

WATER QUALITY

Samples from 15 ground-water wells and 5 surface-water sites were used to document the quality of ground water and surface water in the Salem River study area. Water has the capacity to dissolve at least small amounts of almost all substances that it contacts (Heath, 1987, p. 64). The chemical characteristics of ground water are controlled by temperature, pressure, the amount of time of contact with the rocks and sediment through which it flows, and human activities. The quality of water in an unconfined aquifer system can vary more than that in a confined aquifer because the water table is near the land surface and the downward movement of surface-related constituents is unimpeded by a confining unit.

The ground-water samples were intended to represent background water quality, so samples from wells located near, or at, landfills and hazardous-waste sites or thought to be affected by contamination were not selected. Analyses for 10 of the 15 ground-water samples were selected from the WATSTORE data base, which is maintained by the USGS, and were limited to samples collected in the last 10 (1985-94) years and analyzed for major ions and trace elements. The other five ground-water samples were collected specifically for this study in February 1994. All 15 ground-water samples were collected according to the methods described in Wood (1976) and Clausen (1982). Analyses for all five surface-water samples were selected from the WATSTORE data base and were limited to those collected during base-flow conditions in the last 10 years and analyzed for major ions and trace elements. Surface-water samples were collected at streamflow-gaging stations by using the equal-discharge-increment method described in Ward and Harr (1990). Results of the analyses of the selected ground-water and surface-water samples are presented in tables 4-1 and 4-2, respectively.

The results of the analyses of the ground-water samples shown in table 4-1 were compared with the USEPA drinking-water standards established in accordance with the Safe Drinking Water Act (PL 95-523). Six of the 15 ground-water samples contained nitrate plus nitrite in excess of 10 mg/L (milligrams per liter), which is the USEPA's maximum contaminant level (MCL) (U.S. Environmental Protection Agency, 1991). No other constituents were present in the ground water in concentrations that exceeded USEPA's primary drinking-water standards; however, concentrations of several constituents exceeded the USEPA secondary maximum contaminant levels (SMCLs) (U.S. Environmental Protection Agency, 1996). The SMCLs of 200 µg/L for aluminum, 500 µg/L for iron, and 50 µg/L for manganese were equal to or exceeded in ground-water samples from 6, 2, and 5 of the 15 wells, respectively. The pH of samples of ground water from 14 of the 15 wells was lower than the SMCL range of 6.5 to 8.5.

USEPA drinking-water standards do not apply to untreated surface water. Instead, surface-water standards that vary according to the use of a surface-water body or stream are established by the State of New Jersey (New Jersey Department of Environmental Protection, 1994). Because these standards vary across the Salem River study area, they are not used in this report as a regional index with which to compare surface-water quality.

Stiff diagrams for the 15 ground-water and 5 surface-water samples are plotted in figure 4-1. These diagrams represent the relative concentrations, in milliequivalents per liter, of the major cations to the left of the vertical axis and of the major anions to the right of the vertical axis. Differences in the ionic composition of the samples can be evaluated by comparing shapes of the figures. For all but one of the surface-water samples, dissolved iron is not reported; therefore, a value of zero was used for this constituent in the surface-water Stiff diagrams. Also, concentrations of total nitrate plus nitrite were substituted for concentrations of dissolved nitrate plus nitrite in the surface-water Stiff diagrams because data for the dissolved constituents were unavailable. This substitution is justifiable for two reasons. (1) Nitrate is generally not stable in the natural waters of the study area and, thus, any nitrogen species is likely to be present as nitrate. (2) Nitrate is highly soluble in water; therefore, the nitrate that is present is likely to be nearly all in the dissolved state, and the total-nitrate concentration is nearly the same as the dissolved-nitrate concentration.

A maximum contaminant level (MCL) is the highest concentration, amount, or level of a specific contaminant allowed in water distributed by a public water supplier. MCLs are set by Federal and State agencies to protect the public health, and are enforceable under the authority of the Safe Drinking Water Act.

The USEPA does not have an MCL for lead in ground water but has a treatment requirement (U.S. Environmental Protection Agency, 1991) for ground water in which lead concentrations exceed 15 µg/L (micrograms per liter). Analyses of the 10 samples analyzed before 1994 had lead detection limits of 30 µg/L, so the results are inconclusive with respect to the 15 µg/L treatment requirement; none of the 5 samples contained lead in a concentration that exceeded the treatment requirement.

A secondary maximum contaminant level (SMCL) is the limit for the concentration, amount, or level of a constituent that affects the aesthetic quality of drinking water, such as taste, odor, and color. SMCLs are intended for use as guidelines and are not enforceable.

