UNEARTHING NEW JERSEY

NEW JERSEY GEOLOGICAL SURVEY
Department of Environmental Protection

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MESSAGE FROM THE STATE GEOLOGIST

The New Jersey Geological Survey provides geoscience information to government agencies, consultants, industry, environmental groups and the public. This first edition of the Survey's newsletter, Unearthing New Jersey, highlights a sampling of current projects that use this information to address environmental concerns and make related economic decisions.

The Survey is particularly proud of the support it provided to the Highlands Task Force. An article by Jeff Hoffman highlights the Highlands' water resources and their importance to all New Jersey residents. Over one-third of the state's potable water is provided from the Highlands and almost two-thirds of the state's population depend on this water resource. This amounts to over 147 billion gallons of potable water used annually.

Geologic mapping has been the mainstay for the Survey since its inception in 1835. Scott Stanford writes about the uses of geologic maps to derive an earthquake hazard evaluation for Middlesex County. This derivative product provides earthquake damage predictions to the New Jersey State Police Office of Emergency Management Response and the Federal Emergency Management Agency for use in planning for emergencies. These evaluations have also been completed for five other urban counties of the state.

The New Jersey Geological Survey continues a focus on mineral resources with its efforts in mapping offshore deposits of sand and gravel. Jane Uptegrove reports on vibracoring and seismic surveys that are used to map the three dimensional distribution of these deposits on the sea floor. The Survey and DEP Engineering and Construction in cooperation with the U. S. Army Corps of Engineers and the U. S. Mineral Management Service, assess this information to identify sand for replenishing and maintaining the beaches and dunes along the New Jersey coast. These features are the state's first line of protection against storm and wave damage.

The Survey welcomes feedback you wish to provide on the content or format of this first newsletter (http://www.njgeology.org/comments.html). Other recent geologic activities and digital publications of the Survey are noted in the newsletter and elsewhere on the Survey's Web site. Printed maps and reports are available to the public through the DEP Maps and Publications Office (609) 777-1038, PO Box 438, Trenton, N.J. 08625-0438 and a publications price list is maintained on the Web. Unpublished information is provided at cost by writing the State Geologist's Office, N.J. Geological Survey, PO Box 427, Trenton, N.J. 08625-0427. Staff are available to answer your questions 8 a.m. - 5 p.m. Monday through Friday by calling (609) 292-1185.

Karl W. Muessig,
New Jersey State Geologist

Heaters Pond, Ogdensburg, Sussex County. *Photo by R. A. Volkert.*

PROTECTING THE HIGHLANDS' POTABLE WATER

By Jeffrey L. Hoffman

The historic Highlands Protection and Planning Act enacted last summer preserves nearly 400,000 acres of environmentally sensitive land in New Jersey's treasured Highlands region and protects its high-quality water resources, the source of clean drinking water for 5.4 million residents.

The headwaters of three major river systems are located in the Highlands, which also contributes water to the Delaware River. Water for potable supplies is withdrawn directly in the Highlands and downstream from it. The New Jersey Geological Survey (NJGS) determined that the Highlands supplied 34 percent of all the state's potable water used in 1999. It is estimated that Highlands water was distributed to 292 municipalities in 16 counties. Some municipalities were completely dependent on this water while others needed only a small amount. Taken together, a substantial 64 percent of the state's population receives some or all of its water from the Highlands.

HIGHLANDS & SMART GROWTH

New Jersey's smart growth initiative encourages new development in designated growth areas and strives to limit growth in environmentally sensitive locations. New Jersey's Development and Redevelopment Plan identifies the Highlands as a "Special Resource Area," defined as "an area or region with unique characteristics or resources of statewide importance which are essential to the sustained well being and function of its own region and other regions or system -- environmental, economic, and social -- and to the quality of life for future generations.”

This attention to the Highlands is not new; recognition of its value to New Jersey’s water supply dates to 1907.

