# WATER-QUALITY DATA FOR 90 COMMUNITY WATER SUPPLY WELLS IN NEW JERSEY, 1994-95

*By R.M. Clawges, T.D. Oden, and E.F. Vowinkel*

U.S. GEOLOGICAL SURVEY

Open-File Report 97-625

Prepared in cooperation with the

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

West Trenton, New Jersey

1998

USGS

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## CONVERSION FACTORS, VERTICAL DATUM, AND WATER-QUALITY ABBREVIATIONS

| Multiply | By | To obtain |
|---|---|---|
| centimeter (cm) | 0.3937 | inch |
| meter (m) | 3.281 | foot |
| kilometer (km) | .6214 | mile |
| square centimeter ($cm^2$) | .155 | square inch |
| square kilometer ($km^2$) | .3861 | square mile |
| square meter ($m^2$) | 10.76 | square foot |
| liter (L) | .2642 | gallon |
| cubic meters per minute ($m^3/min$) | 264.2 | gallons per minute |
| gram (g) | .03527 | ounce, avoirdupois |
| kilogram (kg) | 2.205 | pound, avoirdupois |
| degree Celsius (°C) | 1.8 x °C + 32 | degree Fahrenheit |

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.

Water-quality abbreviations:

mg/L - milligrams per liter

µg/L - micrograms per liter

µS/cm - microsiemens per centimeter at 25 degrees Celsius

DO - dissolved oxygen

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## ABSTRACT

Samples collected from 90 community water supply wells in New Jersey in 1994 and 1995 were analyzed for 143 pesticides and 5 dissolved nutrients. Temperature, pH, concentration of dissolved oxygen, and specific conductance were measured at the sampling site. Quality assurance was maintained by analyzing blank, duplicate, and spiked samples.

Pesticides were present in water from 6 of the 90 wells sampled. Pesticides detected include four herbicides (desethyl atrazine, dinoseb, metolachlor, and simazine) and one fungicide (metalaxyl). One sample contained two pesticide compounds. Concentrations of pesticides ranged from 0.01 to 2.2 micrograms per liter. None of the samples contained pesticide concentrations that exceeded a maximum contaminant level (MCL) established by the U.S. Environmental Protection Agency. Nitrate was the dominant form of nitrogen present in most samples. Nitrate concentrations ranged from less than the detection limit of 0.05 milligrams per liter to 7.6 milligrams per liter, and concentrations of dissolved nitrate (as N) in water from the 90 wells were below the MCL of 10 milligrams per liter.

## INTRODUCTION

Recent regulations enacted by the U.S. Environmental Protection Agency (USEPA) and the New Jersey Department of Environmental Protection (NJDEP) will require community water supply purveyors to monitor ground water for pesticides routinely (Louis and others, 1994). Monitoring requirements for pesticides in water samples can be waived if (1) the part of the aquifer from which the water is withdrawn is insensitive to contamination by pesticides, or (2) the aquifer is sensitive to contamination but pesticides are not used in the area near the wellhead. The U.S. Geological Survey (USGS), in cooperation with the NJDEP, previously developed a numerical rating model using a geographic information system (GIS) data base to determine the vulnerability of water from community water supply wells to contamination by pesticides. The GIS data base and model were used to rank 1,945 community water supply wells in New Jersey into groups of low, medium, and high vulnerability (Vowinkel and others, 1994).

The vulnerability of a well to contamination by pesticides is related to the sensitivity of the part of the aquifer in which the well is screened and the intensity of pesticide use in areas where the aquifer is sensitive to contamination. Wells were ranked into groups of low, medium, and high aquifer sensitivity and low, medium, and high pesticide-use intensity. Variables used to evaluate aquifer sensitivity are (1) the distance of a well from the outcrop area of the aquifer in which the well is screened, (2) the percentage of organic matter in the soil at the wellhead, and (3) the depth to the top of the open interval of the well. Variables used to evaluate the pesticide-use intensity near wells in sensitive parts of an aquifer are (1) the predominant land use within an 800-m-radius buffer zone of the wellhead, (2) the distance of the well from agricultural land, and (3) the distance of the well from a golf course (Vowinkel and others, 1994).

To test the validity of the numerical rating model, water from a stratified sample of 90 community water supply wells was sampled and analyzed for concentrations of 143 pesticides, 5 dissolved nutrients, and dissolved oxygen; temperature, pH, and specific conductance also were measured. The samples were analyzed for dissolved nutrients because a significant association between concentrations of nitrate and the presence of pesticides in water samples was determined in the previous study by Vowinkel and others (1994). The concentration of nitrate was significantly higher in water from wells in which pesticides were present than in water from wells in which pesticides were absent.

## Purpose and Scope

This report presents the results of analyses of water-quality samples collected from 90 community water supply wells in New Jersey during 1994 and 1995 to test the validity of a numerical rating model to determine the vulnerability of water from wells to contamination by pesticides. Sampled wells were located throughout the State and were completed in several different aquifer materials. Data on well identification, well construction, temperature, pH, concentration of dissolved oxygen, specific conductance, and concentrations of pesticides and dissolved nutrients are included in the report. Results of quality-assurance analyses also are presented.

## Description of the Study Area

New Jersey is a mid-Atlantic state with a humid, temperate climate. Average annual precipitation is about 112 cm. New Jersey is divided into 21 counties and contains parts of four major physiographic provinces (fig. 1). A mix of commercial, industrial, transportation, residential, agricultural, and undeveloped land is present throughout the State. Pesticides are applied to agricultural, urban, and undeveloped land to control weeds, insects, and other pests. Types of pesticides commonly used in New Jersey include herbicides, insecticides, and fungicides.

New Jersey's principal aquifers (table 1) can be classified into two groups: unconsolidated sediments and bedrock. Aquifers consisting of unconsolidated sediments are in the Coastal Plain Physiographic Province in southern New Jersey or areas of glacial deposition in northern New Jersey. The aquifers of the Coastal Plain vary in areal extent and thickness; they generally are permeable units of unconsolidated sand and gravel that are separated from each other by less permeable units of silt and clay. Aquifers in the Coastal Plain generally are confined except where they crop out. An exception is the Kirkwood-Cohansey aquifer system, a predominantly unconfined aquifer that underlies approximately 7,770 $km^2$ (Zapecza, 1989). The glacial aquifers are mostly valley-fill sediments consisting of narrow deposits in the northern part of the State, most commonly north of the terminal moraine of the Wisconsinan glaciation (fig. 1). The bedrock aquifers include fractured shales and sandstones of the Newark Supergroup in the Piedmont Province, weathered and fractured crystalline rocks of the New England Province, and sedimentary rocks of the Valley and Ridge Province.

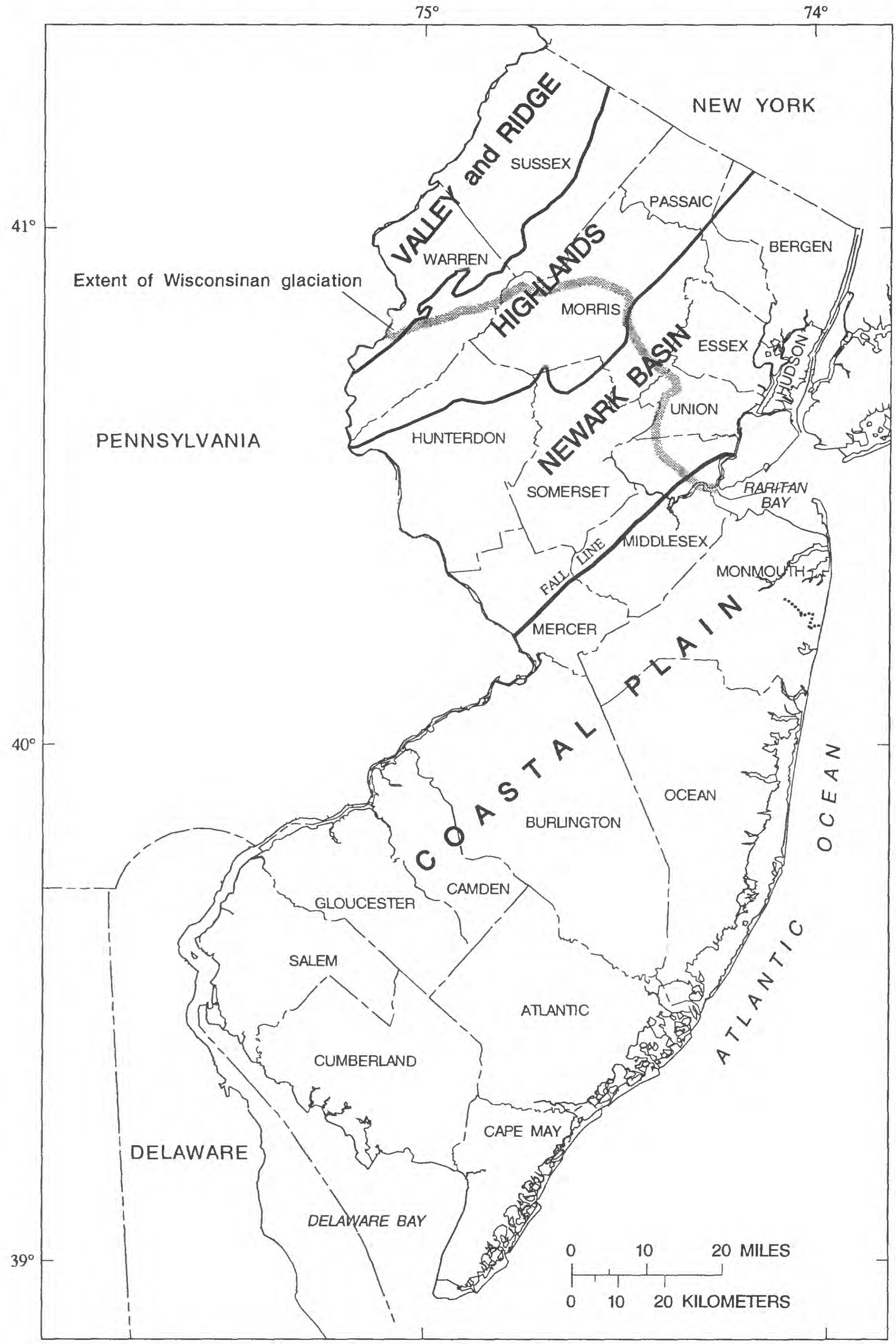


Figure 1. Location of counties and physiographic provinces in New Jersey.

Table 1. Generalized description of aquifers in New Jersey

[From Vowinkel and others, 1994]

| Aquifer type / Physiographic province or feature / Geologic materials | Major aquifers and aquifer systems |
|---|---|
| **Unconsolidated sediments** | |
| Coastal Plain Province | Kirkwood-Cohansey aquifer system, Atlantic City 800-foot sand, Wenonah-Mount Laurel aquifer, Englishtown aquifer system, Potomac-Raritan-Magothy aquifer system |
| Sand and gravel aquifers with alternating silt and clay confining units | |
| Glacial deposits | |
| Sand and gravel with interbedded silt and clay | Glacial valley-fill deposits |
| **Bedrock** | |
| Piedmont Province | Passaic Formation; undifferentiated sedimentary bedrock of the Brunswick Group; Lockatong Formation; Stockton Formation |
| Shale, sandstone, siltstone, mudstone, conglomerate, basalt, and diabase | |
| New England Province | Franklin Marble, Hardyston Quartzite, Precambrian gneiss |
| Gneiss, marble, quartzite, pegmatite, schist, amphibolite, and granite | |
| Valley and Ridge Province | Kittatinny Limestone, Leithsville Formation, Allentown Dolomite, Martinsburg Formation |
| Limestone, shale, dolomite, sandstone, siltstone, conglomerate, and slate | |

## Well-Numbering System

The well-numbering system used in this report is used by the USGS in New Jersey for the Ground Water Site Inventory data base. The number consists of a two-digit county code followed by a one- to four-digit sequence number of the well in the county. County code numbers for New Jersey are

01.....Atlantic
03.....Bergen
05.....Burlington
07.....Camden
09.....Cape May
11.....Cumberland
13.....Essex
15.....Gloucester
17.....Hudson
19.....Hunterdon
21.....Mercer
23.....Middlesex
25.....Monmouth
27.....Morris
29.....Ocean
31.....Passaic
33.....Salem
35.....Somerset
37.....Sussex
39.....Union
41.....Warren

For example, well 01-517 is the 517th well inventoried in Atlantic County.

## Acknowledgments

The authors thank the many purveyors for allowing access to their wells. Appreciation also is extended to Judy Louis of the NJDEP for her assistance and guidance throughout this project.

# METHODS OF INVESTIGATION

The following section describes the well-selection process, sample-collection procedures, laboratory analyses of the samples, and quality-assurance sampling procedures.

## Well Selection

Community water supply wells were ranked into groups of low, medium, and high vulnerability to contamination by pesticides by means of three major tasks: (1) compilation of available hydrogeologic, well-construction, soils, and land-use information into a GIS data base; (2) use of univariate and multivariate statistical analysis of the data to determine the best predictors of contamination by pesticides; and (3) development of a numerical rating model to rate the vulnerability of the wells to contamination by pesticides as low, medium, or high (Vowinkel and others, 1994).