The Stiff diagrams indicate that either calcium or magnesium is the major cation in 17 of the 20 ground-water and surface-water samples collected throughout the Salem River study area. In ground water, nitrate plus nitrite and chloride are the major anions; in surface water, carbonate plus bicarbonate is the major anion. Carbonate plus bicarbonate is noticeably low in 15 of the 15 ground-water samples. Stiff diagrams for the samples from wells 33-698 and 33-699 are different from those for the rest of the ground-water samples because these samples contained the greatest proportion of the anion carbonate plus bicarbonate and the cations sodium and potassium.

Ground Water

The results of analyses of ground-water samples from all the wells except 33-698 and 33-699 were similar enough to be interpreted together; the analysis results for these two wells are interpreted separately. The prevalence of elevated concentrations of dissolved nitrate plus nitrite probably is related to the predominance of agricultural land throughout the Salem River study area. The agricultural sources of nitrate and nitrite are mainly the leaching of fertilizer and manure applied to fields and the leaching of wastes from facilities. The presence of the nitrogen species ammonia suggests proximity to a source of nitrogen. Sources of chlorine to the shallow ground-water system could be road salt or fertilizer. The significant levels of the cations calcium, magnesium, and strontium in the ground water suggest dissolution of calcium carbonate material. However, none of these wells is screened to or near geologic units that contain significant amounts of calcium carbonate material such as calcareous sand or shell beds. Therefore, the most likely source of the weathered calcium carbonate is agricultural lime that has dissolved in the soil and leached to the water table. The relatively low pH of the precipitation most likely enhances the dissolution of agriculturally-related calcium carbonate in the soil column. The low pH (4.5 to 5.5) of the ground water causes the carbonate ions to be present mainly as carbonic acid (H₂CO₃). This interpretation is consistent with the analytical results, which show low alkalinity (little carbonate plus bicarbonate (CO₃²⁻ + HCO₃⁻)) in the ground water but, at the same time, high concentrations of calcium, magnesium, and strontium.

The chemical composition of the water samples from wells 33-698 and 33-699 is different from that of the samples from the rest of the wells mainly because these two wells are adjacent to low-lying regional discharge areas. These areas are in the low parts of the basins and are adjacent to the extensive wetlands that border the Delaware Bay and River. Ground water in a regional discharge area typically comes from the deep regional flow system and is generally older and has traveled a greater distance than ground water in other parts of the system (Fetter, 1994). The long residence time allows the ground water to fully equilibrate with the aquifer material; thus, pH and alkalinity were higher in the samples from wells 33-698 and 33-699 than in the other 13 ground-water samples, which were collected from wells that were not near regional discharge areas and thus represent ground water with a relatively short residence time.

The presence of high concentrations of dissolved iron and organic carbon and low concentrations of dissolved oxygen in samples from wells 33-678 and 33-698 suggests a local source of organic matter that has consumed dissolved oxygen and allowed high levels of dissolved iron (Fe²⁺) to be stable. Because neither of these wells is hydraulically downgradient from a natural organic carbon source such as a wetland, the source may be an agricultural area or an individual septic system.

Surface Water

The chemistry of the surface-water samples collected at the five sites is largely a reflection of the chemistry of the ground water that provides base flow to the streams. Three of the surface-water sites (01477120, 01477510, 01482500) are located farther downstream and drain a larger upstream area than the other two surface-water sites (01413080, 0147728). Fig. 4-1). Much of the base flow at the three sites probably is derived from deep regional flow that has passed through the calcareous (shaly) layers of the Newark Formation. The calcareous material combined with the long residence time and long flow path of the water is probably the reason that the pH and alkalinity of the surface water at those three sites were higher than at the other two sites. Additionally, as much as 6 percent of the streamflow at these three sites is derived from wastewater-treatment-plant discharges. Treatment-plant discharge typically is alkaline and high in dissolved constituents, which would further increase the pH and alkalinity of the surface water, especially during base-flow conditions.

The other two surface-water sites (01413080, 01477128) drain small areas and probably receive little water from deep regional ground-water flow. Consequently, the Stiff diagrams of the chemical composition of the base-flow samples from these sites show that the alkalinity, pH, and concentrations of almost all dissolved chemical constituents measured were lower at these two sites than at the other three sites. This result is consistent with the observed differences in the water-quality samples from the unconfined aquifer; samples collected from regional discharge areas that receive considerable deep regional flow showed higher alkalinity and pH than those collected from areas that receive little deep regional flow.