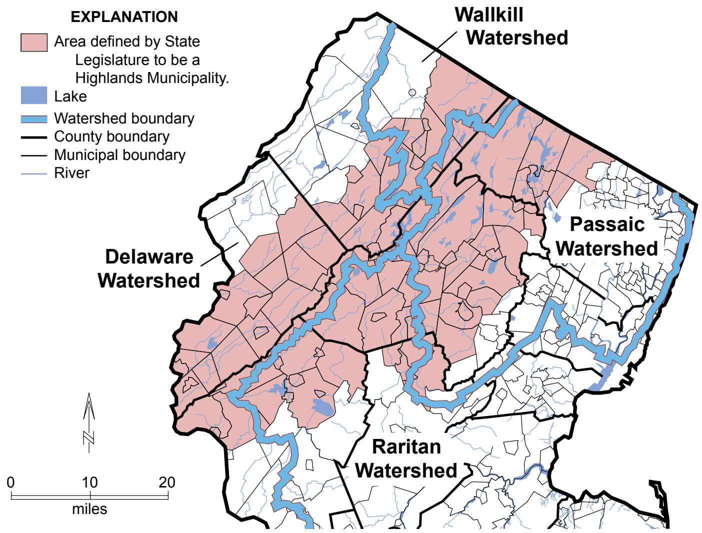

Figure 1. New Jersey Highlands Municipalities with major watersheds.

In that year, a report by the Potable Water Commission stated: “The Highland watersheds are the best in the state … These watersheds should be preserved from pollution at all hazards, for upon them the most populous portions of the state must depend for water supplies. There has been too much laxness in the past regarding this important matter.”

AREA DEFINITION

The State Development and Redevelopment Plan defines 90 municipalities in seven counties (fig. 1) as “Highlands Municipalities” (U.S. Forest Service, 2002). These municipalities cover 1,355 mi^2 or about 17 percent of New Jersey.

The headwaters of the Passaic, Raritan and Wallkill Rivers are located here (fig. 1) as is part of the Delaware River watershed. The Delaware and Passaic basins each cover a little more than a third of the municipalities: 484 mi^2 (36 percent) for the Delaware and 470 mi^2 (35 percent) for the Passaic watershed. The Raritan watershed covers 275 mi^2 (20 percent) of the Highlands municipalities. The remaining 126 mi^2 (9 percent) comprises the Wallkill watershed.

NJGS
1835

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WITHDRAWALS

The Highlands supplies potable water in two ways. Water is withdrawn from surface-water intakes and ground-water wells located in the Highlands, and it contributes to downstream surface-water supplies in the Raritan, Passaic and Delaware River through the runoff of precipitation.

A total of 444 public potable-supply wells and surface-water intakes in the Highlands withdrew 76.9 billion gallons of surface water and 22.8 billion gallons of ground water in 1999. During that year, private household wells withdrew approximately 7.6 billion gallons more, bringing the total amount withdrawn to approximately 107.3 billion gallons.

New Jersey also has 11 surface-water intakes for public potable supplies in the Delaware, Raritan, and Passaic watersheds downstream from the Highlands municipalities. In 1999, these withdrew 120.0 billion gallons of water (Hoffman and Domber, 2004), a portion of which came from the Highlands. Based on the relative volumes from each of the watersheds, about 40.5 of the 120.0 billion gallons withdrawn came from the Highlands.

This means that an estimated 147.8 billion gallons of potable water came from the Highlands in 1999. Because the total volume of potable water used by the state that year was 430.5 billion gallons, municipalities in the Highlands supplied an estimated 34 percent of all potable water used in New Jersey in 1999.