To test the validity of the numerical rating model, 90 of the 1,945 community water supply wells for which well-construction data were available were selected for sampling. Wells in the GIS data base were stratified into categories on the basis of their vulnerability rating. Wells were further stratified to obtain roughly equal numbers of wells from each of three general aquifer categories: (1) unconsolidated sediments of the Coastal Plain, (2) fractured bedrock, and (3) glacial-deposit sediments. A randomly selected subset of wells was generated from the total number of wells from each combination of vulnerability category and aquifer category by using methods developed by Scott (1990).

Using Scott's methods, a study region is subdivided into areal subsets that have a common spatial characteristic to stratify the population of potential sampling sites into several categories from which sampling sites are selected. In this case, the study region was New Jersey, and the areal subsets consisted of areas where certain categories of aquifers were located. For example, the Coastal Plain is an areal subset located south of the Fall Line in New Jersey (fig. 1). Wells were grouped into each areal subset on the basis of the aquifer from which they draw water. Within each aquifer areal subset, wells were further stratified into one of three aquifer-sensitivity and pesticide-use-intensity groups: low, medium, and high (Vowinkel and others, 1994).

The number of wells selected for sampling (table 2) was weighted toward the medium pesticide-use-intensity group, which contained wells primarily in residential areas. A weighted selection was performed toward residential areas because a previous study conducted during 1986-88 had evaluated the frequency of detection of pesticides in community water supply wells in the high pesticide-use group, which included mostly wells in agricultural areas. In the previous study, pesticides were detected at low concentrations in 1 of 10 wells in the outcrop area of the Potomac-Raritan-Magothy aquifer system, 1 of 8 wells in the Kirkwood-Cohansey aquifer system, and 1 of 10 wells open to a bedrock aquifer in northern New Jersey (Louis and Vowinkel, 1989).

Table 2. Number of sampled wells in each aquifer-sensitivity and pesticide-use-intensity group, New Jersey, 1994-95

| Aquifer sensitivity | Pesticide-use intensity | | |
|---|---|---|---|
| | Low | Medium | High |
| Low | 10 | 0 | 0 |
| Medium | 5 | 27 | 6 |
| High | 6 | 20 | 16 |

For this study, 90 wells were selected in three aquifer types: 34 wells in Coastal Plain aquifers, 28 wells in bedrock aquifers, and 28 wells in glacial aquifers. The largest number of wells was chosen in the Coastal Plain aquifer category because that areal subset contained wells rated in all three vulnerability categories. All wells drilled in fractured bedrock or glacial sediments were rated as being in either the medium- or high-vulnerability category. Well-identification information for the 90 community water supply wells sampled is listed in table 3, and location and well-construction data are listed in table 4. Locations of the 90 wells are shown in figure 2.

## Sample Collection and Processing

Water samples were collected from 25 wells during August-October 1994 and from 65 wells during August-October 1995. These sampling times were chosen because they typically follow the annual period of pesticide application. Water samples were collected at the wellhead by using procedures described by Wood (1976), in which the wells were purged to three equivalent casing volumes, and temperature, pH, dissolved-oxygen concentration, and specific conductance were allowed to stabilize before a sample was collected. Teflon tubing was used to run the water from the sampling port of the well to the sample-collection bottle. The Teflon tubing was reused but only after it was cleaned with deionized water, a mixture of deionized water and soap solution, and methanol. Clean metal fittings were used to connect the sampling port to the Teflon tubing.

All pesticide samples were chilled before laboratory analysis. All 25 samples collected in 1994 and the first 7 samples collected in 1995 were filtered using disposable 0.45-micron, polysulfone filter media, tortuous-path-capsule filters with a filtration area of 20 $cm^2$. The remaining 58 pesticide samples collected in 1995 were not filtered because the amount of particulate matter in the samples was generally small, and water from wells rarely is filtered before delivery to the homeowner.

All 90 nutrient samples were filtered using disposable filters to avoid cross-contamination. About 1 L of deionized water was used to condition the filter (Horowitz and others, 1994). Mercuric chloride was used to preserve the 25 nutrient samples collected in 1994. Preserved nutrient samples also were chilled before laboratory analysis. The 65 nutrient samples collected in 1995 were chilled but not preserved with mercuric chloride, in accordance with new nutrient-sample preservation procedures adopted by the U.S. Geological Survey in late 1994 (D.A. Rickert, U.S. Geological Survey, unpublished Office of Water Quality Technical Memorandum 94.16, 1994).

Table 3. Well-identification information for 90 community water supply wells in New Jersey
[USGS, U.S. Geological Survey; NA, not available]

| USGS well number | PWSN[1] | SFID[2] | Well owner | Local well identifier |
|---|---|---|---|---|
| 01- 792 | 0113001 | 11 | Hammonton Water Department | Hammonton WD 5 |
| 01- 973 | 0119002 | 47 | NJ/American Water Company - Southern Division | Smithville 3/17 Mossmill |
| 03- 15 | 0248001 | 12 | Ramsey Boro Water Department | Woodland |
| 03- 28 | 0233001 | 21 | Mahwah Township Water Department | 4096 |
| 03- 94 | 0242001 | 3 | Oakland Boro Water Department | Bush 4C |
| 03- 120 | 0233001 | 28 | Mahwah Township Water Department | Mahwah TWD 17 |
| 03- 346 | 0247001 | 31 | Park Ridge Boro | Park Ridge Bear Bk Twp |
| 03- 350 | 0201001 | 6 | Allendale Boro | AB Meeker Lane TW 17 |
| 03- 395 | 0247001 | 21 | Park Ridge Boro | PR K W 2 |
| 03- 466 | 0228001 | 24 | Ho-ho-kus Boro Water Department | Hollywood Ave OW6 |
| 05- 187 | 0315001 | 7 | Florence Township Water Department | FTWD 4 |
| 09- 43 | 0502001 | 5 | Cape May City Water Department | CMCD 5 |
| 09- 297 | 0511003 | 5 | Shore Acres | Shore Acres A |
| 09- 395 | 0505406 | NA | Cape May National Golf Club | CMNGC Cart Bldg 1991 |
| 11- 273 | 0601001 | 29 | Bridgeton Water Department | BWD 15 |
| 11- 709 | 0613003 | 1 | Upper Deerfield Township | Centerton Rd PW 2 |
| 13- 2 | 0706001 | 13 | Essex Falls Water Department | EFWD 8 |
| 13- 19 | 0710001 | 9 | Livingston Township Water Department | LTWD 3 |
| 13- 65 | 0712001 | 24 | NJ/American Water Company | CWC D |
| 15- 69 | 0807001 | 4 | Greenwich Township Water Department | GTWD 3(NEW 4) |
| 15- 327 | 0821001 | 4 | Westville Water Department | WWD 4 |
| 15- 697 | 0809001 | 4 | Penns Grove Water Company | Bridgeport Backup-2 |
| 15-1065 | 0818004 | 34 | Washington Township Municipality | Washington Mua 11 |
| 19- 302 | 1009001 | 4 | Flemington Boro | Court Street |
| 19- 305 | 1011001 | 6 | NJ/American Water Company | Frenchtown 2 |
| 19- 312 | 1005001 | 20 | Clinton Town | Municipal Parking Lot |
| 19- 349 | 1007001 | NA | Delaware Township Municipality | Delaware TMUA 2 |
| 21- 44 | 0303001 | 4 | Bordentown Water Department | White Horse 1 |
| 21- 73 | 1103001 | 9 | Garden State Water Company | Paxson Ave 9 |
| 21- 373 | 1108001 | 10 | Pennington Water Department | Pennington WD 8 |
| 21- 384 | 1107002 | 8 | Lawrenceville Water Company | LWC PW9 Denow Rd |
| 21- 387 | 1106001 | 6 | Hopewell Township Water & Sewer Authority | McKonkey Way OW-3A |
| 23- 195 | 1216001 | 3 | Perth Amboy Water Department | Perth Amboy 5 |
| 23- 232 | 1213002 | 7 | MonroeTownship Municipality | Forsgate 11 |
| 23- 315 | 1221004 | 8 | South Brunswick Municipality | 13 |
| 23-1213 | 1225001 | 6 | Middlesex Water Company | Park Ave |
| 25- 29 | 1308001 | 5 | Brielle Water Department | BWD 1 |
| 25- 284 | 1329001 | 3 | Matawan Boro Water Department | Matawan Boro 3 |
| 25- 512 | 1344001 | 5 | Sea Girt Water Department | SGWD 7 |
| 25- 726 | 1316001 | 1 | Freehold Township | Koenig Lane T Plant 13 |
| 27- 35 | 1408001 | 7 | Denville Township Water Department | DTWD 5 |
| 27- 55 | 1421003 | 4 | Montville Township Municipality | Indian Lane 1 |
| 27- 62 | 1435002 | 4 | RockawayTownship Water Department | RTWD 6 |
| 27- 77 | 1424001 | 3 | Southeastern Morris County Municipality | Black Brook 1 |
| 27- 108 | 1401001 | 9 | Boonton Town Water Department | BTWD 1 |

Table 3. Well-identification information for 90 community water supply wells in New Jersey--Continued

| USGS well number | PWSN[1] | SFID[2] | Well owner | Local well identifier |
|---|---|---|---|---|
| 27- 113 | 1404001 | 3 | Chatham Boro Water Department | CBWD 2 |
| 27- 183 | 1429001 | 33 | Parsippany-Troy Hills Water Department | PTHWD 14 |
| 27- 189 | 1425001 | 6 | Mountain Lakes Water Department | MLWD 4 |
| 27- 191 | 1425001 | 2 | Mountain Lakes Water Department | MLWD 5 |
| 27- 977 | 1436006 | 4 | Roxbury Township Water Department | Evergreen Acres 1 |
| 27-1002 | 1427007 | 2 | Mount Olive Township | Budd Lake 1 |
| 27-1038 | 1436003 | 6 | Roxbury Township Water Department | VAIL RD 2 |
| 27-1173 | 1436002 | 9 | Roxbury Water Company | RWC PW7-Pleasant Village 1 |
| 27-1323 | 1432001 | 5 | Morris County Municipality | MCMUA PW# WU 1974 Succas |
| 27-1746 | 1410001 | 14 | East Hanover Township Water Department | EHWD 1 |
| 27-1747 | 2108001 | 14 | Hackettstown Municipality | Heath Village 2 |
| 27-1771 | 1436003 | 10 | Roxbury Township Water Department | RTWD 4 |
| 27-1787 | 1426004 | 1 | Arlington Hills Water Company | Sterling Way 1A |
| 29- 5 | 1502001 | 3 | NJ/American Water Company | Bay Head 5 |
| 29- 443 | 1514001 | 5 | NJ/American Water Company | Lakewood 5 |
| 29- 576 | 1511001 | 28 | Jackson Township Municipality | Jackson 8 |
| 29- 595 | 1506001 | 7 | Brick Township Municipality | FP 11 |
| 29- 627 | 1507005 | 43 | Toms River Water Company | TRWC 28 |
| 29- 757 | 1518008 | 5 | Manchester Township Municipality | Holly Oaks 1 |
| 29- 810 | 1518004 | 18 | Crestwood Village Water Company | Crestwood Vil 6 |
| 29- 815 | 1526001 | 8 | Seaside Heights Water Department | SHWD 6 |
| 29- 917 | 1511001 | 14 | Jackson Township Municipality | Jackson MUA 11 |
| 29-1064 | 1517001 | 5 | Long Beach Water System | LBWC Brant Beach 3 |
| 29-1066 | 1512001 | 11 | Lacey Township Municipality | LTMUA 5 |
| 29-1071 | 1504001 | 4 | Beachwood Boro | Beachwood 6 |
| 31- 12 | 1615014 | NA | West Milford Township Municipality | Crescent PK 1 |
| 31- 64 | 1611002 | 4 | Ringwood Boro Water Company | Ringwood Beattie Lane 9 |
| 31- 93 | 1613002 | 8 | Wanaque Boro Water Department | Meadowbrook 1 |
| 33- 346 | 1707001 | 6 | Penns Grove WSC | Layne 1 |
| 35- 63 | 2004002 | 190 | Elizabethtown Water Company | Rutland Rd |
| 35- 68 | 1811001 | 8 | Manville Boro | MB C2 |
| 37- 1 | 1901001 | 3 | Andover Boro Water Company | ABWC 1 |
| 37- 214 | 1909001 | 4 | Hamburg Boro | Hamburg Boro 3 |
| 37- 229 | 1918004 | 4 | Sparta Township | One mile fm OFC OW4 |
| 37- 234 | 1909001 | 2 | Hamburg Boro | Hamburg 1961 |
| 37- 236 | NA | NA | Sussex County - Department of Public Works | Homestead Complex |
| 37- 239 | 1911001 | 9 | Wallkill Water Company | Walden Vill-Wits End Rd |
| 37- 255 | 1919001 | 5 | Stanhope Boro | Boro of Stanhope TW 5 |
| 37- 275 | 1904003 | 4 | Forest Lakes Water Company | TW For Home Dev |
| 37- 297 | 1915001 | NA | Newton Town | Well pw1 |
| 37- 313 | 1902003 | 3 | Lake Lenape Water Company | Old Well |
| 41- 21 | 2121001 | 5 | NJ/American Water Company | Washington 5 |
| 41- 257 | 2101001 | 5 | Pequest Water Company | Pequest WC 2 |
| 41- 262 | 2108301 | NA | State of NJ - Department of Treasury | Stephens State Pk Cmpgrnd |
| 41- 278 | 2102001 | 3 | Alpha Boro | NW of Sch OW 1 |

[1]Public Water Supply Number assigned by the New Jersey Department of Environmetnal Protection (NJDEP) Bureau of Safe Drinking Water (BSDW) that identifies a public water supply system.

