'Imperio property	Atlantic	Hamilton Twp	NJD980529416	15	392718	743932	Public	NJDEP/ USEPA

[1] USEPA Superfund site
[2] The use of industry or firm names in this report is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

Table 1-4.--Sanitary landfills in the Great Egg Harbor River basin

[--, data unavailable; P, Private; M, Municipal; C, Closed; O, Open]

Site identifier (fig.1-8)	Landfill name	County	Municipality	Ownership	Acres	Status	Year closed
1	New Freedom Land Company	Camden	Berlin Borough	P	130	C	1981
2	Levitt Homes	Camden	Winslow Township	P	100	C	1977
3	Monroe Township	Gloucester	Monroe Township	M	190	C	1982
4	Winslow Township	Camden	Winslow Township	M	960	O	1987
5	Folsom Borough	Atlantic	Folsom Borough	M	600	O	1985
6	Hammonton	Atlantic	Hammonton Town	M	500	O	1987
7	Buena Vista Township	Atlantic	Buena Vista Township	M	100	O	1986
8	Buena Borough	Atlantic	Buena Borough	M	190	C	1984
9	Hamilton Township-Mizpah	Atlantic	Hamilton Township	M	400	C	1977
10	Hamilton Township	Atlantic	Hamilton Township	M	170	O	1987
11	Weymouth Township	Atlantic	Weymouth Township	M	400	O	1985
12	Estell Manor	Atlantic	Estell Manor City	M	220	O	1985
13	Linwood Excavating	Atlantic	Egg Harbor Township	P	360	C	--

WATER RESOURCES OF THE UNCONFINED AQUIFER SYSTEM OF THE GREAT EGG HARBOR RIVER BASIN, NEW JERSEY, 1989-90

By
Martha K. Watt and Melissa L. Johnson
1992