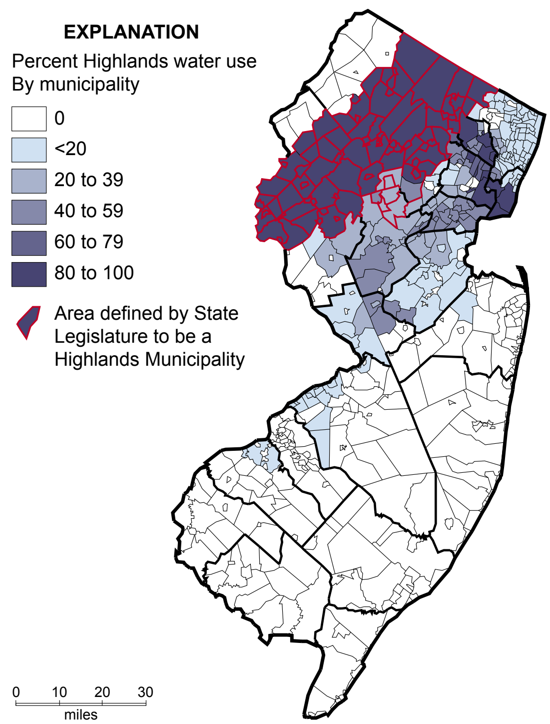

Figure 2. Percentage of potable-water supplied in 1999 to New Jersey municipalities from the New Jersey Highlands.

TRANSFERS

New Jersey water is not necessarily used where it is withdrawn. Water is routinely moved around the State via a complex series of reservoirs and pipelines that run between numerous sources and service areas. Some service areas may also have more than one water source. By carefully tracking water from its withdrawal point through various transfers and ultimately to the final area of use, the NJGS is able to estimate the percentage of water used in a municipality that came from the Highlands. This tracking technique was developed by NJGS as part of its work for the upcoming New Jersey statewide supply plan. More information is available in Hoffman and Domber (2004) and Tessler (2003).

Boonton Reservoir in Morris County is a good example of how water is moved around in New Jersey. All of the water that fills the reservoir is runoff from the Highlands. A pipeline then carries it about 20 miles east to Jersey City in Hudson County, making it the city's single source of water. Other municipalities get small amounts of water from the Highlands. It is estimated that a major intake on the Delaware River in the Camden area receives just 7 percent of its water from the Highlands (Hoffman and Domber, 2004). This water is then distributed to a number of municipalities in southwest New Jersey where it is further blended with additional sources.

Figure 2 shows municipalities that received all or part of their potable water from the Highlands in 1999. Again, note that some of the 292 municipalities and 16 counties receive all of their potable water from the Highlands while others have additional sources. In total, these municipalities contain about 64 percent of the state's population. If water from the Highlands were to be eliminated, all of these people would be affected.

Text references and a list of online resources can be found in Hoffman, J. L. and Domber, S. E., 2004, Potable water supplied in 1999 by New Jersey's Highlands: technical staff report, N.J. Geological Survey, 8p, available on the Web at http://www.savethehighlands.org/.

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PREDICTING EARTHQUAKE DAMAGE IN MIDDLESEX COUNTY

By Scott D. Stanford

Damaging earthquakes in New Jersey are rare, but they have occurred and undoubtedly will again. In 1737, an earthquake with an estimated magnitude of 5.0 on the Richter scale occurred in the vicinity of New York City, and another with a magnitude of 5.5 jolted the area in 1884. Historically, stronger earthquakes (magnitudes 6 and 7) have been recorded near Charleston, S.C. and Boston. Earthquakes of these magnitudes also can occur in New Jersey because it is in a similar tectonic setting.

To predict the potential effects of earthquakes, the New Jersey Geological Survey is using computer software developed under the direction of the Federal Emergency Management Agency (FEMA). Following data entry that simulates geological and other conditions by census tract (small statistical subdivisions of a county designated by the U.S. Census Bureau), the software calculates damage to buildings, utilities, highways, bridges, and other facilities. Crucial geologic data includes a soil class map that calculates the intensity of ground shaking, a liquefaction susceptibility map that identifies areas where soils may flow as liquids when shaken, and a landslide potential map to identify areas where slope failure might occur.