[2]Number assigned by the NJDEP BSDW that identifies an individual well within a public water supply system.

Table 4. Location and well-construction data for 90 community water supply wells in New Jersey

[USGS, U.S.Geological Survey; --, data not available; CP, unconsolidated materials of the Coastal Plain; BR, fractured bedrock; GL, unconsolidated glacial-deposit sediments]

| USGS well number | County | Municipality | Latitude (degrees) | Longitude (degrees) | Elevation of land surface (meters) | Depth of well (meters) | Top of open interval (meters) | Bottom of open interval (meters) | Discharge (cubic meters per minute) | Aquifer[1] | Aquifer type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01- 792 | Atlantic | Hammonton Town | 393823 | 0744929 | 36.6 | 66.4 | 54.3 | 66.4 | -- | CKKD | CP |
| 01- 973 | Atlantic | Galloway Township | 392944 | 0742810 | 9.1 | 56.4 | 40.8 | 56.4 | -- | CKKD | CP |
| 03- 15 | Bergen | Ramsey Boro | 410336 | 0740952 | 109.7 | 91.4 | 14.3 | 91.4 | -- | PSSC | BR |
| 03- 28 | Bergen | Mahwah Township | 410318 | 0741101 | 137.2 | 97.5 | 25.9 | 97.5 | 2.9 | BRCKS | BR |
| 03- 94 | Bergen | Oakland Boro | 410126 | 0741508 | 67.1 | 38.4 | 34.1 | 38.4 | 3.7 | SFDF | GL |
| 03- 120 | Bergen | Mahwah Township | 410506 | 0741055 | 76.5 | 51.5 | 44.5 | 51.5 | 10.3 | SFDF | GL |
| 03- 346 | Bergen | Park Ridge Boro | 410155 | 0740320 | 61.0 | 93.0 | 4.9 | 93.0 | 3.1 | PSSC | BR |
| 03- 350 | Bergen | Allendale Boro | 410235 | 0740757 | 106.7 | 36.6 | 33.5 | 36.6 | 3.2 | SFDF | GL |
| 03- 395 | Bergen | Park Ridge Boro | 410157 | 0740157 | 51.8 | 11.0 | 6.1 | 11.0 | - - | SFDF | GL |
| 03- 466 | Bergen | Ho-ho-kus Boro | 410009 | 0740630 | 38.1 | 91.4 | 10.1 | 91.4 | - | PSSC | BR |
| 05- 187 | Burlington | Florence Township | 400703 | 0744832 | 9.1 | 40.8 | 36.3 | 40.8 | 12.3 | MRPAM | CP |
| 09- 43 | Cape May | Lower Township | 385724 | 0745521 | 4.6 | 84.1 | 75.0 | 84.1 | -- | CNSY | CP |
| 09- 297 | Cape May | Upper Township | 391324 | 0744056 | 3.0 | 54.9 | 44.2 | 54.9 | -- | CNSY | CP |
| 09- 395 | Cape May | Lower Township | 385909 | 0745359 | 5.5 | 83.8 | 77.7 | 83.8 | -- | CNSY | CP |
| 11- 273 | Cumberland | Bridgeton | 392724 | 0751236 | 30.5 | 57.9 | 45.7 | 57.9 | 8.1 | CKKD | CP |
| 11- 709 | Cumberland | Upper Deerfield Township | 393009 | 0751054 | 35.1 | 48.8 | 41.1 | 48.8 | -- | CKKD | CP |
| 13- 2 | Essex | Essex Fells Boro | 404956 | 0741803 | 74.4 | 128.9 | 33.5 | 128.9 | 5.5 | PRKS | BR |
| 13- 19 | Essex | Livingston Township | 404836 | 0742034 | 48.8 | 25.3 | 13.1 | 25.3 | 12.9 | SFDF | GL |
| 13- 65 | Essex | Millburn Township | 404448 | 0742111 | 85.3 | 39.0 | 32.9 | 39.0 | 13.7 | SFDF | GL |
| 15- 69 | Gloucester | Greenwich Township | 394920 | 0751619 | 3.0 | 51.2 | 32.9 | 51.2 | 18.6 | MRPAM | CP |
| 15- 327 | Gloucester | Westville Boro | 395221 | 0750737 | 4.9 | 97.2 | 87.2 | 95.4 | 22.1 | MRPAL | CP |
| 15- 697 | Gloucester | Logan Township | 394755 | 0752108 | 2.4 | 25.6 | 21.0 | 25.6 | 1.8 | MRPAM | CP |
| 15-1065 | Gloucester | Washington Township | 394327 | 0750210 | 46.3 | 25.9 | 18.0 | 25.9 | 18.8 | CKKD | CP |
| 19- 302 | Hunterdon | Flemington Boro | 403035 | 0745138 | 54.9 | 106.7 | 15.5 | 106.7 | -- | PSSC | BR |
| 19- 305 | Hunterdon | Frenchtown Boro | 403122 | 0750338 | 42.7 | 209.7 | 15.2 | 209.7 | -- | PSSC | BR |
| 19- 312 | Hunterdon | Clinton Town | 403804 | 0745418 | 79.2 | 112.8 | 32.0 | 112.8 | - | EPLR | BR |
| 19- 349 | Hunterdon | Delaware Township | 402658 | 0745638 | 129.5 | 76.2 | 45.7 | 76.2 | 0.74 | SCKN | BR |
| 21- 44 | Mercer | Hamilton Township | 401105 | 0744212 | 6.1 | 36.9 | 30.8 | 36.9 | -- | MRPAM | CP |
| 21- 73 | Mercer | Hamilton Township | 401419 | 0744007 | 24.4 | 43.9 | 39.0 | 43.9 | 12.9 | MRPA | CP |
| 21- 373 | Mercer | Pennington Boro | 402004 | 0744745 | 59.4 | 91.4 | 18.7 | 91.4 | 3.2 | PSSC | BR |

**Table 4. Location and well-construction data for 90 community water supply wells in New Jersey--Continued**

| USGS well number | County | Municipality | Latitude (degrees) | Longitude (degrees) | Elevation of land surface (meters) | Depth of well (meters) | Top of open interval (meters) | Bottom of open interval (meters) | Discharge (cubic meters per minute) | Aquifer[1] | Aquifer type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21- 384 | Mercer | Lawrence Township | 401715 | 0744427 | 36.0 | 55.4 | 18.0 | 155.4 | -- | SCKN | BR |
| 21- 387 | Mercer | Hopewell Township | 401846 | 0745048 | 62.5 | 76.2 | 15.2 | 76.2 | -- | PSSC | BR |
| 23- 195 | Middlesex | Old Bridge Township | 402537 | 0742001 | 4.6 | 24.4 | 15.2 | 24.4 | 10.1 | ODBG | CP |
| 23- 232 | Middlesex | Monroe Township | 402023 | 0742858 | 39.6 | 95.7 | 82.9 | 95.7 | 13.1 | FRNG | CP |
| 23- 315 | Middlesex | South Brunswick Township | 402204 | 0743024 | 31.2 | 42.1 | 31.4 | 42.1 | 22.1 | FRNG | CP |
| 23-1213 | Middlesex | South Plainfield Boro | 403540 | 0742432 | 21.3 | 22.5 | 16.7 | 22.5 | -- | SFDF | GL |
| 25- 29 | Monmouth | Brielle Boro | 400644 | 0740344 | 10.7 | 45.7 | 39.6 | 45.7 | 7.4 | CKKD | CP |
| 25- 284 | Monmouth | Matawan Boro | 402515 | 0741450 | 27.4 | 82.6 | 70.4 | 82.6 | 13.4 | ODBG | CP |
| 25- 512 | Monmouth | Sea Girt Boro | 400802 | 0740230 | 6.4 | 37.8 | 28.0 | 37.8 | 17.7 | CKKD | CP |
| 25- 726 | Monmouth | Freehold Township | 401420 | 0741607 | 41.1 | 207.3 | 178.0 | 205.1 | -- | ODBG | CP |
| 27- 35 | Morris | Denville Township | 405354 | 0742905 | 155.2 | 61.3 | 54.3 | 60.4 | 18.8 | SFDF | GL |
| 27- 55 | Morris | Montville Township | 405605 | 0742038 | 57.9 | 73.8 | 61.6 | 73.8 | 22.1 | SFDF | GL |
| 27- 62 | Morris | Rockaway Township | 405448 | 0743002 | 158.5 | 49.7 | 30.5 | 49.7 | 9.9 | SFDF | GL |
| 27- 77 | Morris | East Hanover Township | 404755 | 0742416 | 61.0 | 36.9 | 25.3 | 36.0 | 28.8 | SFDF | GL |
| 27- 108 | Morris | Boonton Township | 405456 | 0742654 | 153.9 | 13.1 | 6.1 | 12.2 | 7.0 | SFDF | GL |
| 27- 113 | Morris | Chatham Boro | 404439 | 0742323 | 59.4 | 43.6 | 31.4 | 43.6 | 12.9 | SFDF | GL |
| 27- 183 | Morris | Parsippany-Troy Hills Township | 405048 | 0742635 | 88.4 | 26.3 | 20.7 | 26.3 | 17.0 | SFDF | GL |
| 27- 189 | Morris | Denville Township | 405417 | 0742737 | 153.6 | 19.5 | 9.8 | 19.5 | 10.3 | SFDF | GL |
| 27- 191 | Morris | Mountain Lakes Boro | 405258 | 0742728 | 153.9 | 101.2 | 71.6 | 101.2 | -- | SFDF | GL |
| 27- 977 | Morris | Roxbury Township | 405503 | 0743628 | 214.9 | 63.4 | -- | -- | -- | SFDF | GL |
| 27-1002 | Morris | Mount Olive Township | 405314 | 0744336 | 292.6 | 104.9 | 28.7 | 104.9 | -- | PCMB | BR |
| 27-1038 | Morris | Roxbury Township | 405429 | 0743925 | 307.8 | 29.9 | 26.8 | 29.9 | -- | SFDF | GL |
| 27-1173 | Morris | Roxbury Township | 405108 | 0744110 | 210.3 | 53.3 | 49.4 | 53.3 | -- | LSVL | BR |
| 27-1323 | Morris | Randolph Township | 405027 | 0743812 | 211.8 | 54.9 | 49.7 | 54.9 | 11.1 | SFDF | GL |
| 27-1746 | Morris | East Hanover Township | 404858 | 0742321 | 54.3 | 33.5 | 30.5 | 33.5 | -- | SFDF | GL |
| 27-1747 | Morris | Washington Township | 404936 | 0744919 | 164.6 | 57.0 | 54.3 | 57.0 | -- | ALNN | BR |
| 27-1771 | Morris | Roxbury Township | 405430 | 0744010 | 277.4 | 22.9 | -- | -- | -- | PCMB | BR |
| 27-1787 | Morris | Mount Arlington Boro | 405355 | 0743808 | 234.7 | 29.9 | 25.3 | 29.9 | -- | MORN | GL |
| 29- 5 | Ocean | Bay Head Boro | 400405 | 0740242 | 3.0 | 254.2 | 228.6 | 254.2 | 4.1 | EGLS | CP |
| 29- 443 | Ocean | Lakewood Township | 400515 | 0741251 | 11.0 | 184.1 | 166.7 | 184.1 | 4.0 | EGLS | CP |

Table 4. Location and well-construction data for 90 community water supply wells in New Jersey--Continued