Table 4-1. Selected results of water-quality analyses of ground-water samples from 15 sites, Salem River study area, New Jersey. [Site locations are shown in figure 4-1; feet, NGVD, National Geodetic Vertical Datum of 1929 (related to this report as "sea level"); µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no reported value; constituents not detected in a sample are reported as the value of the detection limit for that analysis preceded by a less-than symbol (<)]

New Jersey well number	Local name	Date sampled	Depth of well below land surface (feet)	Elevation of land surface above sea level (feet)	Specific conductance (µS/cm)	pH field (measured units)	Temperature, water (deg. C)	Oxygen dissolved (mg/L)	Iron, dissolved (mg/L)
11-287	IRF-1979	06-30-87	50	110	23	4.9	15.2	6.7	0.0
15-276	AUSA CIRCULARS OPER 1	09-20-88	62	140	246	4.7	13.5	8.3	0.0
33-370		02-16-94	52	25	177	4.7	13.5	5.6	0.0
33-466	WILSON I	12-08-88	65	140	362	5.4	13.0	8.9	0.0
33-468	HALTICOM RD	02-16-94	52	25	375	4.0	13.0	7.7	0.0
33-475	FAITH CH CHM	08-14-90	50	134	248	4.8	15.5	5.2	0.0
33-476	PITTSV GOM	05-23-90	40	142	221	4.1	14.1	4.3	0.0
33-677	UPPER PITTSV SLS MW1	07-20-90	40	130	236	4.2	14.5	9.6	0.0
33-678	REVERES COM	06-16-80	40	130	192	11.5	4.3	16.3	9.0
33-679	REVERES COM	05-15-90	70	140	188	4.8	14.5	8.5	0.0
33-682	REVERES COM	05-15-90	115	140	188	4.8	14.5	8.5	0.0
33-689	PAPULSZEWSKI HAND DUG	02-17-84	13	10	277	5.6	8.0	6.0	0.0
33-700	BUZZY HAND DRIVEIN	02-17-84	21.5	22	432	4.6	13.0	8.5	0.0

New Jersey well number	Calcium, dissolved (mg/L as Ca ²⁺)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, dissolved (mg/L as CaCO ₃)	Sulfate, dissolved (mg/L as SO ₄)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO ₂)	Nitrogen, dissolved (mg/L as N)
11-287	14	12	7.1	3.2	3.0	31	27	<0.1	11	145
15-276	5.6	4.3	3.0	2.4	1.9	5.3	11	<1	8.5	<0.10
33-370	22	6.8	1.9	1.0	2.0	0.1	12	<1	7.7	<0.10
33-466	25	19	1.0	3.8	6.0	33	39	<1	10	229
33-468	12	6.5	3.7	6.2	<1.0	<1.0	<1.0	<1.0	8.1	101
33-475	25	22	8.2	5.9	7.0	41	36	<1	9.9	<0.10
33-476	13	11	9.0	3.7	3.8	41	23	<1	13	<0.10
33-477	17	3.8	1.1	1.1	1.1	36	15	<1	15	<0.10
33-477	18.0	7.6	1.7	1.5	1.0	<1.0	<1.0	<1.0	6.8	<0.10
33-478	3.7	2.9	3.8	1.2	<1.0	18	13	<1	10	<0.10
33-482	6.2	5.4	11	2.4	3.6	<1.0	28	<1	6.0	<0.10
33-688	20	9	26	100	143	107	<1	10	423	0.10
33-689	18	11	3.1	20	37	60	3.5	<1	7.1	176
33-700	45	13	2.3	11	<1.0	61	29	<1	7.4	283

New Jersey well number	Nitrogen, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Aluminum, dissolved (mg/L as Al)	Barium, dissolved (mg/L as Ba)	Beryllium, dissolved (mg/L as Be)	Chromium, dissolved (mg/L as Cr)	Cobalt, dissolved (mg/L as Co)	Copper, dissolved (mg/L as Cu)
11-287	8.80	<0.10	<0.10	110	87	<1.0	<1.0	<1.0	<1.0	<1.0
15-276	6.60	<0.10	<0.10	200	210	<1.0	<1.0	<1.0	<1.0	<1.0
33-370	18.0	<0.10	<0.10	240	280	<1.0	<1.0	<1.0	<1.0	<1.0
33-466	20.0	<0.10	<0.10	30	110	<1.0	<1.0	<1.0	<1.0	<1.0
33-468	13.0	<0.10	<0.10	40	80	<1.0	<1.0	<1.0	<1.0	<1.0
33-475	13.0	<0.10	<0.10	670	84	<1.0	<1.0	<1.0	<1.0	<1.0
33-476	20.0	<0.10	<0.10	20	20	<1.0	<1.0	<1.0	<1.0	<1.0
33-477	18.0	<0.10	<0.10	630	230	<1.0	<1.0	<1.0	<1.0	<1.0
33-478	1.40	<0.10	<0.10	910	87	<1.0	<1.0	<1.0	<1.0	<1.0
33-482	6.10	<0.10	<0.10	40	80	<1.0	<1.0	<1.0	<1.0	<1.0
33-688	680	<0.10	<0.10	450	<1	<1.0	<1.0	<1.0	<1.0	<1.0
33-689	6.80	<0.10	<0.10	0.00	<1	<1.0	<1.0	<1.0	<1.0	<1.0
33-700	24.0	<0.10	<0.10	<1	<1	<1.0	<1.0	<1.0	<1.0	<1.0