Soil class is determined by the compaction and density of unconsolidated deposits and bedrock to a depth of 100 feet below land surface. Compact sediments and hard rock transmit seismic energy more efficiently than loose sediments, resulting in less ground shaking. Liquefaction susceptibility is highest in deposits that contain saturated, loose sand and silty sand. These soils can act as a liquid, losing strength when shaken by earthquakes. Landslides can also be triggered during an earthquake. The greatest

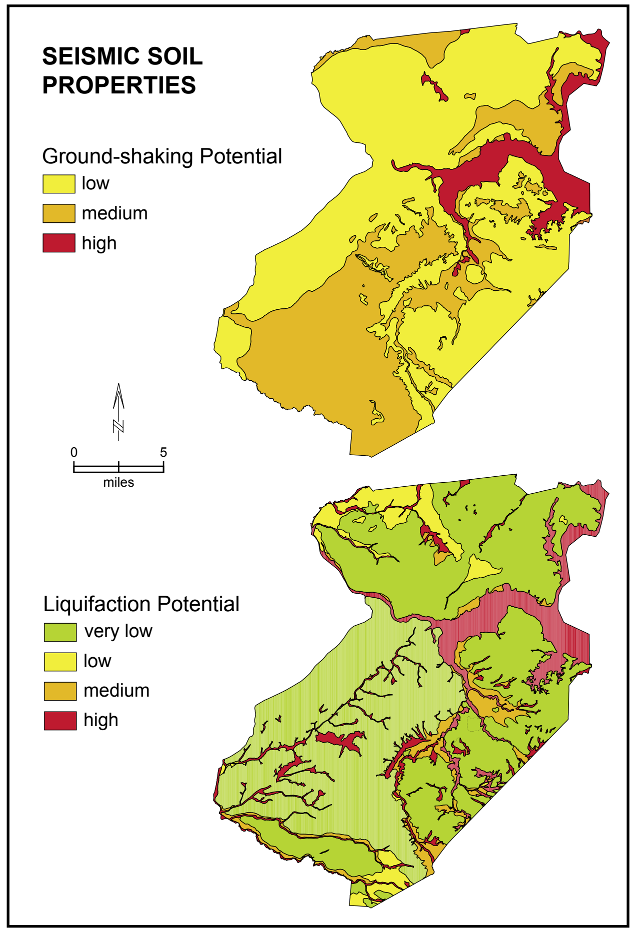

Figure 1. Seismic soil properties in Middlesex County.

potential for this is where slopes of wet clay are steep (greater than 20 degrees). Dry sandy soils or rock with slopes less than 10-15 degrees have little landslide potential.

In Middlesex County, materials most susceptible to shaking and liquefaction are loose deposits in floodplains, wetlands, estuaries, and salt marshes (fig. 1). Somewhat less susceptible are deposits of former rivers, and thick deposits of glacial-lake sediment and till (fig. 1). Areas of thin glacial and river deposits, outcropping bedrock and outcropping Coastal Plain formations have a low shaking potential and a low to very low liquefaction potential (fig. 1). Only a small area of the county has slopes with landslide potential.

To determine the proper soil class, compaction is measured in two ways. The first method, known as a Standard Penetration Test, is routinely performed during preparation for construction projects. A standard 140-pound weight falling freely 30 inches, drives a sampling tube into the sediment with repeated blows. The number of blows needed to drive the tube one foot into the soil is counted, recorded, and later used for analysis. Approximately 3,500 penetration tests from 450 borings were collected in Middlesex County and used to determine soil class.

A second method used to help determine soil class is to measure the velocity of shear waves in the soil using geophysical survey equipment. Shear waves are mechanical vibrations that cause side-by-side motion of particles as they travel through a material. Twelve such measurements were made in Middlesex County, three each on four soil types.