| USGS well number | County | Municipality | Latitude (degrees) | Longitude (degrees) | Elevation of land surface (meters) | Depth of well (meters) | Top of open interval (meters) | Bottom of open interval (meters) | Discharge (cubic meters per minute) | Aquifer[1] | Aquifer type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29- 576 | Ocean | Jackson Township | 400653 | 0741717 | 41.1 | 445.0 | 390.1 | 445.0 | 33.4 | MRPA | CP |
| 29- 595 | Ocean | Brick Township | 400415 | 0740807 | 7.6 | 548.6 | 475.5 | 548.6 | 45.4 | MRPA | CP |
| 29- 627 | Ocean | Dover Township | 395936 | 0741229 | 24.4 | 38.1 | 32.0 | 38.1 | 13.4 | CKKD | CP |
| 29- 757 | Ocean | Manchester Township | 400137 | 0741602 | 24.4 | 25.0 | 20.6 | 25.0 | 7.4 | CKKD | CP |
| 29-810 | Ocean | Manchester Township | 395812 | 0742026 | 42.7 | 53.0 | 45.4 | 53.0 | 9.3 | CKKD | CP |
| 29- 815 | Ocean | Seaside Heights Boro | 395643 | 0740443 | 2.1 | 46.9 | 39.3 | 45.4 | 18.6 | CKKD | CP |
| 29- 917 | Ocean | Jackson Township | 400850 | 0741516 | 22.9 | 59.4 | 38.4 | 56.7 | 7.0 | VNCN | CP |
| 29-1064 | Ocean | Long Beach Township | 393722 | 0741142 | 2.4 | 181.4 | 163.1 | 181.4 | -- | KRKDL | CP |
| 29-1066 | Ocean | Lacey Township | 395037 | 0741133 | 5.8 | 75.6 | 53.6 | 74.7 | -- | CKKD | CP |
| 29-1071 | Ocean | Beachwood Boro | 395548 | 0741219 | 19.8 | 65.8 | 51.8 | 64.0 | -- | CKKD | CP |
| 31- 12 | Passaic | West Milford Township | 410615 | 0742404 | 231.6 | 121.9 | 13.7 | 121.9 | -- | CRNL | BR |
| 31- 64 | Passaic | Ringwood Boro | 410408 | 0741700 | 67.1 | 28.3 | 22.9 | 28.3 | -- | SFDF | GL |
| 31- 93 | Passaic | Wanaque Boro | 410319 | 0741656 | 76.2 | 32.0 | 27.4 | 32.0 | -- | SFDF | GL |
| 33- 346 | Salem | Carneys Point Township | 394256 | 0752718 | 5.8 | 108.8 | 96.6 | 108.8 | 9.8 | MRPAL | CP |
| 35- 63 | Somerset | Montgomery Township | 402607 | 0743926 | 19.8 | 93.0 | 15.2 | 93.0 | -- | PSSC | BR |
| 35- 68 | Somerset | Bridgewater Township | 403304 | 0743525 | 13.1 | 85.3 | 9.8 | 85.3 | -- | PSSC | BR |
| 37- 1 | Sussex | Andover Boro | 405932 | 0744417 | 189 | 45.7 | -- | -- | 4.0 | SFDF | GL |
| 37- 214 | Sussex | Hamburg Boro | 410914 | 0743423 | 140.2 | 91.4 | 30.3 | 91.4 | 14.8 | KTTN | BR |
| 37- 229 | Sussex | Sparta Township | 410207 | 0743858 | 256.0 | 73.5 | 32.9 | 73.5 | 0.7 | PCMB | BR |
| 37- 234 | Sussex | Hamburg Boro | 410900 | 0743440 | 128.0 | 29.5 | 23.7 | 29.5 | -- | SFDF | GL |
| 37- 236 | Sussex | Frankford Township | 410727 | 0744523 | 157.0 | 103.6 | 30.8 | 103.6 | -- | KTTN | BR |
| 37- 239 | Sussex | Hardyston Township | 410812 | 0743621 | 189.0 | 77.1 | 58.5 | 77.1 | -- | KTTN | BR |
| 37- 255 | Sussex | Stanhope Boro | 405414 | 0744246 | 237.7 | 68.6 | 52.7 | 68.6 | -- | PCMB | BR |
| 37- 275 | Sussex | Andover Township | 405840 | 0744406 | 195.1 | 31.1 | 27.4 | 31.1 | -- | SFDF | GL |
| 37- 297 | Sussex | Newton Town | 410244 | 0744507 | 179.8 | 68.3 | 46.3 | 64.9 | -- | ALNN | BR |
| 37- 313 | Sussex | Andover Township | 405950 | 0744415 | 179.8 | 22.4 | -- | -- | -- | SFDF | GL |
| 41- 21 | Warren | Washington Township | 404519 | 0745736 | 140.2 | 143.3 | 46.3 | 124.1 | -- | KTTN | BR |
| 41- 257 | Warren | Allamuchy Township | 405453 | 0745150 | 164.6 | 150.9 | 78.0 | 150.9 | 9.2 | LSVL | BR |
| 41- 262 | Warren | Hackettstown Town | 405227 | 0744827 | 196.6 | 36.6 | 32.0 | 36.6 | 2.8 | SFDF | GL |
| 41- 278 | Warren | Alpha Boro | 403953 | 0750954 | 105.2 | 111.3 | 34.4 | 111.3 | -- | EPLR | BR |

[1]Aquifer codes identified in appendix 1

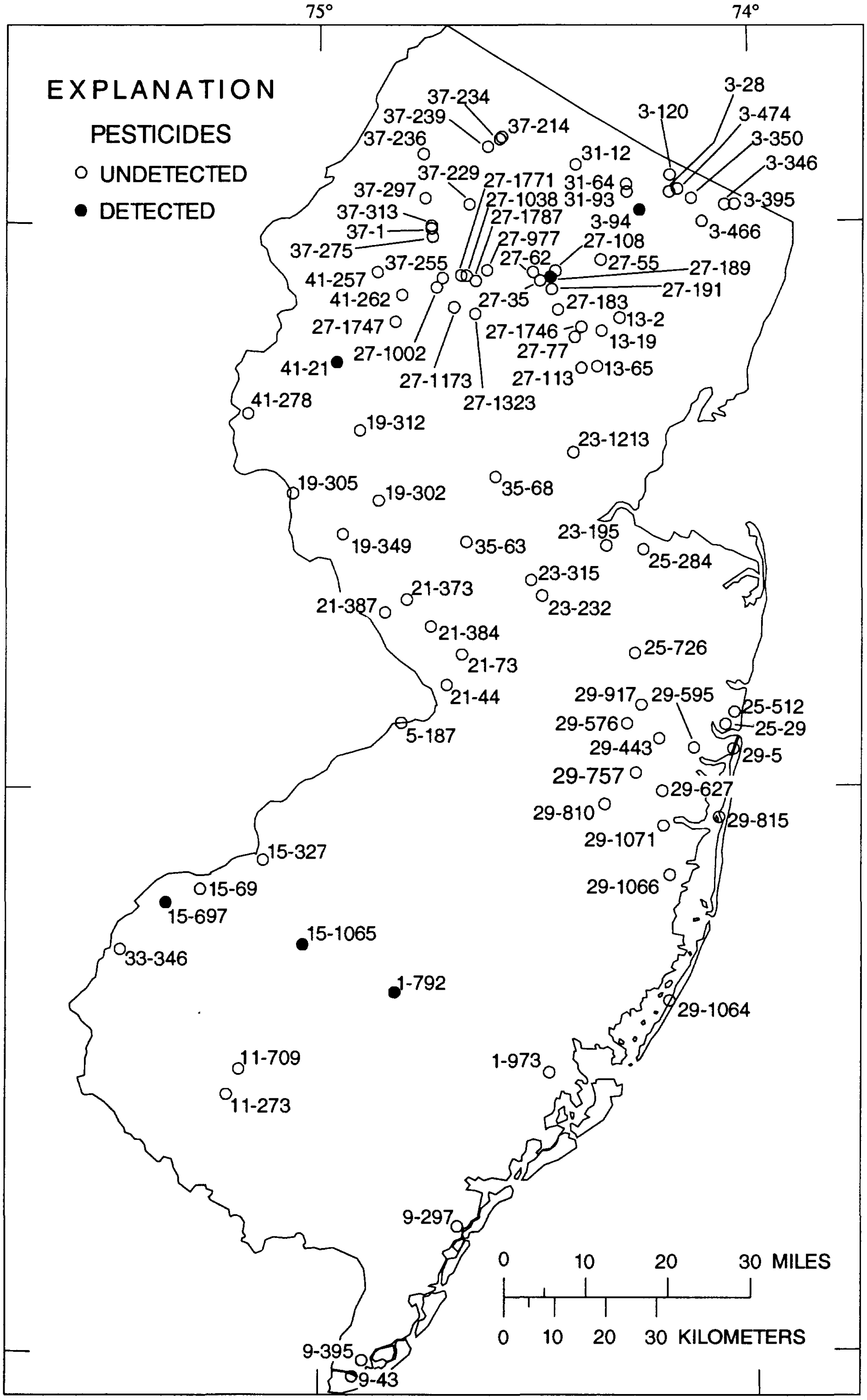


Figure 2. Location of the 90 community water supply wells in New Jersey sampled during 1994-95.

## Laboratory Analyses

All pesticide samples collected from the 90 community water supply wells in 1994 and 1995 were analyzed at the Rutgers University Food Science Department Laboratory (Rutgers Laboratory) in New Brunswick, New Jersey. Samples were analyzed for 143 pesticides by using capillary gas chromatography coupled with an ion trap mass spectrometer operated in the chemical ionization mode (table 5). Sample preparation, preservation, and analysis for pesticides are described in Mogadati and others (1994).

Five of the six wells containing water in which pesticides were detected by the Rutgers Laboratory were resampled in 1996. The samples were sent to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado, for analyses using the NWQL's Schedules 2001 and 2050 (Timme, 1995) for pesticides (table 6). In addition, several quality-assurance pesticide samples were sent to the NWQL. All nutrient samples were analyzed at the NWQL for dissolved forms of nitrate plus nitrite (as N), nitrite (as N), ammonia (as N), ammonia plus organic nitrogen (as N), and orthophosphate (as P). Sample preparation, preservation, and analysis for dissolved inorganic constituents are described by Fishman and others (1994).

## Quality Assurance

A quality-assurance program was used to evaluate the accuracy and precision of the water-quality data presented in this report. Quality assurance was maintained by analyzing blank, duplicate, and spiked samples. Separate quality-assurance samples were prepared for the analysis of pesticides (table 7) and nutrients (table 8). The internal quality-control program followed by the NWQL is documented by Pritt and Raese (1995). This program involves analyzing a large percentage of samples received to evaluate accuracy and precision. The NWQL also is checked by the USGS's Quality Assurance Program, under which standard samples are submitted for analysis and tabulated statistics on the results are reported. Quality-assurance procedures followed by the Rutgers Laboratory are documented by Mogadati and others (1994).

Quality assurance for pesticide samples involved the use of blank, duplicate, and spiked samples. Six blank samples were analyzed at the Rutgers Laboratory. All six samples contained organic-free deionized (OFDI) water and were prepared in the USGS New Jersey District's laboratory preparation room. Two of these samples were sent directly from the laboratory preparation room to the Rutgers Laboratory as a check of possible contamination at the Rutgers Laboratory. Four other samples were brought to field sites where environmental pesticide samples were collected. These samples were used as a check to determine whether sampling procedures introduced contaminants into the water samples. No pesticides were detected in either the laboratory-blank or field-blank water samples. These results indicate that contamination of water samples by pesticides in the field or in the laboratory was unlikely.

Five duplicate samples were collected along with environmental samples and sent to the Rutgers Laboratory for analysis for pesticides. No pesticides were detected in either the environmental sample or the duplicate sample for four sets of samples. In the fifth set, dinoseb was reported at a concentration of 1.6 μg/L in one sample and below the minimum-reporting limit (MRL) in the other sample. At a well sampled the following day, dinoseb was detected and reported at a concentration of 2.2 μg/L. A mix-up of bottles may be responsible for this result.

Table 5. Pesticides determined in water-quality samples at the Rutgers University Food Science Department Laboratory
[From Sensui Wang, Rutgers University, written commun., 1996]

| | | | | |
|---|---|---|---|---|
| Recovery greater than 75 percent | | | | |
| Acifluorfen | Chlorpropham | Dicamba | Linuron | Procymidone |
| Alachlor | Clomazone | Diazinon | Malathion | Prometone |
| Ametryne | Cyanazine | Dichlofopmethyl | MCPA | Prometryne |
| Amnicarb | Cyflurthrin-I | Dieldrin | MCPP | Propanil |
| Bendiocarb | Cyflurthrin-II | Dimethoate | Metalaxyl | Propazine |
| Atrazine | Cyflurthrin-III | Dinoseb | Methiocarb | Propetamphos |
| Bentazon | Cyflurthrin-IV | α -Endosulfan | Methoxychlor | Propoxur |
| α -BHC | cis-Cypermethrin-II | β -Endosulfan | Methyl parathion | Propyzamide |
| β -BHC | trans-Cypermethrin-I | Endosulfan sulfate | Meobromuron | Sideron |
| δ -BHC | trans-Cypermethrin-II | Endothal | cis-Nonachlor | Simazine |
| Bifenthrin | 2,4-D | Endrin | trans-Nonachlor | Simetryne |
| Bromocil | Dacthal | Fensulfothion | 4-Nitrophenol | 2,4,5-T |
| Butachlor | Dalapos | Eenvalerate | Oxaozon | TCPA |
| Carbaryl | 2,4-DB | Folpet | Parathion | Tebuthiron |
| Carbofuran | DBCP | Heptachlor epoxide | Pentachlorophenol | Terbutryne |
| Carbofuran-7-ol | 1,2-Dichloropane | 3-Hydroxycarbofurn | cis-permethrin | 1,4,5-TP |
| Carboxin | o,p-DDD | 3-Hydroxycarbofurn-7-ol | trans-Permethrin | Triadimefon |
| Chlorbromuron | p-p-DDD | Iprodione | Phenamiphos | Triadimenol-I |
| α -Chlordane | o,p-DDE | Isofenofos | O-Phenylphenol | Triadimenol-II |
| ϒ -Chlordane | p-p-DDE | Kelthane | Phosdrin | Trychlopyr |
| α -Chlordene | p,p-DDT | 3-ketocarbfuran-7-ol | Picloram | |
| ϒ -Chlordene | Desethyl atrazine | Lindane | Primiphos-methyl | |
| Recovery between 50 and 75 percent | | | | |
| Aldrin | DEF | Ethalfluralin | Phosalone | Terbufos |
| Benfluralin | Ethion | 3-Ketocarbofuran | Propachlor | Trichlorfon |
| Chlorothalonil | Fonofos | Pendimethalin | Propioconazole | Vinclozolin |
| Recovery less than 50 percent | | | | |
| Acephate | Chorpyriphos | Demeton-I | Disulfoton | Oxythioquinox |
| Butylate | Coumaphos | Demeton-II | Heptachlor | PCNB |
| Captafol | Cyromazine | Dichlobenil | Hexachlorobenzene | Sulferfos |
| Captan | Chlodimform | Dichlorvos | Methamidophos | |