New Jersey well number	Iron, dissolved (mg/L as Fe)	Lead, dissolved (mg/L as Pb)	Lithium, dissolved (mg/L as Li)	Manganese, dissolved (mg/L as Mn)	Molybdenum, dissolved (mg/L as Mo)	Nickel, dissolved (mg/L as Ni)	Silver, dissolved (mg/L as Ag)	Strontium, dissolved (mg/L as Sr)	Vanadium, dissolved (mg/L as V)	Zinc, dissolved (mg/L as Zn)	Carbon, organic, dissolved (mg/L as C)
11-287	44	<30	<4	17	<10	<10	<10	140	<6	5	0.8
15-276	15	<30	<4	59	<10	<10	<10	43	<6	16	5
33-370	30	<30	<4	77	<10	<10	<10	68	<6	16	100
33-466	9	<1	5	44	<10	<10	<10	84	<6	18	5
33-468	5	<30	<4	33	<10	<10	<10	230	<6	2	4
33-475	3	<1	36	<10	<10	<10	<10	210	<6	12	1.0
33-476	11	<30	<4	8	<10	<10	<10	21	<6	7	1.2
33-477	20	<30	<4	8	<10	<10	<10	21	<6	7	1.2
33-478	3900	<30	<4	94	<10	<10	<10	2.6	44	<6	48
33-482	10	<30	<4	6	<10	<10	<10	62	<6	9	6
33-688	9500	<1	<4	600	<10	<10	<10	1.0	27	27	20
33-689	18	<1	<4	12	<10	<10	<10	100	<6	430	1.2
33-700	4	<1	5	32	<10	<10	<10	210	<6	38	6

Analysis done by using whole-water total free-endpoint titration.
*The lead detection limit for samples analyzed before 1994 is 30 µg/L (John Garbarino, U.S. Geological Survey, written comm., 1994).

Table 4-2. Selected results of water-quality analyses of surface-water samples from five sites, Salem River study area, New Jersey. [Site locations are shown in figure 4-1; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; --, no reported value; mg/L, milligrams per liter; µg/L, micrograms per liter; E, estimated value; mg/100 mL, milligrams per 100 milliliters; MPN, most probable number; constituents not detected in a sample are reported as the value of the detection limit for that analysis preceded by a less-than symbol (<)]

New Jersey surface-water site number	Date sampled	Drainage area (mi ²)	Specific conductance (µS/cm)	pH field (measured units)	Temperature, water (deg. C)	Oxygen, dissolved (mg/L)	Biochemical oxygen demand (5-day) (BOD ₅) (mg/L)	Fecal coliform (MPN/100 mL)
01413080	06-13-85	3.19	53	7.3	10.5	12	<10	160
01477120	10-25-83	2.3	73	8.3	10.5	10.1	1.0	40
0147728	11-03-86	2.57	119	6.7	10.5	10.1	1.0	40
01477510	11-04-83	21.0	292	7.4	8.3	12.0	1.0	20
01482500	10-26-93	14.6	273	7.4	14.0	9.1	2.3	100

New Jersey surface-water site number	Calcium, dissolved (mg/L as Ca ²⁺)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, dissolved (mg/L as CaCO ₃)	Sulfate, dissolved (mg/L as SO ₄)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO ₂)
01413080	6.1	1.0	2.0	0.41	12	8.5	2.8	0.22	4.8
01477120	23	4.1	6.0	4.2	39	27	16	20	12
0147728	31	2.7	2.9	1.9	21	12	12	12	12
01477510	5.0	0.9	6.9	7.6	35	39	24	20	7.1
01482500	19	1.0	3.0	1.0	12	12	12	12	12

New Jersey surface-water site number	Solids, dissolved (mg/L)	Nitrogen, dissolved (mg/L as N)	Nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Aluminum, dissolved (mg/L as Al)	Barium, dissolved (mg/L as Ba)	Beryllium, dissolved (mg/L as Be)	Chromium, dissolved (mg/L as Cr)	Cobalt, dissolved (mg/L as Co)	Copper, dissolved (mg/L as Cu)
01413080	104	0.017	0.980	<0.006	0.30	0.120	<0.010	7	<1	<1	<1
01477120	142										