Using standard penetration tests and shear-wave measurements, glacial till has been shown to be a compact sediment because it was subjected to the enormous weight of continental ice sheets. Sand and clay of Coastal Plain formations also is compact, but these were compressed by several hundred feet of overlying sediments that have since been eroded away. River, wetland, and estuarine deposits, which were never covered by a glacier or by thick overlying sediments, are much less compact.

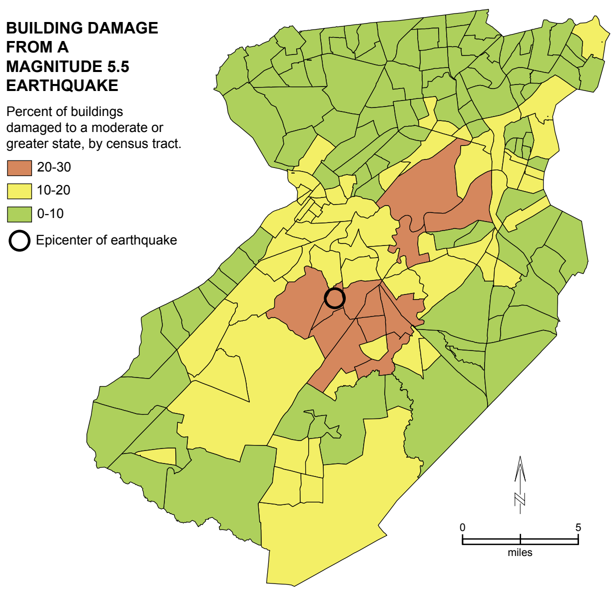

Figure 2. Building damage from a magnitude 5.5 earthquake.

Potential damage to buildings constructed on these soils is shown on figure 2. Census tracts close to the simulated epicenter that have large areas of soils with high or medium ground-shaking and liquefaction potential suffer the greatest building damage (fig. 2). In these tracts it is estimated that 20 to 30 percent of buildings would be damaged to a moderate or greater extent. Moderate damage requires evacuation and assessment before reoccupancy, and represents a significant social disruption. Census tracts farther from the epicenter but still with sizable areas of soil with medium or high ground-shaking and liquefaction hazard show 10 to 20 percent damage (fig. 2). Tracts with low soil hazard, and those farthest from the epicenter, show the least damage (fig. 2). For the entire county, a simulated magnitude 5.5 earthquake at the epicenter shown on figure 2, would cause major damage to 1,000 to 6,000 buildings and displace between 1,200 and 5,000 households. The simulation software also calculates estimates of financial loss. For the magnitude 5.5 earthquake shown in figure 2, the total economic loss for the county, which includes building damage, loss of building contents and loss due to business interruption, is estimated at between 1.3 and 5.2 billion dollars.

The New Jersey Geological Survey has completed similar earthquake damage assessments for Essex, Bergen, Hudson, Union, and Passaic Counties (http://www.njgeology.org/enviroed/infocirc/eqdamage.pdf). The geologic data acquired from these assessments can be used to identify areas with vulnerable soil and then prioritize efforts to strengthen critical structures. Additional counties in northeastern New Jersey will be completed in the future. Funding for this work is provided by the New Jersey State Police, Office of Emergency Management.

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OFFSHORE SAND EXPLORATION FOR SHORE PROTECTION PROJECTS

By Jane Uptegrove

New Jersey's active and successful shore protection program requires large and readily available sources of offshore sand for beach nourishment projects. The New Jersey Geological Survey (NJGS) works cooperatively with other state and federal agencies to locate potential sources of sand that will be critical to executing long-range plans for protecting the safety and property of New Jersey's residents.

NJGS collects vibracores each year as part of an ongoing offshore resources exploration project. To date, more than 125 vibracores have been drilled along the length of the New Jersey Coast. In June 2004, the New Jersey Geological Survey Offshore Resources Exploration Team drilled 20 vibracores in and around potential offshore sand resources, each to a depth of 20 feet (fig. 1). The coring investigated a stretch from Brigantine to an area south of Corson's Inlet.