Table 6. Pesticides determined in water-quality samples at the U.S. Geological Survey National Water Quality Laboratory
[From Timme, 1995; MRL, minimum reporting limit; µg/L, micrograms per liter]

| Schedule 2001 | MRL (µg/L) | Schedule 2050 | MRL (µg/L) |
|---|---|---|---|
| Acetochlor | 0.009 | 2,4,5-T | 0.05 |
| Alachlor | .009 | 2,4-D | .05 |
| Atrazine | .017 | 2,4-DB | .05 |
| Atrazine, desethyl- | .007 | Acifluorfen (Blazer) | .05 |
| Azinphos, methyl- | .038 | Aldicarb | .05 |
| Benfluralin | .013 | Aldicarb sulfone | .05 |
| Butylate | .008 | Aldicarb sulfoxide | .05 |
| Chlorpyrifos | .005 | Bentazon | .05 |
| Carbaryl (Sevin) | .046 | Bromacil | .05 |
| Cyanazine | .013 | Bromoxynil | .05 |
| Carbofuran | .013 | Carbaryl (Sevin) | .05 |
| DCPA (Dacthal) | .004 | Carbofuran | .05 |
| DDE,p,p'- | .010 | Carbofuran, 3-hydroxy- | .05 |
| Diazinon | .008 | Chloramben (Amiben) | .05 |
| Dieldrin | .008 | Chlorothalonil | .05 |
| Diethylaniline | .006 | Clopyralid | .05 |
| Disulfoton | .028 | Dacthal, mono-acid- | .05 |
| EPTC (Eptam) | .005 | Dicamba | .05 |
| Ethalfluralin | .013 | Dichlobenil | .05 |
| Ethoprop | .012 | Dichlorprop (2,4-DP) | .05 |
| Fonofos | .008 | Dinoseb (DNBP) | .05 |
| HCH,alpha- | .007 | Diuron | .05 |
| HCH,gamma-(Lindane) | .011 | DNOC | .05 |
| Linuron | .039 | Esfenvalerate (Asana XL) | .05 |
| Malathion | .010 | Fenuron | .05 |
| Metolachlor | .009 | Fluometuron | .05 |
| Metribuzin | .012 | Linuron | .05 |
| Molinate | .007 | MCPA | .05 |
| Napropamide | .010 | MCPB | .05 |
| Parathion, ethyl- | .022 | Methiocarb | .05 |
| Parathion, methyl- | .035 | Methomyl | .05 |
| Pebulate | .009 | 1-Naphthol | .05 |
| Pendimethalin | .018 | Neburon | .05 |
| Permethrin, cis- | .019 | Norflurazon | .05 |
| Phorate | .011 | Oryzalin (Surflan) | .05 |
| Pronamide | .009 | Oxamyl | .05 |
| Prometon | .008 | Picloram | .05 |
| Propachlor | .015 | Propham (IPC) | .05 |
| Propanil | .016 | Propoxur | .05 |
| Propargite I and II | .006 | Silvex (2,4,5-TP) | .05 |
| Simazine | .008 | Triclopyr | .05 |
| Thiobencarb | .008 | | |
| Tebuthiuron | .015 | | |
| Terbacil | .030 | | |
| Terbufos | .012 | | |
| Triallate | .008 | | |
| Trifluralin | .012 | | |

Table 7. Summary of types and results of quality-assurance and quality-control analyses for pesticide samples
[ µg/L, microgramss per liter; NWQL, U.S. Geological Survey National Water Quality Laboratory]

| Type of sample: Laboratory and number of samples (x) | Purpose, results, and conclusions |
|---|---|
| Blank: | **Purpose**: To determine whether analytical results may be biased by interferences produced during sampling (field blanks) or in the laboratory (laboratory blanks). Organic-free deionized water was used for both types of blanks. |
| Rutgers Laboratory Field (4) Laboratory (2) | **Results**: No pesticides were detected in any of the field or laboratory blanks. |
| | **Conclusions**: Field-sampling methods and laboratory analytical techniques probably did not introduce any biases in the results. |
| Duplicate: | **Purpose**: To determine whether analytical results are reproducible. |
| Rutgers Laboratory (5) | **Results**: Pesticides were not detected in four of five sets of consecutive duplicate samples. In one set of duplicate samples, dinoseb was reported at 1.6 µg/L in one sample and below the minimum reporting level of 1 µg/L in the other sample. At a well sampled the following day, dinoseb was reported at a concentration of 2.2 µg/L. A mix-up of bottles may explain this result. |
| | **Conclusions**: Analytical results were fairly reproducible. |
| NWQL (1) | **Results**: Pesticides were not detected in either sample in the duplicate set. |
| | **Conclusions**: Analytical results were reproducible. |
| Spiked: | **Purpose**: To determine the accuracy and precision of analytical methods used in the laboratory. |
| Rutgers Laboratory (8) | **Results**: The Rutgers Laboratory detected 12 of 19 pesticides common to its list of analytes and the list of 41 analytes in Schedule 2050 at the NWQL. The method used by the Rutgers Laboratory was unable to detect the methyl esters of the acid herbicides such as 2, 4-D. For the 12 pesticides detected, recoveries of pesticides were typically greater than 1 µg/L in the 1-µg/L spikes and less than 5 µg/L in the 5-µg/L spikes. |
| | **Conclusions**: Analytical results obtained from the Rutgers Laboratory are best used to indicate presence or absence of pesticide compounds in water. Concentration data should be used with caution. |
| NWQL (9) | **Results**: The NWQL detected 38 of the 41 analytes in Schedule 2050. Non-detection of the remaining three analytes was probably the result of interferences at the laboratory. The median recovery was about 80 percent for both spiking levels. |
| | **Conclusions**: The NWQL has a high precision in its analytical methods. |

Table 8. Summary of types and results of quality-assurance and quality-control analyses for nutrient samples
[ mg/L, milligrams per liter; NWQL, U.S. Geological Survey National Water Quality Laboratory]

| Type of sample: Laboratory and number of samples (x) | Purpose, results, and conclusions |
|---|---|
| Blank: | **Purpose**: To determine whether analytical results may be biased by interferences produced during sampling procedures (field blanks) or in the laboratory (laboratory blanks). Organic-free deionized water was used for both types of blanks. |
| NWQL | |
| Field (4) | **Results**: No nutrients were detected in any of the field or laboratory blanks. |
| Laboratory (2) | **Conclusions**: Field-sampling methods and laboratory analytical techniques probably did not introduce any biases in the results. |
| Duplicate: | **Purpose**: To determine whether analytical results are reproducible. |
| NWQL (5) | **Results**: Nutrient concentrations were identical in four of five sets of consecutive duplicate samples. In one set of duplicate samples, the concentration of nitrate was 0.1 mg/L greater in the duplicate sample than in the environmental sample. |
| | **Conclusions**: Analytical results were reproducible. |

Spiked samples were prepared and sent to the Rutgers Laboratory and the NWQL. Spiked samples were prepared in the USGS New Jersey District's laboratory preparation room. Reference spiking solutions were obtained from Supelco[1] through the NWQL for USGS pesticide Schedule 2050, which includes 41 analytes (table 6). Eight spiked samples were sent to the Rutgers Laboratory for analysis. Samples of OFDI water were spiked at either 1 or 5 µg/L. The Rutgers Laboratory detected 12 of 19 pesticides common to its list of analytes and the list of 41 analytes at the NWQL. The method used by the Rutgers Laboratory was unable to detect the methyl esters of the acid herbicides such as 2, 4-D. For the 12 pesticides detected, recoveries of pesticides were typically greater than 1 µg/L in the 1-µg/L spikes and less than 5 µg/L in the 5-µg/L spikes.

The results of analyses of the quality-assurance samples at the Rutgers Laboratory indicate that data on pesticide concentrations are not precise and should be used with some caution. Also, because some pesticides present in the spiked samples sent to the Rutgers Laboratory were not detected, it is possible that some water samples for which no pesticides were reported may have contained one or more pesticides.

Nine spiked samples were prepared using the same reference spiking solutions and sent to the NWQL for analysis using Schedule 2050 (table 6). The NWQL detected 38 of the 41 pesticide analytes contained in the spiked samples. The non-detection of the other three pesticide analytes was probably the result of interferences in laboratory equipment used by the NWQL (Mark Sandstrom, U.S. Geological Survey, oral commun., 1996). The median recovery was about 80 percent for both the 1-µg/L and the 5-µg/L spiking levels. This result indicates that recovery of pesticide compounds by analysis at the NWQL is good for most of the compounds on its analyte list.

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[1]Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Quality assurance for nutrient samples involved the use of blank and duplicate samples. A total of six blank samples was analyzed at the NWQL. All six samples contained OFDI water and were prepared in the USGS New Jersey District's laboratory preparation room. Two of these samples were sent directly from the laboratory preparation room to the NWQL as a check of possible contamination at the NWQL. Four other samples were brought to field sites and exposed to the air where environmental nutrient samples were collected. The field blanks were not put through the sampling equipment. These samples were used as a check to determine whether sampling-handling procedures or the air could have introduced contaminants into the water samples. No nutrients were detected in either the field-blank or laboratory-blank water samples. These results indicate that contamination of water samples by nutrients in the field or in the laboratory was unlikely.

Five duplicate samples were collected along with the environmental samples and sent to the NWQL for nutrient analysis. Concentrations of nutrients were identical in the environmental sample and the duplicate sample in four of five sample sets. In the fifth set, the concentration of nitrite plus nitrate (as N) was 0.1 mg/L greater in the duplicate sample than in the environmental sample. Overall, analytical results for nutrients at the NWQL were reproducible.

## Effects of Filtering on Pesticide Analyses

Because 32 of the 90 samples collected for pesticide analysis were filtered and 58 were unfiltered prior to analysis at the Rutgers Laboratory, a small-scale experiment was conducted to evaluate whether the pesticide results were affected by filtering. Concentrations of pesticides were expected to be smaller in the filtered samples than in the unfiltered samples because some pesticides may sorb to particulate matter that is removed during filtering. Four samples of OFDI water were spiked with reference spiking solutions obtained from Supelco containing 41 pesticides and analyzed at the USGS NWQL using Schedule 2050 (table 9, samples 1-4). One 2-L container of OFDI water was spiked at a concentration of 1 μg/L and then split into a 1-L unfiltered water sample and a 1-L water sample passed through a disposable 0.45-micron polysulfone filter. Likewise, a 2-L container of OFDI water was spiked at a concentration of 5 μg/L and then split into a 1-L unfiltered sample and a 1-L filtered sample.

Although recoveries of individual pesticides varied considerably, the differences in concentrations of individual pesticides between filtered and unfiltered samples generally were small. The median recoveries of all 38 pesticides together were greater in the two filtered samples than in the two unfiltered samples. The results of this experiment indicate that the effect of filtering a sample using an OFDI water matrix on the concentrations of most pesticides probably was negligible.

A second experiment was conducted in which spiked pesticide concentrations were introduced to water obtained from a domestic well in Mercer County (table 9, samples 5-8). This experiment was conducted to evaluate whether pesticide concentrations differ between unfiltered and filtered water samples as a result of the presence or absense of particulate matter in the water. Pesticide concentrations were expected to be smaller in the filtered water samples than in the unfiltered water samples because pesticides that may sorb to particulate matter are removed during filtering. The same procedures used to spike and split the OFDI samples were used with the ground-water samples; in this case, however, the spiked samples with concentrations of 1 μg/L were analyzed at the Rutgers Laboratory and the spiked samples with concentrations of 5 μg/L were analyzed at the NWQL.

Table 9. Summary of results of experiment to determine the effects of filtering on pesticide analyses

[NWQL, U.S. Geological Survey National Water Quality Laboratory; OFDI, organic-free deionized water; Q1, first quartile; Q3, third quartile; µg/L, micrograms per liter; U, unfiltered; F, filtered]

| Item | Spiked-sample number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Laboratory | NWQL | NQWL | NWQL | NWQL | NWQL | NWQL | Rutgers | Rutgers |
| Spiked concentration (µg/L) | 1 | 1 | 5 | 5 | 5 | 5 | 1 | 1 |
| Matrix type | OFDI | OFDI | OFDI | OFDI | Well | Well | Well | Well |
| Unfiltered or filtered | U | F | U | F | U | F | U | F |
| Q1 percent recovery | 32 | 30 | 26 | 40 | 30 | 36 | 37 | 12 |
| Median percent recovery | 65 | 67 | 54 | 70 | 70 | 61 | 79 | 86 |
| Q3 percent recovery | 76 | 87 | 73 | 82 | 84 | 84 | 180 | 180 |
| Number of analytes | 41 | 41 | 41 | 41 | 41 | 41 | 143 | 143 |
| Number of analytes detected | 38 | 38 | 38 | 38 | 38 | 38 | 19 | 19 |

The specific conductance of water from the domestic well used in this experiment was 410 µS/cm. The median specific conductance of water from the 90 sampled wells was 390 µS/cm, the 25th percentile was 135 µS/cm, and the 75th percentile was 575 µS/cm. The specific conductance in the domestic well represents about the mid-range of conductivities of the water samples. The experiment is limited in that the effect of sorption of pesticides on particulates is unknown for wells containing water with specific conductances lower or higher than that of water in the domestic well.

Although recoveries of individual pesticides varied considerably, the differences in concentrations of individual pesticides between filtered and unfiltered samples generally were small. The median recovery of all analytes in the ground-water samples sent to the NWQL was lower for the filtered sample (61 percent) than for the unfiltered sample (70 percent). The median recovery of all analytes from samples sent to the Rutgers Laboratory was higher for the filtered sample (86 percent) than for the unfiltered sample (79 percent). For all samples sent to the NWQL for analysis, the median recoveries of spikes in the OFDI (samples 1-4) were close to the median recoveries of spikes in ground water (samples 5 and 6). The variability in recoveries of pesticides from the samples sent to the Rutgers Laboratory was greater than the variability in recoveries of pesticides from the samples sent to the NWQL. This result may be related to the smaller number of analytes measured at the Rutgers Laboratory or it may be an indication of the precision of the analytical method used by the Rutgers Laboratory.