This year, sites were selected based on review of approximately 300 line-miles of a seismic survey conducted in 2003. Target areas were identified in consultation with the U.S. Army Corps of Engineers and included shoal features offshore of Atlantic City, Brigantine, Ocean City and Longport. Drilling was extended north and east of Brigantine to improve coverage of shoal and channel features in the vicinity of Little Egg Inlet. As illustrated on the map (fig. 1), the majority of drilling locations run parallel to the coast approximately three miles offshore. Shoals nearer to shore were not sampled because the Survey does not have 2-D seismic data for them. Further, potential deposits close to shore would not be candidates for dredging because of their importance in modulating near-shore and onshore wave energy.

Figure 1. Viracore location map.

WHY A 20-FOOT CORE?

As discussed in the NJGS Information Circular “Sand Resources for Shore Protection Projects in New Jersey” (http://njgeology.org/enviroed/infocirc/sand.pdf), analysis of 2-D seismic data alone shows only the shape and location of sediment layers (fig. 2). Physical samples are required to determine the material’s composition. These are retrieved from a ship using a pneumatic hammer that drives a steel barrel with a tube of clear PVC lining 20 feet into sea-floor sediments. As the barrel is driven into the sediments, a sensor, known as a penetrometer and mounted on the core bit, records the time elapsed and depth of penetration. The power of the pneumatic hammer determines how deep the core barrel will penetrate. Typically, a 20-foot core is drilled in about three minutes. If any one-foot interval takes more than one minute, the drilling is stopped. The sample is then brought to the work deck and extracted, and a second run begins where the first drilling left off. Resistance is encountered at gravel- or clay-rich zones, and the graph created by the penetrometer is correlated with the seismic profile and the lithologic log from the core. Twenty-foot cores are economically collected in this shallow setting and provide quality samples to the depth of penetration. Checked against the seismic profile, sediment intervals disturbed during the drilling process can be corrected. Thus, while vibracore drilling is limited to shallow cores, it does provide sediment samples and verifiable lithologic contacts that enable stratigraphic correlation.

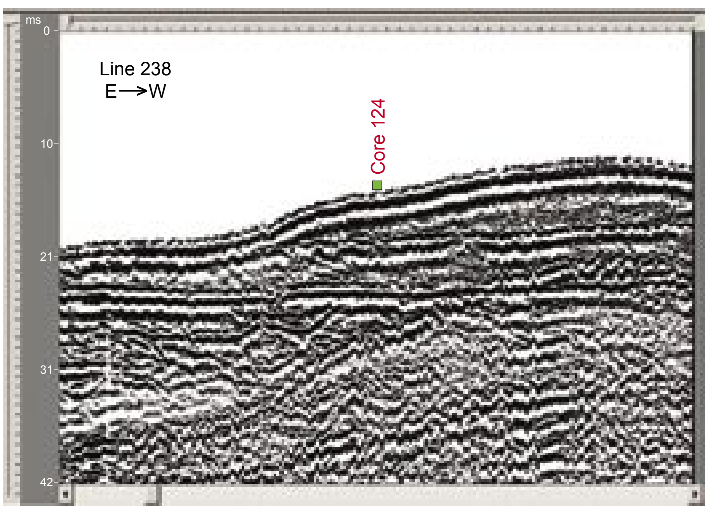

Figure 2. Seismic line with core location.

EXTRACTION AND ANALYSIS

When a core is brought to the deck of the ship, the clear PVC tubing containing the sample is extracted from the core barrel. At this time, NJGS performs a preliminary lithologic description, and the core is sectioned for storage and transport. This first, brief examination can reveal the depth of lithologic contacts, organic material for dating and grain size characteristics. At the Survey’s facility in Trenton, the cores are split lengthwise, photographed, described and sampled every 30 cms for grain size analysis (fig. 3). Organic material also is sampled at this time and sent to a lab for radiocarbon age-dating or amino-acid racemization. To illustrate, figure 3 shows Core 127, which penetrated a peat layer thought to have been deposited in a back barrier lagoon as sea level rose after the last glacial maximum, approximately 20,000 years ago. The lagoon was at sea level at the time of deposition. The radiocarbon date can pinpoint the age of the shoreline at that depth as sea level rose following the last glacial maximum.

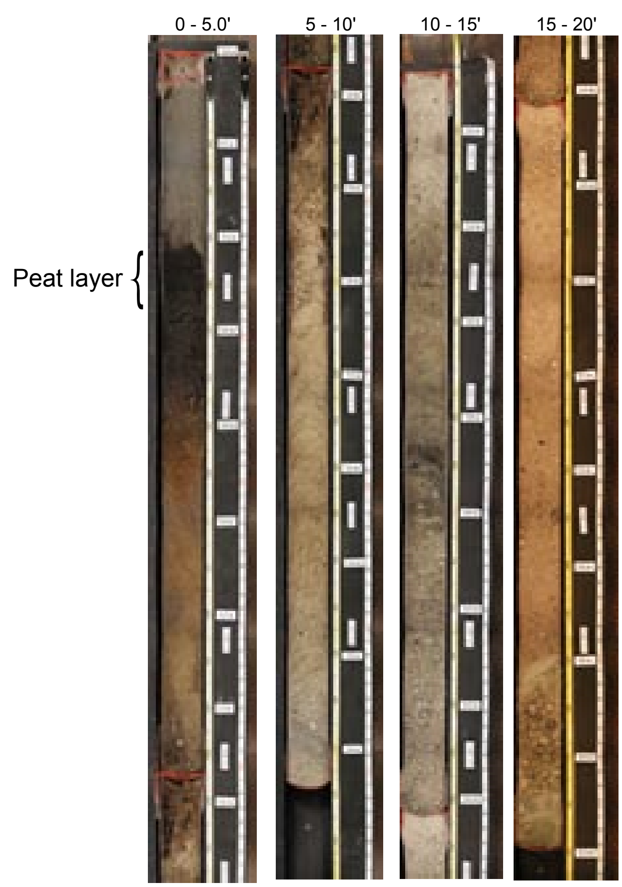

Figure 3. Core 127. Peat layer was sent for radiocarbon dating.

A GEOLOGIC FRAMEWORK

Seismic surveys and vibracore sampling are essential to developing a geologic picture that will provide a framework to evaluate individual shoal features found on the shelf. Correlation of lithologic units between vibracores and along or between seismic profiles enables Survey geologists to create computer images and calculate sand volumes. This information is used to replenish eroded beaches identified by the U.S. Department of Interior's Minerals Management Service, the U.S. Army Corps of Engineers and the New Jersey Department of Environmental Protection.

This method has proved to be a cost-effective approach to locating and characterizing sand resources for shore protection. Cooperation between NJGS and its client agencies allows for the sharing of expertise and funding and supports regional, long-term planning to protect New Jersey's people, property, coastal wildlife habitat, and the scenic coastline.

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NEW PUBLICATIONS

NJGS OPEN-FILE MAP SERIES (OFM)

NEW MAP. Ground-Water Recharge and Aquifer Recharge Potential for Monmouth County, New Jersey, French, Mark A., 2003, scale: 1 to 100,000, size 36x55. OFM 53. $15

NEW MAP. Surficial Geology of the Woodbury Quadrangle, Gloucester County, New Jersey, Stanford, Scott D., 2004, scale: 1 to 24,000, size 32x36, 1 cross-section. OFM 58. $10

NEW MAP. Bedrock Geology of the Woodbury Quadrangle, Gloucester County, New Jersey, Stanford, Scott D. and Sugarman, Peter J., 2004, scale: 1 to 24,000, size 31x32, 1 cross-section. OFM 59. $10