The results of this experiment indicate that the difference in pesticide concentrations is probably small between a filtered and unfiltered water sample with a specific conductance of about 410 µS/cm. Because the amount of particulate matter in the 90 ground-water samples generally was small, it is assumed that the differences in concentrations of pesticides between filtered and unfiltered samples also are relatively small.

## WATER-QUALITY DATA FOR COMMUNITY WATER SUPPLY WELLS

Results of water-quality analyses of samples from the 90 community water supply wells are presented in tables 10, 11, and 12. The data are listed by the USGS well number. Data on physical and chemical properties--temperature, pH, dissolved-oxygen concentration, and specific conductance--are shown in table 10.

Results of analyses of water samples for selected pesticides are listed in table 11. For samples in which pesticides were detected, the name of the pesticide(s) is shown, as well as the concentration detected and the type of pesticide. Pesticides were detected in 6 of the 90 wells (fig. 2 and table 11). Pesticides detected include four herbicides (desethyl atrazine, dinoseb, metolachlor, and simazine) and one fungicide (metalaxyl). One sample (from well 15-697) contained two pesticide compounds. Concentrations of pesticides ranged from below the method detection limit to 2.2 µg/L. None of the samples contained concentrations that exceeded a U.S. Environmental Protection Agency (USEPA) maximum contaminant level (MCL). Pesticides were detected in samples from wells in all three aquifer categories. Three of the wells were screened in Coastal Plain sediments, two were screened in glacial-deposit sediments, and one was drilled in fractured bedrock.

Results of analyses of water samples for selected dissolved nutrients are listed in table 12. All nutrient concentrations are expressed in the elemental form. Concentrations of dissolved ammonia, nitrite, ammonia plus organic nitrogen, nitrite plus nitrate, and orthophosphorus are reported. Nitrate was the dominant form of nitrogen found in water samples because most samples contain some dissolved oxygen. Reduced forms of nitrogen, such as ammonia and nitrite, typically are transformed to nitrate and other nitrogen forms in aerobic environments by nitrifying bacteria. Concentrations of nitrate ranged from below the detection limit of 0.05 mg/L to 7.6 mg/L. The USEPA MCL for nitrate is 10 mg/L (U.S. Environmental Protection Agency, 1991).

Five of the wells in which pesticides were detected in water in the fall of 1995 were resampled in the late winter and spring of 1996 in an attempt to confirm the presence of pesticides and nitrate. The results of the resampling effort are shown in table 13. Well 41-21 was not resampled for pesticides by the USGS because the presence of desethyl atrazine was confirmed by resampling of the well by the NJDEP (J.B. Louis, N.J. Department of Environmental Protection, oral commun., 1996). Two samples were collected at four of the five resampled wells; one sample was sent to the Rutgers Laboratory and the other was sent to the NWQL for analysis. A water sample from well 27-189 was not

Table 10. Physical and chemical properties measured in the field in water samples from 90 community water supply wells in New Jersey, 1994-95

[USGS, U.S. Geological Survey; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter]

| USGS well number | Date | Time | Temperature, water (°C) | pH, water, field (standard units) | Oxygen, dissolved (mg/L) | Specific conductance (µS/cm) |
|---|---|---|---|---|---|---|
| 01- 792 | 08-28-95 | 0955 | 13.5 | 4.7 | 8.7 | 53 |
| 01- 973 | 08-16-95 | 1535 | 14.0 | 4.8 | 1.1 | 46 |
| 03- 15 | 09-12-95 | 1340 | 11.5 | 7.5 | 5.4 | 413 |
| 03- 28 | 09-12-95 | 1025 | 11.5 | 7.8 | 7.7 | 350 |
| 03- 94 | 09-12-95 | 1505 | 13.0 | 7.6 | 11.8 | 857 |
| 03- 120 | 09-12-95 | 0915 | 14.5 | 7.9 | 1.1 | 483 |
| 03- 346 | 09-13-95 | 1040 | 12.0 | 6.9 | 6.5 | 511 |
| 03- 350 | 09-13-95 | 1410 | 12.0 | 7.1 | 1.8 | 447 |
| 03- 395 | 09-13-95 | 0935 | 12.0 | 7.5 | 4.4 | 575 |
| 03- 466 | 09-11-95 | 1315 | 12.5 | 7.4 | 6.5 | 660 |
| 05- 187 | 09-09-94 | 1235 | 15.0 | 5.5 | 3.6 | 139 |
| 09- 43 | 08-17-95 | 1015 | 15.5 | 7.6 | .4 | 311 |
| 09- 297 | 08-18-95 | 1310 | 14.0 | 5.3 | 7.3 | 43 |
| 09- 395 | 08-29-95 | 1420 | 15.5 | 7.5 | .3 | 198 |
| 11- 273 | 08-31-95 | 1100 | 14.0 | 4.5 | 7.4 | 136 |
| 11- 709 | 08-31-95 | 1235 | 13.5 | 4.1 | .3 | 157 |
| 13- 2 | 08-11-94 | 1240 | 12.5 | 8.3 | 3.6 | 470 |
| 13- 19 | 08-11-94 | 1030 | 12.0 | 7.6 | 3.7 | 607 |
| 13- 65 | 10-02-95 | 0940 | 12.5 | 7.9 | .7 | 516 |
| 15- 69 | 09-09-94 | 1015 | 14.0 | 5.0 | 1.1 | 327 |
| 15- 327 | 08-28-95 | 1310 | 14.5 | 7.0 | .5 | 547 |
| 15- 697 | 09-01-95 | 1125 | 13.5 | 5.1 | 6.5 | 204 |
| 15-1065 | 08-29-95 | 1030 | 13.0 | 4.8 | 7.2 | 122 |
| 19- 302 | 08-08-95 | 1345 | 15.0 | 7.5 | 1.5 | 1,040 |
| 19- 305 | 09-08-94 | 0940 | 13.0 | 8.0 | 6.5 | 441 |
| 19- 312 | 09-06-94 | 1210 | 13.5 | 6.9 | 4.4 | 592 |
| 19- 349 | 08-08-95 | 1055 | 13.0 | 6.5 | 7.8 | 253 |
| 21- 44 | 08-31-94 | 1350 | 14.0 | 4.4 | 6.6 | 73 |
| 21- 73 | 09-07-94 | 1430 | 13.5 | 5.0 | 7.8 | 132 |
| 21- 373 | 09-08-95 | 1220 | 12.5 | 7.5 | 3.9 | 450 |
| 21- 384 | 08-31-94 | 0930 | 13.5 | 6.9 | 2.7 | 503 |
| 21- 387 | 08-03-95 | 1015 | 13.0 | 7.7 | 2.0 | 419 |
| 23- 195 | 10-13-95 | 1135 | 14.0 | 5.1 | .1 | 277 |
| 23- 232 | 09-21-94 | 1350 | 12.5 | 5.0 | 8.4 | 132 |
| 23- 315 | 08-10-95 | 1057 | 13.0 | 4.5 | 2.0 | 126 |
| 23-1213 | 08-10-94 | 1445 | 13.5 | 7.4 | 7.5 | 600 |
| 25- 29 | 08-14-95 | 1425 | 13.5 | 6.1 | 3.1 | 80 |
| 25- 284 | 10-04-94 | 1115 | 12.5 | 5.6 | 1.3 | 84 |
| 25- 512 | 08-14-95 | 1055 | 14.0 | 5.7 | .4 | 81 |
| 25- 726 | 09-06-95 | 1135 | 15.0 | 5.8 | .1 | 63 |
| 27- 35 | 09-16-94 | 1105 | 12.0 | 7.8 | 3.3 | 461 |
| 27- 55 | 09-26-95 | 1435 | 11.5 | 8.1 | .2 | 458 |
| 27- 62 | 09-27-95 | 1140 | 12.0 | 7.9 | 2.1 | 408 |
| 27- 77 | 09-25-95 | 1000 | 12.0 | 7.7 | .2 | 835 |
| 27- 108 | 09-26-95 | 1305 | 19.0 | 6.5 | 1.5 | 263 |
| 27- 113 | 08-10-94 | 1210 | 12.5 | 8.2 | 2.5 | 435 |

Table 10. Physical and chemical properties measured in the field in water samples from 90 community water supply wells in New Jersey, 1994-95--Continued

| USGS well number | Date | Time | Temperature, water (°C) | pH, water, field (standard units) | Oxygen, dissolved (mg/L) | Specific conductance (µS/cm) |
|---|---|---|---|---|---|---|
| 27- 183 | 09-25-95 | 1455 | 17.5 | 7.7 | 3.1 | 574 |
| 27- 189 | 10-10-95 | 1255 | 13.5 | 6.5 | 4.1 | 246 |
| 27- 191 | 10-10-95 | 1135 | 11.5 | 8.1 | 2.0 | 387 |
| 27- 977 | 10-03-95 | 0835 | 11.5 | 8.1 | .6 | 210 |
| 27-1002 | 09-13-94 | 1430 | 11.5 | 7.6 | 3.2 | 353 |
| 27-1038 | 09-13-94 | 1230 | 12.5 | 7.3 | 3.0 | 1,550 |
| 27-1173 | 09-27-95 | 0915 | 10.5 | 7.4 | 9.1 | 213 |
| 27-1323 | 09-13-94 | 1050 | 11.0 | 9.0 | 8.8 | 118 |
| 27-1746 | 09-25-95 | 1220 | 12.0 | 7.8 | .1 | 712 |
| 27-1747 | 08-11-95 | 1023 | 11.0 | 7.8 | 7.2 | 320 |
| 27-1771 | 10-06-94 | 1130 | 11.5 | 7.8 | 5.1 | 441 |
| 27-1787 | 10-10-95 | 0940 | 11.0 | 6.5 | 7.3 | 548 |
| 29- 5 | 08-16-95 | 1040 | 21.5 | 8.2 | .3 | 210 |
| 29- 443 | 08-23-95 | 0955 | 19.0 | 8.0 | .3 | 239 |
| 29- 576 | 09-20-94 | 1440 | 20.5 | 6.4 | .4 | 80 |
| 29- 595 | 09-21-94 | 1050 | 26.5 | 7.0 | .6 | 112 |
| 29- 627 | 08-22-95 | 1406 | 12.5 | 4.9 | 6.5 | 120 |
| 29- 757 | 09-20-94 | 1220 | 12.5 | 5.2 | 8.3 | 32 |
| 29- 810 | 09-20-94 | 1030 | 13.0 | 4.6 | 4.5 | 44 |
| 29- 815 | 08-22-95 | 1130 | 14.0 | 6.0 | .5 | 858 |
| 29- 917 | 09-06-95 | 1400 | 13.5 | 8.1 | .1 | 146 |
| 29-1064 | 08-24-95 | 1425 | 17.0 | 5.9 | .4 | 60 |
| 29-1066 | 08-23-95 | 1235 | 13.0 | 4.5 | .5 | 56 |
| 29-1071 | 08-23-95 | 1535 | 13.0 | 4.3 | .5 | 60 |
| 31- 12 | 09-14-95 | 1550 | 10.0 | 6.4 | 9.7 | 80 |
| 31- 64 | 09-14-95 | 1125 | 13.5 | 6.2 | 1.2 | 223 |
| 31- 93 | 09-14-95 | 0945 | 13.0 | 6.7 | .9 | 332 |
| 33- 346 | 09-01-95 | 1240 | 14.5 | 7.4 | .5 | 1,030 |
| 35- 63 | 08-11-95 | 1423 | 13.0 | 7.6 | 1.7 | 1,750 |
| 35- 68 | 09-11-95 | 1030 | 13.0 | 7.4 | 2.4 | 782 |
| 37- 1 | 09-15-94 | 1110 | 11.5 | 7.7 | 7.4 | 664 |
| 37- 214 | 10-04-95 | 1735 | 12.0 | 7.2 | 7.0 | 578 |
| 37- 229 | 09-20-95 | 1430 | 13.0 | 7.5 | 2.4 | 704 |
| 37- 234 | 10-04-95 | 1555 | 11.5 | 7.4 | 6.4 | 673 |
| 37- 236 | 10-11-95 | 1230 | 12.0 | 7.4 | .1 | 392 |
| 37- 239 | 09-21-95 | 1425 | 11.0 | 7.3 | 4.2 | 863 |
| 37- 255 | 10-11-95 | 0950 | 12.0 | 7.2 | 3.4 | 732 |
| 37- 275 | 09-21-95 | 1100 | 12.5 | 7.6 | 2.5 | 572 |
| 37- 297 | 09-20-95 | 1220 | 11.0 | 7.4 | 5.8 | 615 |
| 37- 313 | 09-21-95 | 1205 | 11.5 | 7.8 | 4.8 | 542 |
| 41- 21 | 08-09-95 | 1409 | 12.0 | 7.8 | 6.8 | 421 |
| 41- 257 | 09-16-94 | 1430 | 12.0 | 7.5 | .5 | 629 |
| 41- 262 | 10-11-95 | 1510 | 10.5 | 7.8 | 7.7 | 349 |
| 41- 278 | 09-06-94 | 1010 | 13.5 | 7.6 | 8.1 | 486 |

Table 11. Results of analyses for selected pesticides in water samples from 90 community water supply wells in New Jersey, 1994-95