NEW MAP. Surficial Geology of the Camden and Philadelphia Quadrangles, Camden, Gloucester and Burlington Counties, New Jersey, Stanford, Scott D., 2004, scale: 1 to 24,000, size 32x39, 2 cross-sections. OFM 60. $10

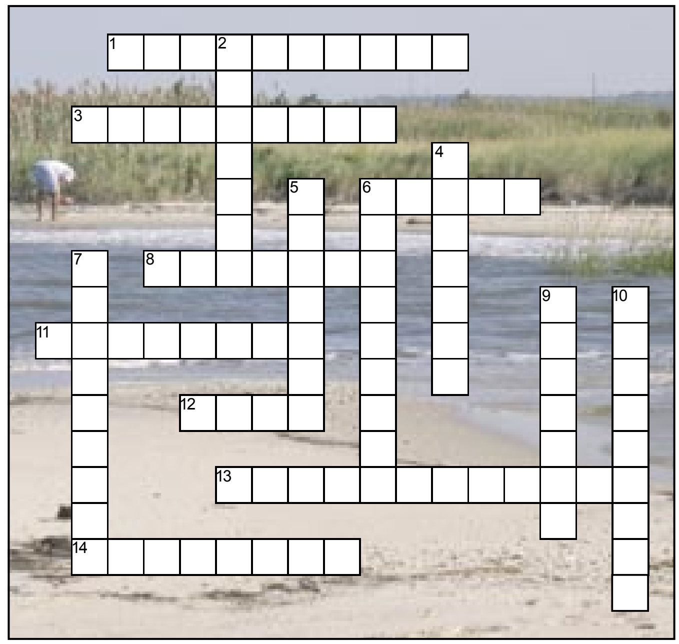
NEW MAP. Bedrock Geology of the Camden and Philadelphia Quadrangles, Camden, Gloucester and Burlington Counties, New Jersey, Stanford, Scott D., Sugarman, Peter J. and Owens, James P., 2004, scale: 1 to 24,000, size 33x36, 2 cross-sections. OFM 61. $10

NJGS TECHNICAL MEMORANDA (TM)

NEW REPORT. Modifications to New Jersey's Watershed Management Area Boundaries, 1996-1999, Hoffman, Jeffrey L., 7 p., 5 illus., 4 tables. TM 04-01. $2

Title banner: A photo collage of the mineral zincite [Zn0]. Zincite, from mines at Franklin and Ogdensburg, New Jersey, was described and analyzed by Dr. Archibald Bruce in 1810. This was one of the earliest mineralogical investigations in this country. Bruce called the mineral "red oxide of zinc", Wilhelm K. von Haidenger gave it the name "zincite" in 1845. Color ranges from deep red ("ruby zinc") to orange-yellow. Zincite is an uncommon mineral and well-developed crystals (euhedral) are exceedingly rare.

By John. H. Dooley
Banner photos by J. H. Dooley



GEOLOGY CROSSWORD TIDES

ACROSS

1. The source of a stream; its younger part.
3. The study and description of rocks.
6. A shallow submerged ridge, bank or bar of sand.
8. A salt of nitric acid.
11. The action of reducing concentration.
12. A compact, mixed sediment deposited by a glacier.
13. A condition where sands and silts flow as liquids when shaken.
14. The process that adds water to a saturated zone or aquifer.

DOWN

2. A persistent period of less than normal precipitation.
4. Water fit to drink.
5. The deeper part of a moving body of water, where the main current flows.
6. A ground motion where particles move side-to-side.
7. The point on the earth's surface directly above the location of an earthquake.
9. Pertaining to earthquake or Earth vibration.
10. A branch of geology that studies large-scale structures of Earth's crust.

ANSWERS. Across: (1) headwaters, (3) lithology, (6) shoal, (8) nitrate, (11) dilution, (12) till, (13) liquefaction, (14) recharge. **Down:** (2) drought, (4) potable, (5) channel, (6) shearwave, (7) epicenter, (9) seismic, (10) tectonics.