[USGS, U.S. Geological Survey; µg/L, micrograms per liter; --, none]

| USGS well number | Date | Pesticide detected by Rutgers Laboratory | Pesticide name and concentration in µg/L | Type of pesticide |
|---|---|---|---|---|
| 01- 792 | 08-28-95 | Yes | Dinoseb (1.6) | Herbicide |
| 01- 973 | 08-16-95 | No | -- | -- |
| 03- 15 | 09-12-95 | No | -- | -- |
| 03- 28 | 09-12-95 | No | -- | -- |
| 03 - 94 | 09-12-95 | Yes | Desethyl atrazine (0.6) | Herbicide |
| 03- 120 | 09-12-95 | No | -- | -- |
| 03- 346 | 09-13-95 | No | -- | -- |
| 03- 350 | 09-13-95 | No | -- | -- |
| 03- 395 | 09-13-95 | No | -- | -- |
| 03- 466 | 09-11-95 | No | -- | -- |
| 05- 187 | 09-09-94 | No | -- | -- |
| 09- 43 | 08-17-95 | No | -- | -- |
| 09- 297 | 08-18-95 | No | -- | -- |
| 09- 395 | 08-29-95 | No | -- | -- |
| 11- 273 | 08-31-95 | No | -- | -- |
| 11- 709 | 08-31-95 | No | -- | -- |
| 13- 2 | 08-11-94 | No | -- | -- |
| 13- 19 | 08-11-94 | No | -- | -- |
| 13- 65 | 10-02-95 | No | -- | -- |
| 15- 69 | 09-09-94 | No | -- | -- |
| 15- 327 | 08-28-95 | No | -- | -- |
| 15- 697 | 09-01-95 | Yes | Simazine (0.01) Metolachlor (0.02) | Herbicide, Herbicide |
| 15-1065 | 08-29-95 | Yes | Dinoseb (2.2) | Herbicide |
| 19- 302 | 08-08-95 | No | -- | -- |
| 19- 305 | 09-08-94 | No | -- | -- |
| 19- 312 | 09-06-94 | No | -- | -- |
| 19- 349 | 08-08-95 | No | -- | -- |
| 21- 44 | 08-31-94 | No | -- | -- |
| 21- 73 | 09-07-94 | No | -- | -- |
| 21- 373 | 09-08-95 | No | -- | -- |
| 21- 384 | 08-31-94 | No | -- | -- |
| 21- 387 | 08-03-95 | No | -- | -- |
| 23- 195 | 10-13-95 | No | -- | -- |
| 23- 232 | 09-21-94 | No | -- | -- |
| 23- 315 | 08-10-95 | No | -- | -- |
| 23-1213 | 08-10-94 | No | -- | -- |
| 25- 29 | 08-14-95 | No | -- | -- |
| 25- 284 | 10-04-94 | No | -- | -- |
| 25- 512 | 08-14-95 | No | -- | -- |
| 25-726 | 09-06-95 | No | -- | -- |
| 27- 35 | 09-16-94 | No | -- | -- |
| 27- 55 | 09-26-95 | No | -- | -- |
| 27- 62 | 09-27-95 | No | -- | -- |
| 27- 77 | 09-25-95 | No | -- | -- |
| 27- 108 | 09-26-95 | No | -- | -- |

Table 11. Results of analyses for selected pesticides in water samples from 90 community water supply wells in New Jersey, 1994-95--Continued

| USGS well number | Date | Pesticide detected by Rutgers Laboratory | Pesticide name and concentration in µg/L | Type of pesticide |
|---|---|---|---|---|
| 27- 113 | 08-10-94 | No | -- | -- |
| 27- 183 | 09-25-95 | No | -- | -- |
| 27- 189 | 10-10-95 | Yes | Metalaxyl (0.008) | Fungicide |
| 27- 191 | 10-10-95 | No | -- | -- |
| 27- 977 | 10-03-95 | No | -- | -- |
| 27-1002 | 09-13-94 | No | -- | -- |
| 27-1038 | 09-13-94 | No | -- | -- |
| 27-1173 | 09-27-95 | No | -- | -- |
| 27-1323 | 09-13-94 | No | -- | -- |
| 27-1746 | 09-25-95 | No | -- | -- |
| 27-1747 | 08-11-95 | No | -- | -- |
| 27-1771 | 10-06-94 | No | -- | -- |
| 27-1787 | 10-10-95 | No | -- | -- |
| 29- 5 | 08-16-95 | No | -- | -- |
| 29- 443 | 08-23-95 | No | -- | -- |
| 29- 576 | 09-20-94 | No | -- | -- |
| 29- 595 | 09-21-94 | No | -- | -- |
| 29- 627 | 08-22-95 | No | -- | -- |
| 29- 757 | 09-20-94 | No | -- | -- |
| 29- 810 | 09-20-94 | No | -- | -- |
| 29- 815 | 08-22-95 | No | -- | -- |
| 29- 917 | 09-06-95 | No | -- | -- |
| 29-1064 | 08-24-95 | No | -- | -- |
| 29-1066 | 08-23-95 | No | -- | -- |
| 29-1071 | 08-23-95 | No | -- | -- |
| 31- 12 | 09-14-95 | No | -- | -- |
| 31- 64 | 09-14-95 | No | -- | -- |
| 31- 93 | 09-14-95 | No | -- | -- |
| 33- 346 | 09-01-95 | No | -- | -- |
| 35- 63 | 08-11-95 | No | -- | -- |
| 35- 68 | 09-11-95 | No | -- | -- |
| 37- 1 | 09-15-94 | No | -- | -- |
| 37- 214 | 10-04-95 | No | -- | -- |
| 37- 229 | 09-20-95 | No | -- | -- |
| 37- 234 | 10-04-95 | No | -- | -- |
| 37- 236 | 10-11-95 | No | -- | -- |
| 37- 239 | 09-21-95 | No | -- | -- |
| 37- 255 | 10-11-95 | No | -- | -- |
| 37- 275 | 09-21-95 | No | -- | -- |
| 37- 297 | 09-20-95 | No | -- | -- |
| 37- 313 | 09-21-95 | No | -- | -- |
| 41- 21 | 08-09-95 | Yes | Desethyl atrazine (0.9) | Herbicide |
| 41- 257 | 09-16-94 | No | -- | -- |
| 41- 262 | 10-11-95 | No | -- | -- |
| 41- 278 | 09-06-94 | No | -- | -- |

Table 12. Results of analyses for selected nutrients in water samples from 90 community water supply wells in New Jersey, 1994-95

[USGS, U.S. Geological Survey; mg/L, milligrams per liter; <, less than; --, data not available]

| USGS well number | Date | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, nitrite dissolved (mg/L as N) | Nitrogen, ammonia + organic dissolved (mg/L as N) | Nitrogen, nitrite plus nitrate dissolved (mg/L as N) | Phosphorus ortho, dissolved (mg/L as P) |
|---|---|---|---|---|---|---|
| 01- 792 | 08-28-95 | <.015 | <.01 | <.2 | 2.80 | <.01 |
| 01- 973 | 08-16-95 | .04 | <.01 | <.2 | <.05 | <.01 |
| 03- 15 | 09-12-95 | <.015 | <.01 | <.2 | 1.4 | <.01 |
| 03- 28 | 09-12-95 | <.015 | <.01 | <.2 | 2.2 | .02 |
| 03- 94 | 09-12-95 | <.015 | <.01 | <.2 | 4.5 | <.01 |
| 03- 120 | 09-12-95 | <.015 | <.01 | <.2 | .88 | <.01 |
| 03- 346 | 09-13-95 | <.015 | <.01 | <.2 | 2.9 | .02 |
| 03- 350 | 09-13-95 | <.015 | <.01 | <.2 | 1.1 | .05 |
| 03- 395 | 09-13-95 | <.015 | <.01 | <.2 | 2.0 | .02 |
| 03- 466 | 09-11-95 | <.015 | <.01 | <.2 | 4.4 | <.01 |
| 05- 187 | 09-09-94 | .01 | <.01 | <.2 | .80 | .01 |
| 09- 43 | 08-17-95 | .64 | <.01 | .7 | <.05 | .12 |
| 09- 297 | 08-18-95 | .02 | <.01 | <.2 | <.05 | <.01 |
| 09- 395 | 08-29-95 | .27 | <.01 | .3 | <.05 | .12 |
| 11- 273 | 08-31-95 | <.015 | <.01 | <.2 | 7.6 | <.01 |
| 11- 709 | 08-31-95 | .10 | <.01 | <.2 | <.05 | .02 |
| 13- 2 | 08-11-94 | .02 | <.01 | <.2 | 1.9 | .02 |
| 13- 19 | 08-11-94 | .02 | <.01 | <.2 | 1.8 | .06 |
| 13- 65 | 10-02-95 | <.015 | <.01 | <.2 | .42 | .07 |
| 15- 69 | 09-09-94 | .28 | <.01 | .3 | .42 | .01 |
| 15- 327 | 08-28-95 | .69 | <.01 | .8 | <.05 | <.01 |
| 15- 697 | 09-01-95 | <.015 | <.01 | <.2 | 4.7 | .03 |
| 15-1065 | 08-29-95 | <.015 | <.01 | <.2 | 4.3 | <.01 |
| 19- 302 | 08-08-95 | <.015 | <.01 | <.2 | 2.1 | <.01 |
| 19- 305 | 09-08-94 | .01 | .01 | <.2 | 1.9 | <.01 |
| 19- 312 | 09-06-94 | .02 | <.01 | <.2 | 2.2 | .07 |
| 19- 349 | 08-08-95 | <.015 | <.01 | <.2 | 4.6 | .15 |
| 21- 44 | 08-31-94 | .01 | <.01 | <.2 | 1.6 | <.01 |
| 21- 73 | 09-07-94 | .01 | <.01 | <.2 | 4.5 | <.01 |
| 21- 373 | 09-08-95 | <.015 | <.01 | <.2 | 1.8 | .03 |
| 21- 384 | 08-31-94 | .01 | <.01 | <.2 | 1.6 | .04 |
| 21- 387 | 08-03-95 | .02 | <.01 | <.2 | 1.5 | .02 |
| 23- 195 | 10-13-95 | .87 | <.01 | 1.1 | .06 | <.01 |
| 23- 232 | 09-21-94 | <.01 | <.01 | <.2 | 6.6 | <.01 |
| 23- 315 | 08-10-95 | .02 | <.01 | <.2 | 5.8 | <.01 |
| 23-1213 | 08-10-94 | .02 | <.01 | <.2 | 4.2 | .06 |
| 25- 29 | 08-14-95 | .03 | <.01 | <.2 | <.05 | .10 |
| 25- 284 | 10-04-94 | -- | <.01 | <.2 | .07 | .09 |
| 25- 512 | 08-14-95 | .02 | <.01 | .4 | <.05 | .07 |
| 25- 726 | 09-06-95 | .02 | <.01 | <.2 | <.05 | .02 |
| 27- 35 | 09-16-94 | <.01 | <.01 | <.2 | 1.7 | .03 |
| 27- 55 | 09-26-95 | <.015 | <.01 | <.2 | .35 | .02 |
| 27- 62 | 09-27-95 | <.015 | <.01 | <.2 | 1.6 | .05 |
| 27- 77 | 09-25-95 | .04 | .01 | <.2 | <.05 | .09 |
| 27- 108 | 09-26-95 | <.015 | <.01 | <.2 | .30 | .01 |

Table 12. Results of analyses for selected nutrients in water samples from 90 community water supply wells in New Jersey, 1994-95--Continued

| USGS well number | Date | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, nitrite dissolved (mg/L as N) | Nitrogen, ammonia + organic dissolved (mg/L as N) | Nitrogen, nitrite plus nitrate dissolved (mg/L as N) | Phosphorus ortho, dissolved (mg/L as P) |
|---|---|---|---|---|---|---|
| 27- 113 | 08-10-94 | 0.01 | <0.01 | <0.2 | 1.7 | 0.04 |
| 27- 183 | 09-25-95 | <.015 | <.01 | <.2 | 1.4 | .04 |
| 27- 189 | 10-10-95 | <.015 | <.01 | <.2 | 3.5 | .01 |
| 27- 191 | 10-10-95 | <.015 | <.01 | <.2 | 1.5 | .05 |
| 27- 977 | 10-03-95 | <.015 | <.01 | <.2 | <.05 | .09 |
| 27-1002 | 09-13-94 | .01 | <.01 | <.2 | 1.0 | .11 |
| 27-1038 | 09-13-94 | .02 | <.01 | <.2 | 5.70 | .01 |
| 27-1173 | 09-27-95 | <.015 | <.01 | <.2 | .90 | .01 |
| 27-1323 | 09-13-94 | <.01 | <.01 | <.2 | .46 | .02 |
| 27-1746 | 09-25-95 | <.015 | <.01 | <.2 | <.05 | .13 |
| 27-1747 | 08-11-95 | <.015 | <.01 | <.2 | 2.1 | .01 |
| 27-1771 | 10-06-94 | -- | <.01 | <.2 | .19 | .04 |
| 27-1787 | 10-10-95 | <.015 | <.01 | <.2 | 3.0 | .02 |
| 29- 5 | 08-16-95 | .37 | <.01 | .3 | <.05 | .03 |
| 29- 443 | 08-23-95 | .03 | <.01 | <.2 | <.05 | .11 |
| 29- 576 | 09-20-94 | .04 | <.01 | <.2 | <.05 | .02 |
| 29- 595 | 09-21-94 | .07 | <.01 | <.2 | <.05 | <.01 |
| 29- 627 | 08-22-95 | .05 | <.01 | <.2 | 1.6 | <.01 |
| 29- 757 | 09-20-94 | <.01 | <.01 | <.2 | .72 | <.01 |
| 29- 810 | 09-20-94 | .01 | <.01 | <.2 | .34 | <.01 |
| 29- 815 | 08-22-95 | .15 | <.01 | <.2 | <.05 | .12 |
| 29- 917 | 09-06-95 | .02 | <.01 | <.2 | <.05 | .08 |
| 29-1064 | 08-24-95 | .07 | <.01 | <.2 | <.05 | .03 |
| 29-1066 | 08-23-95 | <.015 | <.01 | <.2 | <.05 | <.01 |
| 29-1071 | 08-23-95 | <.015 | <.01 | <.2 | <.05 | <.01 |
| 31- 12 | 09-14-95 | <.015 | <.01 | <.2 | .09 | .01 |
| 31- 64 | 09-14-95 | <.015 | <.01 | <.2 | .21 | <.01 |
| 31- 93 | 09-14-95 | <.015 | <.01 | <.2 | 2.0 | <.01 |
| 33- 346 | 09-01-95 | .24 | <.01 | .2 | <.05 | .34 |
| 35- 63 | 08-11-95 | <.015 | <.01 | <.2 | .57 | <.01 |
| 35- 68 | 09-11-95 | <.015 | <.01 | <.2 | 1.7 | .02 |
| 37- 1 | 09-15-94 | .01 | <.01 | <.2 | 1.1 | <.01 |
| 37- 214 | 10-04-95 | <.015 | <.01 | <.2 | 2.5 | <.01 |
| 37- 229 | 09-20-95 | <.015 | <.01 | <.2 | 2.5 | <.01 |
| 37- 234 | 10-04-95 | <.015 | <.01 | <.2 | 3.0 | <.01 |
| 37- 236 | 10-11-95 | <.015 | <.01 | <.2 | <.05 | <.01 |
| 37- 239 | 09-21-95 | <.015 | <.01 | <.2 | 1.8 | <.01 |
| 37- 255 | 10-11-95 | <.015 | <.01 | <.2 | 2.5 | .03 |
| 37- 275 | 09-21-95 | <.015 | <.01 | <.2 | .38 | <.01 |
| 37- 297 | 09-20-95 | <.015 | <.01 | <.2 | 2.5 | .04 |
| 37- 313 | 09-21-95 | <.015 | <.01 | <.2 | 1.5 | .01 |
| 41- 21 | 08-09-95 | .30 | <.01 | .3 | 1.4 | <.01 |
| 41- 257 | 09-16-94 | <.01 | <.01 | <.2 | <.05 | <.01 |
| 41- 262 | 10-11-95 | <.015 | <.01 | <.2 | .13 | .02 |
| 41- 278 | 09-06-94 | <.03 | <.01 | <.2 | 5.0 | <.01 |

Table 13. Comparison of results of analysis of multiple samples from selected wells for pesticides and nitrate in New Jersey, 1995 and 1996

[mg/L, milligrams per liter: μ g/L, micrograms per liter, YYMMDD, year/month/day; USGS, U.S. Geological Survey; NWQL, National Water-Quality Laboratory]

| USGS well number | Date first sampled (YYMMDD) | Pesticide(s) detected at the Rutgers Laboratory during first sampling round and concentration (μ g/L) | Concentration of nitrite plus nitrate as nitrogen (mg/L) | Date resampled (YYMMDD) | Pesticide(s) detected at the USGS/NWQL during second sampling round and concentration (μ g/L)[1] | Concentration of nitrite plus nitrate as nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 01- 792 | 950828 | Dinoseb (1.6) | 2.8 | 960402 | Carbofuran (0.08) | 3.0 |
| 03- 94 | 950912 | Desethyl atrazine (0.06) | 4.5 | 960307 | Simazine (0.006) | 5.0 |
| 15- 697 | 950901 | Simazine (0.01)<br>Metolachlor (0.02) | 4.7 | 960306 | Simazine (0.034)<br>Prometon (0.018)<br>Dieldrin (0.012)<br>Metolachlor (0.05)<br>Atrazine (0.099)<br>Tebuthiuron (0.37) | 4.7 |
| 15-1065 | 950829 | Dinoseb (2.2) | 4.8 | 960306 | None detected | 4.6 |
| 27- 189 | 951010 | Metalaxyl (0.01) | 3.5 | 960307 | Not analyzed at NWQL | 3.3 |
| 41- 21 | 950809 | Desethyl atrazine (0.9) | 1.4 | 960311 | Not analyzed at NWQL | 5.5 |

[1]Samples also were analyzed for pesticides at the Rutgers Laboratory. No pesticides were reported at concentrations greater than the method detection limit (MDL of about 1 μg/L) used by the Rutgers Laboratory. MDL's used by the NWQL and the Rutgers Laboratory were different for each compound and were different between laboratories for some compounds.

sent to the NWQL for pesticide analysis because the compound metalaxyl, which was detected by the Rutgers Laboratory in the first sampling round, is not on the NWQL analyte list. The Rutgers Laboratory detected no pesticide compounds in water from any of the five resampled wells; however, the NWQL detected pesticides, including some that were not detected in the first sampling round, in three of the four water samples sent there for analysis.

The presence of dissolved nitrate in water in all six wells was confirmed by the NWQL. Concentrations of nitrite plus nitrate (as N) in the resampling round for five of the six wells were very close to those determined previously. In well 41-21, the concentration of nitrite plus nitrate (as N) was 1.4 mg/L for the first sampling round and 5.5 mg/L for the resampling round. This difference in the concentration of nitrite plus nitrate between sampling events may be partly explained by the hydrogeologic setting of the well. Well 41-21 is completed in a limestone aquifer; water quality in limestone aquifers can change quickly because of the high rate of flow that can occur in the large solution cavities that typically develop in such aquifers.

The NWQL detected a total of seven different compounds in the four water samples sent for analysis. Six pesticides were detected in water from well 15-697 at the NWQL. Two of these, simazine and metolachlor, were found in samples by the Rutgers Laboratory in the original sampling round. The other four pesticides detected by the NWQL are on the analyte list of the Rutgers Laboratory but were not detected in either sampling round by the Rutgers Laboratory. Dinoseb was found in water from wells 15-1065 and 1-792 by the Rutgers Laboratory in the original sampling round. Dinoseb was not detected in water samples from these two wells sent to the NWQL for analysis during the resampling round; however, the NWQL did detect carbofuran in water from well 1-792. In water from well 3-94, desethyl atrazine was detected by the Rutgers Laboratory in the original sampling round; in the water sample sent to the NWQL, desethyl atrazine was not found, but simazine was detected.

The results of resampling indicate that pesticide detection was not reproducible by the Rutgers Laboratory for the two sampling events. The differences may result from the presence of different pesticides in the water from the well at the two sampling times. In addition, differences in MRL's and method detection limits (MDL's) may account partly for these results. The MRL is the smallest concentration of a compound that the analyst can report with confidence. The MDL is the smallest concentration of a compound that the laboratory can reliably detect. The MRL's used by the Rutgers Laboratory for the first sampling round were lower than those used for the resampling round. Differences in MRL's and MDL's may also account for differences between Rutgers Laboratory and NWQL findings. For some of the pesticides determined during the resampling round, the NWQL MRL's are as much as 10 times lower than the MRL's of the Rutgers Laboratory. In some cases, this means that if the NWQL detected very low pesticide concentrations in a water sample, the concentrations might have been below the MRL's of the Rutgers Laboratory and, therefore, would not have been reported.

## SUMMARY

Water-quality samples were collected from community water supply wells in New Jersey as part of a study to evaluate the validity of a model designed to estimate the vulnerability of ground water used for community water supplies to pesticide contamination. Samples collected from 90 community water supply wells in 1994 and 1995 were analyzed for 143 pesticides and 5 dissolved nutrients. The 90 wells were a subset of the population of 1,945 community water supply wells in New Jersey. The subset was chosen randomly from the population of community water supply wells using methods of stratification of wells into categories of well vulnerability and aquifer type.

Pesticides were present in water from 6 of the 90 wells sampled. Pesticides detected include four herbicides (desethyl atrazine, dinoseb, metolachlor, and simazine) and one fungicide (metalaxyl). One sample contained two pesticide compounds. Concentrations of pesticides ranged from 0.01 to 2.2 μg/L. None of the samples contained concentrations that exceeded a USEPA maximum contaminant level. Pesticides were detected in samples from wells in each of three aquifer categories. Three of the wells were screened in Coastal Plain sediments, two were screened in glacial-deposit sediments, and one was completed in fractured bedrock.

Nitrate was the dominant form of nitrogen present in most samples. Nitrate concentrations in samples ranged from below the detection limit of 0.05 to 7.6 mg/L, and concentrations of dissolved nitrate (as N) were below the USEPA maximum contaminant level of 10 mg/L.

## REFERENCES CITED


Fishman, M.J., Raese, J.W., Gerlitz, C.N., and Husband, R.A., 1994, U.S. Geological Survey approved inorganic and organic methods for the analysis of water and fluvial sediment, 1954-94: U.S. Geological Survey Open-File Report 94-351, 55 p.

Horowitz, A.J., Demas, C.R., Fitzgerald, K.K., Miller, T.L., and Rickert, D.A., 1994, U.S. Geological Survey protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water: U.S. Geological Survey Open-File Report 94-539, 57 p.

Louis, J.B., and Vowinkel, E.F., 1989, Effect of agricultural chemicals on ground-water quality in the New Jersey Coastal Plain, *in* Weigmann, E.L., ed., Pesticides in terrestrial and aquatic environments, Proceedings of a National Research Conference, May 11-12, 1989: Blacksburg, Va., Virginia Water Resources Research Center, p. 80-88.

Louis, J.B., Sanders, P.F., and Bono, P.M., 1994, Implementation of a program to assess the vulnerability of New Jersey's drinking water supplies to pesticide contamination, *in* Weigmann, D.L., ed., Proceedings of the Fourth National Conference on Pesticides, November 1-3, 1993--New directions in pesticide research, management, and policy: Blacksburg, Va., Virginia Water Resources Research Center, p. 167-183.

Mogadati, P.S., Wang, S., Roinestad, K.S., and Rosen, J.D., 1994, Significant improvements in multiresidue pesticide analysis, *in* Weigmann, D.L., ed., Proceedings of the Fourth National Conference on Pesticides, November 1-3, 1993--New directions in pesticide research, management, and policy: Blacksburg, Va., Virginia Water Resources Research Center, p. 409-427.

Pritt, J.W., and Raese, J.W., 1995, Quality assurance / quality control manual--National Water Quality Laboratory: U.S. Geological Survey Open-File Report 95-443, 35 p.

Scott, J.C., 1990, Computerized stratified random site-selection approaches for design of a ground-water-quality sampling network: U.S. Geological Survey Water-Resources Investigations Report 90-4101, 109 p.

Timme, P.J., 1995, National Water Quality Laboratory 1995 services catalog: U.S. Geological Survey Open-File Report 95-352, 120 p.

U.S. Environmental Protection Agency, 1991, Fact sheet: National primary drinking-water standards: EPA 570/9-91-012FS, August 1991, 8 p.

Vowinkel, E.F., Clawges, R.M., and Uchrin, C.G., 1994, Evaluation of the vulnerability of water from public supply wells in New Jersey to contamination by pesticides, *in* Weigmann, D.L., ed., Proceedings of the Fourth National Conference on Pesticides, November 1-3, 1993--New directions in pesticide research, management, and policy: Blacksburg, Va., Virginia Water Resources Research Center, p. 495-510.

## REFERENCES CITED--Continued

Wood, W.W., 1976, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, book 1, chap. D2, 24 p.

Zapecza, O.S., 1989, Hydrogeologic framework of the New Jersey Coastal Plain: U.S. Geological Survey Professional Paper 1404-B, 49 p., 24 pl.

## Appendix 1. Aquifer codes used in New Jersey

| Aquifer code[1] | Aquifer name |
|---|---|
| 112MORN | Moraine |
| 112SFDF | Stratified drift |
| 121CKKD | Cohansey Sand-Kirkwood Formation |
| 121CNSY | Cohansey Sand |
| 122KRKDL | Kirkwood Formation, Lower Sand |
| 125VNCN | Vincentown Formation |
| 211EGLS | Englishtown Formation |
| 211FRNG | Farrington Sand Member |
| 211MRPA | Undifferentiated Potomac-Raritan-Magothy aquifer system |
| 211MRPAL | Lower aquifer of the Potomac-Raritan-Magothy aquifer system |
| 211MRPAM | Middle aquifer of the Potomac-Raritan-Magothy aquifer system |
| 211ODBG | Old Bridge Sand Member of Magothy Formation |
| 227BRCKS | Brunswick Group Sedimentary |
| 227PRKS | Preakness Basalt |
| 227PSSC | Passaic Formation |
| 231SCKN | Stockton Formation |
| 344CRNL | Cornwall Shale |
| 360KTTN | Kittatinny Limestone |
| 367EPLR | Epler Formation |
| 371ALNN | Allentown Dolomite |
| 374LSVL | Leithsville Formation |
| 400PCMB | Precambrian Erathem |

[1]The first three digits of the aquifer code represent the geologic age of the matrix and the four or five letters are an abbreviation of the aquifer name. The first three digits do not appear in table 4.